Ecological Economics 143 (2018) 276–285

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

The Global Water Grabbing Syndrome

Jampel Dell'Angelo [a,b,*], Maria Cristina Rulli [c], Paolo D'Odorico [d]

[a] Department of Environmental Policy Analysis, Institute for Environmental Studies, VU University Amsterdam, Amsterdam, The Netherlands
[b] National Socio-Environmental Synthesis Center, Annapolis, MD, USA
[c] Department of Civil and Environmental Engineering, Politecnico di Milano, Milan, Italy
[d] Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA, USA

ARTICLE INFO

Article history:
Received 13 June 2016
Received in revised form 28 February 2017
Accepted 28 June 2017
Available online xxxx

ABSTRACT

Large-scale acquisitions of agricultural land in developing countries have been rapidly increasing in the last 10 years, contributing to a major agrarian transition from subsistence or small scale farming to large-scale commercial agriculture by agribusiness transnational corporations. Likely driven by recent food crises, new bioenergy policies, and financial speculations, this phenomenon has been often investigated from the economic development, human right, land tenure and food security perspectives, while its hydrologic implications have remained understudied. It has been suggested that a major driver of large-scale land acquisitions (LSLAs) is the quest for water resources that can be used (locally) to sustain agricultural production in the acquired land. The appropriation of water resources associated with LSLAs has often been termed 'water grabbing', though to date a formal definition of such a normative and inherently pejorative term is missing. The intrinsic assumption is that the acquisition of water undergoes the same dynamics of unbalanced power relationships that underlie many LSLAs. Here we invoke hydrological theories of "green" and "blue" water flows to stress the extent to which water appropriations are inherently coupled to land acquisitions and specifically focus on blue water. We then propose a formal definition of blue water grabbing based both on biophysical conditions (water scarcity) and ethical implications (human right to food). Blue water grabs are appropriations of irrigation (i.e., blue) water in regions affected by undernourishment and where agricultural production is constrained by blue water availability. We use this framework to provide a global assessment of the likelihood that LSLAs entail blue water grabbing.

1. Introduction

At the beginning of the 21st century human societies live in a world with limited natural resources, increasing population and expansion of production systems that are highly material, energy, waste and pollution intensive (Rockström et al., 2009; Giampietro et al., 2011; Muradian et al., 2012; Ravera et al., 2014). In the context of escalating societal demand for food, fuel and fibers, agribusiness corporations have increased their pressure on land and land based resources, particularly in the developing world where large agricultural areas are considered as "underperforming". In recent years, a large number of business operations have specifically concentrated on land acquisition in developing countries (e.g., Cotula, 2009; Byerlee and Deininger, 2013). The phenomenon, which has been popularized as 'land grabbing' or 'global land rush', has attracted the attention of media and international organizations, as well as academic research. An emerging body of scholarly literature has analyzed the transformations associated with large-scale land acquisitions (LSLAs) and the power dynamics of access and use of land resources (e.g., Borras et al., 2011; De Schutter, 2011; Cotula, 2013). Recent work has synthesized the acquisition procedures and social dynamics of LSLAs (Nolte et al., 2016; Dell'Angelo et al., 2017), investigated their impacts on rural livelihoods (Davis et al., 2014; D'Odorico and Rulli, 2014; Oberlack et al., 2016) on food security (D'Odorico and Rulli, 2013) on sustainable development (Dell'Angelo et al., in press) and the underlying drivers of the phenomenon (Messerli et al., 2014) pointing at determining factors such as food security (Kugelman, 2012), financial speculation (Fairhead et al., 2012), or energy production (Scheidel and Sorman, 2012).

In the arena of studies on large-scale land acquisitions and land grabbing an alternative hypothesis has been investigated: what if the fundamental driver of the global land rush were the need for water rather than for land itself? (Skinner and Cotula, 2011; Allan et al., 2012; GRAIN, 2012; Mehta et al., 2012; Woodhouse, 2012; Franco et al., 2013). Water is a natural resource that is key to the economic development and many rural and industrial societies. An understudied mechanism of water appropriation in a globalized world is associated with large-scale land investments in agriculture. Understanding the issue of land acquisition through hydrological lenses provides an alternative way to look at transnational land deals and their effects on target and investors countries. The use of concepts such as virtual water and water footprint in

* Corresponding author at: Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands.
E-mail address: jampel.dellangelo@vu.nl (J. Dell'Angelo).

http://dx.doi.org/10.1016/j.ecolecon.2017.06.033
0921-8009/

the study on transnational land investments show that globalization dynamics may involve and affect water resources of developing countries, often in a hidden - but not less relevant - way (Rulli et al., 2013; Rulli and D'Odorico, 2013; Breu et al., 2016). A first preliminary assessment of global appropriation of water through large-scale acquisition - defined as "water grabbing" - quantified the amount of water globally appropriated through crop production in the acquired land and its potential effects on food security in the developing countries affected by these land investments (Rulli et al., 2013). In other instances the term water grabbing has been used to identify the direct physical appropriation of local water resources for example through withdrawals for hydropower (Matthews, 2012; Islar, 2012) or mining (Sosa and Zwarteveen, 2012).

In fact, there is some ambiguity in the way the term "water grabbing" has been used in the literature. At least part of the confusion arises from by the fact that it has been used with respect to different forms of water appropriation and to describe different dynamics. The formal definition of this term is not a trivial task because of its normative/value charged character and the need to specify the biophysical and institutional conditions characteristic of water grabs.

In this paper we first review the peer-reviewed literature that explicitly uses the term 'water grabbing' and analyze the different meanings this concept can assume. We then provide a novel operational framework to define and assess the water grabbing associated with large-scale land acquisitions (LSLAs) at the global scale, focusing on the distinction between blue and green water. We then use this framework to provide a global characterization of this phenomenon, and examine the ongoing "global water grab syndrome".

2. Water Grabbing: Different Definitions and Defining Characteristics

2.1. What is Water Grabbing?

While on the concept of land grabbing there is a broad semantic consensus and it has been formally defined by a coalition of international organizations (ILC Tirana Declaration), the concept of water grabbing is neither used officially in policy *fora* nor unofficially by international development organizations. As we show in this section, the concept of water grabbing has been used by different authors in peer-reviewed publications to indicate relatively different phenomena. The common denominator among the different definitions is that there is an aspect of injustice and power imbalance which is represented by the word 'grabbing'. Water grabbing means something different from water appropriation, exploitation, extraction, consumption, or use. It involves the notion of 'grabber' and 'grabbed', a dynamic of usurpation based on the power imbalance between subjects that lose and subjects that win, unjustly. The definition of water grabbing deals with the ethical question of when it is appropriate to define a particular case of typology of natural resources extraction as 'grabbing'. It also deals with the biophysical question of how do we quantify or identify the appropriation of a resource, that by its own nature is fluid, renewable and difficult to quantify (Rodríguez-Labajos and Martínez-Alier, 2015).

2.2. A Complex Problem, Different Conceptualizations

The main attempt to define the concept of water grabbing in a systematic way can be found in a special issue edited by Mehta et al. (2012) in *Water Alternatives*. A collection of 14 different papers addressed different aspects of this phenomenon and characterized the different ways water grabbing may take place. Mehta et al. (2012:197) defined water grabbing as "*a situation where powerful actors are able to take control of, or reallocate for their own benefits, water resources already used by local communities or feeding aquatic ecosystems on which their livelihoods are based*". This broad definition can be applied to a variety of different political and socio-environmental processes of water appropriation.

Wagle et al. (2012) refer to water grabbing as illicit diversion of water from agricultural to industrial uses (e.g., for coal plant refrigeration) without compensation or consultation of the affected farmers. Matthews (2012), instead, uses the concept of water grabbing when powerful private and state actors mobilize political, institutional and economic power to control water for hydropower with no consideration for social and environmental impacts. Arduino et al. (2012) refers to water grabbing when downstream water quality is affected by contamination induced by a large-scale land deal. Bossio et al. (2012) refer to water grabbing in the context of foreign direct investments (FDIs) negatively affecting other local water users and their formal or informal and customary water rights. Velez Torres (2012) uses this concept to illustrate the historical exercise of power that leads to dispossession of a minority in favor of capitalist expansion of water-based projects. Duvail et al. (2012) provide as an example of water grabbing the over-abstraction of water that will affect local users, especially downstream. Sosa and Zwarteveen (2012) describe the changes in water use and land tenure and waterscape reconfigurations caused by mining operations. Islar (2012) consider water grabbing as the physical diversion of water for hydropower development and the associated reallocation of water use rights at the expenses of people's customary rights. Drawing on the definition of land grabbing given by Kay and Franco (2012), Hertzog et al. (2012) define water grabbing as the appropriation of water resulting from large-scale land acquisitions by powerful actors. Bues and Theesfeld (2012) consider water grabbing as a transformation in local water governance systems induced by the appearance of new and more powerful foreign actors that negatively affect the traditional users. Gasteyer et al. (2012) interpret the historical conflict and power dynamics of the Israeli/Palestinian competition over land and water as a case of water grabbing. Finally, Houdret (2012) refers to the concept of water grabbing to describe the reallocation of water resources that produces increased ecological and socio-economic marginalization of local farmers.

The common denominator of these definitions is that they all point to situations of power unbalance in the appropriation of water resources, often in disregard of local users and their customary rights.

2.3. Multiple Dimensions of Water Grabbing

The different cases and definitions of water grabbing reviewed above can be summarized in few typologies of water appropriation related to different dimensions of agricultural, industrial, material and energy metabolic expansion (see Table S1). Water can be grabbed for a variety of uses such as coal plant operation (Wagle et al., 2012; Islar, 2012), hydropower production (Matthews, 2012) and mining (Sosa and Zwarteveen, 2012). In the agricultural sector water, a resource that is variable both in space and in time, is grabbed through large-scale land acquisitions as direct appropriation of water, including both rainfall on agricultural land and irrigation water (Rulli et al., 2013; Hertzog et al., 2012) or in the form of environmental contamination (Arduino et al., 2012; Duvail et al., 2012; Rulli and D'Odorico, 2013). Moreover, water is considered grabbed as the result of intensification of irrigation promoted by FDIs, water based infrastructural projects, or commercialization of agriculture (Bossio et al., 2012; Velez Torres, 2012; Bues and Theesfeld, 2012; Houdret, 2012). It is important, however, to recognize the difference between consumptive and non-consumptive uses of water. In the former case water is returned to the atmosphere in the form of water vapor through the process of evaporation (e.g., from a reservoir built for hydropower generation) or plant transpiration (e.g., crop production) and is not (immediately) available for other uses. In the case of non-consumptive uses, water is used (e.g., hydropower generation) and then returned to downstream water bodies where it remains available for other environmental, industrial or societal uses (e.g., Hoekstra and Chapagain, 2008). Water footprints of human activities (i.e., water used in those activities) are typically defined with respect to consumptive water uses (Hoekstra and Mekonnen, 2012). Here we refer to water appropriations

and water grabbing that entail a consumptive use of water (e.g., water used for agriculture) because it completely excludes other actors from the use of the same water resources. Moreover, in several instances non-consumptive uses can also exclude other actors from accessing water because they cannot use it at the same time, or because it is returned polluted, at a lower elevation, or in a different location.

2.4. Actors and Outcomes

Actors can be generally classified as grabbers and affected users. The typology of grabbers varies based on the typology of water appropriation and its scale. Grabbers can be local companies and investment groups (Wagle et al., 2012), foreign companies (Duvail et al., 2012), coalitions of local and international investors (Islar, 2012) or coalitions between investors and government (Matthews, 2012). Conversely, the notion of water grabbing entails that there are previous water users - often vulnerable people - who are negatively affected by the actions of more powerful actors. In most of the cases described in the literature, affected users are rural communities, farmers, pastoralists and indigenous people (e.g. Wagle et al., 2012; Velez Torres, 2012; Duvail et al., 2012).

Different authors employing the concept of water grabbing report the negative social and environmental consequences of water grabbing dynamics. Social consequences include marginalization of indigenous communities with social impacts such as migration, impoverishment, disappearance of cultural practices, and loss of self-subsistent capacity of agricultural production as in the case of the water-based projects described by Velez-Torres (2012) in Colombia. Other studies specifically address other impacts of water grabbing, such as emergence of water scarcity, reduction of water availability and increased limitations to water access in rural communities (Wagle et al., 2012; Bossio et al., 2012; Duvail et al., 2012). The environmental aspect of water grabbing range from Kenya's cases of direct contamination of drinkable water as a result of intensive agricultural practices (Arduino et al., 2012) to biodiversity losses, as in the case of hydropower development in the Mekong river basin (Matthews, 2012).

Local users that are impacted by dynamics of water grabbing are often depicted as vulnerable and characterized by power imbalance. However, there are significant societal responses that demonstrated the response populations affected by environmental injustice and the environmental costs of natural resource exploitation associated with globalization and economic growth. These groups are not passive; in many instances they are capable of self-organization and collective reaction. In several cases — described by the *Water Alternative* (2012) special issue on water grabbing — local communities resisted often supported by NGOs and other external actors. Similarly, a recent special issue in the *Journal of Peasant Studies* (2015) describes a variety of organized efforts of resistance and political reactions "from below" that include responses that range from local mobilization to transnational movements. Targeted populations often react entering explicit conflict. Dell'Angelo et al. (2017), with a meta study on large-scale land acquisitions and land grabbing, show that in almost half of the cases reviewed, the local users reacted engaging in different typologies of conflicts that ranged from nonviolent contestation and resistance to violent confrontation. Rodríguez-Labajos and Martínez-Alier (2015) producing a conceptual map and a synthesis of water justice conflicts globally, show how in many cases social movements that were born in conflictive contexts develop new creative modalities and propositions for alternative water governance approaches, principles and values (2015).

2.5. What Type of Water is Grabbed?

Water on Earth's land masses is stored in ice caps, below ground (i.e., groundwater stored in geologic formations known as "aquifers"), in the shallow soil (i.e., soil moisture in the root zone of most terrestrial plants), and in surface water bodies (e.g., streams and lakes). Ice caps do not contribute to major productive uses of freshwater resources until the ice is melted and contributes to surface and subsurface flows. Root zone soil moisture - known also as "green water" (Falkenmark et al., 1989) - can only be extracted by plants (and soil organisms), and therefore contributes to the productivity of terrestrial ecosystems. Water stored in aquifers and surface water bodies is often termed as "blue water", and differs from its "green" counterpart because it can be extracted in great quantities and conveyed through canals and pipelines to cities, factories, and agricultural fields where it can be used for a variety of activities. Thus, while green water is indissolubly tied to the land, blue water can be transported. Agriculture may rely only on green water (rainfed agriculture), or on both green and blue water (irrigated agriculture). The acquisition of agricultural land is directly associated with the appropriation of green water resources; if land investors develop irrigation infrastructure they are likely to appropriate also blue water resources. In other words, every 'land grab' is also a 'green water grab'; it can also turn into a 'blue water grab' if land investors decide to irrigate the land. The decision to irrigate will depend on whether the irrigation water that would be used by crops in conditions of optimal irrigated production would be a substantial fraction of the total water used by crops (i.e., blue + green water).

Most of the studies reviewed in this paper concentrated on cases of blue water grabbing (e.g., water used for mining, hydropower, coal plant cooling), except for Rulli et al. (2013), Rulli and D'Odorico (2013), and Breu et al. (2016), who investigated water appropriations associated with land acquisitions for agriculture, considering both the green water (rainfed agriculture) and blue water components of water grabbing.

3. Characterizing Water Grabbing at the Global Scale: A New Framework for LSLAs

Water grabbing encompasses a variety of socio-environmental dynamics of water dispossession. This widespread phenomenon does not seem to result just from localized dynamics but also from drivers of globalization. We identify a global "water grab syndrome" as associated with the ongoing phenomenon of LSLAs. Following the approach proposed by Schellnhuber et al. (1997) we also refer to the term syndrome in two ways, in the more strict etymological ancient Greek meaning as 'things running together' and in the normative and medical sense, as a complex 'clinical' phenomenon with manifesting co-occurring symptoms. In line with Schellnhuber and colleagues we understand the global water grabbing syndrome as an "archetypical pattern of civilization-nature interaction" and as a "…sub-dynamic of Global Change." (Schellnhuber et al., 1997: 23). Despite its recurrent and coherent global symptomatic traits, the global water grabbing phenomenon has been only marginally recognized and no diagnostic criteria have been developed for its identification. Few authors have pointed to the hydrological component of the global dynamics of large-scale land acquisitions and how fundamental, yet difficult to assess, this phenomenon is (Woodhouse, 2012; Rulli et al., 2013; Breu et al., 2016). A limitation with this approach is that treating every LSLA deal as 'water grabbing' does not take into account important hydrological and ethical differences associated with deals in different regions of the world.

To move beyond the assumption that every LSLA represents a case of water grabbing or, as opposite approach, to move beyond the localized, contextual, and case-specific analyses of water grabbing, we propose a new conceptual framework. We study the hydrological and human right traits of land grabbing, considering both its biophysical and ethical dimensions. To define water grabbing in relation to large-scale land acquisitions we first differentiate between blue water and green water grabbing. We then deal with the normative/value laden character of the term 'grabbing' by invoking the human rights approach to food (De Schutter, 2009:2): "*Under Article 11 of the International Covenant on Economic, Social and Cultural Rights, every State is obliged to ensure for everyone under its jurisdiction access to the minimum essential food which is sufficient, nutritionally adequate and safe, to ensure their freedom from*

hunger." Even though the United Nations have adopted a human right to safe drinking water, here we invoke the right to food because most of the human appropriation of freshwater resources is for agriculture (>80%) and not for drinking (<1%) (Hoekstra and Chapagain, 2008), while crop production remains often limited by water scarcity and lack of irrigation infrastructure (e.g., Müller and Lotze-Campen, 2012). In our view, such an indissoluble nexus between water and food production is the essential element that characterizes both the biophysical implications of large-scale land acquisitions and the ethical threshold beyond which these implications can be negatively evaluated and the associated water appropriations constitute a 'water grab'.

Therefore, the first step of our diagnostic approach is to assess the green vs blue hydrological traits. We first determine whether LSLAs in a certain country are more likely to appropriate green or blue water. While green water is directly appropriated with land, the estimate of blue water grabs is more complex because they take place only if the land is irrigated, which is likely to occur for relatively large ratios, ζ, between the potential blue water use by crops (in hydrologically optimal conditions for crop productivity) and the total blue and green water use by optimally irrigated crops (i.e., when irrigation water is applied just in the amount needed to prevent crop water stress).

The second step is to determine whether in a certain country LSLAs are likely to be instances of water grabbing, either blue or green depending on the results of the hydrologic analysis (step 1). To determine the likelihood that in a certain country LSLAs are (green or blue) water grabs we use 2 criteria: an indicator of food insecurity and an indicator of biophysical water scarcity. A high likelihood of "water grabbing" associated with LSLAs is expected to exist when biophysically water scarce countries experience high levels of malnutrition. We define this a case of "water grabbing" as these countries, which have scarce water resources, do not use all their potential for agricultural production to fulfill their nutritional needs; rather, foreign or private interests impose their own commercial objectives despite the existence of endemic food scarcity. Under such conditions, based on the UN article 11 (U.N., 1966), the acquisition of land and water resources is here considered to be unethical and therefore potentially constituting a "grab" because those resources could be used to reduce malnourishment in the target country.

In this way, by differentiating between blue and green water first, and then by combining an indicator that addresses ethical concerns (i.e., likelihood that water appropriation associated with land acquisitions erodes the right to food in the target country) with a hydrological indicator of water scarcity, we provide a conceptual framework for a nuanced global identification of water grabbing vulnerability in countries targeted by LSLAs.

4. Operationalizing the Framework

4.1. Step 1: Blue or Green Water Appropriation

The first level of analysis determines the likelihood that LSLAs entail an appropriation only of green water or also blue water. We expect agriculture to rely only on green water in areas where the yields attained by rainfed agriculture would not be substantially increased by irrigation. In other words, rainfed crops are not water stressed enough to justify investments in irrigation technology. The occurrence of these conditions depends on soil, climate, and crop characteristics. Conversely, blue water is likely to be used in areas in which irrigated agriculture is able to attain yields that are substantially greater than rainfed production. The implicit assumption here is that large-scale agribusiness corporations invest not only in the land but also in modern technology typically used in commercial agriculture to close the yield gap. Thus the likelihood of reliance on irrigation (and of the consequent blue water appropriation) is based on biophysical conditions, more specifically, on the ζ ratio between the blue water and the total water (i.e., blue + green) that would be used by crops in case of irrigated agriculture. The ζ depends on hydroclimatic conditions and crop type. Small values of the ζ ratio indicate that the amount of blue water that needs to be supplied with irrigation is too small to justify investments in irrigation technology and therefore in this case agriculture is assumed to be rainfed. ζ is determined using hydrologic methods based on the surface energy and water balance to calculate the amount of water evapotranspired by plants.

Potential evapotranspiration (PET) is the maximum amount of water (volume of water per unit area and unit time) plants that can evapotranspire with the available solar radiation. Thus PET depends on crop type, incoming solar radiation and plant canopy reflectivity (or "albedo", which determines the fraction of solar radiation reflected by vegetation), but does not depend on soil water availability, which is assumed to be unlimited. In other words, PET is the maximum rate of evapotranspiration that can be sustained in case of an unlimited supply of water to plant roots. In conditions of water limitation, the actual rate of evapotranspiration, ET, is smaller than PET and water stress conditions ensue. Typically, rainfed agriculture does not reach ET rates equal of PET all the time, but water stressed periods (i.e., with ET < PET) occur. By definition, rainfed systems use only green water at a rate (per unit area) that is equal to ET. To prevent the emergence of water stress conditions, irrigated agriculture closes the gap between ET and PET. Thus in optimal irrigation conditions the amount of blue water consumption (per unit area and unit time) is roughly equal to PET-ET. The reason why it is not exactly equal to PET-ET is that irrigation can modify the biophysical environment (e.g., near surface air humidity and temperature), thereby altering the ET rates as well. These second order effects, however, are beyond the scope of this work and the interested reader can refer to the more technical hydrology literature (e.g., Brutsaert, 1982).

We also notice that blue water applications will likely have to exceed PET-ET, depending on the efficiency of the irrigation system, which is higher in drip irrigation than sprinkling or surface irrigation. The excess water, however, will either drain into the soil or contribute to overland flow, thereby returning to surface or groundwater bodies, while the consumptive use of irrigation water will be PET-ET. The ζ ratio can be roughly calculated as $\zeta = (\text{PET-ET}) / \text{PET}$. It is sensible to assume that when $\zeta <$ 0.10 the gap between ET and PET is too small to justify investments in irrigation technology. The estimate of ET and PET can be based on the Penman-Montieth method (e.g., Bonan, 2002) and a variety of models is typically used to account for the effects of soil water limitation, crop type, and cropping calendars. Because several different crops are expected to be planted in the land acquired in each country, the ζ ratio is here calculated based on an aggregate estimation of the total blue and green water consumption by agriculture in each country [i.e., ζ = Blue / (Blue + Green)]. In Fig. 1 we present the results of the first level of analysis characterizing countries targeted by LSLAs based on the relative importance of blue and green water consumption.

4.2. Step 2: Biophysical Indicator: Water Scarcity

Determining water scarcity at the country level is particularly challenging. There are two main definitions of water scarcity, a physical definition and a socio-economic one. The first definition refers to the lack of available water in nature considering the water requirements or potential water requirements of the country. The second definition instead refers to countries where, despite a relative abundance of water resources, the water needs of the human population are not satisfied because of institutional, economic and technological constraints. A variety of indicators have been used to capture either one or more dimensions of water scarcity (Falkenmark et al., 1989; Shiklomanov, 1991; Raskin et al., 1997; Seckler et al., 1998; Alcamo et al., 2000; Vorosmarty et al., 2000; Sullivan et al., 2003). All these indicators have different strengths and weaknesses, depending on their use and the purpose they were developed for. Here we employ the Brauman et al. (2016) depletion metric for assessing water scarcity which incorporates seasonal variations. Brauman et al. (2016) define water depletion at basin scale as the fraction of available renewable water consumptively used by human activities. In Fig. 2 we classify countries as having mid-to-high water scarcity

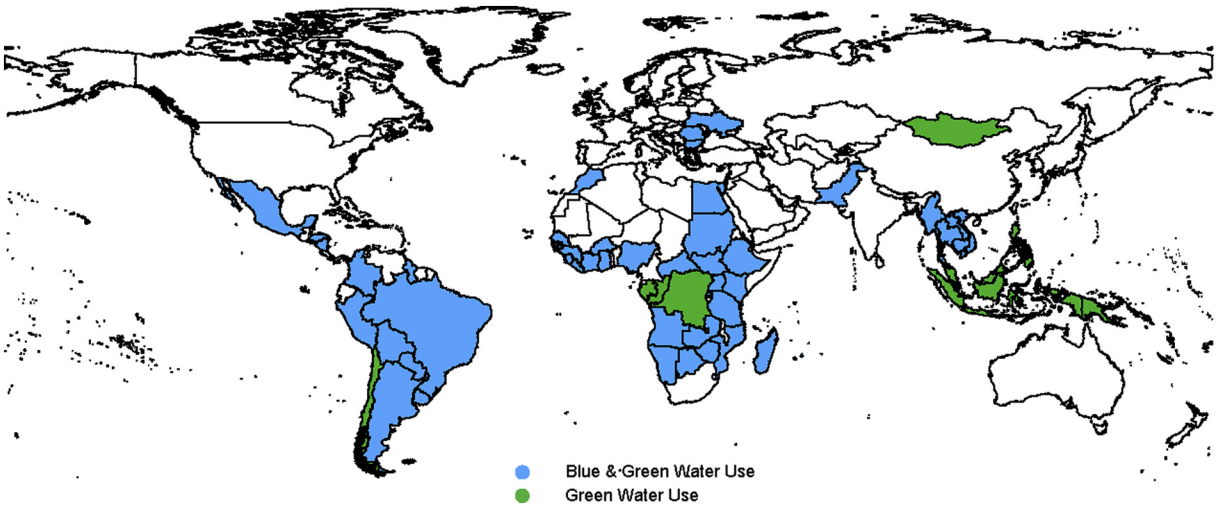

Fig. 1. In blue, countries in which land investors are more likely to develop irrigation infrastructure ($\zeta > 0.10$); in green, countries in which crop yields would not substantially benefit from irrigation ($\zeta < 0.10$) and therefore agriculture is more likely to be rainfed. Based on country-specific analyses of blue and green water consumption in crops reported for LSLAs by The Land Matrix, (TLM, 2016). While some of these data are subject to continuous revisions and changes that could slightly modify these patterns of blue and green water use, the framework proposed in this paper for the definition of blue water appropriations, is general and can be applied to other data sets. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

if >15% of their area experiences depletion higher than 75% (seasonal and dry year included), and low water scarcity otherwise.

4.3. Step 3: Prevalence of Undernourishment as an Ethical Indicator

According to the framework developed in this paper malnutrition is a dimension that is critical to the assessment of water grabbing. It accounts for the normative/justice aspects of the term "grabbing" and is directly related to water. In fact, blue and green water acquisitions are here defined as "water grabs" if they take place in countries affected by malnourishment, where land and water resources could be used to address local food needs (Rulli and D'Odorico, 2014) and the associated deficits in the right to food (De Schutter, 2009, 2011). In fact, it has already been stressed by some international organizations that when national food security is at risk as in cases of acute droughts, national trade policies should limit the rights of foreign investors to export food commodities (von Braun and Meinzen-Dick, 2009). In particular, blue water appropriations in regions where water resources are already heavily depleted are likely to compete with irrigation water needs of local populations or their ability to develop irrigation in the future. Thus, the combination of a hydrological indicator of water scarcity with an indicator of malnutrition is motivated by the nexus existing in these regions between blue water and food production. While blue water is a critical factor for food production, agriculture and livestock use account for ~92% of the blue water footprint of humanity (Richter, 2014) and the lion share of this is for food.

We use the FAO (2015) data on prevalence of undernourishment, which classifies countries as having low or moderately low food insecurity if <15% of their population is undernourished, and moderately high or high if the prevalence of undernourishment in the population exceeds 15% (FAO, IFAD and WFP, 2015). In our analyses we use the same 15% threshold to classify food secure and food insecure countries (Fig. 3).

4.4. Step 4: Synthesis: Assessing the Likelihood of Blue Water Grabbing

Based on the previous steps of country categorizations on the basis of irrigation needs, blue water scarcity, and prevalence of malnourishment we finally determine the likelihood that LSLAs in a certain country entail

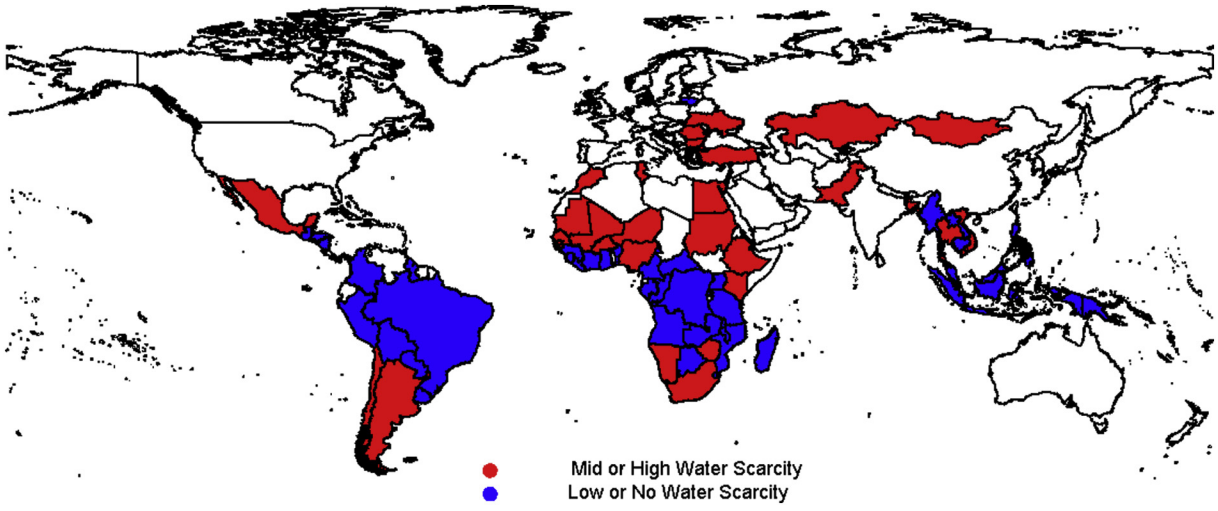

Fig. 2. Countries with mid-to-high levels of water scarcity (red) and low levels of water scarcity or no water scarcity at all (blue). Based on data from Brauman et al. (2016). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

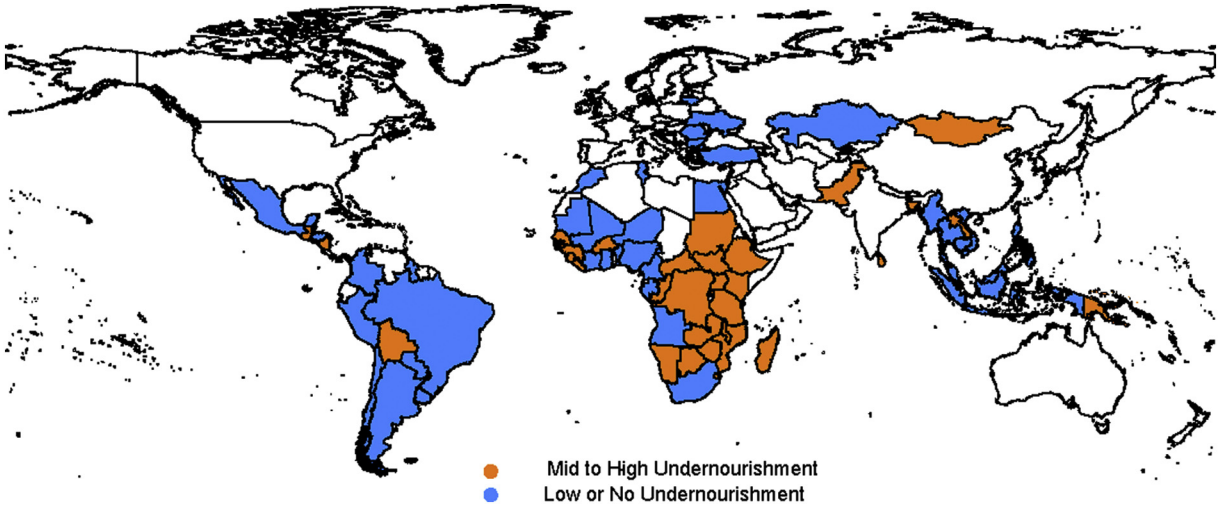

Fig. 3. Prevalence of undernourishment. Countries with low (<15%) and mid to high (>15%) undernourishment levels.

(blue) water grabbing using the framework shown in Fig. 4. Appropriation of water resources constitutes a "grab" when it takes (blue) water that could have been used to reduce undernourishment in the target country. Of course it could be argued that in many instances those water resources would not be used by the local populations because of lack of investment in irrigation technology. The appropriation of blue water resources by large scale land investors, however, could prevent future agricultural development. This is more likely to be the case when (i) a country is affected by undernourishment and (ii) its blue water resources are already heavily used (i.e., high levels of (blue) water scarcity). Conversely, the likelihood of water grabbing is relatively low when the above two conditions are not met, and moderate when only one of them is met.

Using this framework we employ the data from The Land Matrix (TLM, 2016) to provide a first global assessment of the likelihood of blue water grabbing associated with LSLAs. Based on land deal information reported by TLM (2016) on negotiation status, size, location and cultivated crops we evaluated, the likelihood of blue water grabbing and the amount of blue water likely appropriated by each land deal. In this analysis we considered both signed deals and deals that are under production, with blue water footprints calculated using the methods by Rulli and D'Odorico (2013).

Using land deals information reported by TLM2016 on negotiation status, spatial dimension, location and cultivated crops we evaluated, for all concluded land deals (i.e. signed contract, under production)the water needs associated with each land deal cultivation following the method by Rulli and D'Odorico (2013). To date (December, 2016) agriculture and forestry land deals under signed contract cover an area of about 40 million ha where about 11% ha (4.5 million ha) is under production. We analyzed 1312 land deals with concluded contracts; 780 of these deals are presently in operation. There are some limitations in TLM database accuracy due to the lack of transparency and information of the land acquisition process (Anseeuw et al., 2013). Here the land deals reported by TLM that are defined as failed are not taken in account in our blue water calculation.

Based on this assessment we produce a global map (Fig. 5) that shows the likelihood that countries targeted by large-scale land investments are affected by water grabbing. As with many global assessments, the level of analysis does not allow for finer scale, discussions and interpretations; nevertheless this conceptual and graphical representation allows us to show how global patterns of water appropriation have the potential to impact very differently countries with diverse socio and environmental conditions.

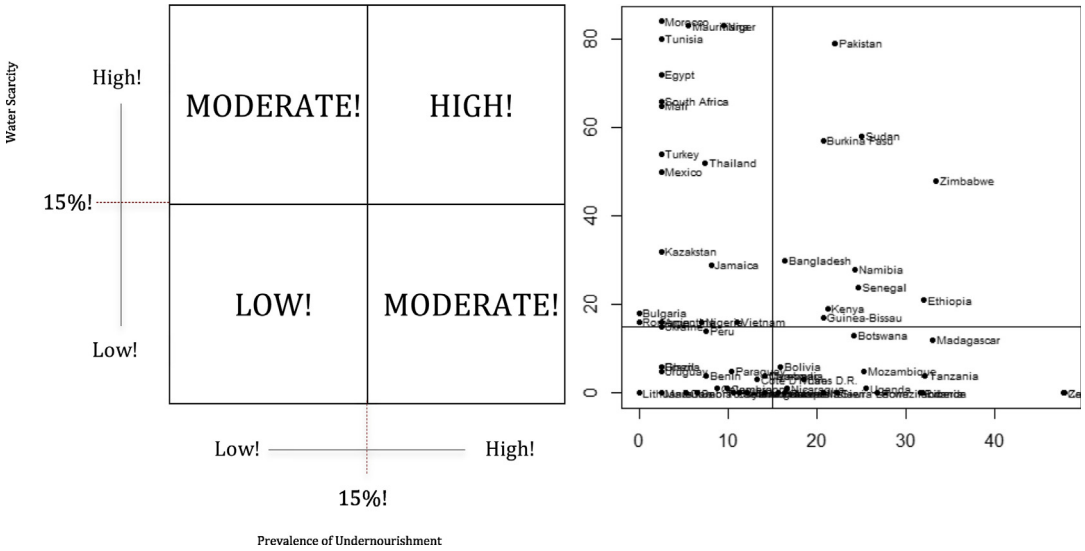

Fig. 4. Likelihood of blue water grabbing associated with LSLAs. (For a complete list of the countries see Supplementary materials). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

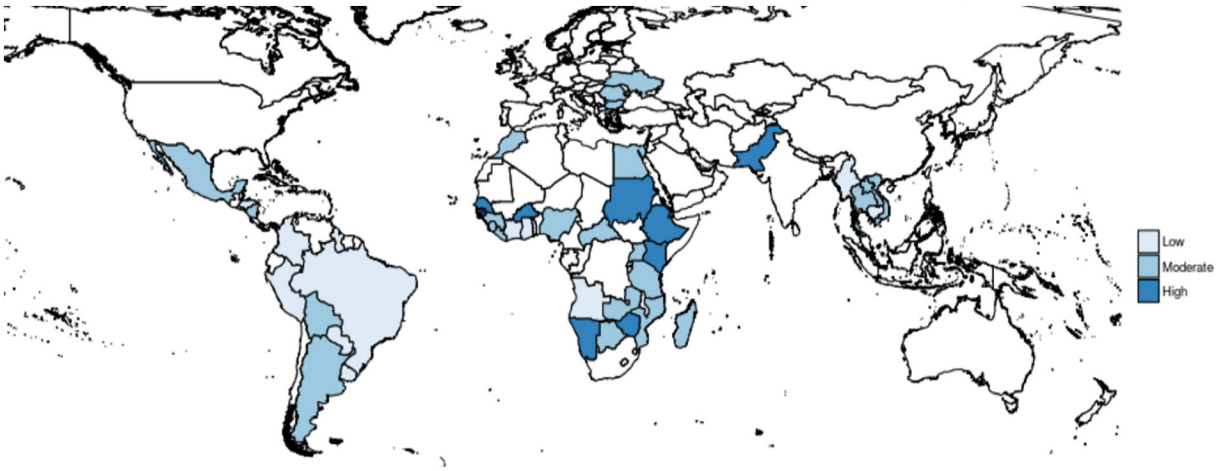

Fig. 5. Likelihood of blue water grabbing associated with LSLAs based on our framework. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

4.5. Step 5: Aggregating the Numbers

The estimate of the volumes of water appropriated through LSLAs shows two different pictures depending on whether the data used are related to the deals under production or the deals that have been contracted but are not necessarily under production, based on the Land Matrix database (TLM, 2016). An analysis based on deals under contract shows that 28% of the global appropriation of blue water through LSLAs has a high likelihood of being a blue water grab, while 63% has a moderate likelihood of blue water grabbing. A more conservative estimate should take into account only deals that are under production because no irrigation water is actually used if the land is not cultivated. In this case <1% of the blue water appropriated through LSLAs falls in the category of high likelihood of water grabbing while ~57% of that water is in the category of moderate likelihood of blue water grabbing (See Fig. 6).

Both scenarios reveal a concerning picture. The occurrence of both moderate and high likelihoods of water grabbing in countries affected by LSLAs reveal the problematic nature of the phenomenon of transnational virtual water appropriation. Both assessments show that the majority of deals are in countries that have either high levels of water scarcity or high levels of malnourishment; moreover, about one third of the deals that are under contract are in countries that have both. Following our line of reasoning on the vulnerability of countries affected by water stress and food insecurity this is a picture that raises questions on basic ethical and human rights standards of LSLAs as a global phenomenon.

Quantitative assessment of water appropriations associated with LSLAs (Rulli et al., 2013; Rulli and D'Odorico, 2014; Breu et al., 2016) assume that most of the agricultural production from the acquired land is exported to other countries. This is a reasonable assumption in all those instances in which land acquisitions are motivated by the need to enhance food security in their home country or make profit in the global food market. In several cases, however, the lease contract specifies that part of the harvested crops should remain in the target country (Lisk, 2013). Unfortunately, information on whether crops are exported or sold domestically is generally not available, and it is therefore difficult to assess precisely what share of the production is for export. We often work under the assumption that investors produce in target countries to then import the harvested crops to their own countries.

Despite the lack of information on the export of agricultural commodities and the complexity of the actors involved in transnational deals, it is interesting to provide a depiction of the conditions of water availability in the investors' countries. Any analysis of the investors' countries, however, needs to be interpreted considering that, while information on the investors' countries are often available for every land deal, the share distribution among investors involved in the joint ventures is seldom reported (TLM, 2016). For example deal that results from a joint venture between an Ethiopian and a Saudi company would neither document their shares nor the form of the partnerships (e.g., private-public partnership). In some countries joint ventures can be very common, particularly when international companies are required to partner with local companies or national governments to abide with national legislations on international investments.

The water scarcity characteristics of investors' countries are here analyzed focusing on the case of investors targeting countries that fall in the

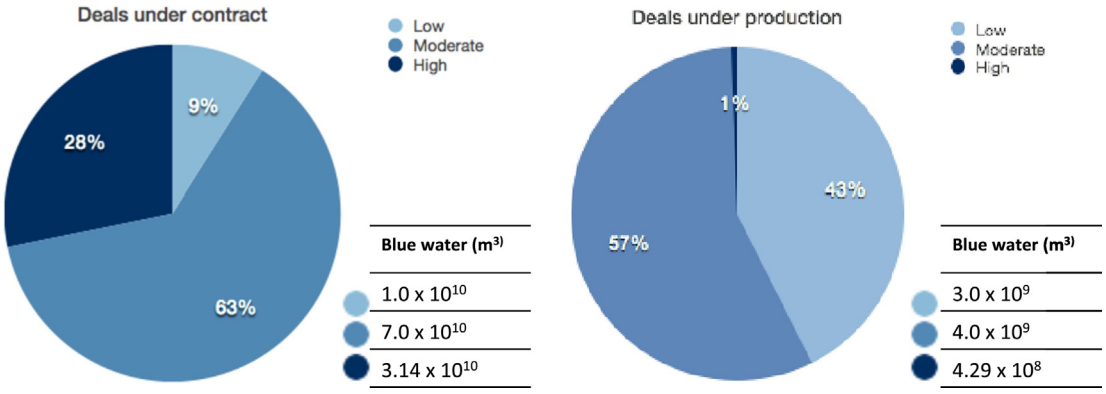

Fig. 6. Global blue water appropriation classified as low, moderate and high water grabbing. We consider two scenarios with deals under contract and deals under production. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

'high likelihood' category of blue water grabbing. Using the data on the deals under contract (TLM, 2016), we provide 2 scenarios (Fig. 7): one assuming that all the agricultural commodities potentially produced are exported to the investor countries, and the other "allowing" part of the production to remain in the target country based on the different shares between different nationalities of the companies participating to the same deal.

Interestingly, investor countries that suffer from mid or high water scarcity appropriate more than double the amount of water taken by investors from countries with low or no water scarcity. This suggests that LSLAs are often water driven. This type of assessment contributes to the explanation and understanding of the different drivers and causes underlying the syndrome. While dynamics of land acquisitions are complex and driven by a plurality of causal factors, a diagnosis of the processes and outcomes of this global syndrome needs to develop further the analysis of structural social and biophysical characteristics of importing and exporting countries, including their water limitations.

5. Discussion and Conclusions

Water scarcity represents one of the most pressing challenges for humanity, one fifth of the global population lives in areas with physical water scarcity, and even more people live in areas affected by economic water scarcity (Brown and Matlock, 2011; Gassert et al., 2013). The linkage between water scarcity and food security is evident: irrigated agriculture represents the largest human use of blue water with ~69% of annual withdrawals and ~92% of annual consumptive blue water use (e.g., Richter, 2014). In this hydrological context approximately 800 million people in developing countries are undernourished (FAO, IFAD and WFP 2015). Nevertheless, water is often appropriated from these countries through the trade of agricultural commodities and transnational land investments without accounting for the hydrological vulnerability of the target region.

Particularly concerning is the recent spike in large-scale land investments for commercial agriculture. Despite the lack of accurate information there is some consensus that the agricultural commodities produced through transnational land deals are prevalently exported (e.g. IFPRI, 2012; Rulli and D'Odorico, 2014; Breu et al., 2016). Since many of these investments target developing countries, it is of utmost importance to understand the hydrological implications of LSLAs and the associated transnational transfer of agricultural commodities. In this context an increasing number of studies have focused on the political economy of LSLAs prevalently addressing dynamics of land grabbing, while the hydrological implications of LSLAs have received less attention. Similarly, policy makers and international development organizations concerned with the problem of land grabbing have prevalently focused on issues of land governance and land tenure but did not fully evaluate the water dimension of this phenomenon (Breu et al., 2016).

Investor country water scarcity condition	Scenario of export	Blue water (m^3)
Low or absent	proportional	6.21 billions
	all exported	6.96 billions
Mid or high	proportional	17.4 billions
	all exported	20.4 billions

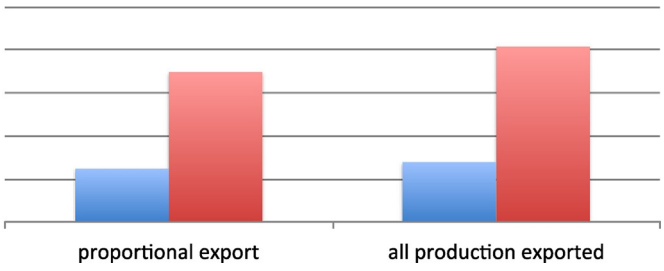

Fig. 7. Water grabbing by investors from countries with low or no water scarcity (in blue) and mid to high water scarcity (red) under two export scenarios. Only deals in countries with high likelihood of blue water grabbing are included in this analysis (Fig. 5). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Addressing the water dimension of transnational land investments is complex for several reasons. As pointed out by Franco et al. (2013), water grabbing has a 'slippery' nature both for biophysical and institutional reasons. From a biophysical perspective, understanding hydrological dynamics is more complicated than understanding land issues. Water is both a renewable and non-renewable source and its availability changes both in space and time (Brauman et al., 2016). Moreover, water resources are often shared by different countries in a relationship of interdependence (Wolf, 2007). From an institutional point of view water rights are particularly complicated, often tied to land, but rarely able to fully govern the necessary dynamics of access and competition. Water, in many cases such as in the case of groundwater basins, has the characterizing features of common-pool resources (i.e. high levels of excludability and high levels of subtractability) (Ostrom et al., 2002) but often water resources are appropriated under what de facto are open access conditions leading then to potential resource degradation and/or conflicts (Ostrom et al., 1999).

However, despite its normative, politically charged, and difficult to assess nature, it is fundamental to stress the risk of negative hydrological implications of large-scale land acquisitions. Instead of focusing on context-dependent definitions of water dispossession, we have provided a framework to assess the likelihood that blue water appropriations associated with large-scale land acquisitions constitute a water grab. Water grabbing has specific ontological characteristics that differ from those of land grabbing. While it can be argued that the water embodied in commodities exported from "grabbed land" is also grabbed, there are analytical differences that arise when focusing specifically on the water dimension of LSLAs.

A first element that we highlighted with this study is that not all water is qualitatively the same. Agricultural investments consume different amounts of green and blue water (Rulli and D'Odorico, 2013). This nuance has not been highlighted in previous studies on water grabbing but it has some fundamental implications for future agricultural development and water governance. In fact, while green water is "tied" to the land and is therefore directly acquired with it, blue water is withdrawn from water bodies and delivered to farmlands by systems of canals and conduits. In regions with scarce blue water resources other farmlands in the area might compete for the same blue water. Because blue water is not attached to the land, neighboring farmers can try to subtract it from one another. Thus the appropriation of blue water by land investors requires additional action (e.g., investments in hydraulic infrastructures) with respect to the acquisition of land and may lead to water dispossession in local communities, or exclude other farmers from future access to blue water resources. A second element is that water scarcity is often a problem of hungry rather than thirsty people because it takes much more water to produce the food a person eats than to quench her thirst. This means that water dispossession is likely to limit the agricultural production, rural livelihoods and food security of local communities before affecting their access to drinking water. For this reason, the ethical concerns about blue water appropriations should refer to the human right to food rather than to drinking water (UN, 1966; Von Braun and Meinzen-Dick, 2009; De Schutter, 2009).

Large-scale land investments in the developing world might limit access to food and undermine food security in local communities both directly through land dispossession, and indirectly through (blue) water appropriations that prevent irrigation in the remaining land. Blue water grabbing is here defined as an "unethical" appropriation of water resources for irrigation or other activities associated with LSLAs. It is considered "unethical" when it erodes the human rights to food, more specifically, when (i) limited access to food exists within the target

country to the point that relatively high rates of undernourishment are reported; and (ii) blue water resources are scarce, which means that their appropriation by land investors may compete with local uses.

The implicit assumption of this framework is that LSLAs do not necessarily enhance economic access to food by improving rural livelihoods, employment or income levels. This point is central to the debate on the ongoing land rush and is relevant also to the associated appropriation of freshwater resources (Robertson and Pinstrup-Anderson, 2010). While proponents of LSLAs see in these land investments an opportunity to improve agricultural development (Chakrabarti and Da Silva, 2012) there is a clear concern that they could erode food security in countries with high levels of malnutrition (e.g., De Schutter, 2011) if land investors gain control of agricultural resources (i.e., land and water) without delivering the promised opportunities.

The LSLA literature has been trying to address the key question of whether LSLAs impact positively or negatively food security in countries with high malnutrition rates and scarce water resources (Schiffman, 2013; Narula, 2013). The same question remains relevant to the study of water grabbing. More in general, it is still unclear whether and under what conditions the ongoing agrarian transformation from smallholding and traditional systems of production to extensive, industrialized and commercial agriculture have a positive impact on food security in water scarce countries. The emerging phenomenon of water grabbing calls for new research on water governance aiming at identifying the type of institutional arrangement that could maximize the positive outcomes and minimize the risk that blue water appropriations associated with LSLAs negatively affect the local populations.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2017.06.033.

Acknowledgments

This work was supported by the National Socio-Environmental Synthesis Center (SESYNC)—National Science Foundation Award Grant # DBI—1052875. We thank the anonymous reviewers for their many helpful suggestions that improved this paper.

References

Alcamo, J., Henrichs, T., Rosch, T., 2000. World water in 2025: global modeling and scenario analysis. In: Rijsberman (Ed.), World Water Scenarios Analyses. World Water Council, Marseille.
Allan, T., Kerlertz, M., Sojamo, S., Warner, J., 2012. Handbook of Land and Water Grabs in Africa: Foreign Direct Investment and Water and Food Security. Routledge, London.
Anseeuw, W., Lay, J., Messerli, P., Giger, M., Taylor, M., 2013. Creating a public tool to assess and promote transparency in global land deals: the experience of the Land Matrix. J. Peasant Stud. 40, 521–530.
Arduino, S., Colombo, G., Ocampo, O.M., Panzeri, L., 2012. Contamination of community potable water from land grabbing: a case study from rural Tanzania. Water Altern. 5 (2), 344.
Byerlee, D., Deininger, K., 2013. Growing resource scarcity and global farmland investment. Ann. Rev. Resour. Econ. 5 (1), 13–34.
Borras Jr., S.M., et al., 2011. Towards a better understanding of global land grabbing: an editorial introduction. J. Peasant Stud. 38 (2), 209–216.
Bossio, D., Erkossa, T., Dile, Y., McCartney, M., Killiches, F., Hoff, H., 2012. Water implications of foreign direct investment in Ethiopia's agricultural sector. Water Altern. 5 (2), 223.
Bonan, G., 2002. Ecological Climatology. Cambridge University Press, Cambridge.
Breu, T., Bader, C., Messerli, P., Heinimann, A., Rist, S., Eckert, S., 2016. Large-scale land acquisition and its effects on the water balance in investor and host countries. PLoS One 11 (3).
Brauman, K.A., Richter, B.D., Postel, S., Malsy, M., Flörke, M., 2016. Water depletion: an improved metric for incorporating seasonal and dry-year water scarcity into water risk assessments. Elementa 4 (1).
Brown, A., Matlock, M.D., 2011. A review of water scarcity indices and methodologies. White Paper. 106.
Brutsaert, W., 1982. Evaporation Into the Atmosphere. D. Reidel, Dordrecht, Holland.
Bues, A., Theesfeld, I., 2012. Water grabbing and the role of power: shifting water governance in the light of agricultural foreign direct investment. Water Altern. 5 (2), 266.
Chakrabarti, S., Da Silva, J.G., 2012. Hungry for investment: the private sector can drive agricultural development in countries that need it most. Wall Street J. 6.
Cotula, L., 2009. Land Grab or Development Opportunity? Agricultural Investment and International Land Deals in Africa (Iied).
Cotula, L., 2013. The new enclosures? Polanyi, international investment law and the global land rush. Third World Q. 34 (9), 1605–1629.
Dell'Angelo, J., D'Odorico, P., Rulli, M.C., Marchand, P., 2017. The tragedy of the grabbed commons: coercion and dispossession in the global land rush. World Dev. 92, 1–12.
Dell'Angelo, J., Rulli, M.C., D'Odorico, P., 2017. Threats to sustainable development posed by land and water grabbing. Curr. Opin. Environ. Sustain. (in press).
De Schutter, O., 2009. Large-scale Land Acquisitions and Leases: A Set of Core Principles and Measures to Address the Human Rights Challenge. Briefing Note, 11 June 2009. UN Office of the High Commissioner for Human Rights, Geneva.
De Schutter, O., 2011. Green Rush: The Global Race for Farmland and the Rights of Land Users. 52. The. Harv Int'l LJ, p. 503.
Davis, K.F., D'Odorico, P., Rulli, M.C., 2014. Land grabbing: a preliminary quantification of economic impacts on rural livelihoods. Popul. Environ. 36 (2), 180–192.
D'Odorico, P., Rulli, M., 2013. The fourth food revolution. Nat. Geosci. 6 (6), 417–418.
D'Odorico, P., Rulli, M., 2014. The land and its people. Nature Geoscience 7 (5):324–325. http://dx.doi.org/10.1038/ngeo2153.
Duvail, S., Médard, C., Hamerlynck, O., Nyingi, D.W., 2012. Land and water grabbing in an East African coastal wetland: the case of the Tana delta. Water Altern. 5 (2), 322.
Fairhead, J., Leach, M., Scoones, I., 2012. Green grabbing: a new appropriation of nature? J. Peasant Stud. 39 (2), 237–261.
Falkenmark, M., Lundquist, J., Widstrand, C., 1989. Macro-scale water scarcity requires micro-scale approaches: Aspects of vulnerability in semi-arid development. Nat. Res. Forum 13 (4), 258–267.
FAO, IFAD, WFP, 2015. The State of Food Insecurity in the World 2015. Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress. Rome, FAO.
Franco, J., Mehta, L., Veldwisch, G.J., 2013. The global politics of water grabbing. Third World Q. 34 (9), 1651–1675.
Gasteyer, S., Isaac, J., Hillal, J., Hodali, K., 2012. Water grabbing in colonial perspective: land and water in Israel/Palestine. Water Altern. 5 (2), 450.
Gassert, F., Landis, M., Luck, M., Reig, P., Shiao, T., 2013. Aqueduct Global Maps 2.0. Water Resources Institute (WRI), Washington, DC.
Giampietro, M., Mayumi, K., Sorman, A.H., 2011. The Metabolic Pattern of Societies: Where Economists Fall Short. 15. Routledge, London.
GRAIN, 2012. Squeezing Africa dry: Behind Every Land Grab is a Water Grab.Barcelona. Available online at. https://www.grain.org/article/entries/4516-squeezing-africa-dry-behind-every-land-grab-is-a-water-grab (Last Accessed June 2016).
Hertzog, T., Adamczewski, A., Molle, F., Poussin, J.C., Jamin, J.Y., 2012. Ostrich-like strategies in Sahelian sands? Land and water grabbing in the Office du Niger, Mali. Water Altern. 5 (2), 304.
Hoekstra, A.Y., Chapagain, A.K., 2008. Globalization of Water: Sharing the Planet's Freshwater Resources. Blackwell Publishing, Oxford, UK.
Hoekstra, A.Y., Mekonnen, M.M., 2012. The water footprint of humanity. Proc. Natl. Acad. Sci. U. S. A. 109 (9):3232–3237. http://dx.doi.org/10.1073/pnas.1109936109.
Houdret, A., 2012. The water connection: irrigation, water grabbing and politics in southern Morocco. Water Altern. 5 (2), 284.
IFPRI, October 2012. International Food Policy Research Institute 2012 Global Hunger Index Bonn/Washington, DC/Dublin.
Islar, M., 2012. Privatised hydropower development in Turkey: a case of water grabbing? Water Altern. 5 (2), 376.
Kay, S., Franco, J., 2012. The Global Water Grab: A Primer. Transnational Institute (TNI), Amsterdam.
Kugelman, M., 2012. The Global Farms Race: Land Grabs, Agricultural Investment, and the Scramble for Food Security. Island Press.
Lisk, F., 2013. 'Land grabbing' or harnessing of development potential in agriculture? East Asia's land-based investments in Africa. Pac. Rev. 26 (5), 563–587.
Matthews, N., 2012. Water grabbing in the Mekong basin-an analysis of the winners and losers of Thailand's hydropower development in Lao PDR. Water Altern. 5 (2), 392.
Mehta, L., Veldwisch, G.J., Franco, J., 2012. Introduction to the Special Issue: water grabbing? Focus on the (re)appropriation of finite water resources. Water Altern. 5 (2), 193.
Messerli, P., Giger, M., Dwyer, M., Breu, T., Eckert, S., 2014. The geography of large-scale land acquisitions: analysing socio-ecological patterns of target contexts in the global South. Appl. Geogr.:53 http://dx.doi.org/10.1016/j.apgeog.2014.07.00.
Müller, C., Lotze-Campen, H., 2012. Integrating the complexity of global change pressures on land and water. Glob. Food Sec. 1 (2), 88–93.
Muradian, R., Walter, M., Martinez-Alier, J., 2012. Hegemonic transitions and global shifts in social metabolism: implications for resource-rich countries. Introduction to the special section. Glob. Environ. Chang. 22 (3), 559–567.
Narula, S., 2013. The global land rush: markets, rights, and the politics of food. Stanford J. Int. Law 49 (1), 101–175.
Oberlack, C., Tejada, L., Messerli, P., Rist, S., Giger, M., 2016. Sustainable livelihoods in the global land rush? Archetypes of livelihood vulnerability and sustainability potentials. Glob. Environ. Chang. 41, 153–171.
Ostrom, E., Burger, J., Field, C.B., Norgaard, R.B., Policansky, D., 1999. Revisiting the commons: local lessons, global challenges. Science 284 (5412), 278–282.
Ostrom, E.E., Dietz, T.E., Dolšak, N.E., Stern, P.C., Stonich, S.E., Weber, E.U., 2002. The Drama of the Commons. National Academy Press.
Raskin, P., Gleick, P., Kirshen, P., Pontius, G., Strzepek, K., 1997. Water Futures: Assessment of Long-range Patterns and Prospects. Stockholm Environment Institute, Stockholm.
Ravera, F., Scheidel, A., Dell'Angelo, J., Gamboa, G., Serrano, T., Mingorría, S., Cabello, V., Arizpe, N., Ariza, P., 2014. Pathways of rural change: an integrated assessment of metabolic patterns in emerging ruralities. Environ. Dev. Sustain. 16 (4), 811–820.
Richter, B., 2014. Chasing Water. Island Press, Washington, DC.
Robertson, B., Pinstrup-Andersen, P., 2010. Global land acquisition: Neo-colonialism or development opportunity? Food Sec. 2 (3), 271–283.
Rodríguez-Labajos, B., Martínez-Alier, J., 2015. Political ecology of water conflicts. Wiley Interdisciplinary Reviews: Water. 2(5), pp. 537–558.
Nolte, K., Chamberlain, W., Giger, M., 2016. International Land Deals for Agriculture. Fresh Insights From the Land Matrix: Analytical Report II.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., 2009. A safe operating space for humanity. Nature 461 (7263), 472–475.
Rulli, M.C., D'Odorico, P., 2014. Food appropriation through large scale land acquisitions. Environ. Res. Lett. 9 (6), 064030.
Rulli, M.C., D'Odorico, P., 2013. The water footprint of land grabbing. Geophys. Res. Lett. 40 (23), 6130–6135.
Rulli, M.C., Saviori, A., D'Odorico, P., 2013. Global land and water grabbing. Proc. Natl. Acad. Sci. 110 (3), 892–897.
Schellnhuber, H.J., Block, A., Cassel-Gintz, M., Kropp, J., Lammel, G., Lass, W., ... Petschel-Held, G., 1997. Syndromes of global change. GAIA-Ecological Perspectives for Science and Society. 6(1), pp. 18–33.
Schiffman, R., 2013. Hunger, food security, and the African land grab. Ethics Int. Aff. 27 (3), 239–249.
Shiklomanov, I.A., 1991. The World's water resources. Proc. Int. Symp. to Commemorate 25 years of the IHP. UNESCO/IHP, Paris, pp. 93–126.
Scheidel, A., Sorman, A.H., 2012. Energy transitions and the global land rush: ultimate drivers and persistent consequences. Glob. Environ. Chang. 22 (3), 588–595.
Seckler, D., Amarasinghe, U., Molden, D.J., de Silva, R., Barker, R., 1998. World Water Demand and Supply, 1990 to 2025: Scenarios and Issues. IWMI Research Report 19. IWMI, Colombo.
Sullivan, C.A., et al., 2003. The water poverty index: development and application at the community scale. Nat. Res. Forum 27 (2003), 189–199.
Skinner, J., Cotula, L., 2011. Are land deals driving 'water grabs'. Briefing: The Global Land Rush. IIED, London http://pubs.iied.org/1702IIED.html.
Sosa, M., Zwarteveen, M., 2012. Exploring the politics of water grabbing: the case of large mining operations in the Peruvian Andes. Water Altern. 5 (2), 360.
The Journal of Peasant Studies, 2015. Special issue: global land grabbing and political reactions 'from below'. J. Peasant Stud. 42, 467–878.
Torres, I.V., 2012. Water grabbing in the Cauca basin: the capitalist exploitation of water and dispossession of afro-descendant communities. Water Altern.
TLM, 2016. The land matrix database. (Land Matrix 2016) Last Accessed May 2016, Available online:. http://www.landmatrix.org/en/.
U.N, 1966. International Covenant on Economic Social and Cultural Right, Article 11, United Nations General Assembly, 16 December, 1966, Resolution 2200 A XXI. U.N. United Nations Population Division 2015, New York.
Von Braun, J., Meinzen-Dick, R.S., 2009. "Land Grabbing" by Foreign Investors in Developing Countries: Risks and Opportunities. International Food Policy Research Institute, Washington, DC.
Vorosmarty, C.J., Green, P., Salisbury, J., Lammers, R.B., 2000. Global water resources: vulnerability from climate change and population growth. Science 289, 284–288.
Wagle, S., Warghade, S., Sathe, M., 2012. Exploiting policy obscurity for legalising water grabbing in the era of economic reform: the case of Maharashtra, India. Water Altern. 5 (2), 412.
Water Alternatives, 2012. Special Issue on "Water grabbing? Focus on the (re) appropriation offinite water resources. Water Altern. 5 (2), 193–468.
Wolf, A.T., 2007. Shared waters: conflict and cooperation. Annu. Rev. Environ. Resour. 32 (1), 241–269.
Woodhouse, P., 2012. Foreign agricultural land acquisition and the visibility of water resource impacts in Sub-Saharan Africa. Water Altern. 5 (2), 208.