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Authors
Davis, Kyle Frankel
Rulli, Maria Cristina
D'Odorico, Paolo

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Key Points:

- Concern over food, energy, and CO_2 emissions have heightened demand for land
- Climate change has an important influence on the drivers of land acquisitions
- Debate over land deals should make climate change an essential consideration

Corresponding author:
K. F. Davis, (kfd5zs@virginia.edu)

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The global land rush and climate change

Kyle Frankel Davis[1], Maria Cristina Rulli[2], and Paolo D'Odorico[1]

[1]Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia, USA, [2]Department of Civil and Environmental Engineering, Politecnico di Milano, Milan, Italy

Abstract Climate change poses a serious global challenge in the face of rapidly increasing human demand for energy and food. A recent phenomenon in which climate change may play an important role is the acquisition of large tracts of land in the developing world by governments and corporations. In the target countries, where land is relatively inexpensive, the potential to increase crop yields is generally high and property rights are often poorly defined. By acquiring land, investors can realize large profits and countries can substantially alter the land and water resources under their control, thereby changing their outlook for meeting future demand. While the drivers, actors, and impacts involved with land deals have received substantial attention in the literature, we propose that climate change plays an important yet underappreciated role, both through its direct effects on agricultural production and through its influence on mitigative or adaptive policy decisions. Drawing from various literature sources as well as a new global database on reported land deals, we trace the evolution of the global land rush and highlight prominent examples in which the role of climate change is evident. We find that climate change—both historical and anticipated—interacts substantially with drivers of land acquisitions, having important implications for the resilience of communities in targeted areas. As a result of this synthesis, we ultimately contend that considerations of climate change should be integrated into future policy decisions relating to the large-scale land acquisitions.

1. Introduction

The global demand for land has steadily increased over the past 50 years [*FAO*, 2014]. Population growth, changing diets, and increasing biofuel use are placing unprecedented pressure on the global food system [*Cohen*, 1995; *Godfray et al*., 2010a; *Foley et al*., 2011; *Davis et al*., 2014b] while climate change threatens agricultural production in many regions [*Schmidhuber and Tubiello*, 2007; *Wheeler and von Braun*, 2013]. Many governments and corporations have become increasingly active in the purchase of land in response to this uncertainty, recognizing the limitation of the agricultural system, the need to reduce greenhouse gas (GHG) emissions, the growing demand for energy and food, and the susceptibility of agricultural yields to climate fluctuations [*Klare*, 2012].

At the start of this century, peaking oil production and concerns over energy security and GHG emissions spurred a more than sixfold increase in the production of crop-based biofuels [*OECD/FAO*, 2014]. Within a decade, growth of the agrofuel sector increased competition between food and fuel for cropland and, in turn, contributed substantially to higher food prices and a more volatile commodity market vulnerable to climate fluctuations [*von Braun et al*., 2008; *Hochman et al*., 2012, 2014]. The vulnerability of the global food market culminated in 2008 when droughts in major producer countries were followed by spikes in world food prices (Figure 1) [*IMF*, 2008; *Beddington*, 2010; *Godfray et al*., 2010b]. To curb the domestic escalation in food prices, some governments went so far as to ban grain exports, much to the concern of import-dependent countries [*Fader et al*., 2013]. It thus became clear that food security was at risk in many importing countries and that the adequacy of resources for long-term food and energy security required redefinition. At first, many import-reliant countries tried to negotiate long-term contracts for supplies of major grains [*Brown*, 2012]. Finding this option largely unsuccessful, governments and corporations then began acquiring rights to land in the global South [*Cotula et al*., 2009], as part of a phenomenon often referred to in academia and the popular media as "land grabbing" [*Cotula et al*., 2009; *The Economist*, 2009; *Rulli et al*., 2013].

Taken together, land for food, fuel, or forests is available only in finite amounts and demand for it is expected to increase in the decades to come. Given this situation, the corporate world has realized the prospects for

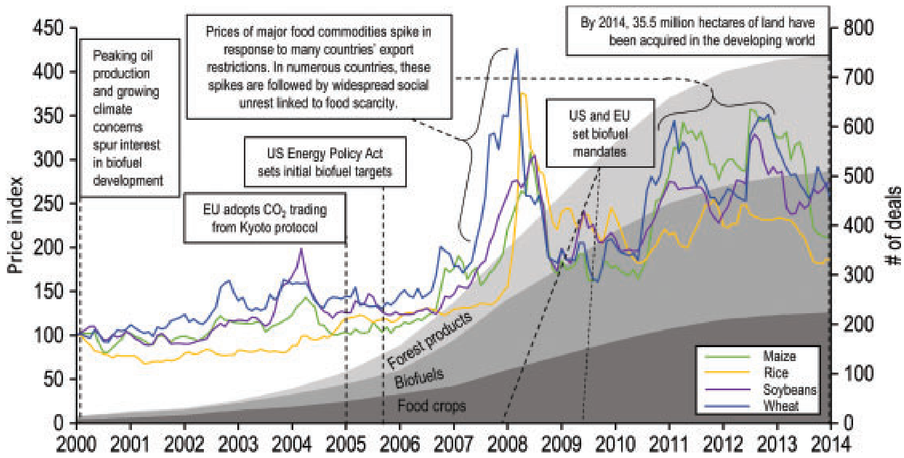

Figure 1. Timeline of land acquisitions and food prices. Major events that have contributed to the global land rush are highlighted. Food prices are normalized to January 2000 values. Time series of land acquisitions represents the number of deals involving food crops, biofuel crops, and forestry products and is based on data from *Land Matrix* [2015]. Evidence relating social unrest to food prices came from Lagi *et al.* [2011] and *Barrett* [2013].

profitable investments in agricultural land. As evidenced by the fact that many areas are not actively used for production once acquired, many land deals also appear to be merely speculative in the hopes that the land will become more valuable as demand rises [*Deininger and Byerlee*, 2011; *Brown*, 2012]. Overall, the potential for profit has frequently led to the treatment of land as a commodity, which can prioritize a purely economic focus and in turn downplay the potential impacts on local populations (e.g., lost livelihoods, food insecurity) and the environment (e.g., soil erosion, deforestation) [*Cotula et al*., 2009; *von Braun and Meinzen-Dick*, 2009; *Borras et al*., 2010; *Messerli et al*., 2013; *D'Odorico and Rulli*, 2014]. While proponents of land investments often argue that large-scale land acquisitions will bring economic development, energy security, and improved crop production in underperforming agricultural land, many times the resources acquired through land deals are no longer available in, or are removed from, the targeted areas [*Cotula et al*., 2009] and exported for sale elsewhere [*von Braun and Meinzen-Dick*, 2009; *Robertson and Pinstrup-Andersen*, 2010; *Brown*, 2012]. Therefore the process can often entail the displacement of small-hold farmers or the exclusion of previous users from access to the land (see *Deininger and Byerlee* [2011]). However, in some cases there might be positive outcomes, as the suite of benefits and impacts is unique to each land deal and can differ between local and national scales [*Lisk*, 2013].

Climate change may significantly influence the global land rush, although its role has been largely unrecognized. We hypothesize that climate change affects land acquisition in two important ways (Figure 2). First, many governments have enacted regulations in response to the current and anticipated impacts of GHG emissions on global climate and in turn on the global economy. Through carbon credit mechanisms (e.g., Kyoto Protocol, Clean Development Mechanism, reducing emissions from deforestation and forest degradation — REDD+) and renewable energy mandates (e.g., US Renewable Fuel Standard, EU Renewable Energy Directive), land-intensive policies appear to have heightened the demand for land. Second, climate extremes have recently impacted agricultural production in many regions of the world [*IPCC*, 2014], contributing to higher food prices, and raising concerns over food and energy security. Here we evaluate our contention that the influence of climate change is important by more closely examining how and to what extent it is interwoven with the various aspects surrounding large-scale land acquisitions.

Given the recent acceleration in land acquisitions and the emerging evidence of climate impacts now and in the near future, our synthesis comes at a crossroads when many countries are faced with the decision of how reliant they want to be on foreign resources in the future and how best to prepare in turn. Our aim here is not to provide a comprehensive account of the complex phenomenon of the global land rush (see *Deininger* [2013]) rather to present representative examples of where and how climate plays a role in shaping the drivers, actors, and impacts of the ongoing acquisition of land. We argue that by increasing concerns over energy security, food security, and the impacts of continued GHG emissions, climate change exerts substantial influence in the motivation for land investments and that the heightened demand for land that has

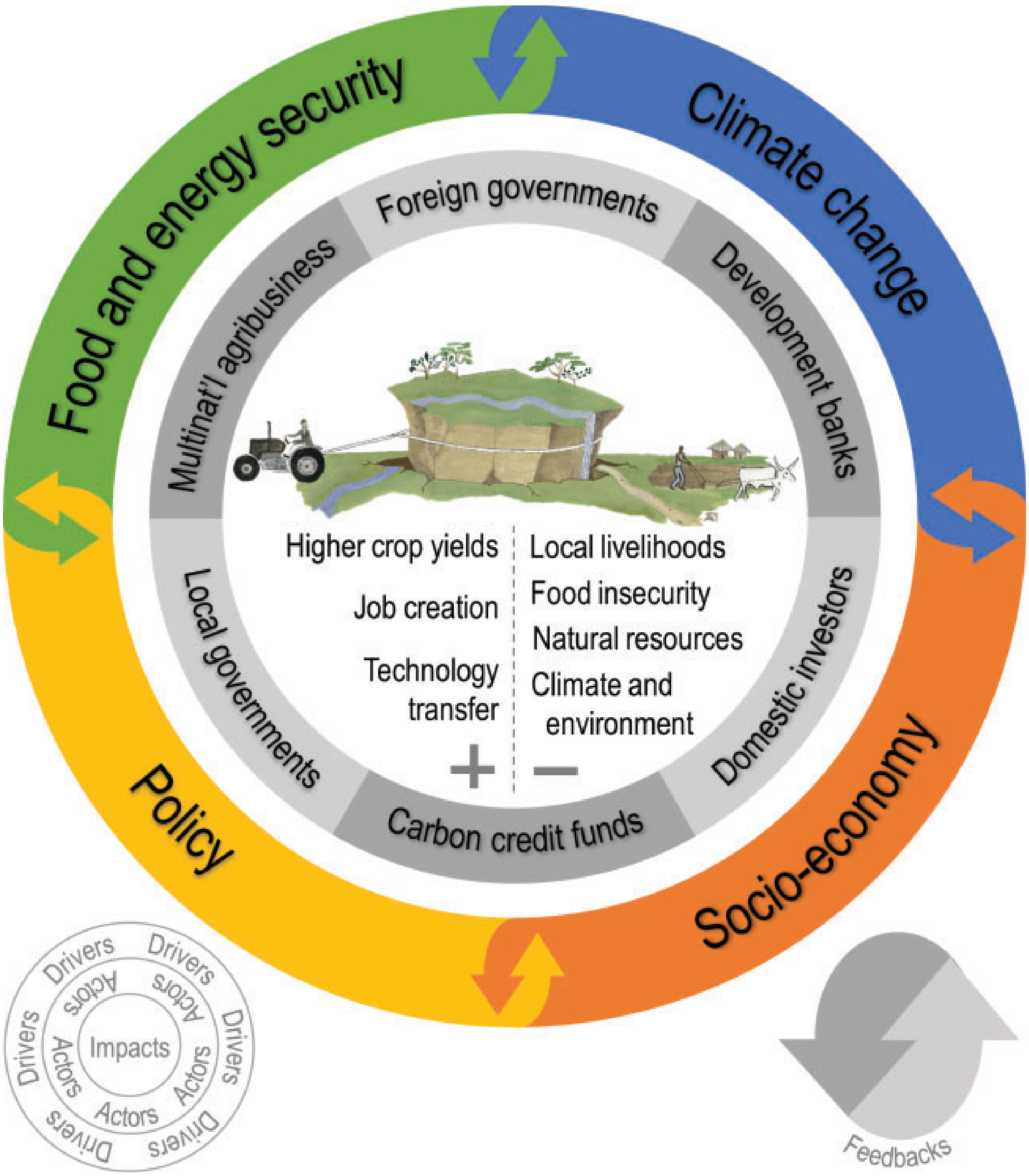

Figure 2. Conceptual framework of the drivers, actors, and impacts associated with land acquisitions. Climate change already has detectable influences on crop yields, food prices, and food and energy security. Agriculture and the world socioeconomy as well contribute substantially to climate change through GHG emissions from land use change, transport, industry, and energy production. Policy is ultimately the response to changes in climate, agricultural production, and the world economy and ideally seeks to minimize the former while maximizing the latter two. All these drivers act to influence the decisions of actors (i.e., where, when, and how they invest in land acquisitions). These decisions may be taken in reaction to a change in one of the drivers (e.g., domestic crop failures) or in anticipation of a change (e.g., projections of decreased precipitation domestically) depending on the goals and resources of the governing body or institution. Positive and negative effects of land acquisitions listed here are a suite of potential impacts, the actual occurrence of which is unique to each land acquisition.

emerged has created a situation in which (inter-)national economic benefits often trump local human welfare and environmental stewardship. In support of our argument, we first highlight the sources and methods used in constructing this synthesis. Following this, we examine the role of climate change in influencing land deals for biofuel crops and carbon credit markets in response to recent "green" energy and climate mitigation policies. We then consider the direct impacts of climate (both historical and anticipated) on staple food crops and how concerns over future food security may heighten demand for land. After briefly examining the possible climate feedbacks of land deals (e.g., CO_2 emissions from land use change), we consider the potential impacts of land acquisitions on local communities and the environment and how these deals may

Table 1. Summary of Reported Land Acquisitions by Target Region[a]

	Africa	Asia and Oceania	South America	Europe	Total
Acquired land (Mha)	23.6	14.0	5.1	5.3	48.1
% under production	3	20	29	26	13
% from foreign investors	89	72	76	65	80
Acquired land for biofuels[b](Mha)	5.0	3.4	0.6	0.3	9.3
% under production	4	42	31	5	82
% from foreign investors	91	71	57	31	79

[a]Values are derived from the *Land Matrix* [2015] data.
[b]The land acquired for biofuels (9.3 Mha) is part of the total acquired land (48.1 Mha).

alter the vulnerability of targeted areas to future climate change. Finally, we conclude by highlighting the remaining research needs for land acquisitions and contend that future land policies should give greater consideration to the influence of climate while better integrating the needs of local communities.

2. Supporting Literature and Analyses

Large-scale land acquisitions have received much attention in the media and the social science literature as a result of their social and environmental impacts. However, this phenomenon is generally difficult to quantify given not only how recently these land deals started to occur but also the lack of transparency in many of the negotiations. Though not always the case, land deals are many times characterized by little or no prior informed consent from previous land users as well as a lack of enforcement and monitoring of existing protective legislation [*Deininger and Byerlee*, 2011; *Deininger*, 2013; *D'Odorico and Rulli*, 2014]. The dearth of information on land deals is why many previous studies have focused solely on the extent of area affected or land acquired. To date, roughly 48 million hectares (ha) are estimated to be under international and domestic contracts (Table 1), with many more acquisitions currently in progress and under negotiation [*Land Matrix*, 2015]. Also though this area is small (3.1%) in comparison to the extent of total land cultivated globally, these acquisitions—concentrated mostly in sub-Saharan Africa and Southeast Asia—have substantially increased the amount of land and water resources under the control of certain countries and the corporations based in them (e.g., Saudi Arabia, South Korea, UK) [*Toft*, 2013; *Land Matrix*, 2015].

Land rush scholars have also started to account for aspects other than areal extent, including the negotiation and implementation stage of each land deal, the type of land use, and the appropriation of water and other land-based resources [*Rulli and D'Odorico*, 2013] as well as the potential impacts on incomes [*Davis et al*., 2014a] and diets [*Rulli and D'Odorico*, 2014] of local communities. Many of these more in-depth analyses have been possible with the emergence of new databases. One such publicly available database is the *Land Matrix* [2015], which has catalogued detailed information on reported large-scale land acquisitions including area, location, negotiation status, contract date, investor company and country of origin, and intended use. The development of this database faces some challenges because of the difficulty in maintaining an accurate and up-to-date data set, potential bias toward foreign investments only due to including deals larger than 200 ha, and difficulty in on-ground validation and assessment [*Anseeuw et al*., 2013; *Edelman*, 2013; *Oya*, 2013]. With these shortcomings fully in mind, our examination uses information from this global database—combined with a rapidly growing land rush literature from the environmental and social sciences—to place the recent surge in the large-scale land acquisitions into the broader context of climate and climate change.

3. Land-Intensive Climate Policies as Drivers of Acquisitions

Fossil fuel consumption and land-use change are two major sources of anthropogenic CO_2 emissions contributing to climate change. It has been estimated that about 70% of global GHG emissions are contributed by a combination of the energy, transport, and industry sectors as well as land use change (e.g., forest conversion, peat fires) [*IPCC*, 2014]. In an effort to promote environmental protection [*Phelps et al*., 2012] and to ensure energy security, certain countries have adopted policies intending to preserve native forests for carbon storage or mandating a certain reliance on agrofuels. Many of these policies are "land-intensive" as they require large areas to have an important effect. Seeking to benefit from such programs, some governments and investors have found it more economical to acquire lands in the developing world to achieve reductions in emissions [*Phelps et al*., 2010]. Recent examples of these "green" acquisitions include land deals for oil palm and carbon sequestration in Indonesia's Outer Islands [*McCarthy et al*., 2012] and the establishment of carbon-offset tree plantations in Uganda [*Lyons and Westoby*, 2014]. In turn, an unintended yet frequent consequence of these emissions-curbing policies is to promote acquisitions that restrict the access to and use of the land by reliant local communities [*Fairhead et al*., 2012]. Generally, there exist two main avenues through which environmental land acquisitions (i.e., acquisitions for environmental ends [*Fairhead et al*., 2012]) can occur: (1) from the establishment of carbon credit markets [*Meyfroidt et al*., 2013] and (2) from increasing biofuel demand [*Kim et al*., 2009].

3.1. Land Acquisitions for Carbon Storage

In carbon credit markets, a company is permitted to emit more GHG domestically if it invests in carbon reduction projects either domestically or abroad, effectively acting as an offset. Often, such an approach can be more cost-effective for a company than making process upgrades to their production, and thus incentivizes participation in the carbon market [*Meyfroidt et al*., 2013]. Just as in any market-based system, speculators have the opportunity to purchase large tracts of land inexpensively and sell them for profit to investment funds assembling carbon reduction projects [*Fairhead et al*., 2012]. The appropriation and commodification of land for carbon credit markets (or other projects with environmental credentials) is often termed "green grabbing" [*Fairhead et al*., 2012]. Though part of a system with explicit environmental goals, "green" land acquisitions can contribute to a disconnect between investors who acquire the land rights and the local populations and ecosystems that such investments may unwittingly harm. While the extent of current acquisitions for carbon storage remains unclear, *Fairhead et al*. [2012] suggest that the substantial financial backing for carbon markets — now in the billions of dollars [*World Bank*, 2010] — may spur a flurry of land deals related to carbon offsetting. It is therefore important that mechanisms put in place to facilitate the buying and selling of carbon credits are aware of such unintended consequences for communities and the environment and take steps to prevent their occurrence. However, the often multilateral nature of carbon markets can make it difficult (if not impossible) to incorporate sufficiently strict and specific regulations into policy.

With the goal of conserving forests and maintaining their capacity for carbon storage, the REDD+ is just such a mechanism, that is based on the implementation of carbon markets and that has received widespread attention and criticism. One of the concerns with the mechanism surrounds certain decisions taken at the most recent United Nations Framework Convention on Climate Change (UNFCCC) tasked with advancing the REDD+ agenda. There the role of defining what a "forest" is and to whom the embedded carbon belongs was largely left to each country to decide [*UNFCCC*, 2013]. Given the many vested interests in and implications of land use policy and forest conservation, carbon credit and conservation policies may therefore take on different forms from country to country to include not only native forests but also possibly tree plantations and monocultures [*UNFCCC*, 2006]. The definition adopted by each country will have important implications for all of its stakeholders as well as its carbon storage potential [*Fargione et al*., 2008]. In any case, recent multi-country studies of REDD+ pilot programs (see *Larson et al*. [2013]) have shown that the marginalization of local and indigenous land rights is a common if not ubiquitous occurrence and that the topic of traditional land rights under REDD+ has been largely absent from the public and political discourse. Though limited thus far in its implementation (partly because the greater profitability of oilcrops [e.g., oil palm] can incentivize other land uses [*Butler et al*., 2009]), REDD+ represents a potentially viable means for conserving forests and reducing emissions due to land use change [*Angelsen*, 2008]. However, in light of the potential adverse consequences, what is essential for policy makers to address is that further forest conservation for carbon reduction projects can lead to potential changes in land tenure and, in turn, act as a conduit for impacting the livelihoods of local people (Figure 2).

3.2. Land Demand of Crop-Based Biofuels

The use of crop-based fuels is one of the most widely adopted practices in attempting to address GHG emissions and climate change. Land deals intended for biofuel production constitute 19% of the international concluded acquisitions (Table 1) [*Deininger and Byerlee*, 2011; *Land Matrix*, 2015]. Renewable energy production through hydropower, wind farms, and solar energy is also contributing — though to a lesser extent—to "green" land acquisitions [*Scheidel and Sorman*, 2013; *Land Matrix*, 2015]. With fossil fuel production expected to decline [*Pfeiffer*, 2006], energy sources that are both renewable and less environmentally impactful have received serious attention as concern over GHG emissions and energy security has risen. The production and consumption of crop-based biofuels have increased rapidly since the start of the century, contributing substantially to increasing food prices (~30%) [*von Braun et al*., 2008; *Hochman et al*., 2012, 2014] and volatility [*Searchinger et al.*, 2008; *OECD/FAO*, 2014]. The influence of biofuels is also projected to continue in the near future, as increasing production (57%–61% over the next decade) [*OECD/FAO*, 2014] continues to raise food prices (7%–15%) [*OECD/FAO*, 2014] and price volatility (see *Timilsina and Shrestha* [2010]). However, while growing biofuel demand continues to drive purchases of large tracts of inexpensive land abroad [*Scheidel and Sorman*, 2013], the future of crop-based fuels—and the accompanying land investments—remains unclear. The long-term path of agrofuel production is very much subject to policy changes and likely to decline as the cons of crop-based biofuel production (e.g., competition with food, lower net carbon savings) have become more apparent and as later generation biofuel production becomes more affordable.

4. Uncertainty of Future Food Security

Land acquisitions in the name of food security also feature prominently in the global land rush, accounting for 27% of all concluded land deals to date [*Land Matrix*, 2015]. While many past agricultural investments were focused on export-oriented tropical commodities, the ongoing land rush also concentrates on staple crops [*Kugelman and Levenstein*, 2012]. The need and opportunity for such investments partly results from the increased competition with biofuel production, food market volatility [*FAO/OECD*, 2011] and climate uncertainty [*Rosenzweig and Parry*, 1994; *Parry et al*., 2004; *Hatfield et al*., 2011; *Lobell et al*., 2011], especially after recent food price spikes and widespread sociopolitical instability [*Lagi et al*., 2011; *Barrett*, 2013] that followed climate extremes in major producer countries [*IPCC*, 2014]. Climate change is also expected to increase the frequency of extreme climate events [*IPCC*, 2014] and to at least modestly contribute to elevated food prices in the future (e.g., *Lobell et al*. [2011]). In response to a suite of challenges—the current and anticipated impact of climate on food supply and prices in a world with limited availability of arable land, rapid population growth, and urbanization—import-reliant countries have become increasingly active in the acquisition of agricultural land abroad for the purposes of food security [*von Braun and Meinzen-Dick*, 2009; *Robertson and Pinstrup-Andersen*, 2010; *Brown*, 2012]. The uptick in food-related land deals is especially apparent for investments originating from the Middle East where 82% of all concluded deals have occurred after the 2008 food crisis, 76% of which are primarily intended for food crops, according to *Land Matrix* [2015]. In comparison, globally only 35% of concluded land acquisitions reported in *Land Matrix* [2015] were for the expressed intent of food crops over the same time period.

More broadly, certain countries from which investments originate have already substantially increased the amount of land under their control [*Rulli et al*., 2013] whether for biofuels, food, or another purpose. By combining information on cultivated land [*FAO*, 2014] with *Land Matrix* [2015] estimates of acquired area, it is possible to identify which countries potentially benefit from such land deals. These countries include Malaysia (with a 69% "virtual" increase over its 2010 cultivated land), the UK (38%), Saudi Arabia (178%), and South Korea (76%) as well as several Middle Eastern countries (>250%). Those investing governments are from both the global North and South make apparent the fact that the global land rush does not necessarily follow the historical paradigm of resources flowing from South to North [*Margulis et al*., 2013]. Furthermore as a result of some land transactions, targeted countries are potentially experiencing significant reductions in the cultivated land available to them. In the event that future climate change significantly impacts crop yields in these target countries, they may require greater agricultural area to maintain production levels. Contracting large tracts of cultivatable land out to investors thus effectively reduces the resilience of targeted areas to future climate shocks and can potentially leave them more dependent on imported—and likely higher priced—food commodities. In Gabon, 0.47 million ha are reported to have been contracted out to domestic and foreign investors [*Land Matrix*, 2015], an area equivalent to 95% of the country's area of arable and permanent crop land [*FAO*, 2014]. Also, Liberia has reportedly leased 1.80 million ha of its land [*Land Matrix*, 2015], roughly three times as much as the country's current arable and permanent crop land [*FAO*, 2014] (see Table 2). In presenting information on how a country can potentially change the amount of land under its control, we should note that while the effects on the targeted country can be better defined,

Table 2. List of Top Targeted Countries[a]

Target Country	Acquired Area (Mha)	Cropland (Mha)	% of Cultivated Land
Argentina	1.34	40.29	3
Brazil	1.49	79.61	2
Cambodia	1.55	4.26	36
China	0.65	122.53	1
Colombia	0.58	3.45	17
Congo	2.13	0.60	355
DRC	2.85	7.81	37
Ethiopia	1.25	16.49	8
Gabon	0.47	0.50	96
Ghana	0.91	7.40	12
Guyana	0.81	0.45	180
Indonesia	3.97	45.50	9
Kenya	0.29	6.13	5
Laos	0.50	1.62	31
Liberia	1.80	0.71	254
Madagascar	1.06	4.11	26
Malaysia	2.24	7.46	30
Mali	0.39	7.01	6
Morocco	0.70	9.40	7
Mozambique	2.37	5.95	40
Nigeria	0.70	41.70	2
Papua New Guinea	4.01	1.00	401
Russia	3.22	121.35	3
Senegal	0.28	3.42	8
Sierra Leone	1.48	1.90	78
Sudan and South Sudan	4.86	24.01	20
Tanzania	0.36	16.65	2
Timor Leste	0.45	0.23	194
Ukraine	1.91	33.41	6
Uruguay	0.77	1.80	43
Vietnam	0.30	10.20	3
Zambia	0.47	3.84	12
Zimbabwe	0.39	4.10	10

[a]A list of target countries that currently account for 95% of total acquired land area. In total, *Land Matrix* [2015] reports 75 countries are the targets of large-scale land acquisitions. Cropland is the sum of “Arable land” and “Permanent crops” as estimated in *FAO* [2014]. In cases where the percent of cultivated land is greater than 100%, this is likely because a country has contracted a large area of previously uncultivated land (e.g., forests, grasslands).

the involvement of multinational corporations can make identifying the beneficiaries of such investments more difficult.

When large-scale land acquisitions occur for crop production, they are generally touted by investors and governments as a way to bring technological investments [*Cotula et al*., 2009; *von Braun and Meinzen-Dick*, 2009; *Deininger and Byerlee*, 2011; *Messerli et al*., 2013] to the developing world in order to improve crop yields and to better ensure economic development and food security. However, many land deals occur in areas where climate’s impact on crop yields is expected to be particularly pronounced [*Wheeler and von Braun*, 2013]. Thus, an important question that remains is how crop yields in targeted areas may be affected by climate change in the future [*Parry et al*., 2004; *Jaggard et al*., 2010; *Hatfield et al*., 2011]. While there exists limited spatial data sets on land acquisitions, we can infer from national and regional

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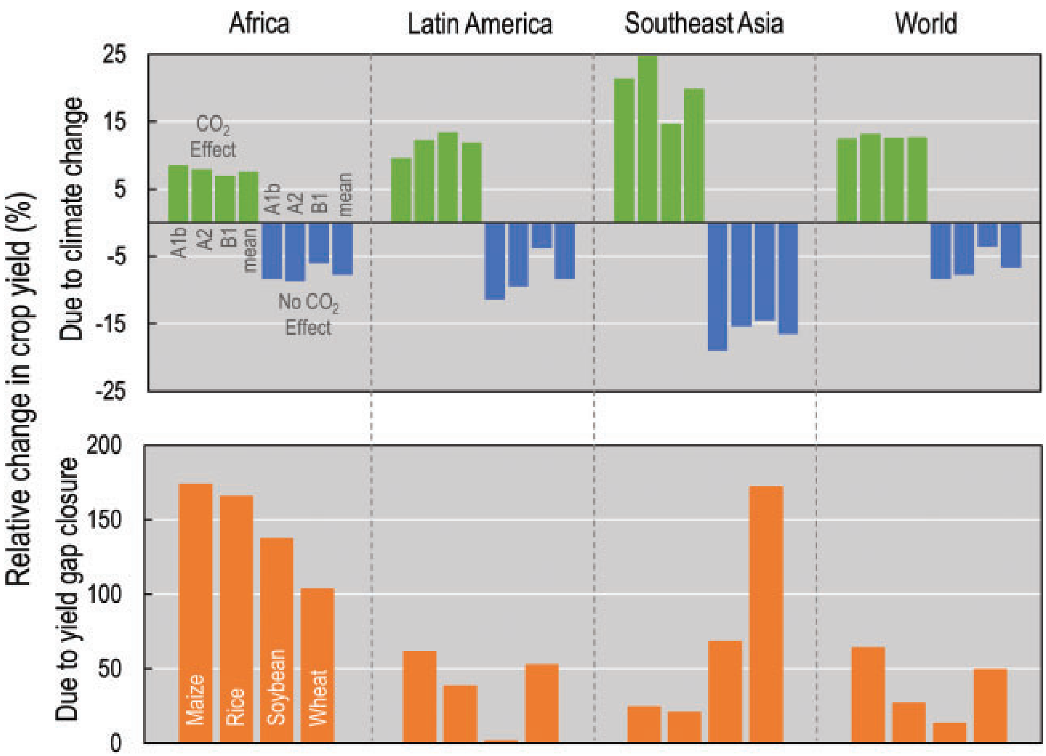

Figure 3. Comparison of changes in crop yields due to factors of climate change, CO_2 fertilization, and increased yields. In the upper panel, the effects of climate change with (without) CO_2 fertilization are expected to increase (decrease) crop yields in the targeted regions, based on data from *Müller et al*. [2013]. These data agree well with other estimates [*Ainsworth and McGrath*, 2010; *Jaggard et al*., 2010; *IPCC*, 2014] of the CO_2 effect on future crop yields (~10%–20% relative yield increase for C3 crops at 550 ppm CO_2). The lower panel shows the potential to increase crop productivity through yield gap closure using conventional technologies (e.g., irrigation, synthetic fertilizer application) based on data from *Mueller et al*. [2012]. The data shown represent 75% of the maximum attainable yield. These values agree well with case studies making estimates of yield gaps in the developing world (see *Lobell et al*. [2009]).

projections what the net changes in yield may generally be as a result of climate change, CO_2 fertilization and yield intensification. In the regions most targeted by land deals (Figure 3), climate change alone is expected to reduce major crop yields (3%–18% decline). When the effects of climate change are considered in conjunction with CO_2 fertilization, all regions experience a positive effect (7%–23% increase). These changes from climate stress and the CO_2 effect are, however, modest in comparison to the potential changes in crop yields that can occur as a result of improved technology and efficiency [*Godfray et al*., 2010a; *Tilman et al*., 2011; *Mueller et al*., 2012; *Rulli and D'Odorico*, 2014]. The potential for intensification to markedly improve crop production is most apparent in Africa where relative changes to major crop yields can exceed 100%. Due in large part to this fact, Africa is the most heavily targeted continent for land deals [*Deininger*, 2013] (53% of globally acquired agricultural area and 65% of all food crop deals, according to *Land Matrix* [2015] [Figure 4]). Ideally, the influx of technology associated with land acquisitions could help feed and fuel the African continent whose population is expected to double by mid-century (~2.4 billion people) and quadruple by century's end (~4.2 billion people) [*UN-DESA*, 2012]. To date, though, much of the agricultural production is exported and often does not benefit local populations [*Cotula et al*., 2009].

5. Supporting Evidence for Climate Feedbacks

It is apparent that climate change (both historical and anticipated) exerts influence on land purchases both through its effect on policy decisions and its direct impact on crop production. However, there is also evidence that large-scale land deals may contribute to climate change, most notably through the increased CO_2 emissions associated with land use change and deforestation [*Fargione et al*., 2008]. For example, land acquisitions are turning forests into oil palm plantations in Papua New Guinea [*Laurance et al*., 2012] and in Indonesia [*Carlson et al*., 2012], where 7.6 million ha [*Land Matrix*, 2015] (equivalent to 44% of all harvested

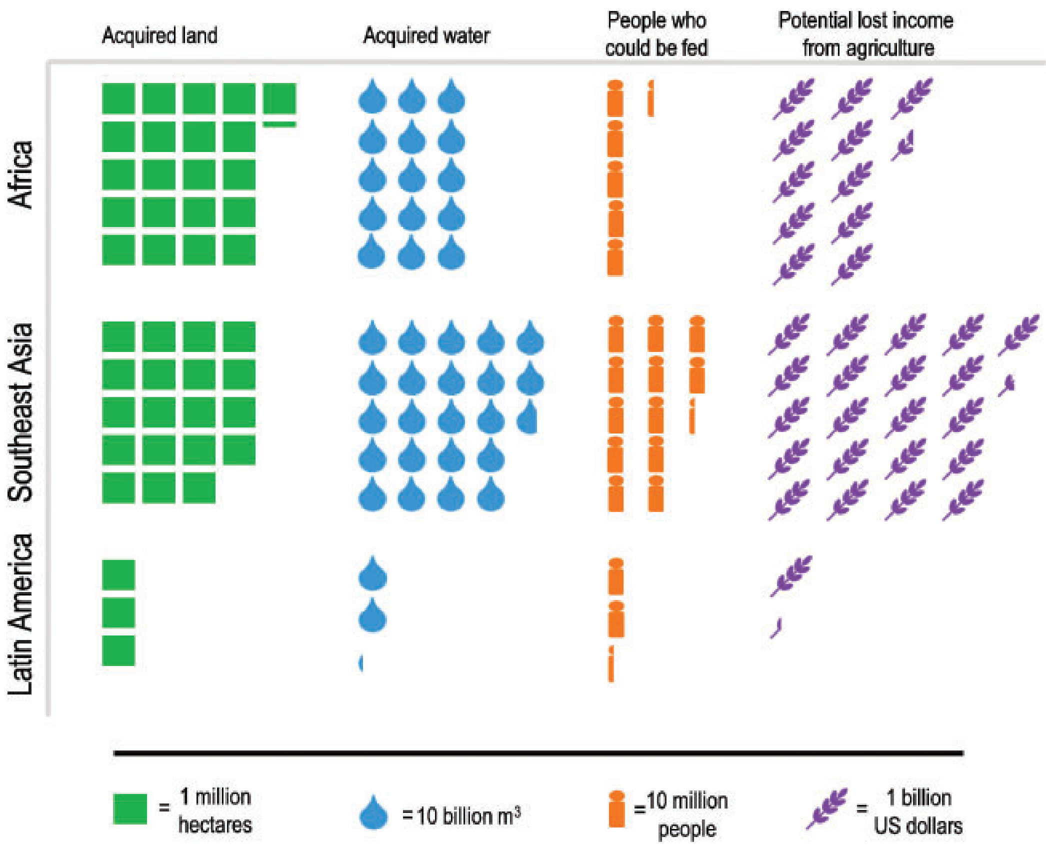

Figure 4. Global summary of human and environmental impacts of land appropriation. Comparison of the most targeted regions in terms of acquired land [*Land Matrix*, 2015], acquired water [*Rulli and D'Odorico*, 2013], the number of people who could potentially be fed by crop production on acquired lands [*Rulli and D'Odorico*, 2014], and the amount of agricultural income potentially lost by farmers as a result of changes in land access [*Davis et al*., 2014a]. We have included Papua New Guinea in Southeast Asia. Also, acquired water includes both green (i.e., rainwater) and blue (i.e., irrigation) water, assuming irrigated fractions equal to those reported for the host country [2014*Rulli and D'Odorico*, 2013]. These estimates are based on large-scale land acquisition data from Land Matrix database [*Land Matrix*, 2015] which includes both international and domestic land deals greater than 200 ha in the years after 2000. For each land deal the Land Matrix reports [*Anseeuw et al*., 2013] the area, the dominant crop, negotiation state (i.e., concluded or just intended/under negotiation). Here we considered only signed land deals with a known contract area. The water appropriation associated with these land acquisitions was calculated by 2014*Rulli and D'Odorico* [2013] using the CROPWAT 8.0 [*FAO*, 2009] model, based on the Penman–Monteith method with crop parameters from *Allen et al*. [1998], soil properties from the Harmonized World Soil Database [FAO/IIASA/ISRIC/ISSCAS/JRC, 2012], and meteo data from *NOAA* [2014]. The crop and food that could be produced by the acquired land was calculated by *Rulli and D'Odorico* [2014] using crop types from *Land Matrix* [2015] and agricultural yields from *Mueller et al*. [2012]. The study by *Davis et al*. [2014a] estimates potential lost income assuming the intended crop of the land deal was already grown there and that crop yields remain the same (i.e., at national average levels).

Indonesian oil palm land [*FAO*, 2014]) are reportedly under contract from land deals. Any carbon debt generated by these associated land use changes will take several decades before biofuels can pay it back [*Fargione et al*., 2008] and, in the case of non-biofuel crops, will remain as a more permanent impact on the environment and the global climate. To prevent further deforestation in the name of biofuel production, European Union policies do not count toward the renewable energy requirements any agrofuels grown on lands converted from primary forests or woodlands [*EU*, 2009]. However, commonly observed patterns of land use change in many target countries involve the displacement of food crops and rangelands by biofuels and the establishment of new rangelands at the expense of forests [*Hermele*, 2014]. In turn, such land conversions can cause a net increase in CO_2 emissions as farmers convert natural systems to cropland in response to higher food prices [*Butler et al*., 2009; *Fargione et al*., 2008]. In fact, recent studies in Indonesia [*Lee et al*., 2014] and Brazil [*Godar et al*., 2014] have shown that areas utilized by smallholder farmers can, in certain cases, exhibit higher deforestation rates than large-scale land acquisitions, despite the latter being highly capitalized. Such indirect replacements of forests can therefore make it difficult to track and monitor the land use change induced by biofuel production.

6. Cascading Effects on Societies and the Environment

The avenues by which climate change influences land acquisitions are through its impacts on agricultural production and through "land-intensive" programs aimed at its mitigation. But ultimately why the global land rush as a whole has raised concern is because of its potential impact on people and the environment in targeted areas (Figure 4). The commercialization of agriculture on acquired lands can offer great benefits for a target country in terms of increased food supply, economic growth, rural development, and resilience to climate change. Indeed there have been instances where investors have provided the benefits promised to local communities (e.g., job creation, assisted relocation) (see *Deininger and Byerlee* [2011]). However, local communities frequently see their livelihoods compromised as a result of such deals [*D'Odorico and Rulli*, 2013], potentially leading to losses in household income [*Davis et al*., 2014a] and in available food calories [*Rulli and D'Odorico*, 2014] as well as land conflicts and migrations [*Anseeuw et al*., 2012; *Feldman and Geisler*, 2012; *Julia and White*, 2012; *Adnan*, 2013; *Chinsinga et al*., 2013; *Hermele*, 2014]. Likely environmental impacts include soil loss and compaction [*Soane and van Ouwerkerk*, 1994; *Lal*, 1995; *Montgomery*, 2008], elevated runoff [*Tilman et al*., 2001] and GHG emissions from fertilizers [*Tilman et al*., 2001] and increased competition for water resources [*Mueller et al*., 2012; *Rulli et al*., 2013]. In addition, the fact that much of the crop production from land acquisitions will be sent elsewhere also means that consumers will be disconnected from these environmental impacts [*Meyfroidt et al*., 2013] and thus be less aware of the effects of their choices. However, we should note that though the environmental impacts listed here are generally associated with a transition to mechanized agriculture, many have yet to be demonstrated specifically on acquired land. Also, the extent to which lands acquired for carbon storage and forest conservation actually preserve forests remains poorly understood. This lack of evidence about the environmental effects of land acquisitions therefore remains a significant knowledge gap in the land rush literature.

This synthesis leads to the conclusion that the acquisition of land and the export of the crops produced there may ultimately alter the resilience of countries and communities to climate change. In destination countries, crops from acquired areas may provide a buffer against the adverse effects of climate change and demographic growth on food security. Nowhere is this more the case than in the Middle East—a region with little arable land [*FAO*, 2014], low potential to further increase crop yields [*Mueller et al*., 2012], a projected 43% increase in population by mid-century [*UN-DESA*, 2013] and substantial expected impacts of climate change on agriculture [*Müller et al*., 2013]. By committing considerable investments toward acquiring African croplands, several Middle Eastern countries have effectively more than doubled the arable land under their control [*FAO*, 2014; *Land Matrix*, 2015]. More generally, the fact that potential yield increases in targeted areas more than offset climate impacts means that many land deals (especially for food crops) can essentially be thought of as a purchase of resilience to climate change. This exchange of resources may also leave targeted countries less resilient to climate extremes (e.g., droughts, floods) [*D'Odorico et al*., 2010; *Wheeler and von Braun*, 2013]. Many of the countries targeted by land investments have low levels of development, making them less equipped—both financially and in terms of infrastructure—to cope with climate shocks. Many land deals also occur in areas that experience high levels of food insecurity [*IFPRI*, 2012]. Yet despite the apparent long-term need for agricultural land in targeted areas, many current policies related to land acquisitions frequently allow the export of the agricultural goods that were once consumed and sold locally [*Cotula et al*., 2009; *Anseeuw et al*., 2012]. This practice may exacerbate problems of local malnourishment [*D'Odorico and Rulli*, 2013] and prevent benefits—both financial and nutritional—from accruing locally.

7. Lessons Learned

The role of climate change in the global land rush has been generally unrecognized. In the regions most targeted by the global land rush, the impacts of climate change are expected to be especially pronounced (particularly for the poor) as a result of direct economic dependence on agriculture and a lack of infrastructure [*Schmidhuber and Tubiello*, 2007; *Wheeler and von Braun*, 2013]. Thus the fact that many land deals seek to promote energy and food security, foster rural development or curb GHG emissions may be viewed as a means to provide a buffer for vulnerable communities against climate change impacts. However, accepting a large-scale land acquisition carries with it substantial political, social, and environmental implications. It is therefore important in using land acquisitions as a means to address economic development, global food

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and energy security and GHG emissions that leaders and policy-makers in target countries do not overvalue short-term gains at the expense of lasting human welfare and environmental stewardship.

The issue of large-scale land acquisitions is a complex one involving various drivers, actors, and impacts. The general lack of transparency and accountability with which many deals occur only compounds the complexity. Despite these significant challenges, land rush scholars have tried to keep pace with such a rapid moving phenomenon. Yet a deeper understanding of several key issues related to land acquisitions is still needed in order to better inform policy decisions. This is especially true for the linkages between land acquisitions and climate change, where knowledge continues to be deficient despite ongoing government and academic research. In particular, it is still unclear whether investments preferentially target areas that are expected to be least affected by (or to benefit from) climate change. The use of acquired land for biofuel crops also remains poorly documented with considerable uncertainty regarding to what extent the crops will be actually used for bioenergy production rather than for food, feed, or other uses. In fact, the global patterns of biofuel crop production and trade have only recently started to be investigated. Therefore, the direct and indirect impacts of new bioenergy policies (e.g., in the U.S. and Europe) on land investments in countries targeted by the land rush are difficult to quantify, and overall, the connections among biofuel consumers, agribusiness investors, and feedstock producers need to be better understood.

To evaluate the impact on local populations and their livelihoods, it is essential to determine to what extent the crops produced on the acquired land remain locally available and how frequently changes in land rights can result in eviction and marginalization. Land use change associated with this phenomenon also remains poorly quantified. To date information on whether the land was previously cultivated, fallow or forested is lacking, which prevents a quantitative assessment of the impacts that land acquisitions have on CO_2 emissions and climate. Such analyses are strongly limited by the lack of georeferenced maps of land concessions, permits, leases, and purchases made by large-scale investors in the target countries. Thus, without knowing the exact location of the acquired land it is difficult to evaluate changes in land use.

Despite these challenges, regional studies on the global land rush have stressed the relationship existing between land grabbing and bioenergy production (e.g., *Naylor* [2011]), and highlighted the associated impacts on rural livelihoods and the environment, including GHG emissions. Thus, new policies need to be put in place to prevent the increasing demand for agricultural products (including those used for bioenergy) from contributing to large-scale land acquisitions, GHG emissions, and livelihood losses. Preference should be given to less land-intensive climate policies (other renewables) and improved credit schemes that include the needs of local communities in the evaluation of REDD+ projects. To date, the international community has not adopted any effective policy aimed at regulating large-scale land acquisitions and preventing them from contributing to environmental degradation, forced evictions, livelihood losses, and food insecurity for the local populations. Existing principles [*FAO/IFAD/UNCTAD/World Bank*, 2010] and guidelines [*FAO*, 2011] are only weak instruments for the regulation of large-scale land acquisitions and the protection of the interests of local communities. In fact, because of their voluntary nature these guidelines are not enforceable, and compliance with the professional standards indicated therein remains an investor's decision. On the other hand, recent energy policies clarify that biofuel produced at the expense of "valuable ecosystems" [*EU*, 2009] should not count toward the renewable energy mandates of EU countries. Those policies, however, remain completely silent on the impacts of such mandates on large-scale land acquisitions. By stressing the linkage existing between climate change and the ongoing land rush, this paper has highlighted how some of the detrimental effects of this phenomenon are indeed the result of deficiencies in the recent energy policies.

Finally, evidence from this synthesis indicates that acquired lands may ultimately represent a way for an investing country to improve its resilience to climate change. By controlling agricultural land in different regions, a country essentially diversifies its land holdings and may as a result reduce its susceptibility to local climate shocks. Given evidence that a growing reliance on trade has left the global food system more vulnerable to perturbations such climate variability [*Suweis et al*., 2015], large-scale land acquisitions may therefore represent a mechanism for circumventing participation in a food market of increased prices and volatility. While the many studies examined here attest to these climate change–land acquisition connections, further research is still required to determine more conclusively these linkages and to ensure a more equitable balance between local impacts and global benefits.

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