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Environmental, climate and socio-economic factors in large-scale land acquisitions (LSLAs)

Chiara Mazzocchi [a,*], Luigi Orsi [b], Guido Sali [a]

[a] *Department of Agricultural and Environmental Sciences, University of Milan, Via Celoria 2, 20133, Italy*
[b] *Department of Environmental Science and Policy, University of Milan, Via Celoria 2, 20133, Italy*

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ABSTRACT

Since the economic crisis of 2007–2008, during which food commodity prices peaked, there has been an increase in Large-Scale Land Acquisitions (LSLAs) worldwide (Landmatrix, 2017). In addition to socio-economic factors, climate change might be in relation to LSLAs but its possible role has largely been unrecognized. We assessed the role of economic, political, environmental and climate variables on LSLAs, both in host and investor countries. We hypothesized that investors may be influenced in their land acquisitions by the level of climate change both in the target and the investor countries. We used a gravity model starting from a raw dataset of 2402 concluded deals from 2003 to 2017. The results suggest that climatic conditions play a statistically significant role as explanatory factors for LSLAs in Target countries, confirming the original assumptions.

1. Introduction

The last decade saw a renewed interest in investing in land in land-available countries (Lay and Nolte, 2017; Land Matrix, 2017). The economic crisis of 2007–2008 in which food commodities prices peaked was followed by Large-Scale Land Acquisitions (LSLAs) all over the world (Land Matrix, 2017).

The attractiveness of a country in terms of LSLAs mainly depends on the availability of land with agricultural potential (Arezki et al., 2015). The majority of deals have been signed in land-abundant and fertile countries in Africa, Latin-America and Asia, by transnational firms, entrepreneurs and countries themselves (Aha and Ayitey, 2017). In fact, land endowment is a typical investment which can also lead to economic bilateral deals directly between countries (Mazzocchi et al., 2018).

Investor countries exploit LSLAs to bypass market intermediaries to secure resources for import, by finding stable investments in land, and avoiding restrictive domestic rules relating to the environment and the lack of natural resources (Ingalls et al., 2018). Thus, agricultural lands are acquired not only to produce food, but also to invest in non-food agricultural goods, such as bio-energy products, wood and timber, mining. As an example, Davis et al. (2020) found that LSLAs can cause high deforestation of tropical forests, due to the cultivation of oil palm, wood fibre and tree plantations for timber. Alternatively, such land is seen as a safe capital investment, without necessarily using land for agricultural production (Land Matrix, 2017), thus leading to underused land and speculation (Debonne et al., 2019). In fact, the increasing competition among land uses in LSLAs has contributed substantially to higher food prices and a more volatile commodity market (Davis et al., 2015) affecting food security (Santangelo, 2018).

* Corresponding author.
E-mail addresses: chiara.mazzocchi1@unimi.it (C. Mazzocchi), luigi.orsi@unimi.it (L. Orsi), guido.sali@unimi.it (G. Sali).

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The current debate on LSLAs is led by the fear of landgrabbing (Conigliani et al., 2018) and watergrabbing (Theesfeld, 2018; Dell'Angelo et al., 2017), because these acquisitions are often characterized by lack of transparency, scarce care for indigenous populations, and corruption (Ingalls et al., 2018; Nally, 2015). The last decade also witnessed the involvement of States in the land transactions (Mazzocchi et al., 2018). In fact, Borras et al. (2012) identified three government behavior among State and non-State actors concerning land grabbing governance. These three actions are aimed at i) regulating and fostering land deals; ii) mitigating opposing effects and optimizing chances for land deals; and iii) stopping and rollbacking land contracts.

Potentially, LSLAs could contribute to reduce poverty in the target countries by generating local employment opportunities, stimulating rural economic growth, increasing agricultural labor productivity, and improving nutritional status (Baumgartner et al., 2015). However, investors tend to hoard these resources rather than developing local communities, actually preventing their survival (Mazzocchi et al., 2018), without improving the economy of the regions where investments are being made.

Determining the amount of production remained available for local populations is essential when assessing the regional impact of LSLAs (Davis et al., 2015). This is because investors usually have a purely economic focus and do not consider the potential impacts on the local population, or on the environment (Davis et al., 2020); moreover, productions are often sold elsewhere (Brown, 2000). In fact, according to Lay and Nolte (2017), investors usually come from the Global North and the emerging economies of Asia and the Middle East, with a low amount of fertile lands but a good financial availability, thus the hypothesis is that investor countries ensure their own food security (or energy security) through LSLAs, targeting regions with better agricultural potential (Messerli et al., 2014; Muller et al., 2020) and bigger water availability (Chiarelli et al., 2016). Investors have diverse aims from each other, mainly linked to the principal needs of a particular country. For example, Saudi and Korean investments are aimed at food productions, whereas European investors are mainly interested in fuel and flex crop cultivation (Mazzocchi et al., 2018).

In addition, even when unconverted LSLA areas are still available for farming by smallholders, the land acquisition creates insecure land tenure conditions for these farmers, which means that although the original land use continues, the ownership becomes insecure (Debonne et al., 2019).

Target countries are usually located in the Global South, of considerable size, with a relatively low population density, land and water availability (Mazzocchi et al., 2018; Nolte et al., 2016) and weak land tenure rights (Dell'Angelo et al., 2017; Giovannetti and Ticci, 2016). Nevertheless, the lack of available data on land deals has meant for a long time that the LSLA issue could not be easily analyzed. Since the 2000s the Land Matrix database, an independent initiative regarding LSLAs, has been collecting data on land deals at global scale and is reputed to be a reliable source (Conigliani et al., 2018; Lay and Nolte, 2017; Giovannetti and Ticci, 2016). Thus, the literature on LSLAs is quite recent, and in the last ten years has focused on determinants of LSLAs in terms of economic, political and social parameters (among others: Lay and Nolte, 2017; Arezki et al., 2015; Anseeuw et al., 2012; Borras et al., 2012; Aha and Ayitey, 2017) as well as more rarely environmental topics (Dell'Angelo et al., 2017; Rulli et al., 2013; Chiarelli et al., 2020; Messerli et al., 2014). Studies tend to focus on estimating Foreign Direct Investment (FDI) drivers (Olayinka, 2018; Conigliani et al., 2018, Arezki et al., 2015, Giovannetti and Ticci, 2016).

To the best of our knowledge, there are no scientific studies that have empirically established the link between Climate Change (CC) and LSLAs. Both empirical works and the theoretical analysis of this relationship are scarce. Davis et al. (2015) suggested that CC also encourages the LSLAs phenomenon, as a potential driver whose role has largely been unrecognized. Olayinka (2018) found the "average precipitation" factor to be positively correlated to the FDI in Sub-Saharan countries. According to Davis et al. (2015) CC can significantly influence LSLAs because climate extremes have recently impacted agricultural productions in many regions of the world. Climate trends have affected air, land, and water resources, and knowledge of the future effects are also crucial in achieving sustainable agricultural production and food and water security (Wheaton and Kulshreshtha, 2017). Thus, in this work we have hypothesized that investors may be influenced in their land acquisitions by the climate conditions of both the target and the investor countries. Another indirect impact of climate factors may be due to the use of carbon credit mechanisms, which also intensified the demand for land (Davis et al., 2015). Our study investigates the influence of economic, political, environmental and climate variables on LSLAs, both in host and investor countries. A gravity model in which both host and investor countries parameters were taken into consideration was therefore employed, to assess LSLAs influence including climate factors.

This research contributes to the literature mainly in two ways: the first is the impact assessment of climate variables on LSLAs, which has never been investigated before. The second contribution is related to the methodology, including various socio-economic variables that have never been tested before but which are important in tracing the profile of the hosts and investors involved in LSLAs.

The paper is organized as follows. Section 2 details the issues of factors related to LSLAs and CC. Section 3 presents the methodology and data. Sections 4 and 5 present and discuss the results. Section 6 draws conclusions.

2. Literature on factors related to LSLAs and CC issue

As mentioned in the introduction, to the best of our knowledge no study has assessed the relationship between CC and LSLAs. The recent literature on LSLA relationships has mainly focused on FDI in order to explain this phenomenon using bilateral gravity models (Olayinka, 2018; Lay and Nolte, 2017; Giovannetti and Ticci, 2016; Arezki et al., 2015; De Maria, 2015) unilateral regression models (Conigliani et al., 2018; Mazzocchi et al., 2018) scenario assessments (Baumgartner et al., 2015), network analysis (Interdonato et al., 2020) and qualitative and quantitative analyses of a number of case studies (Chiarelli et al., 2020; Tura, 2018; Hausermann et al., 2018; Hules and Singh, 2017; Augustine et al., 2016).

The analyze carried on by Interdonato et al. (2020) has shown as all continents are affected by LSLAs phenomenon and that a Global North-Global South dynamic typifies the land trades. At the same time, the main target countries resulted to be characterized by low governance and food security and high corruption levels. As for gravity models, the literature suggests that the distance between the host and investor countries is a strong predictor of the land investment relationship, as confirmed by many studies (Arezki et al., 2015; Lay and Nolte, 2017; Olayinka, 2018). Thus, the greater the distance, the less likely that an investment will take place. On the other hand, a past colonial relationship between two countries, together with a common official language, have been demonstrated to be positively correlated to the amount of land acquired (Lay and Nolte, 2017; De Maria, 2015). Arezki et al. (2015) and Lay and Nolte (2017) used the number of LSLA deals as the dependent variable in their gravity models; they confirmed that land and water availability as well as weak land rights of the hosts are the main factors related to LSLAs, together with the fact that investor countries with insufficient fertile lands primarily invest in land in order to obtain food crops. De Maria (2015) employed the size of LSLAs in hectares as a dependent of the gravity model, using as explanatory variables a battery of agricultural and institutional indicators without focusing on environmental issues. The author supported the literature findings in affirming that some of the most important factors in explaining a greater size of LSLAs deals are the weak rule of law and the high level of corruption of the target countries. Mazzocchi et al. (2018) highlighted the positive influence of the availability of water resources of hosts countries on land acquisitions by investigating the LSLA related factors in Sub-Saharan Africa, one of the most affected regions of the world by large-scale land trade. Along with landgrabbing, which is considered the basis of LSLAs, watergrabbing should also be considered, i.e. the rush to acquire water resources. Dell'Angelo et al. (2018) looked at LSLAs under a "hydrological lens", which is an alternative way of looking at this issue by trying to reveal the role of water resources.

The role of forests in LSLAs was taken into account by Conigliani et al. (2018) who found that the share of land left to forests was a driver in land acquisition in Africa, where it was an attractor of LSLAs for agricultural production, wood and fiber, carbon trading, industry, renewable energy production, conservation, and also tourism. On the other hand, protected areas could be considered as off-limit zones for LSLAs, as reported by Carter et al. (2017), thus this variable should be excluded from the analysis. Nevertheless, according to Soares et al. (2010) land use change within and outside protected areas may not differ; for example,Woods (2015) affirmed that in Myanmar, the constraints on forest reserves have not been respected and this has led to forest land acquisitions (Carter et al. (2017)). In this sense, Mazzocchi et al. (2018) involved the amount of protected areas in their work on Sub-Saharan Africa, although in this case it was not found to be significant. The issue of land degradation was treated in Chiarelli et al. (2020), who showed that LSLAs can increase the surface susceptible to landslides highlighting the role of governments in releasing concessions in forests.

In terms of LSLAs themes in specific sectors of agricultural investments, Giovannetti and Ticci (2016) explored the issue of biofuel-oriented land acquisitions, by analyzing the number of large-scale deals with at least one energy crop in the investment aim. They highlighted that the preferred characteristics of the host countries for foreign investors were the importance of an efficient institutional environment, a higher endowment of land and water resources and a weaker protection of land rights.

Olayinka (2018) investigated the extensive and intensive margins of LSLAs in Africa considering firm heterogeneity. Olayinka (2018) confirmed the literature on environmental and agricultural variables mentioned before but found that a weak institutional framework discouraged foreign investment in land, contradicting Arezki et al. (2015) who stated that weak land governance attracted investors. Similar results for De Maria (2015), that estimated a negative relation between a strong rule of law in target countries, and the dependent, implying that where the legal framework and the enhancement of legality is low the LSLAs size is greater. Conigliani et al. (2018) see the fundamental institutional requisites that could foster LSLAs as the presence of good laws, few crimes and a low level of violence of hosts, and that more advanced institutional features linked to weak land governance tend to do the opposite. Olayinka (2018) found that the economic size of investor countries influenced the extent of LSLAs.

Davis et al. (2015) mentioned climate change as a fundamental factor to understand the LSLA phenomenon. They hypothesized that CC may affect LSLA both because governments enacted regulations constraining GHG emissions and began to exploit carbon credits and renewable energy mandates, and because climate extremes have impacted on agricultural productions all over the world (Davis et al., 2015; IPCC, 2014). We thus hypothesize that climate factors could substantially influence LSLAs, especially in countries that have been recently affected by climate disasters, such as increased temperatures, droughts, water stresses and other meteorological issues. This could be an issue both in host and in investor countries, with hosts becoming less interesting for investors, and investors showing greater interest in buying land elsewhere. The investor countries may want to ensure their resilience to CC by acquiring land in different regions. In the LSLAs literature, only Olayinka (2018) used the "average precipitation" factor as an explanatory variable potentially influencing fertility and land yield, and which they found to be positively correlated to foreign investments. Nevertheless, to the best of knowledge, there have been no studies investigating the influence of climate change on large-scale land investments.

3. Modeling variables and data

We used a gravity model to assess the impact of economic, political, environmental and climate variables on LSLAs, in which both host and investor countries factors were taken into consideration.

The relationship between economic, political, environmental and climate variables and LSLAs is likely to reflect competition over land use due to the scarcity of natural resources, the socio-political characteristics of the countries involved and the increasing issue of climate change. Fig. 1 highlights the factors belonging both to investor and host countries, which are expected to influence the acquisition of large-scale lands by Investors.

3.1. Dependent variable description and data sources

The relationship between LSLAs and explanatory variables can be analyzed by a gravity model both at a country level and at a single deal level. We employed the size of land deals of a country in hectares as dependent variable and thus we assessed the relationship between LSLAs and environmental and climate factors by taking into consideration the total land area under contract.

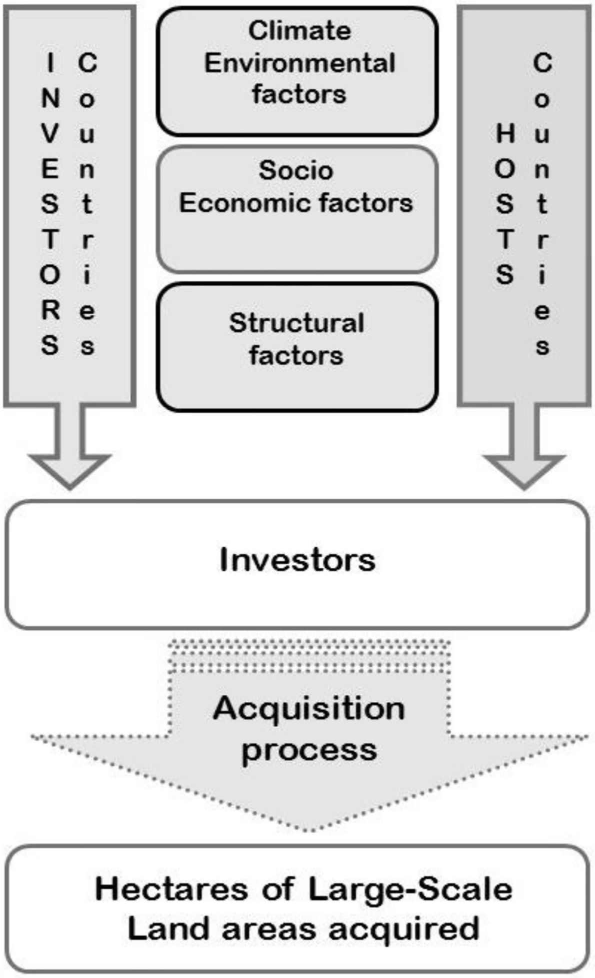

Fig. 1. Conceptual model of the relatiole 5nship between climate, environmental and socio-economic factors and LSLAs.

Our dependent variable measures the size of land acquisitions related to a pair of host and investor countries from 2000 to 2017 using a dataset of 2.402 signed deals, for a total of 76.849 million ha. The size of land deals (ha) was taken from the Land Matrix database, which is an independent initiative coordinated by academic institutions and local NGOs that collect data on the LSLAs at global scale using national observatories. The contracts in the Land Matrix database all involve a change in the rights of use, control or possession of the land by sale, rent or concession. All the deals involves surfaces of over 200 ha.

The Land Matrix database is a reliable source (Conigliani et al., 2018; Lay and Nolte, 2017; Giovannetti and Ticci, 2016). It collects 2.810 land deals, including not only signed deals but also intended and failed deals. According to this dataset, the most diffused crops are oil palm, jathropa, sugar cane, rubber and corn, with differences in the distribution of crops all around the world. In fact, South East Asia is the target area for oil palm cultivations, especially in Indonesia, while Cambodia, and Laos are the main targets for rubber.

Africa is the most targeted continent in terms of the number of deals, representing the 32% of the total deals, with the Sub-Sahara being the location of the greatest number of LSLAs. Nevertheless, all continents are involved in the global land rush, with Democratic Republic of Congo, Papua New Guinea, Russia, Indonesia, being the top four target countries, characterized by low population density and relatively high land and water availability (Nolte et al., 2016). The top four investors countries, United States, Malaysia, Singapore, United Kingdom, are typified by high population densities compared to the available natural resources.

Fig. 2 shows a chord diagram plot depicting cumulative bilateral links for LSLAs. A chord diagram represents flows or connections between several entities (in our case countries). Each country is represented by a fragment on the outer part (total size of land deals per country) of the circular layout. Then, arcs are drawn between each entity. The size of the arc is proportional to the size of the land deals between two countries. Some countries, such as the United States and Malaysia, are net investors; their main target countries are Papua Nuova Guinea, Democratic Republic of Congo and Indonesia. On the hard, Guyana is a net host country whose land is mainly acquired by China and India.

Fig. 2. LSLAs flows (signed deals) in 2000–2017 period from our database.

3.2. Description of explanatory variables and data sources

A number of factors influence LSLAs, including geographical, political, economic, environmental and social parameters, both for investors and for hosts (see Section 2). We collected several potential variables and divided them into two groups: the socio-economic variables group (SE) and the climate-environmental variables group (CLE). In line with the literature on LSLA determinants assessed by gravity models in which some geographical variables are recognized as significant predictors (Lay and Nolte, 2017; Arezki et al., 2015; Giovannetti and Ticci, 2016), we included a third group of variables which we called the structural variables group (ST). This group comprises: the agricultural area of a country (Agricultural Land), a former colonial relation between hosts and investors (Colony), and a common official language (Language) between hosts and investors, which have previously been found to be positively correlated to the amount of land acquired in a country (Lay and Nolte, 2017; Arezki et al., 2015; Giovannetti and Ticci, 2016; De Maria, 2015). Our ST group also includes the distance between the hosts and investors (Distance) which has been found to have a negative relationship with the amount of LSLAs (Arezki et al., 2015). Lastly, we included a macro region dummy variable (comprising: East Asia/Pacific, Europe/Central Asia, South Asia, Latin America/Caribbean, Sub-Saharan Africa, Middle East/North Africa) for the host countries to take into account for macro social, cultural and economic dependencies.

The SE group included the following variables: Population, GDP per capita, Unemployment, Tariff Rate, Public Debt, Business Freedom, Women, Property Rights, and Government Integrity. According to Messerli et al. (2013), populated areas can be attractive to

LSLAs investors, so we have included it in the model. GDP per capita can be used as an indicator of how richer countries (considering per capita values) are more likely to engage in LSLAs (Lay and Nolte, 2017) as well as to test the influence of the host's market size on land acquisitions. The unemployment rate of a host country highlights the potential number of people that would be interested in working in new investment projects, and for investors it identifies the level of well-being in a country.

With regard to the Tariff Rate, large acquisitions are more likely to happen where investors see a good return on their investment. For example, legal regimes impact on the likelihood of LSLAs (Edelman et al., 2013; Carter et al., 2017), and in our hypothesis the Tax Rate should have a negative relation with the land purchase. In terms of economic variables, we included the Public Debt rate as a proxy of the economic solidity of the state, verifying whether investors are tempted to invest in the host countries with a high public debt and that seem more fragile. The Business Freedom index measures "*the extent to which the regulatory and infra-structure environments constraint the efficient operation of businesses*" (pp. 462 Miller et al., 2019), and assesses the level of constraints an investor country may meet in its investment.

The resilience of small agricultural communities is strongly linked to land rights issue. Nevertheless, although some authors (Giovannetti and Ticci, 2016; Arezki et al., 2015) found that countries with a scarce protection of local population land tenure rights were more targeted by land acquisitions, others (Lay and Nolte, 2017) did not find any relation between property rights and LSLAs.

Government integrity includes the transparency of government policymaking, the level of corruption and the perception of such corruption. An institution's integrity is usually negatively related to land acquisitions, especially in African countries where the level of transparency is low and corruption is common (Mazzocchi et al., 2018). Women, as a variable, is a proxy of gender equality i.e. the percentage of women in a country's parliament, a topic included in the Millennium Development Goals project, which also represents women's public role. To the best of our knowledge, this variable has never been tested in the literature of LSLAs.

The impact of environmental and climate factors on LSLAs (climate-environmental variables group) was assessed using the following variables: Water Resources, Protected Areas, Precipitation, Climate Disasters, CO_2 Emissions. Water resources is calculated as the renewable freshwater resources expressed in millions of m^3 while the protected areas are indicated as surfaces (km^2). Precipitation represents the mean yearly average precipitation calculated from 1900 to 2006, taken from the data by Willmott and

Table 1
Variables description.

Variable	Description	Measure unit	Source (year)
Land Deals Size	Size of land deal *Dependent variable*	Ha	Land Matrix, 2017
Distance	Distance between host and investor *Structural variables group (ST)*	n.a.	CEPII (2015)
Language	Host and investor have a common official language *Structural variables group (ST)*	dummy (0 = not, 1 = yes)	CEPII (2015)
Colony	Host and investor have a past relationship (colonial) *Structural variables group (ST)*	dummy (0 = not, 1 = yes)	CEPII (2015)
Agricultural Land	Agricultural area of the country *Structural variables group (ST)*	Ha	Faostat (2013)
Population	Population of the country *Socio-Economic variables group (SE)*	number (millions)	Miller et al. (2019)
GDP per capita	Gross Domestic Product of the country per capita *Socio-Economic variables group (SE)*	$ (billions)/ inhabitants (n)	Miller et al. (2019)
Unemployment	Unemployment rate of the country *Socio-Economic variables group (SE)*	%	Miller et al. (2019)
Tariff Rate	Tariff rate of the country *Socio-Economic variables group (SE)*	%	Miller et al. (2019)
Public Debt	Public debt in percentage of GDP of the country *Socio-Economic variables group (SE)*	%	Miller et al. (2019)
Business Freedom	Business freedom of the country *Socio-Economic variables group (SE)*	0–100 (0 = low; 100 = high)	Miller et al. (2019)
Property Rights	Property rights index measures the strength of property tenure in a country *Socio-Economic variables group (SE)*	0–100 (0 = low; 100 = high)	Miller et al. (2019)
Government Integrity	Government integrity index measures the degree of institutions fairness in a country *Socio-Economic variables group (SE)*	0–100 (0 = low; 100 = high)	Miller et al. (2019)
Women	Seats held by women in national parliament in the country *Socio-Economic variables group (SE)*	%	MDGI, 2015
Water resources	Renewable freshwater resources *Climate-Environmental variables group (CLE)*	mio m^3	UNSD, 2017
Protected Areas	Protected areas in a country *Climate-Environmental variables group (CLE)*	Ha	UNSD, 2017
Precipitation	Average annual precipitation *Climate-Environmental variables group (CLE)*	100 s mm/year	Dell et al. (2012)
Climate Disasters	Climate disasters *Climate-Environmental variables group (CLE)*	number of persons affected by climate disasters	UNSD, 2017
CO2 emissions	CO_2 emissions *Climate-Environmental variables group (CLE)*	mio tonnes	UNSD, 2017

Matsuura indicated in Dell et al. (2012). Precipitation is considered to be a major driver of CC and the data between 1900 and 2006 is a significant and reliable period to consider (Dell et al., 2012). We expected to find a positive relationship between high water availability and investments in land.

In the same way we hypothesized that the more climate disasters occurred in investor countries, the higher the amount of land would be acquired by these investor countries in other (target) countries. On the other hand, the higher number of climate disasters in a host country, the fewer the LSLAs by investor countries. CO_2 emissions, as a variable, is linked to the industrialization of a country and with its population level. It is thus strictly related to the Population variable, and CO_2 emissions can be considered as a proxy of the environmental health of a country. We expected to find this variable positively correlated with investors in LSLAs, and negatively related with the hosts side.

The explanatory variables came from several sources as described in Table 1. We used the following databases: Heritage Foundation Index of Economic Freedom (HF), CEPII GeoDist, Faostat, Millennium Development Goals Indexes (MDGI), United Nation Statistics Division (UNSD), the Terrestrial Air Temperature and Precipitation: 1900–2006 Gridded Monthly Time Series, Version 1.01 (Dell et al., 2012). The Index of Economic Freedom of Heritage Foundation is a composite index which comprises several single equally weighted indices, built on different sub-indices. In our model, we used some of the individual indices and included them in the socio-economics variables group. The CEPII GeoDist provided us with data on the characteristics of the countries linked to their geographical distance and their past colonial relationship.

The "Terrestrial Air Temperature and Precipitation: 1900–2006 Gridded Monthly Time Series" database includes the mean precipitations used as an explanatory variable linked to CC in our model. We used Dell et al.'s version (2012), which calculated the average yearly precipitation within each country using geospatial software. The version of the database (1.01) was compiled by Matsuura and Willmott in conjunction with NASA. This dataset combines station data on mean precipitations from several sources. For an in-depth description of the database, see Dell et al. (2012). Many of the Climate and Environmental parameters included in our model come from UNSD databases.

3.3. Econometric specification

Gravity models are widely used to relate trade flows to a number of variables based on the idea that flows are proportional to the output of economic masses of the importing and exporting country, and inversely proportional to their physical distance (among others: Deardorff, 1998; Anderson and Van Wincoop, 2003; Carrère, 2006).

In relation to landgrabbing, gravity models have been used to analyze the determinants of foreign land acquisitions, especially, in low- and middle-income countries (Arezki et al., 2015; De Maria, 2015; Giovannetti and Ticci, 2016; Lay and Nolte, 2017).

Our dependent variable measures the size of land acquisitions related to a pair of host and investor countries from 2003 to 2017 starting from a raw dataset of 2402 concluded deals. When multilateral agreements were found to be in operation, in which for one individual contract there was only one target country but several investor countries, we kept all pairs of countries, that is repeating the area of transactions equally for all investing countries.

Because our dependent variable - size of land deals - is a continuous variable with values greater than 0, we used an ordinary least square (OLS) to estimate a log-normal gravity specification.

We introduce the notation $y_{i,j}$ as the sum in hectares of all land acquired by players of the investor country (j) in the host country (i) registered in the Land Matrix database.

We built a bilateral database of the size of concluded land deals considering investor country–host country pairs including land acquisitions in high-income countries.

We regressed the sum of land deal pairs including a set of socio-economic variables (SE) from host country and investor country, a group of climate-environmental variables (CLE) from host country and investor country and characteristics of the gravity model (GM), as well as an error term $\varepsilon_{i,j}$. We thus obtained the following OLS log–log gravity model equation:

$$y_{i,j} = a_{i,j} + \beta GM_{i,j} + \beta SE_i + \beta SE_j + \beta CLE_i + \beta CLE_j + \varepsilon_{i,j}$$

We used the "gravity" package in the R 3.5.1[1] software (R Core Team, 2013) to estimate the OLS log–log gravity model.

4. Results

4.1. Descriptive insights

Both investors and hosts in all the countries[2] involved in stipulating land deals (at least one contract), were included in our database. It consists of 596 possible investor country–host country combinations and includes 124 investor countries and 87 host countries.

We excluded countries without large-scale land deals or those that did not have enough data for inclusion in the gravity model. Our total sample includes 596 investor country–host country pairs that signed contracts, excluding any unsuccessful deals (Table 2).

[1] R is an open source software environment for statistical computing and graphics.

[2] The host and the investor countries in the database are those that directly have been involved in stipulating at least a land deal, or whose companies have been involved in stipulating land deals.

Table 2
Descriptive statistics (n = 596).

Variables	Mean	S.D.	Min.	Max.
Land Deals Size	128,942.46	372,939.03	100.00	5,327,042.00
Distance	6,098.74	4,533.98	18.99	19,110.13
Language (dummy)	0.34	0.47	0.00	1.00
Colony (dummy)	0.28	0.45	0.00	1.00
Agricultural Land_host	528,322.95	911,879.64	487.00	5,145,530.00
Agricultural Land_inv	1,246,643.15	1,858,215.65	487.00	5,145,530.00
Population_host	89.78	242.44	0.20	1,382.70
Population_inv	273.37	483.92	0.20	1,382.70
GDP per capita_host	8,618.28	7,530.35	773.10	29,972.30
GDP per capita_inv	33,345.76	23,173.68	773.10	127,659.60
Unemployment_host	7.34	5.80	0.30	31.40
Tariff Rate_host	6.43	3.93	0.50	17.20
Public Debt_host	51.80	23.06	9.00	116.10
Business Freedom_host	58.01	11.25	20.00	83.90
Property Rights_host	43.56	12.25	5.20	83.80
Government Integrity_host	33.41	10.61	7.50	71.60
Women_host	215.20	121.62	20.00	638.00
Women_inv	238.76	103.12	1.00	638.00
Water Resources_host	802,510.99	1,668,773.52	2,180.00	8,425,901.00
Water Resources_inv	984,064.81	1,497,273.58	92.40	8,425,901.00
Protected Areas_host	277,245.91	566,705.33	0.00	2,485,099.00
Protected Areas_inv	604,308.58	945,605.42	0.00	4,400,994.00
Precipitation_host	13.19	6.39	2.29	39.26
Precipitation_inv	10.03	5.07	0.79	39.26
Climate Disasters_host	10,469,109.3	42,768,300.6	0.00	330,000,000.0
Climate Disasters_inv	29,949,940.3	71,911,560.7	0.00	330,000,000.0
CO2 emissions_host	319.12	1,300.27	0.10	9,019.52
CO2 emissions_inv	1,792.91	3,079.33	0.10	9,019.52

We compared some characteristics of hosts and investors in relation to land acquisitions, in order to obtain an initial descriptive assessment of LSLA drivers.

Host countries seemed to be less populous and much poorer than investors countries, as suggested by Population and GDP variables. Quite surprisingly investors showed a higher average value of Agricultural Land and Water Resources than the hosts value; however, this is because the investor countries include the United States, China, and Argentina that have large agricultural areas and no problems related to water scarcity. In addition, we considered total endowments of natural resources, and not per capita values (Table 3).

In summary, the descriptive statistics seem to support the fact that agricultural land acquisitions are led by richer, more populous and technically advanced countries than poorer and less industrialized countries.

Climate Disasters are higher in investor countries, confirming that many countries affected by climate extremes are acquiring lands to pursue their economic aim on lands outside their own countries (Land Matrix, 2017). Both for Protected Areas and for CO_2 emissions, the investors have higher average values than the hosts. In the first case, many investor countries, such as Canada, have national protected zones; for the second variable, as shown in the correlation matrix (Table 4), there is a high correlation with the Population and GDP per capita variables of investor countries, indicating a high levels of industrialization that lead to pollution.

The results of the gravity model are shown in Table 5. According to the correlation analysis, the variables Population and Water Resources both for host and investor countries have been eliminated. In fact, Population was found to be highly correlated with GDP per capita, Climate Disasters, CO_2 emissions. Water Resources was correlated with Agricultural Land and Protected Areas. Collinearity was further controlled by assessing the Variation Inflation Factors (VIFs) and multicollinearity was found not to be a problem, with the square root of the VIF maximum values for all the models below the suggested cut-off of 2 (O'brien, 2007).

Table 3
Target-Investor Regions per number of concluded deals and size of deals.

Region	Target Countries		Investor Countries	
	Number of concluded deals	Size of Deals (in ha)	Number of concluded deals	Size of Deals (in ha)
East Asia/Pacific	792	21.536.016	949	28.184.857
Europe/Central Asia	269	10.809.594	640	18.996.953
Latin America/Caribbean	769	17.663.599	437	8.988.202
Middle East/North Africa	21	1.002.195	121	6.053.236
North America	0	0	203	9.330.988
South Asia	66	110.351	122	2.286.996
Sub-Saharan Africa	950	37.325.905	395	14.606.428
Total	2.867	88.447.660	2.867	88.447.660

Table 4
Correlation Matrix.

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	Land Deals Size	1																											
2	Distance	-0.11**	1																										
3	Language (dummy)	0.15**	-0.34**	1																									
4	Colony (dummy)	0.11**	-0.31**	0.61**	1																								
5	Agricultural Land_host	0.12**	0.09*	-0.09*	-0.16**	1																							
6	Agricultural Land_inv	0.08*	0.39**	-0.13**	-0.04*	0.03*	1																						
7	Population_host	0.05*	-0.02	-0.02	-0.09*	0.77**	0.02	1																					
8	Population_inv	0.03*	0.33**	-0.16**	-0.15**	0.02	0.83**	0.05*	1																				
9	GDP per capita_host	0.04*	0.01	-0.10*	-0.07*	0.37**	0.02	0.13**	-0.03*	1																			
10	GDP per capita_inv	-0.11**	0.29**	-0.26**	-0.27**	0.05*	-0.19**	-0.01	-0.35**	0.11**	1																		
11	Unemployment_host	-0.01	0.09*	-0.01	-0.02	0.04*	-0.09*	-0.11**	-0.13**	0.04*	0.08*	1																	
12	Tariff Rate_host	-0.02	0.05*	0.07*	-0.02	-0.11**	-0.03*	-0.10*	0.03	-0.45**	-0.05*	-0.11**	1																
13	Public Debt_host	-0.03*	0.06*	-0.06*	-0.05*	0.04*	-0.08*	0.00	-0.08*	-0.20**	0.05*	0.53**	0.12**	1															
14	Business Freedom_host	0.03*	-0.06*	0.01	0.05*	0.07*	0.00	-0.04*	-0.06*	0.57**	0.04*	0.21**	-0.45**	0.01	1														
15	Property Rights_host	-0.06*	-0.02	0.02	0.04*	0.16**	-0.01	0.12**	-0.05*	0.66**	0.09*	0.12**	-0.46**	-0.02	0.62**	1													
16	Government Integrity_host	-0.01	-0.04*	0.04*	-0.03	0.15**	-0.01	0.22**	-0.02	0.50**	0.06*	0.13**	-0.25**	0.00	0.50**	0.69**	1												
17	Women_host	-0.13**	0.09*	0.05*	-0.03*	-0.04*	0.02	-0.08*	0.01	-0.14**	-0.01	0.21**	-0.06*	0.14**	-0.19**	-0.11**	0.02	1											
18	Women_inv	-0.14**	0.00	-0.04*	-0.15**	0.01	-0.12**	-0.03*	-0.14**	0.03*	0.19**	0.06*	-0.04*	0.01	-0.03*	0.02	-0.01	0.16**	1										
19	Water Resources_host	0.19**	0.12**	-0.13**	-0.15**	0.70**	0.03*	0.34**	0.01	0.38**	0.04*	0.04*	-0.07*	0.01	0.17**	0.24**	0.06*	-0.24**	-0.02	1									
20	Water Resources_inv	0.16**	0.27**	-0.09*	0.01	0.04*	0.71**	0.04*	0.57**	0.01	-0.20**	-0.05*	-0.05*	-0.05*	0.04*	0.02	0.00	-0.01	-0.26**	0.07*	1								
21	Protected Areas_host	0.17**	0.07*	-0.11**	-0.16**	0.81**	0.03*	0.39**	0.01	0.41**	0.04*	0.07*	-0.10*	-0.03*	0.17**	0.19**	0.09*	-0.16**	0.01	0.93**	0.06*	1							
22	Protected Areas_inv	0.09*	0.39**	-0.09*	0.06*	0.06*	0.83**	0.03*	0.44**	0.06*	0.04*	-0.02	-0.08*	-0.04*	0.04*	0.05*	0.01	0.01	-0.13**	0.07*	0.71**	0.06*	1						
23	Precipitation_host	0.06*	0.05*	0.04*	0.10*	-0.23**	0.02	-0.08*	0.06*	-0.17**	-0.04*	-0.23**	0.19**	-0.09*	-0.03*	-0.10*	-0.13**	-0.24**	-0.09*	-0.01	0.04*	-0.18**	0.00	1					
24	Precipitation_inv	0.10*	-0.10*	0.10*	0.23**	-0.05*	-0.06*	0.05*	0.03*	-0.05*	-0.35**	-0.13**	-0.01	-0.07*	-0.01	-0.05*	-0.05*	-0.04*	-0.35**	-0.01	0.09*	-0.08*	-0.07*	0.39**	1				
25	Climate Disasters_host	-0.01	-0.01	0.00	-0.04*	0.53**	0.00	0.88**	0.02	0.02	0.00	-0.08*	-0.02	0.10*	-0.08*	0.11**	0.21**	-0.08*	-0.06*	0.24**	0.01	0.22**	0.01	-0.06*	0.05*	1			
26	Climate Disasters_inv	0.01	0.21**	-0.08*	-0.09*	0.01	0.57**	0.05*	0.88**	-0.06*	-0.38**	-0.11**	0.04*	-0.04*	-0.07*	-0.03*	-0.01	0.03	-0.19**	0.01	0.43**	0.00	0.21**	0.06*	0.07*	0.03*	1		
27	CO2 emissions_host	0.06*	-0.04*	-0.03*	-0.11**	0.83**	0.04*	0.87**	0.06*	0.24**	0.00	-0.08*	-0.16**	-0.06*	0.03*	0.10*	0.23**	-0.02	0.01	0.31**	0.05*	0.47**	0.05*	-0.12**	0.01	0.58**	0.03*	1	
28	CO2 emissions_inv	0.04*	0.41**	-0.19**	-0.12**	0.03	0.95**	0.05*	0.89**	0.01	-0.18**	-0.11**	-0.01	-0.09*	-0.03	-0.04*	-0.02	0.00	-0.09*	0.01	0.60**	0.02	0.66**	0.05*	-0.03*	0.01	0.59**	0.07*	1

Notes: *p < 0.05; **p < 0.01.

Table 5
Gravity model results.

	Dependent variable: Land Size Deal			
	Base Mod. (1)	Pol. Var. (2)	Env. Var. (3)	Full Mod. (4)
Intercept	11.183*** (1.624)	10.662*** (1.842)	9.996*** (2.376)	8.192*** (2.651)
Distance	−0.276*** (0.102)	−0.265*** (0.099)	−0.371*** (0.103)	−0.342*** (0.100)
Language (dummy)	0.436* (0.237)	0.535** (0.231)	0.553***(0.234)	0.644*** (0.227)
Colony (dummy)	0.312 (0.255)	0.384 (0.254)	0.206 (0.264)	0.321 (0.259)
log(GDP pro capite_host)	−0.509*** (0.140)	−0.345** (0.175)	−0.570*** (0.144)	−0.307* (0.182)
log(GDP pro capite_inv)	0.036 (0.120)	0.081 (0.118)	0.063 (0.147)	0.104 (0.145)
log(Agricultural Land_host)	0.330*** (0.060)	0.347*** (0.061)	0.474*** (0.082)	0.529*** (0.084)
log(Agricultural Land_inv)	0.100** (0.039)	0.107*** (0.038)	0.071 (0.059)	0.078 (0.058)
Region_Europe_Central Asia	0.545 (0.354)	0.542 (0.374)	0.316 (0.460)	0.401 (0.490)
Region_Latin America_Carib.	−0.148 (0.292)	−0.227 (0.329)	−0.632** (0.313)	−0.917*** (0.351)
Region_Middle East_N_Africa	−1.536* (0.802)	−1.791** (0.808)	−1.706** (0.864)	−1.902** (0.875)
Region_South Asia	−3.178*** (0.635)	−3.715*** (0.636)	−2.793*** (0.627)	−3.313*** (0.638)
Region_Sub-Saharan Africa	−0.949*** (0.300)	−1.281*** (0.395)	−1.249*** (0.341)	−1.622*** (0.441)
log(Unemployment_host)		0.255* (0.148)		0.363** (0.149)
Government Integrity_host		0.026** (0.011)		0.049*** (0.012)
Property Rights_host		−0.040*** (0.012)		−0.051*** (0.013)
Tariff Rate_host		0.045 (0.029)		−0.002 (0.030)
Public Debt_host		0.003 (0.004)		0.003 (0.004)
Women_host		−0.003*** (0.001)		−0.002*** (0.001)
Women_inv		−0.001 (0.001)		−0.001 (0.001)
Business Freedom_host		−0.011 (0.011)		−0.029** (0.011)
log(Precipitation_host)			0.710*** (0.256)	0.842*** (0.271)
log(Precipitation_host)			−0.247 (0.167)	−0.183 (0.162)
log(Climate Disasters_host)			−0.043*** (0.013)	−0.037** (0.014)
log(Climate Disasters_inv)			0.006 (0.015)	0.009 (0.015)
Protected Areas_host			0.057*** (0.020)	0.048** (0.021)
Protected Areas_inv			0.008 (0.015)	0.009 (0.015)
CO2 emissions_host			−0.303*** (0.081)	−0.426*** (0.083)
CO2 emissions_inv			0.029 (0.044)	0.019 (0.042)
Observations	596	596	596	596
R^2	0.138	0.210	0.201	0.269
Adjusted R^2	0.120	0.183	0.174	0.233
Residual Std. Error	2.013 (df = 583)	1.940 (df = 575)	1.951 (df = 575)	1.880 (df = 567)
F Statistic	7.789*** (df = 12; 583)	7.649*** (df = 20; 575)	7.250*** (df = 20; 575)	7.449*** (df = 28; 567)
Anova test (df)		6.54(8) ***	5.69(8) ***	6.33(16) ***
Max VIF^(1/(2*df))	1.681	2.182	1.792	2.351

Notes: Significant levels are: *p < 0.1; **p < 0.05; ***p < 0.01; Standard Errors are in parentheses; Protected Areas and CO2 emissions have been divided by 1000 in order to have readable coefficients; "East Asia_Pacific" is the reference level for Region omitted in the models.

The overall fit of the Full Model (Model 4) is an improvement over the Base Model (Model 1), highlighting that the Full Model better fits our data (the R squared, and the adjusted R squared values are considerably better, and the residual standard errors decrease). The ANOVA test on the goodness of fit of the models shows that Models 2, 3 and 4 are a significant improvement over the Base Model (Pr > LR test is 0.001). In other words, the introduction of the two sets of independent variables (SE and CLE) adds more explanatory power to the econometric models in explaining our dependent variable.

The analysis of the Full Model with all the explanatory variables (Model 4) mainly confirms the results of the previous models both in terms of the effects of the control variables and the explanatory variables, showing a good robustness of the results. The estimates and the significance of the coefficients of the control and explanatory variables were stable compared with Models 1, 2 and 3, except for the Agricultural Land of the investor country, which lost its significance because it is below the threshold of acceptability.

Our comments on the results thus relate exclusively to the Full Model (Model 4).

4.2. Econometric results and discussion

We first analyze the Regions results, and compare the diverse macro-regions, with South-East Asia and the Pacific as our benchmark.

All four significant Regions (Latin America-Caribbean, Middle East-North Africa, South Asia, and Sub-Saharan Africa) have a negative relationship with the benchmark, meaning that South-East Asia investors acquired more land than the other four areas. Indeed, Europe-Central Asia is not significant, which means that there is not a significant distance between this macro-region and the South-East Asia and Pacific benchmark in relation to the amount of land acquired. Consequently, South-East Asia and Pacific and Europe-Central Asia are the macro-regions with the highest amount of land acquired in the world. This is not surprising considering that these regions included the most targeted Asian and European countries such as Indonesia, Papua New Guinea, and Russia.

Regarding the Gravity Model (GM) group, the gravity variables yielded the results expected.

Distance has a negative effect on LSLAs, i.e. the greater the distance between hosts and investors, the fewer lands acquired. On the other hand, a common official language positively influence the relation between two countries, and in this case, foster land acquisitions. The Agricultural Land variable of the hosts is highly significant and positively influences LSLAs. This confirms previous findings where land investments were shown to be more focused on countries with a higher amount of agricultural area (Lay and Nolte, 2017; Giovannetti and Ticci, 2016) and a high share of rural land under traditional systems (Conigliani et al., 2018). As for investors this parameter is not significant, although we know that there is a potential negative relationship between some investor countries with a scarcity of agricultural available land, especially Middle East countries such as Saudi Arabia, and land acquisitions; but, in this case, it was not confirmed by our results.

The GDP per capita resulted to be negatively related with the dependent in host countries, as shown in literature (De Maria, 2015), thus the lower the GDP per capita of a target country, the higher the possibility of LSLAs investments. At the same time, our results on the unemployment rate of host countries, that is positively related to the dependent, on one hand confirmed the relationship explained before, so the GDP per capita is lower also because the unemployment rate is high. On the other hand, this relationship suggested that the more the unemployment rate of a country is high, the more the number of people unemployed that would be potentially interested in working in new investment projects could be high.

Another attractive factor regarding land acquisition is the transparency of government policymaking and a low level of corruption, represented by the variable Government Integrity, which was positively correlated to the amount of land acquired. The parameters of land governance are usually quite ambiguous in the literature, and in some studies, government integrity along with institutions respecting the law are key in an investor's propensity to acquire land (Conigliani et al., 2016). In other cases (Lay and Nolte, 2017), the higher quality of institutions did not attract investors, but rather a land investment where governments are easily corruptible is preferred in some African countries (Mazzocchi et al., 2018). Our results show that government integrity is a key factor for investors in LSLAs, probably because they want to have confidence in the country's institutions in which they invest as this will give them long-term security.

The property tenure of a country is measured by Property Rights and negatively influences LSLAs. This finding is in agreement with Arezki et al. (2015), supporting the notion that investors may find easier to acquire land in weak land tenure contexts, thus to some extent confirming public opinion concerns about "landgrabbing" (i.e. with little concern regarding the benefits for the local population). Moreover, as explained in Conigliani et al. (2018), land investments are aimed more at countries with a high diversity of tenure systems. Thus, the complex structure of property rights and the insecurity of land tenure are liable to commercial pressure.

The level of the Business Freedom of hosts is weakly negatively correlated to the amount of land acquired, thus the time needed to start a business, obtain a license and close a business (the three sub-indicators of the index) seem to be less important than other parameters for LSLA investors.

As in our previous hypothesis, the level of political involvement of women in public institutions, particularly parliament, also helps to explain LSLAs. This factor is negatively related to the land acquisitions, i.e. the more politically active women there are, the fewer the LSLAs in that country. A high level of women participation in public debates in host countries represents a good level of education and equality in that country. Our result on women's role confirms that in hosts where there is little political debate and low levels of gender equality, investors are tempted to invest in LSLAs. This result clearly supports the finding regarding property rights mentioned before. Moreover, in the case of land possession, women in developing countries, and in particular in Africa, have historically had fewer inheritance and land rights since they are largely excluded from land tenure and land inheritance rights (Salvan, 2018).

All the variables included in our model related to Climate and Environmental factors are significant for host countries and confirm our previous hypothesis. This result is important because as explained in the Introduction, the impact of the effects of climate change have never been investigated in LSLA dynamics nor by using specific climate variables.

The Precipitation variable represents the yearly mean precipitation calculated from 1900 to 2006. This factor was positive in terms of land acquisitions in target countries, confirming that if a country has a large availability of water, this will encourage land acquisitions by investors. In fact, the availability of water has impacted on the economy of the host countries involved in land acquisitions (Chiarelli et al., 2016), concentrating investments where the issue of water scarcity doesn't exist. Thus, our study confirms that the availability of water in terms of mean precipitation (which is a key measurable parameter of climate change) impacts on LSLAs. This result is confirmed by Müller et al. (2020) who found that investors do not target locations focusing on the fertility of a country, but rather it is the rainwater availability that tends to drive LSLAs, as occurs in our analysis.

The same was found in relation to Climate Disasters i.e. the number of persons affected, injured or made homeless after a disaster (UNSD, 2017). In fact, our results show a negative influence of Climate Disaster on large land acquisitions in target countries. This confirms the idea that variables that negatively influence the climate thereby causing various types of damage, also financially harm the country where climate disasters occur. Although this issue has been widely investigated in the last twenty years in the economics literature, we believe that this is the first time that climate has been directly associated with the acquisition of large-scale land areas.

Protected Areas was found to be strongly significant and positively correlated with the dependent variable. To a certain extent this contradicts some authors (Conigliani et al., 2018; Lambin et al., 2013) who have supported the notion that a protected area is potentially not eligible for land acquisitions, and thus should not be considered in LSLA analyses. Protected land areas should function as a barrier against LSLAs (Lambin et al., 2013). Indeed, considering the weak governance that some countries have employed in managing their natural resources, we tested this factor as influencing LSLAs. In fact, other studies (Eithelberg et al., 2015; Woods, 2015) have found that although protected areas potentially impede other land uses, croplands may exist within these areas and governments may eliminate the barriers in order to foster investments. In recent years the phenomenon of *"the appropriation of land and resources for environmental ends"* (Fairhead et al., 2012, pp. 238) to create parks and natural reserves by acquiring large surfaces of lands, has been called "green grabbing" (Vidal, 2008). Green grabbing has become part of the debate on "landgrabbing" for its characteristic of appropriation that implies the transfer of land ownership excluding local users and citizens from the acquiring process and the use of the natural resource sold (Fairhead et al., 2012).

In our analysis, investors seem to prefer countries with a higher number of protected zones. On the one hand, these areas are usually rich in natural resources, for example water, and on the other, they are usually uncontaminated and scarcely populated. This could be an advantage in making arrangements directly with governments without being forced to dialogue with local communities.

The level of CO2 emissions in host countries negatively influenced the amount of land acquired i.e. the greater the CO2 emissions are, the fewer the LSLAs. This variable highlights the level of environmental health of a country and would seem to indicate that investors choose countries that do not have high levels of emissions. This finding partially confirms the idea conveyed by Davis et al. (2015) who found that the carbon credit mechanism seems to have pushed up the demand for land. The authors (pp. 299) affirmed that climate change affects land acquisition because "*many governments have enacted regulations in response to the current and anticipated impacts of GHG emissions on global climate and in turn on global economy. Through carbon credit mechanism and renewable energy mandates, land-intensive policies appear to have heightened the demand for land.*"

In sum, Investors may be acquiring land in target countries with low CO_2 emissions in order to mitigate the future impact of such pollution.

5. Conclusions

Although LSLAs have been extensively studied in the recent literature, a number of related issues are still underexplored, including the relationship between LSLAs and CC (Davis et al., 2015). This study assessed the determinants of LSLAs using climate, environmental and socio-economic factors, and highlighted new findings. Firstly, a negative relationship was found between climate disasters due to climate extremes such as droughts, wildfires, and glacial lake outburst caused by CC, and the acquisition of large-scale land areas in target countries. Secondly, a positive relationship was found between average precipitations and LSLAs.

These findings would seem to indicate that investors are not interested in investing in land in countries affected by CC, which could then influence the economy of a country. Similarly, the results on CO_2 emissions that investors choose countries with a low level of emissions for purchasing lands. As affirmed by Davis et al. (2015), acquiring lands can ultimately serve as a way for an investing country to improve its resilience to CC essentially by diversifying the types of land that it owns.

Thirdly, the main results on socio-economic variables confirm the literature findings regarding the weak property rights in the host countries that seem to favor LSLA investments, with investors tempted to acquire land where local population rights are scarce (Dell'Angelo et al., 2017). This occurs along with a good level of government integrity (Arezki et al., 2015; Conigliani et al., 2018) required by investors in order to ensure that the investment is more secure (Carter et al., 2017). Another important socio-economic finding regards the role women in society, that is in the Countries with a low quota of women in parliament, a higher number of LSLAs occurs. A good level of women participation in the public debate represents a State's high level of education and equality, in fact female equality is one of the Millennium Development Goals 2020.

The main limitations of this work are linked to the data sources, which as explained in the methodology, cannot be considered to represent the totality of signed land deals. Nevertheless, these data sources are reputed to be consistent and widely employed in previous literature. Additional variables were also added to the gravity model, although some constraints derived from the lack of data on all the countries involved in LSLAs. Moreover, this study cannot consider for any in-country heterogeneity, also because many variables used are at government-scale. Nevertheless, CC could affect regions within one country in different ways. Thus, future analyses using regional or more granular data (when more reliable data at regional level will be available) could improve our understanding of the link between climate factors and attractiveness of land investments. In conclusion, several key issues and in-depth works related to LSLAs are still required, especially in terms of the link between climate variables and land acquisitions, in relation to both investor and host countries.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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