Geografares
ISSN: 2175-3709
ISSN-L: 1518-2002
claudio.zanotelli@ufes.br
Universidade Federal do Espírito Santo
Brasil

Isasa, Ismael Díaz; Cardoso, Eduardo Schiavone
Agrihydrobusiness in Uruguay: land grabbing, agrarian intensification, and water appropriation
Geografares, vol. 5, no. 41, e-47640, 2025, July-December
Universidade Federal do Espírito Santo
Vitória- Espírito Santo, Brasil

DOI: https://doi.org/10.47456/geo.v5i41.47640

GEOGRAFARES Volume 5, Issue 41
January-June, 2025
e-ISSN: 2175-3709 • https://doi.org/10.47456/geo.v5i41.47640

Agrihydrobusiness in Uruguay: land grabbing, agrarian intensification, and water appropriation

Ismael Díaz Isasa
Universidad de la República
Montevideo, Uruguay
idiaz@fcien.edu.uy

Eduardo Schiavone Cardoso
Universidade Federal de Santa Maria
Santa Maria, Rio Grande do Sul, Brasil
educard2016@gmail.com

ABSTRACT

Water grabbing is a global issue, and the unequal appropriation of water is an emerging topic in Uruguay. This paper analyzes the pathways of water appropriation in rural territories of Uruguay and discusses the existence of water grabbing processes by examining agrarian intensification, land grabbing, and the construction of reservoirs for irrigation. A review of background studies and the processing of official data was conducted to characterize agrarian transformations. In addition, remote sensing techniques were used to georeference reservoirs, and geographic information systems were employed to analyze spatial relationships with agrarian variables. The results show an increase in the appropriation of green and blue water, along with an increase in gray water and international flows of virtual water. These increments, together with recent modifications in irrigation regulations, constitute the prelude to water grabbing in Uruguay.

KEYWORDS: agribusiness; water footprint; irrigation.

INTRODUCTION

Agrarian intensification relies on the intensification of production factors: capital, labor, and natural resources. Over the past decades, water use has markedly increased, as has competition over water between agricultural, industrial, energy, and residential sectors. Various socio-environmental conflicts have arisen due to the high water consumption of certain sectors of the economy, imbalances between supply and demand, pollution and the socialization of externalities, unequal access to resources by different actors and sectors, and the privatization of water. The control of water and its underlying power relations have become critically important, leading to the emergence of the concept of *water grabbing,* which Kay and Franco (2014) define as:

> situations where powerful actors are able to take control of or reallocate to their own benefit water resources at the expense of previous (un)registered local users or the ecosystems on which those users' livelihoods are based. It involves the capturing of the decision-making power around water, including the power to decide how and for what purposes water resources are used now and in the future. Thinking of water grabbing as a form of control grabbing means going beyond the narrow, proceduralist definition of 'grabbing' as 'illegal appropriation' since the means by which new powerful actors gain and maintain access to and benefit from water resources often involve legal but illegitimate dynamics (KAY; FRANCO, 2014).

This problem—linked to the control and unequal appropriation of resources—has historically been present in regions facing structural challenges of water access, but it is progressively gaining importance in humid and temperate regions. Since the late twentieth century, the temperate region of South America has undergone major transformations in its agrarian productive matrix, particularly the replacement of natural environments (grasslands, forests, and wetlands) with agroecosystems (PENGUE, 2015). These transformations have been driven by national investments but also by the arrival of significant regional and international capital. Agriculture and farmland have become a clear target for international capital adjustment strategies, a trend that gained even more importance with the influx of financial capital after 2007 (FAIRBAIRN, 2014). The main modality of capital entering agrarian territories has been agribusiness. This refers both to the agents themselves and to an accumulation logic characterized by the predominance of transnational capital, the promotion and consolidation of capital concentration, and reliance on intensive application of technology and innovation (GRAS; SOSA, 2013). The actions of agribusiness rest on (and reinforce) agrarian intensification processes operating horizontally—through territorial expansion (territorialization)—and vertically, through the increase of capital and labor applied to previously territorialized productive areas (new territoriality). The close connection between agribusiness territorialization and the control of land and water resources led Mendonça and Mesquita (2007) to coin the concept of agrihydrobusiness, which has since been adopted in numerous studies (THOMAZ JUNIOR, 2008, 2010, 2014; NEVES; MENDONÇA, 2020).

Evidence of water grabbing processes has been documented in several regions worldwide (RULLI; D'ODORICO, 2013; RULLI; SAVIORI; D'ODORICO, 2013; CHIARELLI et al., 2022; RAIMONDI; SCOPPOLA, 2022; D'ODORICO; DELL'ANGELO; CRISTINA RULLI, 2024). Building on Hoekstra and Mekonnen's work (HOEKSTRA; MEKONNEN, 2012) on water footprint assessment, Rulli et al. (2013) proposed that water grabbing can materialize not only through control of surface and subsurface water used for irrigation (blue water), but also through increased consumption of rainwater (green water). Moreover, water grabbing is often linked to agrarian intensification processes that lead to higher pollutant inputs into aquatic systems, thus requiring greater water volumes to assimilate pollutant loads (grey water).

The recent study by D'Odorico et al. (2024) on the pathways of water appropriation is highly useful for identifying and understanding appropriation and water grabbing processes in areas where control of water resources is concentrated in the hands of powerful territorial actors, but also in regions where such processes are less evident and/or still in early stages. This may well be the case of Uruguay, where recent territorial transformations (GAZZANO; ACHKAR; DÍAZ, 2019; OYHANTÇABAL; NARBONDO, 2019; DÍAZ, 2023), along with changes in water policies, could signal the onset of water grabbing processes (SANTOS; GONZÁLEZ MARQUEZ, 2021).

Uruguay is an agro-based country with a humid/temperate climate, characterized by the predominance of large-scale operations oriented toward extensive cattle ranching (ACHKAR et al., 2016). The dominant livestock matrix has been joined by rice production since the mid-twentieth century, by forestry agribusiness in the 1990s, and by agricultural agribusiness in the early twenty-first century, which together currently occupy more than 2.6 million hectares (ha) (DÍAZ, 2023; DIEA, 2024). These land use changes have been linked to land concentration and grabbing (PIÑEIRO, 2012; OYHANTÇABAL; NARBONDO, 2019; DÍAZ; SUM; ACHKAR, 2023; DÍAZ; SUM, 2024), to growing water consumption, and to the socialization of negative externalities. Irrigation has historically been marginal in terms of area, yet crucial for sectors such as rice, sugarcane, and horticulture. Santos and González Márquez (2021) identify three fields within Uruguay's irrigation frontier, which can be delineated chronologically, by production type, and by social and technological relations: horticultural irrigation, integral irrigation in rice and sugarcane, and irrigation in agriculture, pastures, and forage. The most significant cases are rice and industrial agriculture, pastures, and forage, where large-scale infrastructure projects linked to major producers predominate.

The Uruguayan state has undertaken various initiatives to foster irrigation infrastructure. These include the development of irrigation for the rice sector, the Natural Resource Management and Irrigation Development Program (PRENADER), and, in recent years, the modification of legislation to promote irrigated agriculture based on World Bank recommendations (KENNEDY; KRAY; TRIER, 2015). This latter impulse, which could provide the ideological foundation for enabling water grabbing processes, has faced strong criticism from civil society and academia on constitutional, strategic, and environmental grounds (SANTOS; GONZÁLEZ MARQUEZ, 2021).

In Uruguay, studies on the relationship between agribusiness expansion and rising water consumption, as well as on the magnitude of water-use concentration for agricultural purposes and its potential impacts, remain incipient. This paper seeks to contribute to the debate by analyzing the most significant land use changes and one of the main strategies for water access and subsequent use: reservoirs[1]. The primary objective of this paper is to analyze the main pathways of water appropriation in Uruguay's rural territories between 1996 and 2024, and to provide insights into the existence of water grabbing processes. Meeting this objective involves analyzing the major land use transformations, characterizing the spatio-temporal evolution of water reservoirs, and examining their relationship with the distribution of agricultural land, livestock density, and agrarian structures in Uruguay.

METHODOLOGY

The research strategy was based on analyzing the pathways of water appropriation in the Uruguayan case. In their global study, D'Odorico et al.

1 Reservoirs are defined as "natural or artificial sites used for the storage, regulation, and/or control of water resources." Surface storage works that are filled through runoff interception in watercourses may be classified as either "dams" or "ponds". According to Decree No. 123/999, dams are distinguished by greater height and/or larger catchment areas. Reservoirs are basic technologies for livestock development (watering trough) as well as for the irrigation of crops, forage, and pastures.

(2024) proposed nine pathways through which water grabbing consolidates: i) appropriation through land acquisition, ii) appropriation via the construction or acquisition of infrastructure, iii) appropriation through pollution, iv) appropriation via the expansion of crops with higher water demand, v) appropriation through the expansion of forestry plantations, vi) appropriation by introducing more efficient irrigation systems, vii) appropriation of virtual water through trade, viii) land–atmosphere interactions, and ix) appropriation via control and provision of energy. To these nine pathways identified by D'Odorico et al. (2024), this study adds appropriation of green water, given that unequal appropriation of green water limits the availability of blue water. Beyond redefining them, the nine pathways were regrouped into four categories: a) appropriation of green water through land use intensification, b) appropriation of green water through land grabbing, c) appropriation of blue water through irrigation reservoirs, and d) other forms of appropriation. This paper focuses on groups "a," "b", and "c". Nonetheless, given the numerous interrelations among the nine pathways—since they occur simultaneously, are both cause and consequence, and are often promoted by the same territorial actors—this paper also provides preliminary discussion elements concerning other forms of appropriation.

Appropiation of green water

This group includes modalities of appropriating rainwater: appropriation through land grabbing, appropriation through the intensification of agriculture, livestock, and forestry. To characterize land grabbing processes in Uruguay, national background studies and official data sources, including agricultural censuses and statistical yearbooks, were used. Land use change analyses drew on official statistical information available from the Agricultural Statistics Office (DIEA, 2024) and the National Environmental Observatory (OAN)[2]. To analyze livestock intensification, livestock stocking rate data from the Ministry of Livestock, Agriculture, and Fisheries (MGAP, 2024) were employed. Additional information was obtained from statistical yearbooks produced by DIEA. This data was complemented with georeferenced land use and land cover information published in Díaz (2023), Bianco et al. (2021), and

2 The Environmental Information Platform (OAN), managed by DINACEA–Ministry of Environment, provides open-access data. From this platform, land-use classifications for the entire country were obtained for the years 2000, 2008, 2011, 2015, and 2022, generated using the LUC–FAO classification system.

Achkar et al. (2016). Finally, various national studies were consulted to document the main transformations of the agrarian productive matrix. To assess the implications of land use changes on water use, secondary international and national sources were used to carry out an ordinal analysis of the impact of each crop on evapotranspiration and water runoff (ALLEN et al., 1998; SILVEIRA; ALONSO, 2009; SAWCHIK, 2012).

Appropriation of blue water

Harvesting rainwater through reservoirs (ponds and dams) is often a necessary productive strategy for the development of different agricultural activities across a wide range of geographic and productive conditions. This technology helps buffer the impacts of climate variability, enabling crop development and yield increases (ROCKSTRÖM; FALKENMARK, 2015; NIBORSKI et al., 2022).

To understand the evolution of water reservoirs and their relationship with agrarian variables, a spatio-temporal and quantitative approach was implemented. The analysis covered the period 1996–2024, divided into five sub-periods based on the main transformations and shifts in Uruguayan agrarian dynamics (ACHKAR et al., 2011; FIGUEREDO; GUIBERT; ARBELETCHE, 2019; ARBELETCHE, 2020; BIANCO et al., 2021; DÍAZ; SUM; ACHKAR, 2023): Period I (1996–2001): stagnation of the agricultural sector and forestry expansion. Period II (2002–2008): expansion of summer agriculture (mainly soybean) and recovery of livestock after the socio-economic and productive crisis. Period III (2009–2014): consolidation and peak growth of summer agriculture with expansion into traditionally non-agricultural areas. Period IV (2015–2019): contraction of agricultural area. Period V (2020–2024): rebound of summer agriculture. Forestry expanded consistently across all periods.

Reservoir identification and georeferencing were conducted using remote sensing techniques. Satellite imagery came from LANDSAT-5TM, LANDSAT-7TM, and LANDSAT-8OLI collections available through the Google Earth Engine platform (GORELICK et al., 2017) for the entire national territory and for each year between 1996 and 2024. The NDWI spectral index was applied (MCFEETERS, 1996; XU, 2006). To minimize classification errors caused by rainfall variability and soil moisture, four classifications per year were performed (one per season), and reservoir boundaries for each year were determined using the mean value of the areas identified as reservoirs that year. The adopted spatio-temporal resolution allowed the identification of reservoirs equal to or larger than 0.4 ha.

To evaluate the spatial distribution of reservoirs across the territory, their relationship with agrarian activities and soil properties was analyzed. The study began with a descriptive analysis of reservoir location and its link with agrarian structures (FERNÁNDEZ-NION, 2021)[3] defined at the census-area scale[4]. Subsequently, also at the census-area scale, Spearman's rank correlation (rS) was used to examine: (i) the relationship between reservoir area and agricultural land (OAN)[5] and livestock density (MGAP, 2024), and (ii) the spatio-temporal evolution of reservoir surface area. Finally, with higher spatial resolution, the analysis examined the evolution of the CONEAT productivity index[6] (IC; MGAP, 1994), the net potentially available soil water (APDN) index (MOLFINO, 2009), and suitability for rainfed agriculture (MGAP, 2014) at the specific location of reservoirs. Spatial data processing was conducted within a Geographic Information System (GIS) environment

RESULTS AND DISCUSSION

From agribusiness to agrihydrobusiness

Since the late twentieth century, rural territories in Uruguay have undergone transformations that are visibly expressed in land use changes but also in shifts in agrarian structures—particularly in land tenure, farm size, and modes of environmental resource use and management (PIÑEIRO, 2014; FERNÁNDEZ-NION; SUM; DÍAZ, 2022; DÍAZ, 2023). Among the main changes, the expansion and consolidation of non-traditional sectors (forestry and soybean) stand out, along with the intensification of historical sectors (such as livestock ranching) and long-established ones (such as dairy and rice) (ACHKAR et al., 2016). Additionally, recent years have seen a

3 Agrarian structure is defined as the set of relatively stable characteristics that condition production forms, reproduction strategies, and value-generation objectives. The study by Fernández Nion (41), based on census data from 2000 and 2011 (the most recent agricultural census in Uruguay), included: land tenure and ownership regimes, main productive activities, production forms (techniques, technologies, infrastructure, etc.), and rural population and workforce.

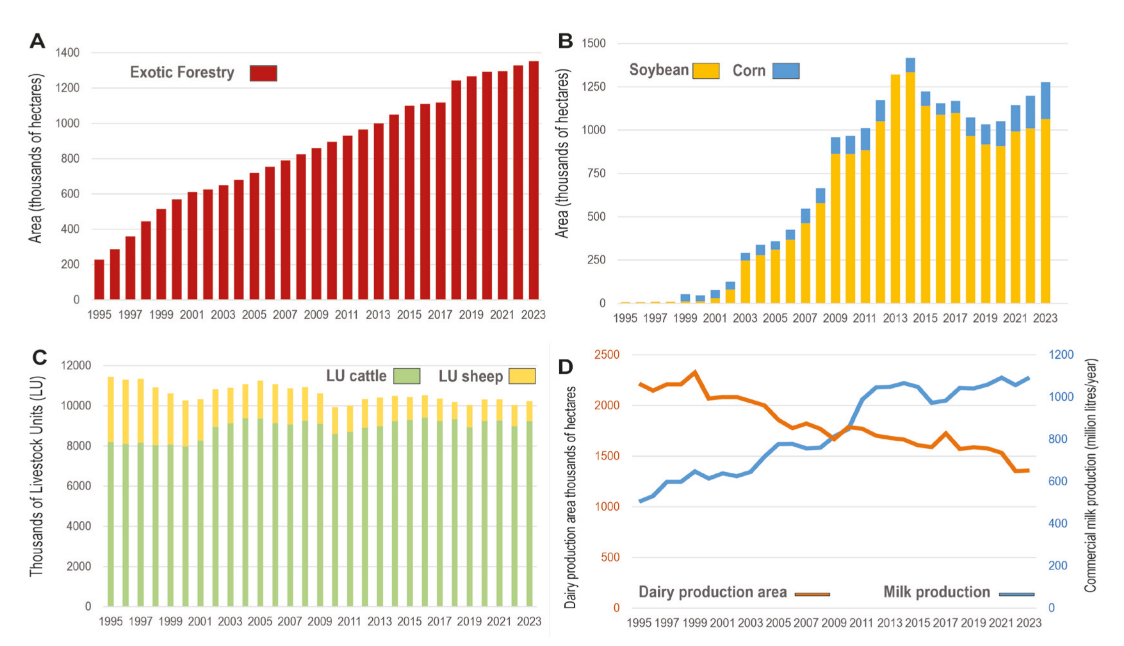
4 Uruguay is divided into 637 census units, each averaging 27,000 hectares in size.

5 Land-use classifications for the years 2000, 2008, 2011, 2015, and 2022 were produced following the LUC–FAO system.

6 The IC was developed by the Ministry of Livestock, Agriculture, and Fisheries in the 1960s and later refined. The IC provides a relative measure of average productive capacity for beef and wool production. A typical soil in the country is assigned IC=100. A soil with IC=200 has double the productive capacity of an average soil, while a soil with IC=50 has only half the productive capacity of the national average. The IC is available nationwide at a 1:20,000 scale.

significant increase in maize cultivation, surpassing 210,000 hectares in the 2023/24 harvest (DIEA, 2024).

Figure 1 – Evolution of the main agricultural land uses in Uruguay, 1995–2023



Source: DÍAZ (2023), DIEA (2024) and MGAP (2024). Prepared by the authors.

Exotic forestry has grown steadily from less than 0.1 million hectares in 1985 to more than 1.3 million hectares by 2024 (Figure 1A). This growth was largely driven by a powerful policy framework promoting the sector, most notably the Forestry Law No. 15.939 of 1987 and the 1994 regulatory decree, which granted major economic and fiscal benefits to investors. Forestry in Uruguay has consolidated in four main regions, primarily occupying soils classified as forestry priority under Decree No. 452/988 of 1988 and its subsequent modifications. Agricultural expansion has been mainly explained by summer cropping, particularly soybean cultivation. With explosive growth from the early 2000s, summer agriculture expanded from 0.14 million hectares in 2002 to 1.4 million hectares in 2014, followed by contraction and later renewed growth, reaching 1.3 million hectares in 2024 (Figure 1B). Summer agriculture is closely associated with the distribution of the country's main agricultural soils, concentrated in the western and southwestern littoral regions. The growth of these non-traditional sectors has been accompanied by a reduction in land devoted to livestock and production (DÍAZ, 2023). Despite this reduction in surface area, livestock stocking rates remained relatively stable during the twenty-first century, and commercial milk production showed continuous growth (Figures 1C and 1D).

Rice cultivation—the country's main irrigated crop—grew strongly in the twentieth century, but has remained relatively stable in surface area and location in the twenty-first century. In summary, the evolution of Uruguay's main agricultural sectors reveals clear processes of agrarian intensification (GAZZANO; ACHKAR; DÍAZ, 2019; DÍAZ, 2023; DIEA, 2024).

Based on international studies and national assessments, a clear trend emerges toward greater consumption of green water (and potentially blue water) and reduced runoff in Uruguay. These changes are largely explained by the replacement of natural grasslands with forestry, industrial agriculture (often double-cropping)[7], and artificial pastures. This growing green water consumption affects watershed hydrological performance, altering surface and subsurface drainage, reducing potential surface water availability for producers, limiting water storage capacity through reservoirs, restricting aquifer recharge, and constraining the use of groundwater. Moreover, considering the heavy reliance on agrochemicals in Uruguay's agricultural production (FERNÁNDEZ NION; DÍAZ, 2024), an increase in grey water is also expected. This trend—well documented in regional studies linking productive land uses and water quality (ALONSO et al., 2019; DÍAZ et al., 2021; GOYENOLA et al., 2021; MAZZEO et al., 2024)—has yet to be quantified specifically for Uruguay.

Parallel to these land use changes, there has been a notable increase in the presence of agribusiness in Uruguay (ACHKAR; DOMÍNGUEZ; PESCE, 2008; ARBELETCHE, 2020; DÍAZ; SUM; ACHKAR, 2023). As both a logic and an agent, agribusiness has played a key role in reshaping Uruguay's agrarian landscape while creating efficient territories for its territorialization and for generating territorialities that ensure permanence (FERNÁNDEZ-NION; SUM; DÍAZ, 2022; DÍAZ; SUM, 2024). This logic is closely tied to large-scale land acquisitions, concentration of land and wealth, and land foreignization (PIÑEIRO, 2014; OYHANTÇABAL; NARBONDO, 2019). Furthermore, the arrival of regional and transnational corporations—mostly as joint-stock companies—has been significant, with a strong presence of investment funds and even indirect state investment (DÍAZ; ACHKAR; SUM, 2023; DÍAZ; SUM, 2024). The main features of transformations driven and/or deepened by agribusiness can be summarized as follows:

7 Crop rotations that include a winter crop (mainly wheat or rapeseed) and a summer crop (primarily soybean or maize).

Intensified concentration and foreignization of land, along with landowner and investor anonymity. Land acquisitions directly imply the appropriation of green water (RULLI; D'ODORICO, 2013), while also enabling control over rivers, lakes, and groundwater resources, thereby affecting other agricultural uses, productive activities, and human consumption (D'ODORICO; DELL'ANGELO; CRISTINA RULLI, 2024). Land concentration has been a historic process in Uruguay, but with new characteristics since the late twentieth century. Between 2000 and 2011, 21.6% of productive units disappeared—49% of them under 10 ha and 91% under 100 ha. Since the late twentieth century, dozens of corporations, mostly foreign, entered Uruguay, with a strong presence of investment funds and indirect state-backed capital (DÍAZ; SUM, 2024).

Agrarian intensification. Intensification is a central pillar of agribusiness, first expanding the agricultural and forestry frontier and then deepening productive intensification. This has multiple consequences: shifts in water use, soil degradation, and changes in runoff/infiltration dynamics that shape water availability. Agribusiness, through crops with high water demand, increases blue water scarcity (CHIARELLI et al., 2022) and exerts pressure on ecosystems, undermining their sustainability. In Uruguay, agribusiness is primarily oriented toward forestry (>1.3 M ha) and industrial agriculture (>1.2 M ha), in addition to water-intensive rice production (~150,000 ha) (DIEA, 2024). Moreover, industrial agriculture and exotic forestry have indirectly driven intensification in livestock and dairy.

Environmental degradation. The expansion of monoculture forestry and industrial agriculture is among the main drivers of ecosystem loss and degradation (PENGUE, 2015). In Uruguay, this has led to drastic replacement and alteration of natural ecosystems, especially grasslands (GAZZANO; ACHKAR; DÍAZ, 2019; DÍAZ, 2023). These processes disrupt the hydrological cycle by modifying runoff and percolation patterns. Furthermore, forestry and agricultural intensification have significantly impacted water quality (AUBRIOT et al., 2017; ALONSO et al., 2019; DÍAZ et al., 2021). The main outcome is reduced blue water availability and increased grey water.

Commodity production for export markets. The water footprint of agricultural commodities includes both the water embedded in the product and that used in production, transport, and commercialization. Water not physically present in the product is referred to as "virtual water" (ALLAN, 1998). Pengue (PENGUE, 2006) argues that global agricultural trade can be seen as a massive transfer of water toward regions where water is scarce, costly, and/or competing with higher-priority uses. Considering that a significant share of Uruguay's commodities are destined for international markets (90% of rice, 92% of soybean, and over 70% of livestock and forestry products), international markets effectively appropriate large volumes of Uruguay's water.

Regulatory adjustments to facilitate agribusiness entry and expansion. Since the late twentieth century, Uruguay has promoted sweeping institutional reforms based on neoliberal policies aimed at attracting foreign direct investment in agriculture (FIGUEREDO; GUIBERT; ARBELETCHE, 2019). These policies underpinned the expansion of forestry and industrial agriculture, consolidation of agrarian intensification, and land grabbing. With regard to water governance, privatization initiatives have generally been dismantled due to unconstitutionality (Article 47 of the Constitution). Nevertheless, since 2017 Uruguay has witnessed new privatization initiatives in agriculture through the approval of the Irrigation Law, which allows private agents and financial capital to operate and commercialize water for irrigation. In this way, the state continues to promote regulatory changes that strengthen agribusiness' negotiating power and its ability to pressure the government for further legal adjustments that consolidate its territorialization and territorialities (e.g., exceptions allowing joint-stock companies to own/manage land, expanded authorization for pesticide use, reclassification of forestry-priority soils, flexible environmental assessments for forestry projects, and tax exemptions).

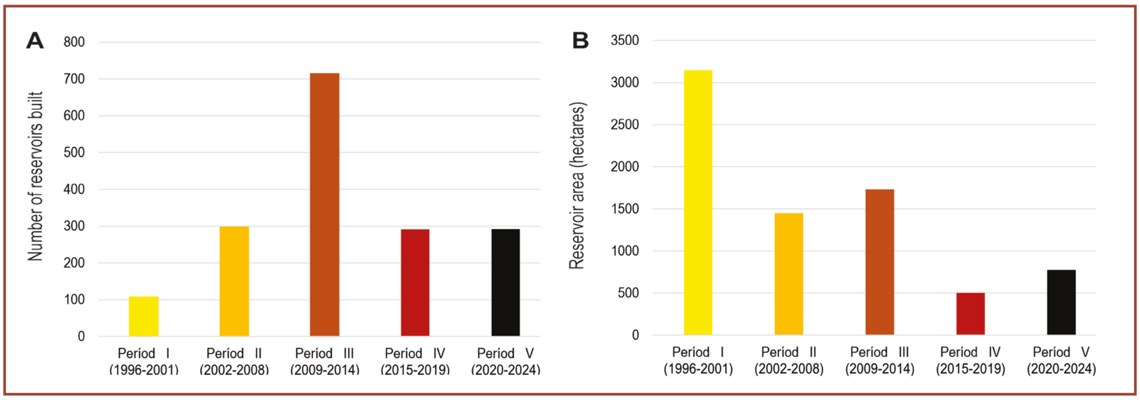
In short, Uruguay has undergone a significant shift in its agrarian matrix toward land uses that demand more water, alongside increased consumption from existing uses and higher input use leading to greater contaminant export from agricultural lands. Concurrently, there is a trend of land concentration and land grabbing. These processes—new in the twenty-first century and building on those consolidated in the twentieth—are closely tied to agribusiness operations and are driving greater water appropriation. When considering the territorial actors behind agribusiness, and the orientation of production toward export markets, it becomes evident that Uruguay is also experiencing a marked rise in international flows of virtual water.

Evolution and spatial distribution of water reservoirs

Despite irrigation growth over the past five decades, irrigated area in Uruguay remains marginal, reaching only about 2% of the country's total agricultural surface (CERES, 2023). Between 1970 and 2000, irrigation expansion was primarily explained by the rice sector, which accounted for 80% of the irrigated area and 90% of the total irrigated water (FAILDE et al., 2013). After 2000, irrigation dynamics became increasingly associated with the expansion of extensive grain agriculture (mainly soybean and maize), forage, and pastures (FAILDE et al., 2013). Current irrigated area continues to be explained mainly by rice (147,000 ha – 100% of the sector), sugarcane (7,100 ha – 100% of the sector), horticultural and fruit crops (13,500 ha – 30% of the sector), while irrigation remains marginal for other cereals and oilseeds (39,000 ha – 3.4% of the sector) (CERES, 2023). According to Failde et al. (2013), in many Uruguayan watersheds by 2010 the maximum allowable water withdrawals for direct surface intake had already been reached, leading to the conclusion that further irrigation growth would need to be based on reservoir construction.

Between 1996 and 2024, there has been a sharp increase in both the number of reservoirs (Figure 2A) and the total area under reservoirs in Uruguay (Figure 2B). Over this period, the total number of reservoirs rose by 500%, while reservoir surface area increased by 80%. Temporally, the largest increase in number occurred between 2009 and 2014, coinciding with high commodity prices and the expansion of agriculture into traditionally non-agricultural regions. In terms of surface area, the greatest increase occurred before 2000, followed by the 2009–2014 period. Although there was a small increase in average reservoir size during peak commodity prices, the overall trend points clearly toward the construction of smaller reservoirs.

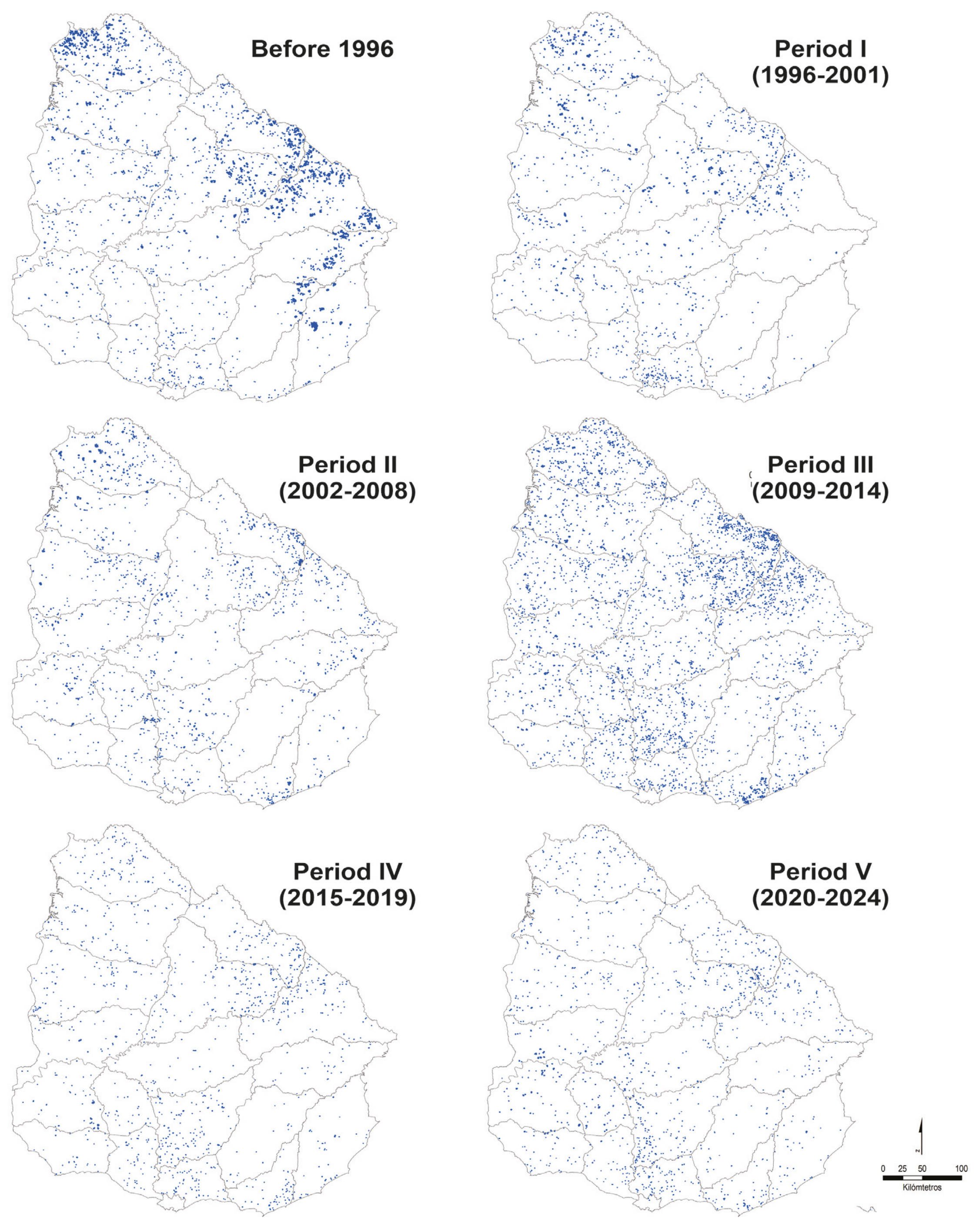
Figure 2 – Evolution of the number of reservoirs (A) and reservoir surface area (B) by period



Source: LANDSAT-5TM, LANDSAT-7TM, and LANDSAT-8OLI satellite images. Prepared by the authors.

Spatially, the greatest growth in both number and area of reservoirs occurred in the northern region of the country, reinforcing a pre-existing pattern of concentration in that area (Figure 3). However, relative to 1996, the largest increases took place in the southern and littoral regions, highlighting two distinct patterns: the continued predominance of reservoirs in the north, and more intense water-use intensification processes in the south and littoral compared to the north.

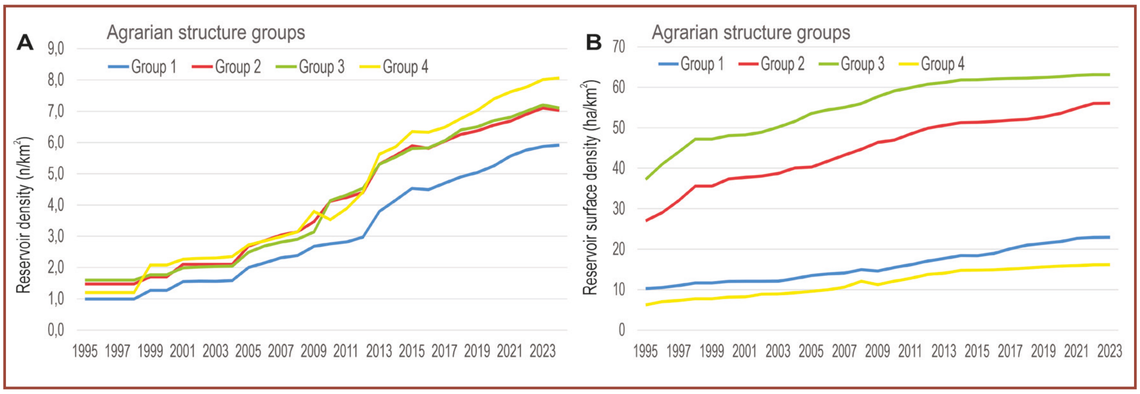
Figure 3 – Spatial distribution of reservoirs built by period



Source: LANDSAT-5TM, LANDSAT-7TM, and LANDSAT-8OLI satellite images. Prepared by the authors.

Fernández Nion (2021) classifies Uruguay into four major agrarian structure groups: Group 1: small- and medium-sized production units, with medium to high intensity; Group 2: medium-to-large production units, with high intensity; Group 3: large-scale units with low intensity; Group 4: large-scale units with high to very high intensity. The regions with large landholding, extensive agrarian structures, dominated by large cattle-ranching establishments (Group 3), recorded between 1996 and 2024 the greatest increase in both number of reservoirs (Δ=5,270) and surface area (Δ=24,652 ha). These were followed by areas of large estates oriented toward livestock and industrial agriculture, characterized by high agrarian intensity and predominance of capitalist enterprises (Group 4; Δ=2,607, Δ=13,628 ha, respectively). On the other hand, reservoir density—measured as number of reservoirs per km^2 (Figure 4)—increased most in large, intensive estates (Group 4; Δ=6.9/km^2), followed by medium-sized, high-intensity farms (Group 2; Δ=5.5/km^2), and finally by extensive low-intensity estates (Group 3) and small-scale farms (Group 1). These results indicate the consolidation of the pattern of greater reservoir surface in extensive cattle-ranching areas, while also revealing a trend of increasing reservoir construction in intensive agricultural zones.

Figure 4 – Evolution of reservoir density (A) and reservoir surface area (B) by agrarian structure group



Source: LANDSAT-5TM, LANDSAT-7TM, LANDSAT-8OLI satellite images, and Fernández Nion (2021). Prepared by the authors.

The spatio-temporal evolution of reservoirs shows a clear pattern of new construction in areas with higher agricultural and livestock productivity potential. In 1996, reservoirs were mainly located on soils with medium productivity (IC=84). In subsequent periods, new reservoirs were built on soils with average productivity levels ranging from IC=95 to IC=105 (a 13–25% increase). No major differences were recorded in the levels of net APDN in areas where new reservoirs were built across periods; mean APDN was

112 mm, and the difference between 1996 and 2024 was under 5%. Finally, there is a trend toward greater construction of reservoirs on land with higher suitability for summer agriculture: in 1996, 24% of reservoir area was located in zones classified as highly or very highly suitable, whereas by 2024 this figure had risen to 28%.

At the census-area scale, a positive association (p<0.001), measured using Spearman's rank correlation coefficient (rS), was found between reservoir surface area (SE) and areas with higher livestock stocking rates (CG) (Table 1). A similar, though weaker, association was found with agricultural land area (SA). In both cases, the positive association strengthened over time, being stronger with livestock stocking rates but growing faster with agriculture.

Table 1 – Statistical relationships between reservoir area and agricultural area (RA–AA), and between reservoir area and livestock stocking rate (RA–LS), by period

	1996-2001	2002-2008	2009-2014	2015-2020	2021-2024
RA - AA	NS	0.26*	0.38*	0.43*	0.48*
RA - LS	0.51*	0.56*	0.62*	0.63*	0.66*

Source: MGAP (2024) and OAN. Prepared by the authors. *Significant at 0.001. NS = not significant.

Reservoir construction partially maintained its spatial pattern over time, since correlations between the number of new reservoirs at census-area scale between one period and the previous one were always positive and significant. In the first two periods (1996–2000 and 2001–2008), reservoirs were built more often in zones with fewer pre-existing reservoirs (rS=0.12) than in later periods. Between 2008 and 2014, during strong agricultural expansion, reservoir construction increased mainly in zones with high reservoir presence (rS=0.72). In periods of agricultural contraction (2015–2019) and the subsequent rebound (2020–2024), this tendency decreased slightly (rS=0.66 and rS=0.54, respectively). Thus, a clear trend emerges: reservoir construction has generally expanded in traditionally livestock-dominated regions, but during agricultural downturns, construction in agricultural areas has gained importance.

The findings of this study align with Chiarelli et al. (15), who argue that investors target land with privileged access to surface and groundwater resources. Such appropriation of land and water for agricultural and forestry expansion represents the strengthening of the economic and political power of capitalist actors, particularly agribusiness (BUENO; CALAÇA, 2024). The results show that agribusiness expands in Uruguay by targeting the best-quality land (DÍAZ; SUM, 2024), while at the same time increasing control over water resources, territorial control, economic power, and, consequently, political power.

At the same time, water appropriation pathways are mutually reinforcing. Agribusiness has been an active territorial agent in land grabbing, while also promoting—and being fueled by—agrarian intensification. Industrial agriculture now relies on irrigation as the main mechanism to increase productivity and reduce risks, which in turn requires expanding water reservoirs. Irrigation expansion also enables agricultural land expansion, likely driven by agribusiness, thereby generating new processes of land concentration and land grabbing. These dynamics lead to higher levels of water appropriation, compounded by growing virtual water exports due to the focus of agribusiness on commodity production for international markets, and by increased grey water from pollution linked to high agrochemical use on agricultural lands.

The trend of water appropriation by agribusiness—further supported by irrigation legislation in Uruguay—creates a scenario that calls for critical reflection on water grabbing processes. As Moore (2019) argues, these processes constitute a form of accumulation by dispossession, where water ceases to be a public good and becomes a commodity, with benefits concentrated in the private sector while transferring the risks of private investment to the public. Finally, considering the arguments put forward by Franco et al. (2013):

> Drawing insight from the discussion on land grabbing, we understand water grabbing as the capturing of control not just of the water itself, but also of the power to decide how this will be used—by whom, when, for how long and for what purposes—in order to control the ben- efits of use (FRANCO; MEHTA; VELDWISCH, 2013).

It becomes clear that Uruguay is entering a new stage, marked by the growing role of capital—particularly financial capital—in water resource management and, consequently, in water grabbing.

FINAL REMARKS

This study contributes to the ongoing debate on the pathways through which agribusiness appropriates water in Uruguay. The main pathways identified include land grabbing, agricultural and forestry expansion and intensification, and the construction of reservoirs to sustain agrarian intensification processes. Additional pathways involve grey water appropriation and international flows of virtual water—both closely tied to agribusiness operations in the Global South.

The feedback loops among these different pathways of water appropriation mean that the current pattern of unequal resource use and growing water demand is likely to deepen. These dynamics can be seen as the early signs—or the onset—of water grabbing processes, which will become fully consolidated if privatization projects under the current irrigation law advance. In this scenario, the territorial control and the economic and political power already concentrated in the hands of agribusiness would be further reinforced through control of water resources and their commercialization.

The results of this study support the hypothesis that, in the Uruguayan case, agribusiness is evolving into agrihydrobusiness. Furthermore, they show that water grabbing processes by agrihydrobusiness are becoming evident not only through familiar patterns but also through new mechanisms that add complexity to existing power relations.

In light of the imminent expansion of irrigation to support agrarian intensification in Uruguay, it is crucial to generate alternatives that prevent the consolidation of water grabbing processes. ●

BIBLIOGRAPHICAL REFERENCES

ACHKAR, M. et al. La intensificación del uso agrícola del suelo en el litoral oeste del Uruguay en la última década. **Pampa:** Revista Interuniversitaria de Estudios Territoriales, n. 7, p. 143–157, 2011. https://doi.org/10.14409/pampa.v1i7_sup.3207.

ACHKAR, M. et al. **Uruguay, naturaleza, sociedad y economía.** 1era. ed. Montevideo: Banda Oriental, 2016.

ACHKAR, M.; DOMÍNGUEZ, A.; PESCE, F. **Agronegocios Ltda.** Nuevas modalidades de colonialismo en el Cono Sur de América Latina. Montevideo: REDES AT, 2008. Disponível em: https://www.redes.org.uy/wp-content/uploads/2008/03/agro_ltda.pdf/. Acesso em: 20 nov. 2024.

ALLAN, J. A. Virtual Water: A Strategic Resource Global Solutions to Regional Deficits. **Groundwater,** v. 36, n. 4, p. 545–546, 1998. https://doi.org/10.1111/j.1745-6584.1998.tb02825.x.

ALLEN, R. et al. **Crop Evapotranspiration:** Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper. Roma: FAO, 1998. Disponível em: https://www.fao.org/4/x0490e/x0490e00.htm/. Acesso em: 20 nov. 2024.

ALONSO, J. et al. Water Quality in Uruguay: Current status and challenges. In: **Water Quality in the Americas.** Risks and Opportunities. Mexico: IANAS, 2019. p. 561–597.

ARBELETCHE, P. El agronegocio en Uruguay: su evolución y estrategias cambiantes en el siglo XXI. RIVAR, v.7, n.19, p.109–129, 2020. https://doi.org/10.35588/rivar.v7i19.4355.

AUBRIOT, L. et al. Evolución de la eutrofización en el Río Santa Lucía: influencia de la intensificación productiva y perspectivas. **Innotec,** v. 14, p.7-16, 2017. https://doi.org/10.26461/14.04.

BIANCO, M. et al. Dinámicas de la expansión agrícola en territorios uruguayos. **Revista Latinoamericana de Estudios Rurales,** v. 6, n. 12, p. 1–35, 2021. Disponível em: https://ojs.ceil-conicet.gov.ar/index.php/revistaalasru/article/view/791/. Acesso em: 20 nov. 2024.

BUENO, F.; CALAÇA, M. O represamento enquanto estratégia de apropriação territorial e controle hídrico. **Ateliê Geográfico,** v. 18, n. 2, p. 223–249, 2024. https://doi.org/10.5216/ag.v18i2.77670.

CERES. Riego y Productividad. **Potenciales beneficios de la expansión del riego en Uruguay.** Montevideo: CERES, 2023. Disponível em: https://ceres.uy/index.php/estudios/ficha_estudio/50/. Acesso em: 20 nov. 2024.

CHIARELLI, D. D. et al. Competition for water induced by transnational land acquisitions for agriculture. **Nature Communications**, v. 13, n. 1, p. 505, 2022. https://doi.org/10.1038/s41467-022-28077-2.

D'ODORICO, P.; DELL'ANGELO, J.; CRISTINA RULLI, M. Appropriation pathways of water grabbing. **World Development,** v. 181, p. 1–12, 2024. https://doi.org/10.1016/j.worlddev.2024.106650.

DELL'ANGELO, J.; RULLI, M.; D'ODORICO, P. The Global Water Grabbing Syndrome. **Ecological Economics,** v. 143, p. 276–285, 2018. https://doi.org/10.1016/j.ecolecon.2017.06.033.

DÍAZ, I. et al. Empirical Modeling of Stream Nutrients for Countries without Robust Water Quality Monitoring Systems. **Environment**, v. 8, n. 129, p. 1–19, 2021. https://doi.org/10.3390/environments8110129.

DÍAZ, I. Principales cambios en el uso del suelo agropecuario del Uruguay reciente. In: CERONI, M.; OYHANTÇABAL, G.; CARÁMBULA, M. (Ed.). **El cambio agrario en el Uruguay contemporáneo.** Montevideo: Ediciones del Berretín, 2023. p. 229–240.

DÍAZ, I.; SUM, T. Territorial Strategies of Forestry and Agricultural Corporations in Uruguay - the Southern Cone region of Latin America. **Territory, Politics, Governance,** p. 1–23, 2024. https://doi.org/10.1080/21622671.2024.2337927.

DÍAZ, I.; SUM, T.; ACHKAR, M. Territorialización de las Sociedades Anónimas (SA) en Uruguay: Acaparamiento y Extranjerización de Tierras. Iberoamericana – **Nordic Journal of Latin American and Caribbean Studies**, v. 52, n. 1, p. 88–102, 2023. https://doi.org/10.16993/iberoamericana.575.

DIEA. **Anuario Estadístico Agropecuario 2024.** Montevideo: MGAP, 2024. Disponível em: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/diea/anuario2024/. Acesso em: 20 nov. 2024.

FAILDE, A. et al. Estudio sobre riego agropecuario en Uruguay. In: **Anuario OPYPA 2013**. Montevideo: MGAP, 2013. p. 449–465. Disponível em: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/comunicacion/publicaciones/anuario-opypa-2013/. Acesso em: 20 nov. 2024.

FAIRBAIRN, M. 'Like gold with yield': evolving intersections between farmland and finance. **Journal of Peasant Studies**, v. 41, n. 5, p. 777–795, 2014. https://doi.org/10.1080/03066150.2013.873977.

FERNÁNDEZ-NION, C. **Estrutura agraria y transformaciones territoriales:** el caso de Río Negro, Uruguay (2000-2020). 2021. Universidad de la República, 2021. Disponível em: colibri.udelar.edu.uy/jspui/handle/20.500.12008/29637/. Acesso em: 20 nov. 2024.

FERNÁNDEZ-NION, C.; DÍAZ, I. Spatial distribution of pesticide use based on crop rotation data in La Plata River basin: a case study from an agricultural region of Uruguay. **Environmental Monitoring and Assessment**, v. 196, n. 7, p. 633, 2024. https://doi.org/10.1007/s10661-024-12759-z.

FERNÁNDEZ-NION, C.; SUM, T.; DÍAZ, I. Transformaciones en territorios agroexportadores y en territorios productores de alimentos. el caso de Río Negro y Canelones, Uruguay. Revista Mutirõ. **Folhetim de Geografias Agrárias do Sul**, v. 3, n. 3, p. 6–37, 2022. https://doi.org/10.51359/2675-3472.2022.254645.

FIGUEREDO, S.; GUIBERT, M.; ARBELETCHE, P. Ciclo sojero y estrategias de los actores de la producción agropecuaria en el litoral uruguayo. **EUTOPÍA**, v. 16, p. 99–118, 2019. https://doi.org/10.17141/eutopia.16.2019.4103.

FRANCO, J.; MEHTA, L.; VELDWISCH, G. J. The Global Politics of Water Grabbing. **Third World Quarterly**, v. 34, n. 9, p. 1651–1675, 2013. https://doi.org/10.1080/01436597.2013.843852.

GAZZANO, I.; ACHKAR, M.; DÍAZ, I. Agricultural Transformations in the Southern Cone of Latin America: Agricultural Intensification and Decrease of the Aboveground

Net Primary Production, Uruguay's Case. **Sustainability,** v. 11, n. 24, p. 7011, 2019. https://doi.org/10.3390/su11247011.

GORELICK, N. et al. Google Earth Engine: Planetary-scale geospatial analysis for everyone. **Remote Sensing of Environment,** v. 202, p. 18–27, 2017. https://doi.org/10.1016/j.rse.2017.06.031.

GOYENOLA, G. et al. Production, nutrients, eutrophication and cyanobacteria blooms in Uruguay: putting puzzle pieces together. **INNOTEC,** v. e558, 2021. https://doi.org/10.26461/22.02.

GRAS, C.; SOSA, A. El modelo de negocios de las principales megaempresas agropecuarias. In: HERNÁNDEZ, C. G. Y V. (Ed.). **El agro como negocio:** producción, sociedad y territorios en la globalización. Buenos Aires: Ed. Biblos, 2013. p. 215–236.

HOEKSTRA, A; MEKONNEN, M. The water footprint of humanity. **Proceedings of the National Academy of Sciences,** v. 109, n. 9, p. 3232–3237, 2012. https://doi.org/10.1073/pnas.1109936109.

KAY, S.; FRANCO, J. The Global Water Grab: A Primer. In: DABELKO, G.; CONCA, K. (Ed.). **Green Planet Blues.** Critical Perspectives on Global Environmental Politics. 6th. ed. New York: Routledge, 2014. p. 15.

KENNEDY, K.; KRAY, H.; TRIER, R. **Intensificación sostenible de la agricultura:** aumento del acceso a soluciones inteligentes desde el punto de vista del clima. Uruguay: desafíos y oportunidades 2015-2020. Buenos Aires: Banco Mundial, 2015.

MAZZEO, N. et al. Inter and transdisciplinarity strategies for evaluating and improving water quality monitoring systems: Uruguay as a study case. **Environmental Science & Policy,** v. 154, p. 103699, 2024. https://doi.org/10.1016/j.envsci.2024.103699.

MCFEETERS, S. K. The use of the Normalized Difference Water Index (NDWI) in the delineation of open water features. **International Journal of Remote Sensing,** v. 17, n. 7, p. 1425–1432, 1996. https://doi.org/10.1080/01431169608948714.

MENDONÇA, M.; MESQUITA, H. **O agro-hidronegócio no cerrado goiano:** a construção das (re)sistências. In: Anais do II Encontro Brasileiro de Ciências Sociais e de Barragens – Salvador, Anais... 2007.

MGAP. **Unidades de suelos CONEAT.** Montevideo: MGAP, 1994.

MGAP. **Zonificación de cultivos de verano de secano.** Montevideo, 2014. Disponível em: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/

comunicacion/publicaciones/zonificacion-cultivos-verano-secano/. Acesso em: 20 nov. 2024.

MGAP. **Declaración Jurada de Existencias DICOSE – SNIG.** Disponível em: https://www.gub.uy/ministerio-ganaderia-agricultura-pesca. Acesso em: 1 nov. 2024.

MOLFINO, J. **Estimación del Agua Potencialmente Disponible en los Grupos CONEAT.** Montevideo: MGAP, 2009.

MOORE, M. **Wellsprings of Resistance:** Struggles over Water in Europe. Brussels: Rosa-Luxemburg-Stiftung, 2019. Disponível em: https://rosalux.eu/wp-content/uploads/kontext-import/documents/2/7/bf7aff.pdf. Acesso em: 20 nov. 2024.

NEVES, P; MENDONÇA, M. Agrohidronegócio canavieiro: apropriação da terra e da água. **Revista de Geografia (Recife),** v. 37, n. 1, p. 97–112, 2020. https://doi.org/10.51359/2238-6211.2020.241975.

NIBORSKI, M. et al. Distribución espacial y controles ambientales de las represas (tajamares) en el Chaco Árido. **Ecología Austral,** v. 32, n. 1, p. 158–173, 2022. https://doi.org/10.25260/EA.22.32.1.0.1797.

OYHANTÇABAL, G.; NARBONDO, I. Land grabbing in Uruguay: new forms of land concentration. **Canadian Journal of Development Studies,** v. 40, n. 2, p. 201–219, 2019. https://doi.org/10.1080/02255189.2018.1524749.

PENGUE, W. Agua virtual, agronegocio sojero y cuestiones económico ambientales futuras. **Fronteras,** v. 5, n. 5, p. 14–25, 2006. Disponível em: https://www.icaa.gov.ar/Documentos/Ingenieria/agua-virtual.pdf. Acesso em: 20 nov. 2024.

PENGUE, W. **Dinámicas y perspectivas de la agricultura actual en Latinoamérica:** Bolivia, Argentina, Paraguay y Brasil. Santiago de Chile: Ed.Böll, 2015. Disponível em: https://cl.boell.org/sites/default/files/dinamicas_completo.pdf. Acesso em: 20 nov. 2024.

PIÑEIRO, D. Land grabbing: Concentration and "foreignisation" of land in Uruguay. **Canadian Journal of Development Studies,** v. 33, n. 4, p. 471–489, 2012. https://doi.org/10.1080/02255189.2012.746216.

PIÑEIRO, D. Asalto a la tierra: el capital financiero descubre el campo uruguayo. In: ALMEYRA, G. et al. (Ed.). **Capitalismo, Tierra y Poder en América Latina (1982-2012).** Argentina, Brasil, Chile, Paraguay, Uruguay. México, d. F.: CLACSO, 2014. p. 215–257.

RAIMONDI, V.; SCOPPOLA, M. The impact of foreign land acquisitions on Africa virtual water exports. **Ecological Economics**, v. 193, p. 107316, 2022. https://doi.org/10.1016/j.ecolecon.2021.107316.

ROCKSTRÖM, J.; FALKENMARK, M. Agriculture: Increase water harvesting in Africa. **Nature**, v. 519, n. 7543, p. 283–285, 2015. https://doi.org/10.1038/519283a.

RULLI, M.; D'ODORICO, P. The water footprint of land grabbing. **Geophysical Research Letters**, v. 40, n. 23, p. 6130–6135, 2013. https://doi.org/10.1002/2013GL058281.

RULLI, M.; SAVIORI, A.; D'ODORICO, P. Global land and water grabbing. **Proceedings of the National Academy of Sciences**, v. 110, n. 3, p. 892–897, 2013. https://doi.org/10.1073/pnas.1213163110.

SANTOS, C.; GONZÁLEZ MARQUEZ, M. El avance de la frontera hídrica en Uruguay: agronegocio, riego y el acaparamiento de las aguas. **Estudios Rurales**, v. 11, n. 22, p. 1–23, 2021. https://doi.org/10.48160/22504001er22.48.

SAWCHIK, J. Necesidades de Riego en Cultivos y Pasturas. In: **Riego en cultivos y pasturas. 2do Seminario Intenracional.** Montevideo-Uruguay: INIA, 2012. p. 55–68.

SILVEIRA, L.; ALONSO, J. Runoff modifications due to the conversion of natural grasslands to forests in a large basin in Uruguay. **Hydrological Processes**, v. 22, n. 3, p. 320–329, 2009. https://doi.org/10.1002/hyp.7156.

THOMAZ JUNIOR, A. Por uma "cruzada" contra a fome e o agrohidronegócio: nova agenda destrutiva do capitalismo e os desafios de um tempo não adiado. **Revista Pegada**, v. 9, n. 1, p. 8–34, 2008. https://doi.org/10.33026/peg.v9i1.1637.

THOMAZ JUNIOR, A. O Agrohidronegócio no centro das disputas territoriais e de classe no Brasil do Século XXI. **CAMPO-TERRITÓRIO**, v. 5, n. 10, p. 92–122, 2010. https://doi.org/10.14393/RCT51012042.

THOMAZ JUNIOR, A. Trabalho e saúde no ambiente destrutivo do agrohidronegócio canavieiro no Pontal do Paranapanema (SP): Brasil. **Revista Pegada**, v. 15, n. 2, p. 4–18, 2014. https://doi.org/10.33026/peg.v15i2.3309.

XU, H. Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. **International Journal of Remote Sensing**, v. 27, n. 14, p. 3025–3033, 2006. https://doi.org/10.1080/01431160600589179.

AUTHORS' CONTRIBUTIONS

Ismael Díaz Isasa: conceptualization, data curation and analysis, funding acquisition, investigation, methodology, visualization, writing, review and editing.

Eduardo Schiavone Cardoso: conceptualisation, supervision, review and editing.

ARTICLE EDITOR

Cláudio Luiz Zanotelli
Federal University of Espírito Santo
Vitória, Espírito Santo, Brazil
claudio.zanotelli@ufes.br

Received: 12/02/2025
Accepted: 25/08/2025
Available online: 29/08/2025