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Andréa Leme da Silva, Carlos José Sousa Passos, Ludivine Eloy, Saulo Aires de Souza

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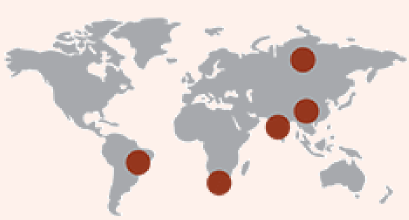

Water grabbing and expansion of agricultural frontiers: case study in a Brazilian Savannah Protected Area, State of Bahia

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Abstract

Over the last three decades, more than half of the Brazilian savannah (*Cerrado*) was converted into soybean monocultures. Despite the focus on land grabbing, the academic literature has paid little attention to relationships between agriculture frontier expansion and water grabbing, which conflicts remain invisible in face of growing large-scale irrigated agriculture (LIA) in the *Cerrado*. Based on the case study of REVIS (Wildlife Refuge) *Veredas do Oeste Baiano*, west of the Bahia State, this study sought to understand the expansion of the soybean agricultural frontier as concerns water grabbing. We evaluated possible temporal relationships between the intensification of irrigation and changes in water river flow, institutional mechanisms related to water grabbing, and perceptions of the LIA by local communities. We employed three methodological approaches: analyses of time series for discharge and precipitation in the Corrente watershed over the last 40 years; institutional analysis of the environmental norms related to water management in the State of Bahia; and interviews with soybean farmers and peasants around the REVIS territory. Our results indicate a decrease of surface streamflow in the Corrente watershed, which might reflect changes in land-use, instead of climatic factors such as precipitation. After 2011, it is observed an intensification of LIA related to the expansion of soybean crops in the study area. The municipality of Jaborandi, one of the seven most irrigating areas in Bahia, augmented from 11 central pivots in 1989 to 163 in 2014. At least 78 pivots are placed in the territory of REVIS *Veredas do Oeste Baiano*, a region of many springs. The hydrological analyses corroborated peasants' perceptions, since 90% of the interviewed persons associated the reduction of river water flow with intensification of LIA. Water use permits have been granted in a context of limited smallholder participation, poor hydrological knowledge and/or weak law enforcement, which all provide an 'easy way in' for newcomers while giving them the formal state government endorsement. Finally, we conclude that the licensing mechanism of water permit grants has led to an increase in water-related conflicts, while legitimising dispossession of peasants in the current era of global resource grabs.

Keywords

Agribusiness; Peasants; Water Grabbing; Western Bahia; Brazilian *Cerrado*.

Acronyms

ANA Water National Agency (Agência Nacional das Águas)
EMBRAPA Brazilian government's agricultural research enterprise (Empresa Brasileira de Pesquisa Agropecuária)
ICMBio Chico Mendes Institute for Biodiversity Conservation (Instituto Chico Mendes para Conservação da Biodiversidade)
INEMA State of Bahia Institute for the Environment and Water Resources (Instituto do Meio Ambiente e Recursos Hídricos do Estao da Bahia)
IWRM Integrated Water Resources Management
LIA Large-scale irrigated agriculture
REVIS Refúgio de Vida Silvestre (Wildlife Refuge) Veredas do Oeste Baiano
SEIA State of Bahia Environmental Information and Water Resources System (Sistema Estadual de Informações Ambientais e Recursos Hídricos)

1. Introduction

The recent expansion of agricultural frontiers in Latin America has radically transformed ecosystems, agricultural practices, agrarian structures and social relations in the territories, creating landscapes mainly dominated by soybean monocultures (Oliveira & Hecht, 2016). Since the 1940s soybean farms have been cultivated in the South Cone, which began to expand northward from the 1980s, reaching the Midwest and north regions of Brazil, as well as other Latin American countries (Brannstrom, 2009; Eloy et al., 2016, Urcola et al., 2015, among others). The broad diffusion of the agro-export model in Latin America lies on the modernisation of agricultural practices and global financialization of the soybean chain, which implied in a new phase of land concentration (Sauer & Leite, 2012; Oliveira & Bühler, 2016; Oliveira & Hecht, 2016).

The "world landrace" has been the subject of increasing academic debate in recent years (Borras & Franco, 2012; Borras & Sauer, 2016). The first studies used the term 'land grabbing' as an expression of the appropriation of large areas of crops by foreigners (Grain, 2008, Zoomers, 2010, Gómez, 2012, among others). However, considering the complexity of the phenomenon in Latin America, the term gained a generic expression to refer to the "recent explosion of transnational commercial land transactions, around the production and export of food, fiber/animal feed, biofuel, woods and minerals" (Borras & Sauer, 2016, p.12). The land grabbing is not a new phenomenon, nor does it refer to the land itself, but to a control over the value chain or labour relations, which is not very different from the previous capitalist logic. This large-scale appropriation extends to other natural resources such as water (water grabbing) (Mehta et al., 2012) and forests (green-grabbing) (Fairhead et al., 2012; Corson & Macdonald, 2012).

The national states play a central role in the phenomenon of private large-scale natural resources grab. On the one hand, neoliberal discourse reduces the role of the state over natural resources, but on the other hand, the government is central to entail the creation of a favourable atmosphere for investments, such as subsidies, infrastructure and the granting of tax incentives, among others. Moreover, there is a growing influence of global environmental institutions and multilateral financial agencies, which create conditions for the reproduction of capitalist accumulation mechanisms, justifications and alliances (Borras & Sauer, 2016, 29).

Brazil represents an emblematic case of this trend. Over the last few years, Brazilian agriculture has rapidly modernised with Green Revolution techniques ranking the country as the world's first tropical agricultural giant of soybean production. This is due to public policies of rural development in favour of agri-food liberalization, largely dominated by transnational corporations (Clapp &

Fuchs, 2009). The relevance of agribusiness to the Brazilian national economy is undeniable. In 2017, the agribusiness sector accounted for 21.6% of the Gross Domestic Product (GDP) and 53.2% of exports, mainly due to soybean and beef (CEPEA, 2018). However, much of this growth depends on the expansion of cultivated areas in the native Brazilian Savannah biome, nationally known as *Cerrado*, which produces more than half (52%) of the Brazilian soybean harvest (Rudorff & Risso, 2015).

From 2000 to 2014, the agricultural area in the *Cerrado* expanded by 87%, and the main factor of this change was the cultivation of soybean. In MATOPIBA (an acronym made with the names for the States of Maranhão, Tocantins, Piauí, and Bahia), the soybean area increased from 1 million to 3.4 million hectares, or 253% in the period. In the Western Bahia, clearing represented one million hectares or nearly 40% of the region between 2002 and 2010 (Salmona et al., 2016). In Matopiba, most expansion of these new frontiers occurs in wild areas or places occupied by peasants or traditional peoples. Trottier and Perrier (2018) define a pioneer front as a space where agriculture is being extended over previously uncultivated land, and farming practices are suddenly intensified over land that had previously been used far less intensively. For example, in Maranhão and Piauí states in Brazil, small-scale ranching or subsistence production prevailed before the expansion of an agricultural frontier (Jepson 2006).

Some authors argue that the flexibilization of environmental regulations favours deforestation and resources grabbing by agribusiness in the *Cerrado* (Brannstrom, 2005; Sauer & Leite, 2012; Silva et al. in press). Hecht (2005) stressed how agricultural lobbies influence the Brazilian states to allow free use of resources in environmental 'sacrifice zones', which are created as territories for the development of agribusinesses. In addition, Eloy et al. (2016) claim that strengthening of environmental policies in the *Cerrado* after the 1990s relies on 'politics of selection' that converged on firefighting and set-aside forest reserves while glossing over other major environmental issues that do not affect soybean producers and traditional populations in equal measure.

Despite the focus on land grabbing in recent years (Edelman et al. 2013; Borras & Franco, 2012; Borras & Sauer, 2016, among others), the academic literature has paid little attention to relationships between agriculture frontier and water grabbing, which conflicts remain invisible in face of growing large-scale irrigated agriculture (LIA) in *Cerrado*.

2. Theoretical framework and study area

Several recent studies have put forward evidence for understanding land grabbing for agriculture as having important water dimensions, even when not explicitly specified in the land deals (Woodhouse, 2012). Water and land grabbing are situated as a global phenomenon. The first studies focused on Africa (Woodhouse, 2012; Duvail et al., 2012; Bues & Theesfeld, 2012), even though empirical evidence also shows examples throughout Latin America (Velez, 2012; Sosa & Zwarteveen, 2012), Palestine (Trottier & Perrier, 2018), India (Wagle et al. 2012; Birkenholtz, 2016), and Eurasia (Gasteyer et al. 2012; Bont et al. 2016).

Resource grabbing broadly refers to the appropriation of natural resources, including land and water, and the control of their associated uses and benefits, with or without the transfer of ownership, usually from poor and marginalised to powerful actors (Fairhead et al., 2012). Most critical analysts working on land grabbing today draw on political economy and Marxist traditions, in particular, David Harvey's notion of "accumulation by dispossession" (2003) (Mehta et al. 2012, p. 195).

Some scholars define land and thereafter water grabbing from three contemporary features. First, land grabbing is ultimately 'control grabbing', or capturing the power to control land and other associated resources such as water, and how they are used, in order to corner the benefits, a point that builds on the theory of access by Ribot and Peluso (2013). According to Mehta et al. (2012) 'control grabbing is a contingent process marked variously by conflict, negotiation, and friction, that can end up ratifying an existing balance of power among state and non-state actors in steps along the way, even if only temporarily'. Although poor people often lose out, under certain conditions their political action can make a difference even if a small one. Secondly, contemporary land grabbing literature tends to define it mainly in terms of the physical size of the land acquired, underlying that business deals are large scale, most visibly in terms of land area and the capital involved (Mehta et al. 2012). By incorporating the scale of capital into the analysis, land, water and other resources become visible as central in the capital operation (Borras et al. 2012). For water grabbing, the fixation on size has a parallel on the volume of water involved, ignoring the fact that access to water concerns distribution in time and space. This also suggests a need to consider scale concerning water flow, in order to highlight an account that makes explicit changes in water distribution and water quality. Third, current land grabbing has been highlighted into the contemporary context of changing global dynamics marked by multiple crisis around food, climate, energy, and finances. Finance capital started to seek new and safer investment opportunities after 2008, as well as resources emerging needs of global capital newer hubs, especially the BRICS (Brazil, Russia, India, China, and South Africa) and some powerful middle-income countries (MICs) (Borras et al., 2012).

Control on water resources is an important cause and effect of the phenomenon known as water grabbing: while land grabbing received a lot of attention, "water as both target and driver of this phenomenon has been largely ignored despite the interconnectedness of water and land" (Mehta et al. 2012).

Franco et al. (2013, p. 1652) observed that “since land and water are interconnected, a focus on the grabbing of water resources helps to bring out an additional, distinct set of issues that are linked to the materiality of water. For instance, water availability fluctuates across time and space, flow within watershed boundaries and often has pronounced dislocated (downstream) effects, in terms of quantities and qualities. Moreover, a focus on the grabbing of this materially distinct and finite natural resource also uncovers additional analytical complexities that have major policy implications. Therefore, it is very difficult to pinpoint the effects of water reallocations, and surface water-groundwater interactions as well as inter-annual variability have some important ‘spillover’ implications for policy and political action”.

Thus, this study sought to analyse implications of the expansion of the agricultural frontier over water resources in a protected area region in western Bahia, in the Brazilian *Cerrado*. Particularly, we expected to answer the following questions: does the expansion of soybean crops in the west of Bahia rely on large-scale water grabbing? If so, which mechanisms do farmers use to grab water on a large scale? Is there a temporal relationship between the intensification of irrigation and water river flow? How has large-scale irrigated agriculture (LIA) in the *Cerrado* biome affected local communities?

Study area

The study area is located in the Wildlife Refuge (*Refúgio de Vida Silvestre* or REVIS) Veredas do Oeste Baiano, created by a Decree of December the 13th 2002 (BRASIL, 2002). REVIS is located in the municipalities of Cocos and Jaborandi, western region of the State of Bahia and has an area of 128,049.99 hectares. The REVIS is part of the MATOPIBA territory, recognised as an official public policy to expand soybean crops in the Brazilian *Cerrado*.

The REVIS Veredas do Oeste Baiano was created to protect the Pratudinho and Pratudão river springs, both of them tributaries of the Corrente River. Situated in the middle São Francisco basin, the Corrente watershed has a total area of 34.9 square kilometers, and it is formed by the Arrojado, Formoso, Corrente, Arrojadinho, Pratudão, and Pratudinho rivers. The Corrente watershed is part of the Urucuia aquifer system[1], an underground spring with an effective area of 76,000 km^2 (Gaspar et al. 2007). The aquifer recharge is important for the maintenance of the medium São Francisco watershed, which occurs by rainwater infiltration of flat and elevated relief areas where the western Bahia

[1] *Cerrado* biome is home to 8 of the 12 hydrographic basins in Brazil, because of its geomorphology predominantly formed by highlands, what gives water courses typical characteristics of plateau areas drainage. Known as "cradle of waters", the biome has three large aquifers - Guarani, Bambuí and Urucuia, which are responsible for the formation of springs and maintenance of important rivers in the continent (Campos & Gaspar, 2008).

sandy latosols play a major role due to their porosity and permeability (Gaspar & Campos, 2007; Gaspar et al. 2007).

The climate of the region is dry, sub-humid and semi-arid. There are two well-defined seasons, wet season from October to March, and a dry season from April to September. The average annual precipitation ranges from 500 to 1200 mm per year, but rains are very irregular and mean annual rainfall decreases quickly westwards. According to Gaspar et al. (2007), rainfall is concentrated in the 100 km area near the border of Serra Geral de Goiás (bordering with the State of Goiás), where most agribusiness farms are located. Nevertheless, irrigation technologies enable to expand the agricultural frontier eastwards, and therefore central-pivot irrigation plots are located in more isolated areas, where rainfall is not so favourable, but the land's reduced market value is attractive for farms set up (Albuquerque, 2015).

The western Bahia soils are ancient, deep, well-drained, with low natural fertility and marked acidity. In this region, yellow and red-yellow latosols, quartzitic neosols and argisols predominate with low nutrients and high aluminium saturation, hence requiring heavy liming and fertilisation. Most region belongs to the Western São Francisco Plateau, where the vegetation of *Cerrado* predominates. In its lower section, belonging to the San Franciscana Depression, there are predominant remnants of seasonal forest and small areas of small-scale agriculture, in addition to extensive cattle ranching (Castro et al. 2010).

Studied populations

Most of the peasants who live in the territory of REVIS Veredas do Oeste Baiano are migrant descendants from the northeast (Bahia state), or from northern Goiás state, who settled in this region in the early twentieth century to scape drought and infertile lands (Souza 2017). Currently, about 650 residents (210 families) live at the Brejão and 53 residents at the Pratudinho village (10 families) (Figure 1). Studied peasants have a livelihood based on multiple subsistence strategies including slash-and-burn agriculture, extensive cattle ranching, and extractivism. Although these and other traditional populations have been living in the *Cerrado* since long before the advent of soybean agriculture, most of them have no land titles (Eloy et al. 2016).

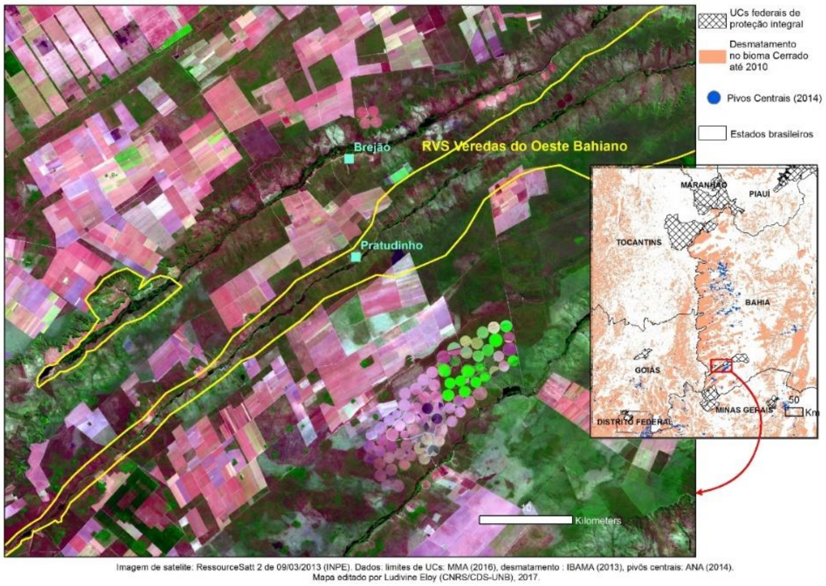


Figure 1: Study area. Satellite image resource Sat 02 from 09/03/2013 (INPE). Source: Elaborated by Ludivine Eloy from PA limits (MMA, 2016), deforestation (IBAMA, 2013), and central-pivots (ANA, 2014).

Since the middle 1980s, cultivated areas reduction resulted from the expropriation of communal lands so-called *gerais* by farmers, along with environmental restrictions imposed by Protected Area (REVIS) in 2000s. Currently, peasants grow food in swidden-plots (*roças*) ranging from 0.4 to 2 hectares per family. Although these peasants have maintained their traditional agrobiodiversity practices based on seed origin productivity, they have changed this over time. Souza (2017) recorded at least 25 plant species (e.g., beans, cassava, banana, and corn) cultivated in swidden and 102 species in the home garden, which are important for these communities' food security. The author observed that the period of fallow reduced from 8-10 years to 2-3 years, which in turn requires chemical fertilisation and compromises ecosystems recovery capacity.

In the early 1970s, the Bamerindus bank installed a pine and eucalyptus farm in the headwaters of the Pratudinho river (municipality of Mambaí, State of Goiás) according to public concessions. The first soybean producers originated from southern Brazil (States of Rio Grande do Sul, Paraná, and São Paulo) arrived in the middle 1980s. The government incentives, such as low land prices, easy interest rates, and promised infrastructure conditions boosted migration processes. The first soybean farmhouses placed in the REVIS territory were Texas that started in 1985 with 500 hectares, and Jarina that started in 1986 with 690 hectares (Souza, 2017). Currently, there is a growing tendency for these owners to sell their properties to larger national or international groups that already own several farms in the country.

Methods

In order to understand recent changes and possible conflicts related to the water use, we undertook fieldwork in 2017. We carried out 20 semi-structured interviews with peasants of two communities situated in the REVIS territory (14 men e 06 women). Questions were addressed to changes in the water flow of the rivers and springs related to deforestation, irrigation and precipitation, along with impacts on the small-scale agriculture and environment.

In addition, we conducted seven interviews with soybean producers in western Bahia (municipality of Jaborandi), including one interview with a producer located in the border of the Goiás State (municipality of Mambaí) in the headwaters of Pratudinho river. The sampling criterion to choose farms included properties proximity of the damping zone or close to REVIS and the studied communities, and properties that are part of the National System of Rural Environmental Registry (SISCAR) database of the Chico Mendes Institute of Biodiversity Conservation (ICMBio), through the Google Earth Pro software.

We obtained data on soybean production and cultivated area in the state of Bahia from historical series of the Brazilian National Supply Company (*Companhia Nacional de Abastecimento*) (CONAB, 2018). We compiled data on environmental norms for water management through an extensive literature review, including official sources and newspaper articles. We obtained environmental norms concerning rights of water use and environmental licensing information from the homepages of the federal and state governments, such as the National Water Agency (ANA), the State of Bahia Institute for the Environment and Water Resources (INEMA), and the State of Bahia Environmental Information and Water Resources System (SEIA).

Time series analysis of outflow and precipitation for the Corrent watershed

The methodology to analyse the flow and precipitation in the Corrente watershed included hydrometeorological data collection (precipitation and flow), exploratory data analysis, and trend detection. For the hydrological pattern analyses, precipitation and daily flow were based on the National Water Agency Hydrological Information System (Hidroweb). For such, we selected all stations under operation that presented no data failure. Figure 2 illustrates the locations of rainfall (circles) and fluviometric stations (pushpin). Stations are classified according to data availability (red stations that present up to 15 years of data without failure, orange ones between 15 and 30 years, and blue ones older than 30 years).

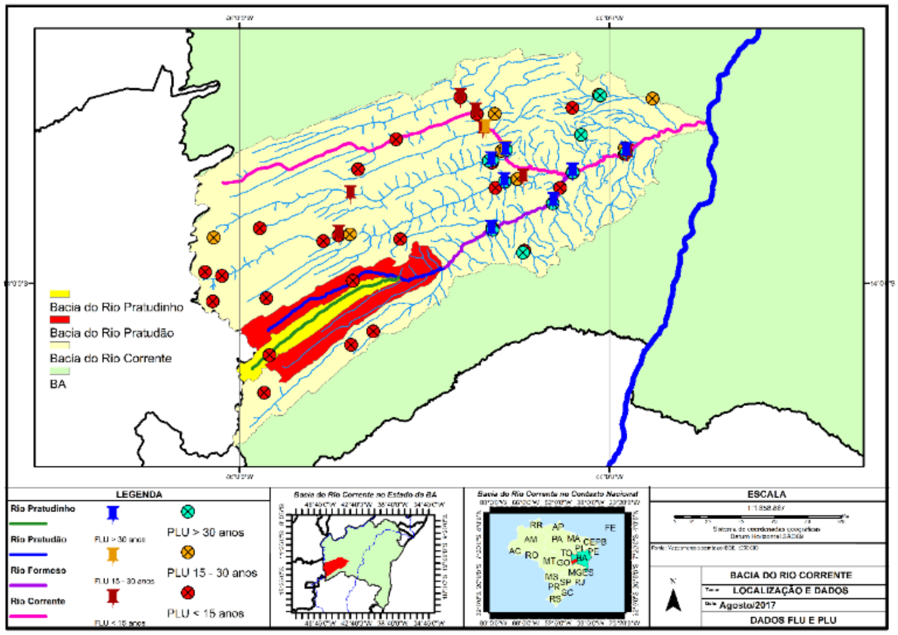


Figure 2 - Location of the fluviometric (pushpin) and pluviometric (circles) stations in the study area. Source: Hydrological Information System (Hydro) of the Brazilian National Water Agency.

Exploratory data analysis considered the mean, maximum, and minimum values to evaluate changes in precipitation patterns and discharges recorded at the measuring stations throughout the Pratudão river basin. Pratudão river discharges (streamflow) and precipitation time series were obtained by regionalisation and interpolation techniques. In the case of the discharges, the regionalisation was carried out using station 45840000 flow series, by means of drainage area ratio transfer. The average precipitation was based on inverse-square-distance (IQD) by using the data from the Corrente watershed rainfall stations.

Possible precipitation and discharge alterations were evaluated through the Mann-Kendall test for trends (MK), using daily, monthly and yearly series of mean, maximum and minimum values from both the rainy season and the dry season. We adopted the "Trend Free Pre-Whitening" (TFPW) approach to consider the effect of autocorrelation in time series. The MK test assumes that series are independent; if the observations in a sample are temporally correlated, the MK test loses its ability to control type I error, which means probability of detecting a significant trend when there is no trend is greater than the specified level of significance (Yue et al., 2002).

In addition to the Pratudão watershed streamflow series, this evaluation was performed considering seven fluviometric stations with at least 30 years of data without failure in the Corrente river basin (blue fluviometric stations of Figure 2). In the case of analyses of rainfall patterns, we considered for the Corrente river basin 14 rainfall stations with at least 30 years of data without failure. The level of significance was 5%, and this methodology review can be found in Kundzewicz and Robson (2004).

The analysis of changes in terms of daily precipitation was made by considering the fact that an annual rainfall change can be caused by the occurrence, combined or not, of two phenomena: fewer rainy days during the year, and lower rainfall on each of the rainy days of the year. This analysis is essential to evaluate the degree of influence of the climatic factors in relation to land-use change patterns on the basin's hydrological regime.

3. Results and discussion

Intensification of water use for irrigation of large-scale agriculture in the western Bahia

Currently, the State of Bahia occupies the sixth position in terms of soybean production in the national scenario, estimated at 118,000 tons in the 2017-2018 harvest period (Figure 3). In 2017, Bahia's irrigated cropland covered approximately 1.58 million ha (Figure 4), followed by 171.552 ha of equipped area with 1,881 central pivots (Table 1). According to the Brazilian National Water Agency (ANA, 2016), irrigation is responsible for 72% of water consumption in the country. The Institute for Applied Economic Research (IPEA) stresses that in 2013 Brazil exported more than 55 million tons of soybean, which corresponded to 123 billion m^3 (CPT, 2018). In accordance with the 2018 World Alternative Water Forum, more than 112 trillion liters of fresh water are exported as "virtual water" in agricultural commodities (e.g., soy, coffee, cotton, sugar, and beef) (CPT, 2018).

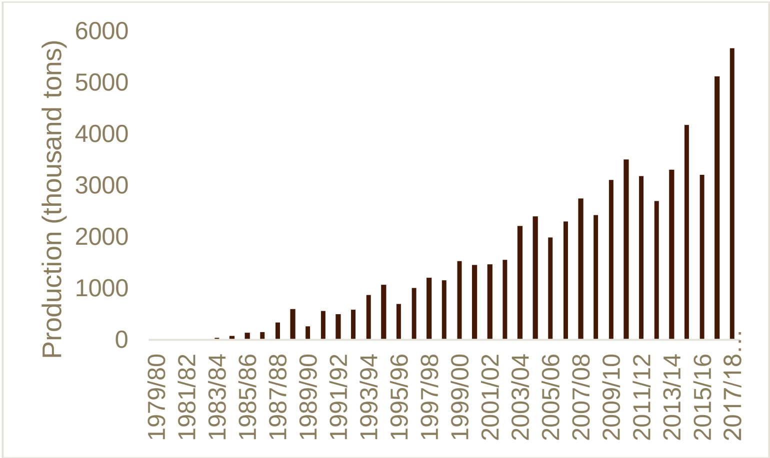


Figure 3: Soybean production in the state of Bahia (in thousand tons). Source: Historical series: soybean crops 1979/1980 to 2017/18 (forecast), CONAB (2018).

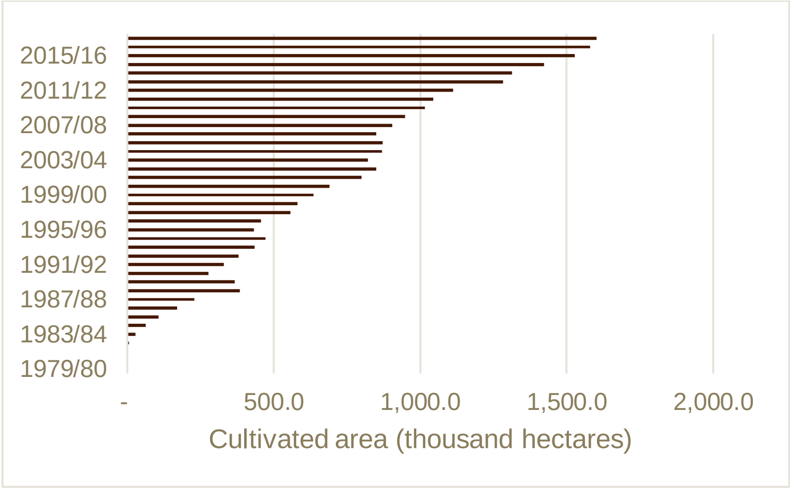


Figure 4: Soybean cultivated area in the state of Bahia (in thousand hectares). Source: Historical series: soybean crops 1979/1980 to 2017/18 (forecast), CONAB (2018).

Irrigated grain crops (e.g. cotton, beans, maize, and soy) with central-pivot systems occupy an area of 1.4 million ha in the country, and 79% of these pivots are concentrated in the *Cerrado* (ANA, 2017). In 2014, there were 1,400 pivots in western Bahia, occupying a total area of 141,998 hectares - an average area of 101 hectares per central pivot (ANA, 2016), and seven municipalities in western Bahia lead the ranking of the ten most 'irrigator' cities in the country. At the Jaborandi municipality, for example, the number of central pivots increased from 11 equipment in 1989 to 163 in 2014, with 78 equipment located in the REVIS territory in 2013 (Table 1).

Table 1: Areas equipped with central pivots above 5,000 hectares for municipalities of the Bahia State (adapted from ANA, 2014)

Municipality	Equipped area (ha)	Number of central pivots	Mean area (ha/pivot)
Barreiras	34.870	340	103
Mucugê	34.293	503	68
São Desidério	33.368	316	106
Jaborandi	18.221	163	112
Luís Eduardo Magalhães	16.298	177	92
Ibicoara	11.354	205	55
Riachão Das Neves	10.997	57	193
Cocos	5.553	57	97
Correntina	6.598	63	105
Total	171.552	1.881	931

In 1984, there was no central pivot installed in the region, but it was possible to observe agribusiness production areas, focusing on forest production in the Pratudinho and Pratudão rivers headwaters (Souza, 2017). According to three interviewed participants of the large-scale irrigated agriculture (LIA), farms E and F capture water directly from the Formoso River (Figure 5), with 34 and 68 pivots (8,340ha and 4,070ha of irrigated area), respectively (Table 2). Farm G is located in the headwaters of the Pratudinho river, with 17 pivots that capture groundwater (2,565 ha of irrigated area). Considering the consumption of about 280,000 liters per pivot per hour (8 hours/irrigation day on average), farms A, B and C consume about 76,160, 152,320 and 38,080 m3 of water per day, respectively. Brannstrom (2005) estimates that each central pivot irrigates 100 ha on average, which is equivalent to the consumption of 7,000 to 8,000 m3 of water per day, enough to 42,000 inhabitants water supply.

Figure 5: Main irrigation canal of the Formoso River, below grade from agricultural fields.

The sampled farms have on average 14 years, the oldest having more than 30 years, and the most recent one five years. The size of rural establishments ranges from 1,650 to 80,000 hectares (averaging 10,000 ha). According to the typology of Oliveira & Bühler (2016), one rural property can be characterised as familiar, five are patrimonial, and one is an investment society (Table 2).

Soybean farms make crop rotation with corn (all, except farm D), cotton (farms B, C, E, and F), and beans (farms F and G). Farms without pivots also cultivate brachial seed (A), native beans and sorghum (D), which constitute plant species more adapted to drought. Farm F also cultivates tobacco in partnership with Phillip Morris, and in addition to grains (Pro, RR and conventional), central pivots farms (E, F e G) produce soybean and maize transgenic seeds, based on trade agreements with Monsanto Dow, Pioneer, Brasmak, and Embrapa.

Table 2: Set of the studies farms, with their typology of production systems: F = family, P = patrimonial, S = investment company.

Farms	Total area (ha)	Cultivated area (ha)	Typology	Number of pivots
A	1.700	660	F	0
B	10.880	3.800	S	0

C	26.000	12.500	P	0
D	22.700	7.600	P	0
E	8.000	4.070	P	34
F	16.000	8.340	P	68
G	80.000	2.565	P	17
Total	165.280	39.535		119

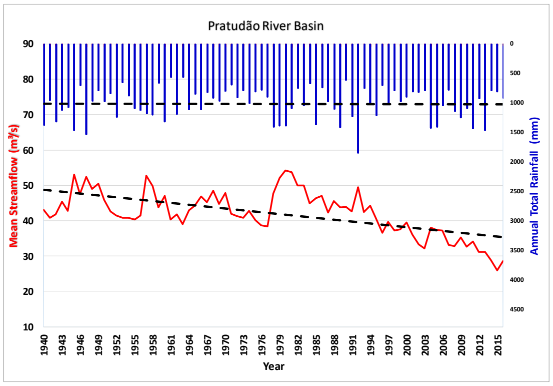
Soybean producers have political narratives on ‘unexploited and underused’ land and water resources in the *Cerrado*, and how these areas ‘need’ new and large-scale investment to ‘unlock’ their potential and promote a blue revolution[2]. They also associate the Formoso river water flow reduction to the precipitation reduction in the region (climate change), instead of the intensification of LIA water use.

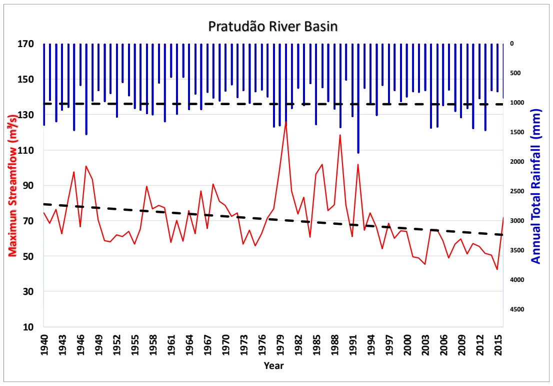
Corrente watershed rainfall and discharge trends

The study of rainfall variability and trends is one of the most important issues of climate change research. Figure 6 shows the mean of discharges in the Pratudão river (red line) and interannual rates of precipitation (inverted blue bars) from 1940 to 2016, while the dashed black line superimposed on the graph represents their respective trend lines. Figures 6a, 6b, and 6c illustrate that total rainfall pattern might not show any trend behaviour over time, while there is a strong downward trend in the series of annual discharges since the 1980s. The lowest values on average flows have been observed after 2000.

(a) (b)

[2] Most agricultural production is based purely on rainwater that has infiltrated the soil locally (so-called ‘green water’), but diverted surface water and pumped-up groundwater (so-called ‘blue water’) are a far more reliable source for commercial agricultural production (Franco et al. 2013).





(c)

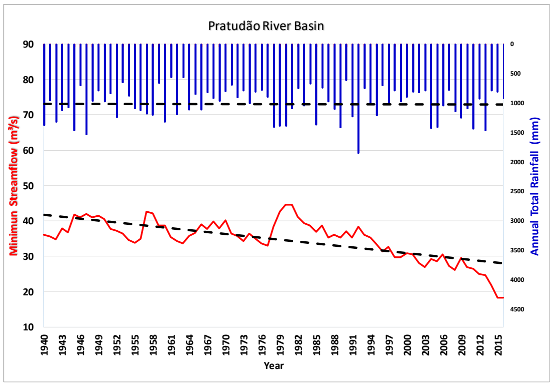


Figure 6 - Mean (a), Minimum (b) and Maximum (c) annual total precipitation and surface flow in the Pratudão river basin (1940 to 2016).

In the late 1990s, the runoff coefficient[3] is less than 0.4, which means that from total precipitated water less than 40% was converted to surface runoff (Figure 7). Such cut-off period matches with an intensification of soybean production in the studied region (Figures 3 and 4).

[3] Since Urucuia aquifer is not a fractured system (Gaspar & Campos, 2007), the runoff equations are valid for this study.

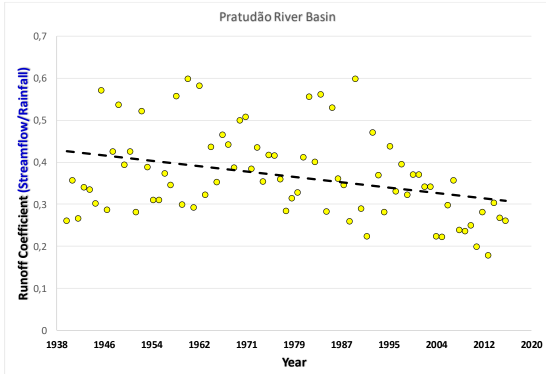


Figure 7 - Coefficient of Runoff from 1940 to 2016.

The results of the MK test for the discharges and rainfall series can be summarised in Figures 8a to 8e. All fluviometric stations (Figures 8a to 8c) showed a downward significant trend for both minimum and mean streamflow series (P≤0.05). For maximum flows just one station trend null hypothesis was rejected (p>0.05), however, this station shows a downward trend. These results indicate a strong decrease in streamflow, especially in the minimum flows.

On the other side, figures 8d and 8e illustrate the results for pluviometers time series and the number of annual rainy days. Most precipitation series analysis showed no significant trends (p>0.05) Only two stations had a significant decreasing trend and one station showed a significant upward trend (p≤0.05) (Figure 8d). This hypothesis of low contribution of climatic factors to hydrological regime changes is reinforced by annual rainy-day serial numbers with no clear sign of change. Such results suggest that climatic factors (rainfall) have contributed little to decrease in streamflow, which means that other factors associated with land-use might be related with river flow reduction.

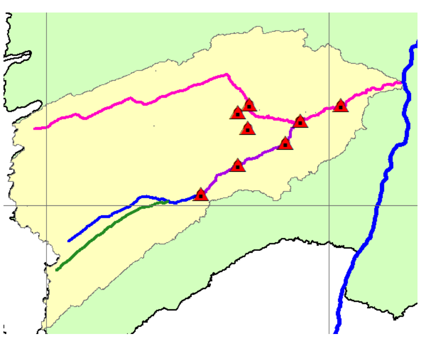


Figure 8a - Trend analysis of Minimum Flows

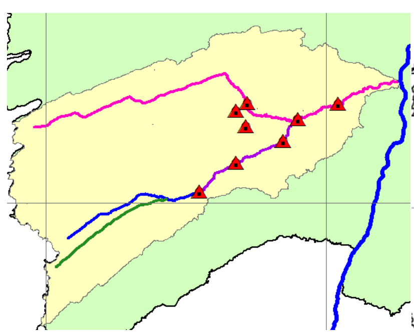


Figure 8b - Trend analysis of Mean Flows

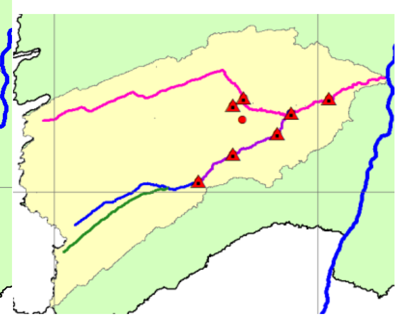


Figure 8c - Trend analysis of Maximum Flows

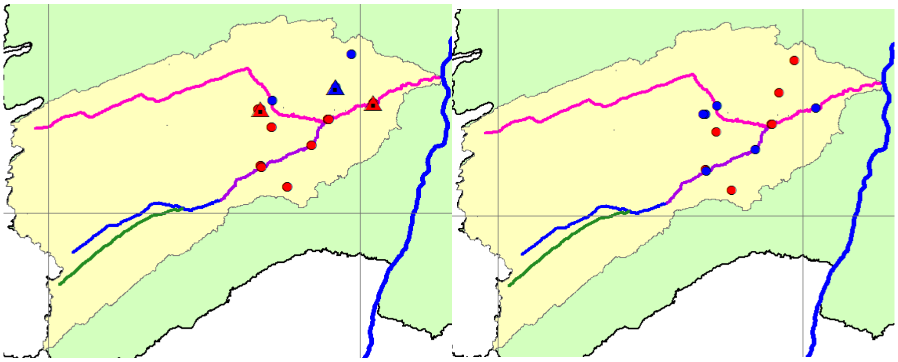


Figure 8d – Trend analysis of total annual precipitated. Figure 8e – Trend Analysis of the number of annual days with precipitation.

Figure 8: Trend analysis for streamflow and precipitation in the Corrente watershed. Legend=Circle red: not trend (downward); Circle blue: not trend (upward); Triangle red: downward trends significant at 5% error level; Triangle blue: upward trends significant at 5% error level.

Studies carried out by ANA (2016) indicate that watershed hydrological pattern changes might reflect changes in land-use (e.g., deforestation) and irrigation demand growth in recent years, since 90% of water use on the basin is for irrigation purposes. Among the factors that seem to be contributing most strongly to changes in the basin's hydrological pattern, ANA (2013) pointed out an increase in irrigation demand in recent years. The main consumptive use in the basin is for irrigation purposes that represent about 90% of the total use of water resources.

In Brazil, studies about the effects of land-use changes on the rainfall variability and trends are scarce, especially in the *Cerrado*. Rosin et al. (2015) carried out a similar study of hydrological trends in the Rio das Mortes watershed in the state of Mato Grosso, and based on Mann-Kendall test for pluviometers time series, the authors demonstrated that only 11% of the series showed significant trends, suggesting evapotranspiration from the surface area has little influence on the local climate system. On the other side, trend analyses carried out for fluviometric time series showed negative as well as positive trends. The measuring station for which all trend analyses had negative results shows a strong relationship with the use and exploration of water resources. In measuring stations that show a trend to increase, the authors concluded that land-use impacts (e.g., deforestation) and soil type, as well as physical characteristics of the soil influence the hydrological balance in the catchment areas.

Regulation and control through permit granting systems

Since the late 1980s, unprecedented water resource management reform has taken place across the globe, and it has radically redefined the role of the public sector. Existing irrigation schemes have been transferred from government control to users, while the domestic water sector privatization has been encouraged. Thus, state role has shifted towards regulators promoting decentralization and users' participation. In order to fulfill their regulatory roles, states have promoted measures such as formal administrative water rights systems strengthening, cost recovery and water pricing (the 'user pays' principle), new watershed institutions creation and better consideration of the environment (the 'polluter pays' principle). Together, this set of regulatory measures is usually referred to as 'Integrated Water Resources Management' (IWRM) (Van Koppen, 2007).

In the water sector, decentralization in practice means water governance reorganisation from administrative units (e.g., districts) to units that coincide with hydrographical boundaries (e.g., basins). Decentralization policies and approaches include an emphasis on water users' participation in water management. However, overarching users' involvement does not prevent strong actors from capturing unfair water shares. Rather, user participation often becomes a forum through which the resource capture is taking shape often excluding informal and legally unrecognised water users (Franco et al. 2013).

In Brazil, the main instrument of water management is the federal law # 9.433 (Brazil, 1997), which recognises water permits granting as Integrated Water Resources Management (IWRM main instrument). After the 1990s, there was a trend for water management decentralization in Brazilian states, along with an emphasis on stakeholder participation on watershed plans. In the state of Bahia, it is observed a huge complexity of water regulations after policy reform of 1997 (Table 1). According to Silva et al. (2017) the IWRM was characterised as an innovative policy for contemplating water through various approaches (decentralized, environmental, economic and social) for recognising the multidisciplinary value of the water. Most Brazilian states have water regulatory agencies with legal attributions to grant water permits. Additionally, each agency has autonomy to determine their procedures, as well as legal and technical criteria to be adopted in the analysis of permits granting processes.

Since 2011, the water permits issuing is a responsibility of the Environmental and Water Resources Institute (INEMA) in the state of Bahia (State Law # 12.212). The application analysis has four support systems: State Water Resources Information System (SEIRH-PROHIDROS), State Environmental Information System (SEIA) and Water Permit Control Management System (SIGO Withdrawal and SIGO Waste water). However, Silva et al. (2017) observe a lack of interrelation among Bahia state water resources management instruments. The State water agency of Bahia (INEMA) adopts water balance equating methodologies between availability and demands, but does not consider the interrelation between withdrawals and waste water discharges. With the exception of the water permit granting system, data from other instruments stored in specific support systems such as SEIA and

INEMA are not integrated. Additionally, there are not internal procedures to integrate instruments.

For the technical analysis, equating process is based on water balance considering availability and demands. Water availability is calculated with hydrological studies using flow data and/or rainfall data time series, where its measurement efficiency is by waterbodies' monitoring. The demand management comprehends that water uses efficiency should be ensured by five integrated instruments at SEIA: water uses inspection, waterbodies framework in classes, water permit, water use, and money charge. However, there is an absence of a consistent information system and uncomprehensive water resources inspection data, fluviometric monitoring data, and water quality in the state of Bahia. In a context that contemplates these limitations, considering water permits application analysis for it is necessary a water resources management progress evaluation from the moment water balance equating methodology was implemented with a water permits quali-quantitative integration.

Brannstrom (2009) highlights that INEMA faces considerable problems in licensing stream water use because basic hydrological data are extremely poor. In the Fêmeas River basin, for example, INEMA's over-licensed irrigation water caused reduced flow that forced a downstream hydroelectricity plant to shut down turbines during the dry season. In addition, Bahia's 1995 water reforms required the extinct Water Resources Secretariat of the State of Bahia (SRH-BA) to know rivers water availability to issue water use permits. Confronted with poor hydrological data, the SRH developed an interpolation equation but officials acknowledge quality of initial data encouraged over-estimated stream flow at very small cartographic scale. Moreover, there is no control over the volume of water used for irrigation, and pivot farms have practically no restrictions on water use. The SRH granted increasing numbers of water permits with insufficient data on spatio-temporal scales adequate to water resources planning and management (ANA 2014).

Water resource management reform also emphasizes user participation. However, in some contexts the water laws and institutions which have followed from this reform have consistently ignored how people actually manage their water (van Koppen, 2007). In Bahia, State Law # 12.212 defined implementation of water management participative stakeholder committee in order to implement their respective plans. Social needs should be represented by watershed priority water uses analysis, as defined in the watershed plans. However, in practice the stakeholder committee for the Corrente river watershed takes no part into the decision-making process of the water licensing in the Corrente watershed.

Franco et al. (2013) highlight that rural informal water users' dispossession through licensing mechanism is prominent in the current era of global resource grabs. Based on colonial legacy, recently introduced or revised permit systems are *de facto* facilitating water grabs. Formal permits with state backup create first-class rights in comparison to any other right, and in many cases smallholders are not even aware of their historic agricultural water rights, since they are not recognised in national legal frameworks that facilitates water grabbing. In the context of limited smallholder water use participation, poor hydrological knowledge and/or weak law enforcement, water permits provide an 'easy way in' for newcomers while giving them the formal state government endorsement.

Table 1: Main water management regulations and laws of the Bahia State.

Regulations	Characteristics
State Law # 6.855 (12/05/1995)	It provides law enforcement for Policy and State Plan of Water Resources Management
Federal Law # 9.433/1997	The water licensing is among the administrative management instruments provided by the National Water Resources Policy
State Decree # 6.296/1997	It provides law enforcement for the granting of the right to use water resources, infraction and penalties and makes other provisions.
State Law # 7.354/1998	Creates the Water Resources State Council (CONERH)
State Law # 7.799/2001	Creates the Bahia State Environmental Information System (SEIA)
State Law # 8.194/2002	Creates the Bahia State Water Resources Fund, reissue the Water Resources Superintendence (SRH), and defines State Council of Water Resources
State Decree # 8.851/2003	Provides law enforcement for an integrated action of Environment and Water Resources Secretary (SEMARH).
State Law # 9.843/2005	It defines stakeholder watershed committee, and strengthens CONERH competencies
State Decree nº 10.255/2007	Provides law enforcement for use water rights concession, authorization or dispensation in the State of Bahia
State Decree # 10.289/2007	Regulates the State Council of Water Resources members composition
State Decree # 11.235/2008	Approves the state Laws # 10,431/2006 and # 11,050/2008, which changes names, purposes, organisational structure and positions in the Environment and Water Resources Secretariat Committee (SEMARH) and indirect administration entities linked to it.
State Law # 11.050/2008	Changes names, purposes, organisational structure and positions in the SEMARH and the Indirect Administration entities linked to it, and other measures.
State Law # 12.035/2010	It amends provisions of Law # 11,612, October 8, 2009, which provides law enforcement to the State Water Resources Policy, and State Water Resources Management System.
State Decree # 12.120/2010	Regulates the Water Resources State Council
State Law # 12.212/2011	Creates INEMA through the integration of environment and water resources system of the State of Bahia, and consolidate State System of Environmental Information of Bahia (SEIA) with the absorption of the State System of Information of Water Resources (SEIRH).
State Decree # 14.024/2012	Approves the regulation of Law 10.431 / 2006 and Law 11,612 of October 08, 2009, which provides law enforcement for the Water Resources State Policy and the Water Resources Management State System

State Law # 11.612/2013	Creates the Water Resources Management State Policy

Conflicts related to water in Bahia

According to the Land Pastoral Commission (CPT, 2018), large-scale irrigated agriculture (LIA) is one of the main causes associated with conflicts in Brazil. Between 2005 and 2017, the number of conflicts related to water increased from 71 to 197, involving 35,418 peasants, indigenous and traditional peoples. From 197 conflicts registered in 2017, 63% occurred in areas of mining companies, along with 17% of conflicts related to hydroelectric dams, and 13% related to irrigation. The State of Minas Gerais concentrated 72 incidents related to mining and irrigation, followed by Bahia with 56 cases related mainly to irrigation (CPT, 2018).

The municipality of Correntina in the west of Bahia (part of Corrente river watershed) is the water conflict most emblematic case registered by the CPT. In 2017, a popular demonstration against the Iragashi Japanese company that consumed approximately 100 times more than Correntina population water supply brought a water grabbing discussion about the big agribusiness in the region[4]. The popular mobilisation turned into a community criminalisation process, revealing state government complicity tied with large capital (Pereira et al. 2017).

In this study area, peasants are unanimous about river flow reduction and springs disappearing and quenching related to agribusiness introduction in the last 15 years. About 90% of the interviewed persons associate river water flow availability reduction with central pivots (both superficial and groundwater) used by LIA, while 60% pointed out rainfall reduction and/or greater irregularity of rainy season. A smaller proportion of interviewed (25%) linked reduction of river water volume (or availability) to deforestation. Peasants also associate rainfall regime changes with vegetation suppression, long and unforeseeable summer occurrence in addition to sparse rains.

According to interviewees, reduction on river flow is associated with intensification of LIA in the Pratudão, Pratudinho and Formoso rivers, along with disappearance of some springs and lakes including the Bamerindus lagoon (lagoa Bamerindus or *Lagoa Feia*) in the Pratudinho river headwaters. Albuquerque (2015) pointed out a reduction of 10 meters at the point where INEMA monitors river level and it was necessary to install a new measuring ruler since the first one lost its water measurement accuracy. According to the author,

[4] The Iragashi Company moved from Chapada Diamantina (State of Bahia) to Correntina prior 2015, after had dried one of the tributaries of the Paraguaçu river. The permit water of the River Arrojado (located at sub-basin of the Corrente River), was issued by INEMA (State Order no. 9,159 of January 27, 2015), during the four-year period, for the use of a flow of 182,203 m3 during 14 hours/ day for irrigation of 2.539 ha by 32 central pivots. INEMA granted this water permit in 2015 in spite of the deliberation of the Corrente river stakeholder committee and Public Ministry against the granting of new licenses (Pereira et al. 2017).

large-scale irrigation technologies can intensify social conflicts between farmers and local communities. The pivots dissemination can also cause changes in the territorial dynamics (e.g., migration) since pivot farms are located in the most isolated areas where traditional communities and peasants have been living.

4. Conclusions

In the Brazilian *Cerrado*, the expansion of soybean monocultures can be situated as a global phenomenon of land and water grabbing, even though water has been less addressed by the current literature. Despite the advances announced by the political reform decentralisation of IWRM in 1997, two mechanisms facilitate farmers use to grab water on a large scale. First, the lack of integration of the management instruments (SEIA) facilitates the lack of control in the issuance of water permits. Second, the promise of effective participation of users from decentralisation is not fulfilled in the decision-making processes regarding water licensing. In the context of limited smallholder water use participation, poor hydrological knowledge and/or weak law enforcement, water permits provide an 'easy way in' for newcomers while giving them the formal state government endorsement.

The analysis of Corrente river watershed flow and precipitation over the last 40 years indicate a decrease of runoff, which might reflect changes in land-use, instead of climatic factors such as precipitation. Most of the rainfall data had very low percentage of significant trends, which in turn might suggest that climatic factors would have only weakly contributed to the stream flow decrease. These preliminary results corroborate peasants' perceptions regarding the reduction of surface flow due to intensification of LIA in the west of Bahia. In order to improve accuracy of the potential impacts of large-scale irrigation on the basin, data concerning water use permits (volume) would be useful to attesting the reduction of river flow related to LIA.

Finally, large-scale irrigated agriculture has intensified social conflicts related to access to water resources. We conclude that licensing mechanism of water permit has legitimized dispossession of peasants in the current era of global resource grabs.

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