

# Beyond the Agrarian Reform Policies in Brazil: An Empirical Study of Brazilian States from 1995 Through 2011

José Sobreiro Filho<sup>1</sup> · Enzo Barberio Mariano<sup>2</sup> ·  
Vinicius Amorim Sobreiro<sup>3</sup> · Charbel José Chiappetta Jabbour<sup>2</sup>

Accepted: 19 October 2015 / Published online: 2 November 2015  
© Springer Science+Business Media Dordrecht 2015

**Abstract** The main land reform movements in the world are taking place in Brazil, where various social groups have coordinated their efforts to acquire legal possession of unproductive estates. Although the results achieved over time regarding this dispute are viewed as progress in terms of social inequality, there is no knowledge about the performance of these various movements to date. Based on this context, the main objective of this paper is to evaluate the performance of the Brazilian states and the last four presidential terms in Brazil in minimising social conflicts over land and efficiently converting occupations into settlements.

**Keywords** Social movements · Performance · Land · Brazil · Data envelopment analysis (DEA)

---

✉ Vinicius Amorim Sobreiro  
sobreiro@unb.br

José Sobreiro Filho  
sobreirounesp@gmail.com

Enzo Barberio Mariano  
enzo@feb.unesp.br

Charbel José Chiappetta Jabbour  
prof.charbel@gmail.com

<sup>1</sup> Geography Department, São Paulo State University (UNESP), 305 Robert Simonsen St., Presidente Prudente, São Paulo 19060-900, Brazil

<sup>2</sup> Production Engineering Department, São Paulo State University (UNESP), Av. Eng. Luiz Edmundo C. Coube 14-01, Bauru, São Paulo 17033-360, Brazil

<sup>3</sup> Department of Management, University of Brasília, Campus Darcy Ribeiro, Brasília, Federal District 70910-900, Brazil

## 1 Introduction

The current conflict over land in Brazil is related to the historical problem of land concentration, and its origin dates back to the Portuguese colonisation with its strategic actions of territorial occupation, such as: (a) the division of the country into hereditary captaincies<sup>1</sup> and *sesmarias*<sup>2</sup> (land grants); (b) donations; and (c) the creation of large estates (Wolford 2003, 2010). These strategic actions were policies undertaken by the Portuguese Crown and by the Brazilian Empire in order to promote and expedite the occupation and settlement of the Brazilian territory, hence improving the economy and ensuring the territorial sovereignty threatened by European and South American countries. Throughout the course of history, these actions were different aspects of land and power concentration which reinforced uneven and contradictory development, manifestations that are still in force (Wittman 2009).

Of the different forms of land tenure, *latifundium* (large estate) is one of the most important, with its origins based on this past where so much is concentrated in the hands of a few, and which still occupies a prominent place in the present time. The origin of large estates dates back to the dissolution and failure of the first forms of occupation promoted by the Portuguese Crown and the Empire of Brazil, which occurred with the Land Law of 1850, an important event in the history of private property in Brazil. This law, from 1850 to 1856, allowed registration of land ownership, which became private property, in such a way that unregistered lands would go back to the State, designated as unoccupied lands. However, as a consequence of the intense process of occupation and settlement headed westward in Brazil, known as the pioneer front, primarily based on the creation of farms and clearing of the forests for production, there was an extensive process of falsifying property documents for unoccupied lands (Brannstrom 2001). This culminated in one of the main processes that led to the formation of large estates and, decades later, to land conflicts.

Apart from the indigenous extermination and slavery, added to intense environmental devastation, the creation of large estates was responsible for incorporating the land into the logic of agricultural production, which meant the expansion of the agricultural frontier. Accordingly, in the nineteenth and twentieth centuries those who created a farm were praised as contributing to the development of the nation; thus, like most colonising policies encouraged and financed by the State, individual actions were meaningful stimuli in the effective occupation and territorial incorporation of agricultural production.

Along with the creation of large estates, one cannot fail to also mention the major economic cycles, with coffee farming as the major driver of immigration and the creator of farms (Wolford 2003). The inclusion of areas of traditional communities, agricultural workers, settlers, etc., in addition to strong incentives for large and medium farms in Brazil, also strongly integrated the formation process of large estates, especially during the dictatorship period, which resulted in a significant rural exodus.

Throughout the history of Brazil, land tenure and economic and political power have always been related, with land ownership synonymous with power (Wittman 2009; Hammond 1999), a fact that further corroborated land concentration in the country. To elucidate this, one can see that Brazil's current agrarian structure retains clear signs of this scenario. Today, Brazil has 851,487,659 acres of territorial extension, of which, according

---

<sup>1</sup> In general, the hereditary captaincies were the first administrative divisions in Brazil.

<sup>2</sup> *Sesmarias* are either large tracts of unproductive or abandoned lands.

to data from the last Census of Agriculture (IBGE 2006), 329,941,393 ha (38.75 %) are effectively in use. In the last four decades, as shown in Table 1, there was an increase of 35,795,927 ha (12.16 %) in the areas used for agriculture, but only 251,470 (5.11 %) in the number of agricultural establishments. Thus, it can be concluded that this increase was the result of a set of public policies destined to large properties and to implement the green revolution technology package based on the use of agrochemicals for agricultural export policies.

Behind this reality of land abundance in the hands of a few, there are two well-defined models of rural development: (a) agribusiness, with research indicating that despite its great participation in the trade balance, it has caused serious environmental, social and health costs (Lopes Soares and Firpo de Souza Porto 2009; Deibel 2012; Wiold et al. 2010; Kloppenburg 2010; Dasgupta et al. 2001); and (b) family farming, which, even with an acreage area two times smaller and subsidies equivalent to only 14.92 % of the amount allocated to commercial agriculture, has been the leading food producer in the country and has also managed to develop agro-ecological production methods, particularly aided by social movements, such as the Landless Rural Workers' Movement (MST) and the Movement of Small Farmers—MPA (Fernandes et al. 2010).

Accordingly, when considering the 2006 census data, presented in Table 2, it can be inferred that 15.60 % of the properties characterised as non-family farms concentrate 75.68 % of the cultivatable land in the country, while 84.40 % of properties classified as family farms occupy only 24.32 % of the cultivatable area, which clearly shows that the Brazilian agrarian structure is still based on concentration.

The Gini index of agrarian structure also clearly reinforces the concentration of land in Brazil, as shown in Fig. 1. As is also shown in this figure, this problem does not occur across the board for all Brazilian states, meaning that agrarian structure is not identical in Brazil's territorial divisions. Consequently, diligently and gradually preparing a set of policies to address this issue will also require the government's considerable effort. However, much of this effort possibly results from the existing difficulty of accurately assessing the results of these policies in the Brazilian states. In this sense, the data envelopment analysis technique can be very useful because it allows comparison, in a relative way, of which policies or social movements were the most efficient in the Brazilian states, considering both their inherent characteristics and the conjectures related to the last four presidential terms in Brazil.

It is noteworthy that in recent years, the DEA has been widely used as a method for the construction of social indicators under different aspects, which were examined and analysed in the work of Mariano et al. (2015). One of the most used ways to build indicators through the DEA is the benefit of the doubt (BoD) approach, which was addressed in Cherchye et al. (2007) in its additive form and Zhou et al. (2010) in its multiplicative form. This approach eliminates the need for inputs and is based only in outputs. The BoD was

**Table 1** Agricultural area and establishments

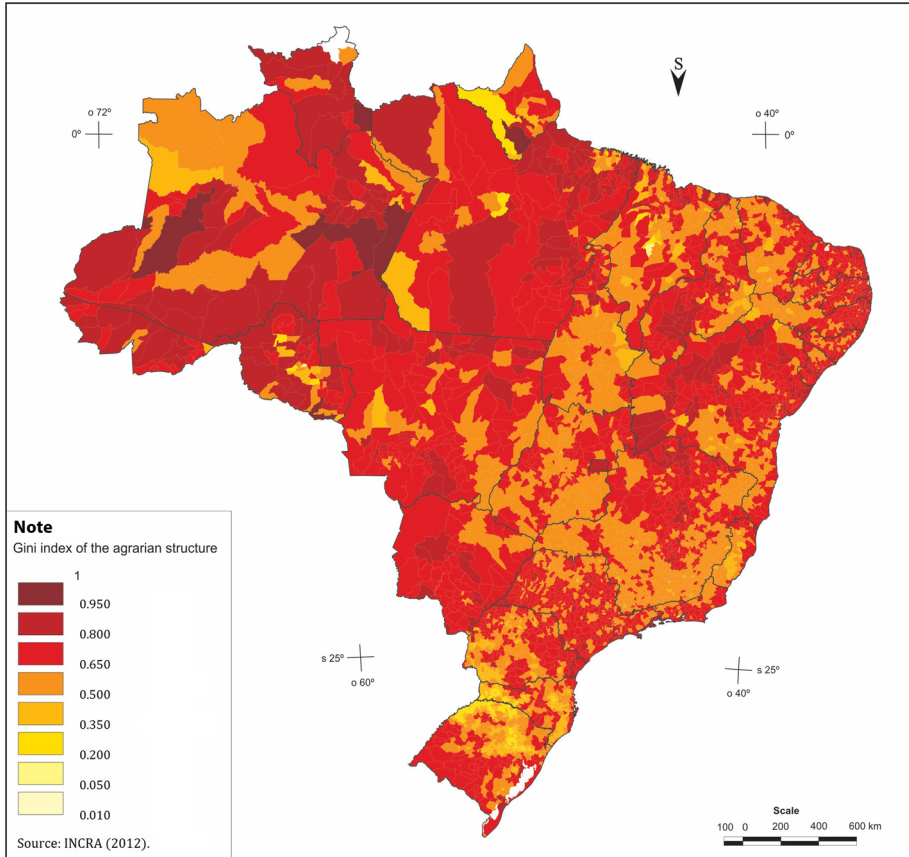
Structural data	1970	2006	Δ%
Establishments	4,924,019	5,175,489	4.86
Area used (ha)	294,145,466	329,941,393	10.85
Area\establishments	59.74	63.75	–

Source: Adapted from IBGE (2006)

**Table 2** Agrarian structure per activities

Activity	Number of properties	%	Area (ha)	%
Family farming	4,367,902	84.40	80,250,453	24.32
Non-family farming	807,587	15.60	249.690.940	75.68
Total	5175.489	100.00	329.941.393	100.00

Source: Adapted from IBGE (2006)



**Fig. 1** Gini index of the agrarian structure in 2011. Source: Dataluta (2011)

used in the work of Bernini et al. (2013), Despotis (2004), Domínguez-Serrano and Blancas (2011), Giambona and Vassallo (2013), Jurado and Perez-Mayo (2012), Morais et al. (2013) and Reig-Martínez (2013). Another possibility to build social indicators with the DEA to use inputs as undesirable variables and outputs as desired variables. This approach was used in the pioneering work of Hashimoto and Ishikawa (1993), in addition to Hashimoto and Kodama (1997), Martín and Mendoza (2013), Murias et al. (2006) and Carboni and Russu (2014).

A third type of social indicator obtained with DEA relates to the efficiency of obtaining a social benefit from some input, which can be related to government costs, production factors or previous environmental conditions. Works that conducted analyses of this type were: Mariano and Rebelatto (2013), Chaaban (2009), Debnath and Shankar (2014), Lopes and Camanho (2013) and Wu et al. (2013). This approach is the one that will be used in this work, which will build a comparative social index that measures the ability of each Brazilian state to resolve land conflicts.

Based on this context, the main objective of this paper is to present and examine the performance of 27 Brazilian states and also the last four presidential terms, from 1995 to 2011, in regards to mitigating social conflicts over land, minimising occupations and maximising the number of settlements created. It should be mentioned that this assessment could be useful to evaluate the states and presidential mandates in terms of the social policies carried out, as well as the actions of social movements within the territory or duration thereof. In order to explain the performance of the states, as a secondary objective it also sought to relate their performance with the most important mechanisms for creating settlements in the states.

Note that although there are some articles in the literature on agrarian reform, such as the work of May et al. (2002), which examined the case of South Africa, and the work of Wolford (2010) together with the recently published book review by Ondetti (2015), who analysed some aspects of Brazilian agrarian reform, there has been no work in which we sought the creation and analysis of indicators related to ability to resolve conflicts in the field.

The main contribution of this paper is the use of data envelopment analysis to construct of an index of agrarian conflict resolution, given that no previously published paper has considered this research question. This index allows us to evaluate how the Brazilian federation units are solving the struggle for land.

Thus, bearing in mind this objective, the outline of the paper is as follows. In Sect. 2, we describe briefly the main concepts and characteristics of the land struggle in Brazil and the structural aspects of Brazilian Agriculture. The basis of the data envelopment analysis (DEA) technique is introduced in Sect. 3. In Sect. 4 we describe the research method of this paper. Finally, our findings and conclusions are given in Sect. 5.

## 2 Theoretical Review

### 2.1 The Struggle for Land in Brazil

The struggle for land is one of the clearest contradictions of the agrarian question in Brazil. Notwithstanding the fact that the country is characterised by its large size, especially its cultivatable land and availability of natural resources, the struggle for land shows a reality of inequality and contradictions in Brazil's rural areas. Though little known, Brazil's rural scenario was and still is a scenario of great conflict. Among the many conflicts recorded in Brazil's history, the following stand out: the War of Canudos in the late nineteenth century, the Contested War in the second decade of the twentieth century, the Trombas and Formoso Revolt in the fifties, and the conflict of the peasant leagues in northeastern Brazil (Wolford 2003). Most of these conflicts were waged among peasants, rural workers, landowners, local political chiefs and the State.

Notwithstanding the contribution and importance of these forms of confrontation, particularly for building struggle and resistance strategies, it was with the creation of the Landless Rural Workers' Movement (MST) that land reform policies intensified (Antunes 2001; Wittman 2009; Hammond 1999; Vergara-Camus 2012).

The MST began with the end of the dictatorship in Brazil. Although conceived in the late 1970s, the movement was only created in 1984 in the state of Paraná, southern Brazil. The MST, in addition to bringing to the surface numerous problems related to the Brazilian agrarian question and also how agrarian reform was conducted by the dictatorial government, was also responsible for organising many isolated movements that began to unfold across the country in the period following the military government (Welch 2009; Fernandes 2000). It is worth noting that, in accordance with Fernandes (2000), land occupation was used by the MST as the key method for access to land.

After the creation of the MST, other peasant movements emerged by means of independent organisations or dissension processes. According to the Dataluta report (DATA-LUTA 2011), from 2000 to 2011, 114 peasant movements and their activities were recorded. This report describes that in the period of 1988–2011, a total of 8,536 land occupations were carried out. Fernandes (2000) points out that the creation of settlements has always been related to the intensification of land occupations. In summary, it can be stated that the struggle carried out by peasant movements in Brazil, from a wide range of topics, focuses on: the struggle for land and agrarian reform; struggle for access to water, gender equality, traditional rights and indigenous issues, public policies, and campaigns against the use of pesticides.

## 2.2 Land Reform Policies in Brazil

In Brazil the first experiences of agrarian reform began in the dictatorial government. The dictatorial agricultural policy gave rise to the creation of the Land Statute, the strategies of which were based on concealing the agrarian reform discourse, but which in fact served as a way to control the emerging conflicts and slow them down by the expropriation of public and private lands. The land reform policies promoted by the dictatorship were aimed at promoting the colonisation of the Midwest and North because these were underutilised and unpopulated regions. However, not even what was proposed by the Land Statute was concluded, and only a few remedial policies were enacted (Pacheco 2009).

At the end of the dictatorship in the 1980s, trade unions, social movements and land workers' coalitions tied to the political left emerged in Brazil. The MST emerged in 1984 and has since then performed numerous militant actions, which culminated in the intensification of the agrarian reform in Brazil (Antunes 2001). The emergence of the MST is considered a significant change, as the appearance of the movement in several Brazilian states and the pressure exerted against the predominance of large estates and against right-wing government has changed the manner of how agrarian reform is conducted.

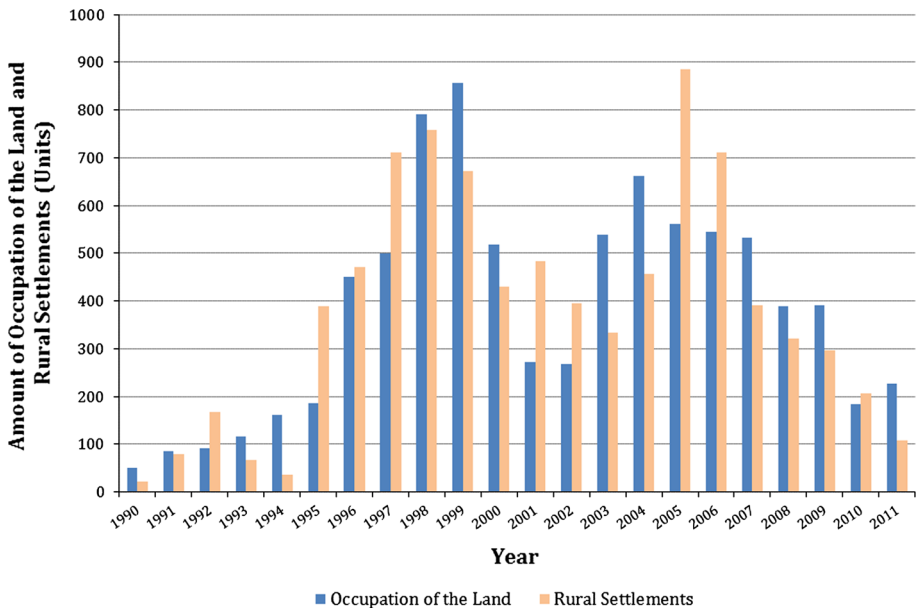
In 1985 President José Sarney approved the National Plan for Agrarian Reform, whose goal was to settle one million four hundred thousand families from 1985 to 1989 (Pacheco 2009). Associated with the plan were projects to support development for agrarian reform settlers, but according to data from the Land Struggle Database (DataLuta), these targets were not achieved. During this period, most of the settlements were created as a colonisation strategy, as carried out by the military government.

The 1990–1994 period was marked by the strengthening of neoliberalism in Brazil, as part of the government policies of Presidents Fernando Collor de Mello and Itamar Franco.

The outcome was strong support to large estates, which brought about an increase in land occupations and ensuing repression of these occupations.

Though previous governments had signaled great possibilities for neoliberalism, it was under FHC's government—President Fernando Henrique Cardoso—that it became stronger. For the rural workers' social movements, particularly the MST, the FHC government was marked in its first term, by a broad settlement policy and in its second term by considerable isolation, criminalisation and political persecution. Among various evident facts of this period, three stood out because of the consequences: (a) the massacre of Corumbiara on August 9, 1995, which began with an occupation and turned into a clash between police, hooligans and landless peasants, resulting in the death of 12 peasants and several victims of torture; (b) the massacre of Eldorado dos Carajás on April 17, 1996, which began with a march and ended with the killing of 19 landless peasants and over 100 injured; and (c) the approval of the 2109-52 interim measure in 2001, which stated that any member taking part in any land occupation would lose his right to access to land through land reform and the farm occupied would not be subject to agrarian reform during a 2-year period.

The land reform policies took another form during the government of President Luiz Inácio Lula da Silva (Lula). However, despite his trajectory in the Workers Party (PT) and his close proximity to the MST, the Lula government was a major disappointment to the peasant social movements (Vergara-Camus 2012), given that the creation of settlements, as well as the materialisation of land occupations significantly diminished. Thus, it can be surmised that this disappointment was based on the movements' expectations in regards to Lula, as well as the reduction in land reform policies, and the Second National Agrarian Reform Plan, prepared by the Lula government, which only escalated the movements'



**Fig. 2** Land occupation and rural settlements between 1990 and 2011. *Source:* Dataluta (2011)

disappointment. This can be observed considering the relationship between the materialisation of land occupations and the creation of rural settlements, as shown in Fig. 2.

In the conflictual context that includes land occupations and the creation of settlements, the ability of governments to resolve conflict through land reform policies, or not, is an important point to understand. However, to understand these points and then compare the performance of these social movements, one must understand the technique or method used in this article, in other words, the data envelopment analysis (DEA), as presented in the next section.

### 3 Data Envelopment Analysis

DEA is an operational research technique that aims, through the construction of an empirical frontier, to determine the efficiency of a set of Decision Making Units (DMUs), which in turn can be defined as an autonomous system responsible for transforming a set of inputs into a set of outputs. In other words, the DEA can be described as a mathematical procedure based on linear programming that is able to find the set of weights that maximises the efficiency of a DMU, allowing it to obtain an index that incorporates multiple inputs and multiple outputs, without having to convert them into a common base.

The type of return to scale specifies the two main DEA models: (a) CRS (Constant Returns to Scale), or CCR (Charnes et al. 1978); and (b) VRS (Variable Returns to Scale), or BCC (Banker et al. 1984). The CCR model is based on a linear relationship, in which an inputs increase causes a proportional and constant increase in the outputs; as for the BCC model, an input increase results in an increase that is not necessarily proportional to the outputs. In this study the BCC model was used because it considered that the number of settlements does not grow in proportion to the number of occupations; in other words, it

**Table 3** Output oriented *DEA BCC* model

Model	Formulations	
Multipliers	min Subject to:	$\sum_{j=1}^n v_j \cdot x_{j0} - s$ $\sum_{i=1}^m u_i \cdot y_{i0} = 1$ $\sum_{i=1}^m u_i \cdot y_{ik} - \sum_{j=1}^n v_j \cdot x_{jk} + s \leq 0, \quad \text{for } k = 1, 2, \dots, h$ $u_i \geq 0 \quad \text{for } i = 1, 2, \dots, m$ $v_j \geq 0 \quad \text{for } j = 1, 2, \dots, n$ $s \text{ without restriction of signal}$
Envelope	max Subject to:	$\eta$ $\sum_{k=1}^h x_{jk} \cdot \lambda_k \leq x_{j0} \quad \text{for } j = 1, 2, \dots, n$ $\sum_{k=1}^h y_{ik} \cdot \lambda_k - \eta \cdot y_{i0} \geq 0, \quad \text{for } i = 1, 2, \dots, m$ $\sum_{k=1}^h \lambda_k = 1,$ $\lambda_k \text{ and } \eta \geq 0 \quad \text{for } k = 1, 2, \dots, h$



was considered that one more occupation in a state with a history of numerous occupations does not have the same impact as an occupation in a state where hardly any occupations take place.

As for the orientation, it determines which type of variable, input or output, will be used as a basis to calculate the efficiency, as follows: (a) input-oriented models seek to determine, given the current level of output, to what degree the inputs could be reduced; and (b) output-oriented models seek to determine, given the current level of inputs, to what degree the outputs could be increased (Cooper et al. 2000). In this work an output orientation was used because it was considered more relevant to study the resolution of land conflicts from the maximisation of settlements than the minimisation of occupations.

In regards to how to represent the linear programming problem of *DEA*, the following are presented: (a) the multiplier model; and (b) the envelope model, as shown in Table 3. The multiplier model allows obtaining, in addition to efficiency, the weights for each input and output. The envelope model, in turn, allows obtaining the goals to be achieved and the benchmarks that serve as reference for the inefficient units. In short, Table 3 shows the formulations of the *BCC* model, output oriented, in the two forms of linear programming problem representation.

For all models presented the following were used:  $x_{jk}$  represents the amount of input  $j$  of *DMU*  $k$ ;  $y_{ik}$  represents the amount of output  $i$  of *DMU*  $k$ ;  $x_{j0}$  represents the amount of input  $j$  of the *DMU* under analysis;  $y_{i0}$  represents the amount of output  $i$  of the *DMU* under analysis;  $v_j$  represents the weight of input  $j$  for the *DMU* under analysis;  $u_i$  represents the weight of output  $i$  for the *DMU* under analysis;  $s$  represents the scale factor;  $\theta$  represents the efficiency of the *DMU* under analysis;  $\eta$  represents the inverse of the efficiency of the *DMU* under analysis;  $\lambda_k$  represents the contribution of *DMU*  $k$  for the goal of the *DMU* under analysis;  $m$  represents the number of outputs analysed;  $n$  represents the number of inputs analysed; and  $h$  represents the number of *DMU* analysed.

### 3.1 Triple Index

Due to the substantial freedom of the *DEA* system to assign weights, it often leads to situations in which there are multiple draws (equal scores) between efficient *DMUs*. In this study we chose to use an indicators set, designated “*Triple Index*”— $\mathbb{E}_k^{\text{Triple}}$ , which was determined by the weighted geometric mean normalised between: (a) the efficiency obtained at the standard frontier— $\mathcal{E}_{kk}$ , (b) the “*multiplicative cross-evaluating index*”— $\mathcal{E}_k^{\text{MCross}}$ , and (c) the “*inverted index*”— $\mathcal{E}_k^{\text{Inv}}$  (Mariano and Rebelatto 2013). The calculation of the “*Triple Index*” is illustrated in Eq. 1.

$$\mathbb{E}_k^{\text{Triple}} = \frac{(\mathcal{E}_{kk})^\alpha \times (\mathcal{E}_k^{\text{MCross}})^\beta \times (\mathcal{E}_k^{\text{Inv}})^\gamma}{\max_k \left\{ (\mathcal{E}_{kk})^\alpha \times (\mathcal{E}_k^{\text{MCross}})^\beta \times (\mathcal{E}_k^{\text{Inv}})^\gamma \right\}}, \text{ with } (\alpha + \beta + \gamma) = 1 \tag{1}$$

wherein:  $\mathbb{E}_k^{\text{Triple}}$  represents the “*triple index*” of a *DMU* $_k$ ;  $\mathcal{E}_k^{\text{Inv}}$  represents the “*inverted index*” of a *DMU* $_k$ ;  $\mathcal{E}_k^{\text{MCross}}$  represents the “*cross-multiplicative index*” of a *DMU* $_k$ ;  $\mathcal{E}_{kk}$  represents the efficiency of the *DMU* $_k$  calculated with the standard frontier; and  $\alpha, \beta$  and  $\gamma$  represent the weights assigned to each of the components of the “*triple index*”.

According to Mariano and Rebelatto (2013), the use of the geometric mean is more appropriate because it penalises large discrepancies between the indexes to be combined, therefore it is widely used in the calculation of index numbers, such as the Fisher, Törnqvist and Malmquist indexes. According to Expression 1, different weights can be assigned

to each index component of the triple index; however, for lack of further information, in this work equal weights of 1/3 were used for each index.

The approach of the “*cross-multiplicative index*” consists of the normalised value obtained in the multiplicative version of the traditional cross-evaluation technique (Doyle and Green 1994). This multiplicative version is based on the geometric mean of the efficiencies obtained with all the different sets of weights, disregarding the weights that maximise the efficiency of the DMU under analysis. Equation 2 illustrates the calculation of this index.

$$\mathcal{E}_k^{MCross} = \frac{\sqrt[h-1]{\prod_{\forall l \neq k} \mathcal{E}_{lk}}}{\max_k \left\{ \sqrt[h-1]{\prod_{\forall l \neq k} \mathcal{E}_{lk}} \right\}} \tag{2}$$

wherein:  $\mathcal{E}_k^{MCross}$  represents the “*cross-multiplicative index*” of a  $DMU_k$ ;  $\mathcal{E}_{lk}$  represents the efficiency of the  $DMU_k$  calculated with the weights that maximise the efficiency of the  $DMU_l$ ; and  $h$  represents the number of  $DMUs$  analysed.

To avoid an undue influence of the software in the calculation of the cross-multiplicative index, since the efficient units admit multiple solutions, in this paper a second optimisation based on a model proposed by Wang and Chin (2010) was performed to find a single set of weights for each DMU. We emphasise that in the work of Mariano and Rebelatto (2013), the variation point of the weights was resolved by the exclusion of the weights from the efficient units. The approach chosen in this work is based on a Maximum model, in which the smallest contribution to efficiency (weight multiplied by the value of the variable), among the inputs and outputs, was maximised, as illustrated by Eq. 3.

$$\begin{aligned} & \max \delta \\ \text{Subject to:} & \\ & \sum_{i=1}^m \mu_i \cdot y_{i0} = 1 \\ & \sum_{j=1}^n v_j \cdot x_{j0} - s = \eta \\ & \sum_{i=1}^m \mu_i \cdot y_{ik} - \sum_{j=1}^n v_j \cdot x_{jk} + s \leq 0, \quad \text{for } \forall k \neq 0 \\ & \mu_i \cdot y_i - \delta \geq 0 \quad \text{for } i = 1, 2, \dots, m \\ & v_j \cdot x_j - \delta \geq 0 \quad \text{for } j = 1, 2, \dots, n \\ & \delta, v_j \text{ and } u_i \geq 0 \\ & w \text{ without restriction of signal} \end{aligned} \tag{3}$$

The “*inverted index*”, on the other hand, consists of the normalised value of one divided by the efficiency obtained from the inverted frontier, using a reversed orientation  $1/\mathcal{E}_{kk}$ . It should also be emphasised that it is important to change the orientation when using the inverted frontier (from inputs to outputs and vice versa), so that the calculation of the inverted value of the index obtained keeps the original orientation (Mariano and Rebelatto 2013). Equation 4 illustrates how to calculate the “*inverted index*”.

$$\mathcal{E}_k^{Inv} = \frac{1/\mathcal{E}'_{kk}}{\max_k \{1/\mathcal{E}'_{kk}\}} \tag{4}$$

$\mathcal{E}_k^{Inv}$  represents the “inverted index” of the  $DMU_k$ ; and  $\mathcal{E}'_{kk}$  represents the efficiency of the  $DMU_k$  calculated with the inverted frontier, using a reversed orientation.

The inverted frontier, developed by Leta et al. (2005), from the proposition of Yamada et al. (1994), consists of exchanging the place of the inputs with the outputs. This frontier can be understood as the frontier of the worst practices, as shown in Fig. 3.

### 4 Method and Data

As discussed earlier, in this paper the relative performance of the Brazilian states and the presidential terms will be evaluated in regards to mediating land disputes. We emphasise that this performance was evaluated by the efficiency of a State, or a presidential mandate, to convert the occupations, or time span, that took place in its territory into settlements.

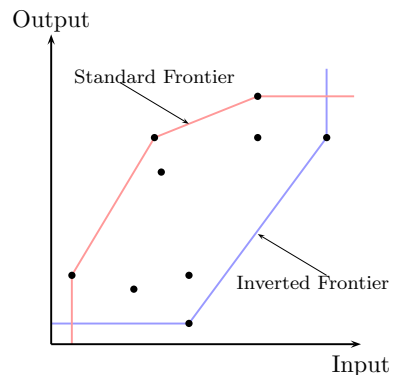
Thus, in the first stage of the work the relative performance of the 27 Brazilian states was determined (26 states plus the Federal District), for each of the last four presidential terms, hence four DEA applications with 27 DMUs each. Figure 4 shows a map of Brazil, considering political divisions, where each state is shown with its respective abbreviations.

In the second stage, the average of the states’ variables for each presidential term was used in order to obtain the relative performance of these mandates, by performing a single DEA application with four  $DMUs$ . In the third stage of the work, the results obtained in the previous stages were correlated with the main types of settlements in every Brazilian state. Table 4 has a brief description of these types of settlements to help interpret the results.

In the first two stages the Microsoft Excel® software solver tool was used in order to determine, from the output-oriented  $BCC$  DEA model, the standard efficiency, inverted index, and single weights of each  $DMU$ , which were used to determine the cross-multiplicative index. Next, with the same software, the calculations of the triple index were performed using equal weights (1/3) for each subindex.

As for the variables, a single input was used, related to the number of land occupations, and two outputs: (a) number of settlements, and (b) the total capacity of these settlements. It is highlighted that although the total capacity of settlements is closely related to the number of settlements created, the two variables have different goals, as it is equally

**Fig. 3** Standard and inverted frontiers. *Source:* Silveira et al. (2012)



important that they be large settlements that can accommodate a large number of people, and also numerous, hence allowing a better distribution of land.

A correlation analysis between variables indicated that the capacity and number of settlements have a correlation ranging between 0.78 and 0.82, depending on the mandate in question; this result, though it indicates some redundancy, does not invalidate the variables to be used in the DEA.

Table 5 shows the input and output data for each state in the last four presidential terms: *FHC 1* (1995–1998), *FHC 2* (1999–2002), *Lula 1* (2003–2006) and *Lula 2* (2007–2010). It is emphasised that these data were used to compare the states in each presidential term and that the mean data for all states (last row of the table) were used to compare the mandates.

According to Table 5, the number of occupations remained stable in FHC's two terms, grew in Lula's first term and declined significantly in the second term. Regarding the quantity and capacity of the settlements, what stands out regards the first mandates of FHC's government and Lula's government, and in the second terms, especially in Lula's second term, there was a significant drop. Also according to Table 4, the states with the highest number of occupations were São Paulo and Pernambuco; and the state with the



**Fig. 4** Map of Brazil and its regions

highest number of settlements was Maranhão, and Pará had the greatest total capacity of settlers.

The data presented in Table 5 were extracted from the Dataluta database. The Database of The Struggle for Land (DATALUTA) is a large database that organises and compares conflict data registries of two institutions and one network, namely: the Pastoral Land Commission (CPT), the National Agrarian Auditor (OAN), and the Dataluta network. The CPT is a body created by the National Conference of Bishops of Brazil (CNBB), which initially conducted a pastoral service with workers, indigenous people and peasants in the fight for freedom and dignity and against the expropriation process in the field. The CPT also began organising information about rural conflicts, such as expropriation, assassinations, death threats, land occupations, and many others. During a significant part of 1990, the data collection was carried out with their presence in the land occupations, but in the last decade it has been carried out by collecting and organizing information based on the main national journals in circulation to reduce costs and because the data were recorded in the field.

OAN was created in 1999 by President Fernando Henrique Cardoso in order to carry out mediation and resolution and to record conflict data in the field. However, over the years OAN has withdrawn from presenting information and actively participating, given that its data can now be obtained from the main national newspapers. The Dataluta Network is basically formed by eleven groups/research laboratories located in the states of Espírito Santo, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Paraíba, Paraná, Rio de Janeiro, Rio Grande do Sul, São Paulo and Sergipe.

The data are collected from national and local newspapers in circulation. The process of recording and organising information by newspapers of national circulation and local circulation is an important means of transmitting the greatest amount of information possible. It is important to point out that according to the national researchers, this way of obtaining data is considered the most viable, given Brazil's large territorial proportions, and the costs required to register this information, as the information is freely transmitted by the newspapers and the indifference of the State in obtaining and creating efficient ways to register the conflict in the country, especially in rural areas, since disseminating

**Table 4** Description of the types of settlement

Type of settlement	Description
Expropriation	Directives stipulated in Articles 184, 185 and 186 of the Federal Constitution of Brazil fundamentally applied to properties which did not fulfill their social function
Recognition	Incorporation of rural settlement projects created by municipal and state powers on the basis of the National Institute of Colonization and Agrarian Reform (INCRA) and therefore integrated into the jurisdiction of the federal government, as well as its programs and policies
Indefinite	No specific definition
Purchase	Based on Article 1 of Decree 433 of January 1992, INCRA can acquire rural properties used to promote agrarian reform and therefore the creation of settlements
Gathering	Objectively based on the incorporation of unoccupied lands to public property
Other	Adds other acquisition policies, and also those of less significance, for example, adjudication, remise and confiscation

**Table 5** Data used to calculate efficiency

DMUs	Occupations				Capacity				Settlements			
	FHC 1	FHC 2	LULA 1	LULA 2	FHC 1	FHC 2	LULA 1	LULA 2	FHC 1	FHC 2	LULA 1	LULA 2
	AC	7	5	6	1	6555	2784	8993	1554	33	27	47
AL	62	151	126	211	2900	2241	2310	5399	31	28	34	57
AM	3	4	1	2	1585	3214	15,029	11,659	7	13	44	51
AP	1	0	1	0	6135	2446	2945	172	17	30	8	2
BA	131	73	156	169	15,541	6111	14,052	4832	146	88	288	78
CE	20	22	26	26	13,262	1599	1939	1981	223	40	45	51
DF	10	3	18	7	395	138	0	0	7	2	0	0
ES	27	24	25	11	1710	691	838	402	22	12	18	7
GO	116	68	129	64	6946	4482	6497	6933	116	83	116	94
MA	31	21	16	15	55,063	23,705	29,697	4563	280	260	281	68
MG	121	174	222	114	7266	6299	5256	2745	102	85	107	64
MS	146	231	89	26	7519	5274	9538	5247	53	41	42	40
MT	38	30	52	10	33,814	25,295	11,923	6624	167	152	158	30
PA	81	136	140	124	55,532	25,081	113,343	29,899	194	191	439	162
PB	66	32	43	32	6657	3031	1854	1083	102	57	45	37
PE	279	339	434	151	7921	7386	12,461	4862	104	137	186	86
PI	23	15	31	1	9319	7167	11,433	4096	89	100	190	87
PR	180	157	210	76	7273	3952	3594	1355	106	82	32	18
RJ	12	29	42	10	1228	616	871	960	10	9	17	12
RN	56	30	21	8	8537	5097	3372	1045	109	95	33	20
RO	23	16	40	18	10,255	10,193	733	2529	46	55	12	45
RR	1	0	6	4	7201	1448	2710	386	23	4	16	4
SC	51	24	41	24	1936	727	542	460	42	26	16	21
SE	47	40	38	10	2946	2110	1685	1801	43	46	44	54

**Table 5** continued

<i>DMUs</i>	Occupations						Capacity						Settlements											
	FHC 1		FHC 2		LULA 1		LULA 2		FHC 1		FHC 2		LULA 1		LULA 2		FHC 1		FHC 2		LULA 1		LULA 2	
SP	352	209	336	334	3771	4607	3250	3564	62	76	58	38												
TO	21	15	14	13	9113	4658	4251	2022	105	78	86	45												

information internationally about Brazil's conflict in rural areas could mean losses and reduced foreign capital investment in the Brazilian economy.

The DATALUTA database is formed by comparing and verifying these three sources. Comparison of data and information is carried out by the researchers from the Nucleus for Studies, Research and Projects in Agrarian Reform (NERA) and is a fundamental part of the process of avoiding differing and duplicated information. Altogether, the Dataluta Base of Land Occupations has organised information since 1988, including the number of occupations, location, date, name of the social movement that conducted the occupation and how many families carried out the action, totaling 8,736 actions by rural workers' social movements.

## 5 Findings and Conclusions

In order to compare the performance of social movements in each Brazilian state, the Triple Index was calculated for the last four presidential mandates in Brazil (FHC 1, FHC 2, Lula 1 and Lula 2). More specifically, this value enabled us to produce a detailed classification of the Brazilian states in creating settlements from the occupation of lands. Table 6 shows the results of the Triple Index as well as the ranking of each state at each term given by this index. It is worth mentioning that the higher value of the Triple Index found in Table 6 represents the worst performance among the Brazilian States.

To make the results in Table 6 more understandable, they were transformed into maps which used a color scale based on the result of the Triple Index, as shown in Fig. 5.

If we take a careful look at the results shown in Table 6 and Fig. 5, it can be highlighted that:

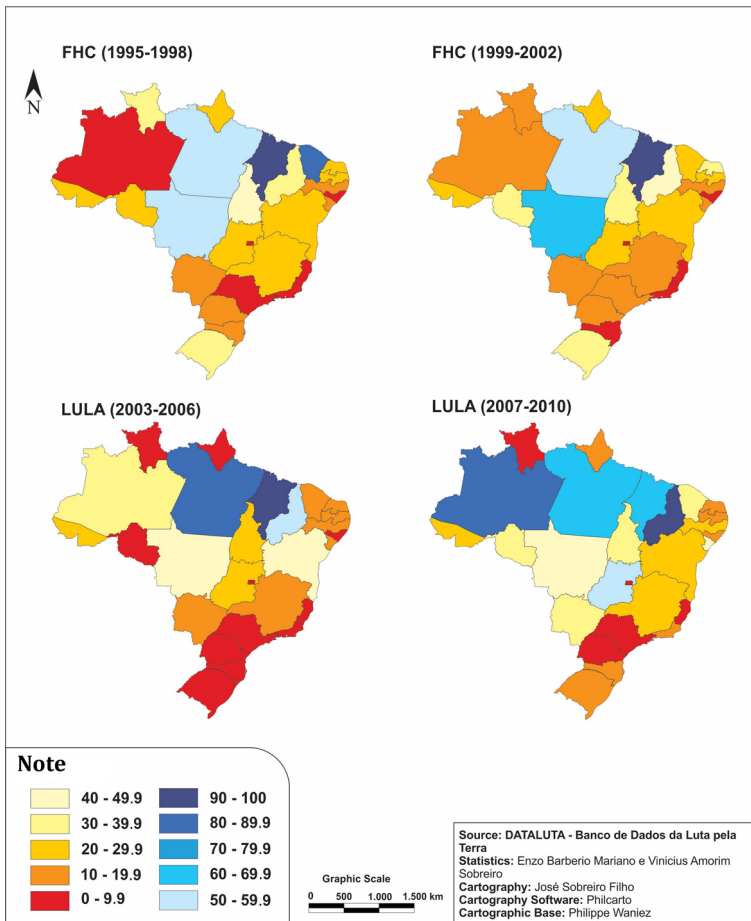
1. In all presidential terms, the southeast and southern regions showed the highest inefficiency in creating settlements compared to other regions, especially the states of São Paulo, Rio de Janeiro and Espírito Santo;
2. On average, the states of the northern region were the most efficient in creating settlements in all mandates, despite the poor performance of Roraima and Amapá in some mandates;
3. Maranhão had the best performance in almost all presidential terms, except for President Lula's second term, when Piauí did better. Its good performance in these three terms is due to the considerable number of settlements created in that state. As for Piauí's excellent performance in the second term of Lula's government, it is due to the incredibly low number of occupations (one only);
4. Piauí and Amazonas were the states that most evolved in comparison to the other states. However, Ceará had a sharp drop after FHC's first term;
5. President Lula's second mandate had the highest average efficiency, which resulted in the map tending more to blue than to red. This indicates that the performance of the states was more homogeneous, with no major discrepancies, and a possible explanation may be that there was a widespread decline of occupations in that period;
6. The high average efficiency of the State of Pará, and as a consequence the extensive policy of creating settlements, is directly related to government strategies to contain the impending conflict in the region, especially due to the past events of threats, murders and massacres, such as the Eldorado dos Carajás, which was widely divulged by the international media and denounced by the Catholic Church;



7. Although the State of Paraná demonstrated an expressive creation of settlements, which included using expropriating policies, its average efficiency remained relatively low during all governments, characterised as one of the most inefficient, despite the higher number of settlements created in the South;
8. During Lula's tenure the efficiency and the relative positions of Rio Grande do Sul and Paraná were among those that most worsened in relation their performance under FHC; and
9. In the Southeast region, the state of Minas Gerais has always been the most efficient, and despite a significant reduction in the number of settlements, its efficiency did not change much.

**Table 6** Results of the triple index

UF	Triple index				Ranking			
	FHC 1	FHC 2	LULA 1	LULA 2	FHC 1	FHC 2	LULA 1	LULA 2
AC	24.54	21.24	26.47	28.61	12	13	8	12
AL	8.31	7.61	6.31	17.97	22	24	21	18
AM	6.93	11.9	38.31	89.67	25	20	6	2
AP	23.76	26.62	7.25	11.04	13	9	18	21
BA	29.34	24.49	45.27	23.44	10	11	4	14
CE	89.08	26.24	13.18	31.74	2	10	12	11
DF	4	2.33	0	0	27	27	27	27
ES	7.85	5.33	5.39	6.45	23	25	22	25
GO	23.62	22.2	20.64	50.89	14	12	9	5
MA	100	100	100	61.58	1	1	1	4
MG	20.64	19.76	14.23	20.48	15	15	10	15
MS	10.38	10.38	10.55	36.7	21	22	16	8
MT	56.62	68.91	44.15	41.27	4	2	5	7
PA	57.62	55.54	87.53	69.42	3	3	2	3
PB	26.11	20.53	12.03	19.23	11	14	13	16
PE	14.61	19.43	13.69	26.38	18	16	11	13
PI	34.8	41.86	58.8	100	6	4	3	1
PR	18.03	17.1	5.07	8.99	17	17	23	24
RJ	5.6	3.71	4.8	13.05	26	26	24	20
RN	29.98	30.8	11.37	18.98	9	7	15	17
RO	20.48	30.22	3.59	36.19	16	8	26	10
RR	30.31	14.27	8.5	5.45	8	18	17	26
RS	31.54	39.92	6.35	17.76	7	5	20	19
SC	10.65	8.6	4.18	10.9	20	23	25	22
SE	12.47	13.82	11.92	41.44	19	19	14	6
SP	7.71	11.01	6.58	9.38	24	21	19	23
TO	42.33	37.33	28.76	36.31	5	6	7	9
Mean	27.68	25.6	22.03	30.86	–	–	–	–



**Fig. 5** Triple Index considering occupation of the land, settlement and settler families

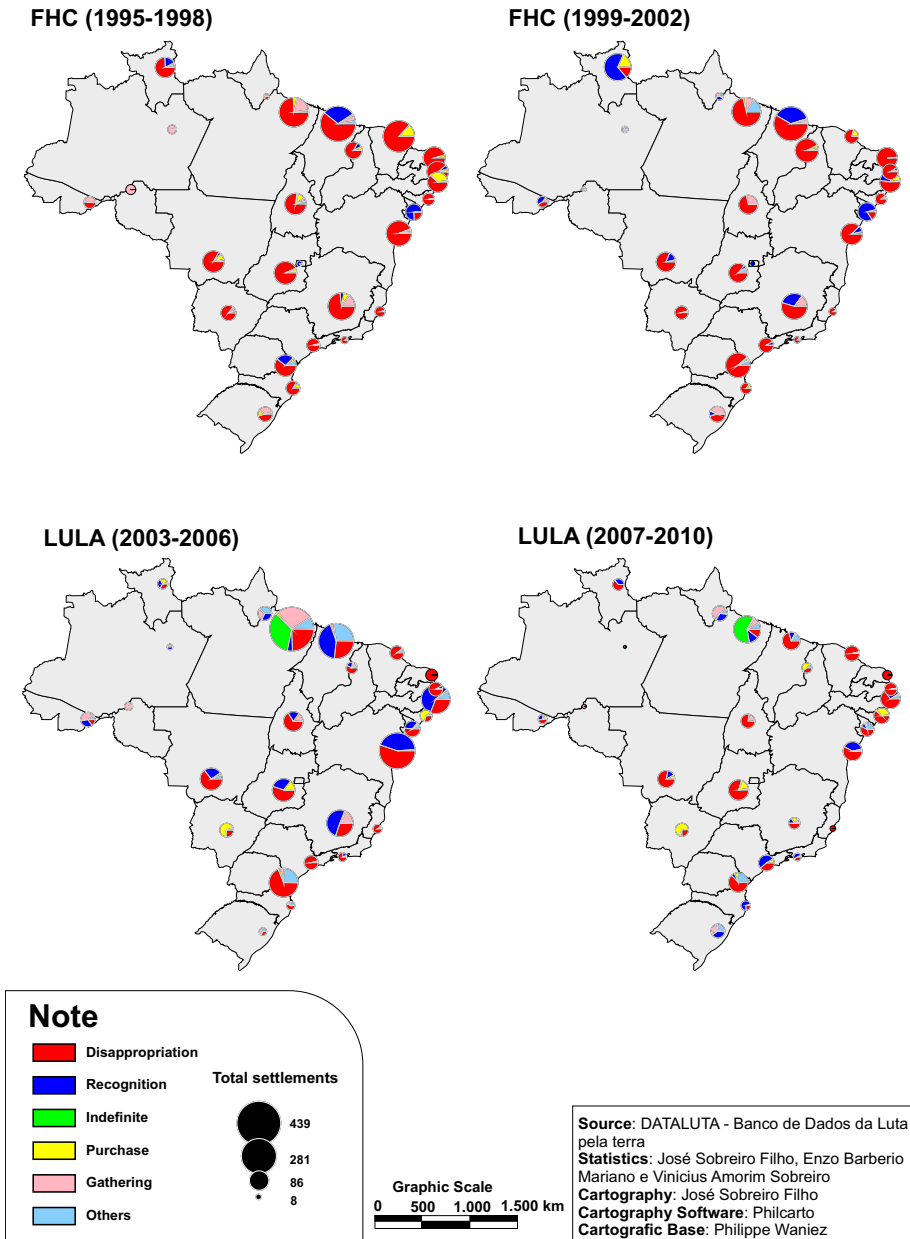
In order to assess the relative performance of each presidential mandate, the triple index had to be calculated, considering that each of the four terms was a separate DMU. From this analysis it was concluded that FHC's first term was the most efficient in creating settlements from the number of occupations, with a triple index of 100 %. President Lula's mandate ranks second, also characterised by a high efficiency, with a triple index of 92.42 %. Finally, it is worth noting that FHC's second term and Lula's first term had weak and very similar performance, with the triple index of 83.65 and 82.89 %, respectively.

However, a full understanding of the reality of agrarian reform policies is only possible by observing the manner in which the settlements are created or the type of settlement policies. Bearing in mind this perspective, Fig. 6 shows the key processes in creating rural settlements.

In similar manner as shown in Fig. 5, Fig. 6 highlights that:

1. President Lula's two terms were marked by a higher variety of policies for creating settlements and also by a decrease in the number of settlements created, especially in the second term;

- In FHC's first term, which was the most efficient, the settlements from expropriation prevail; as for Lula's second term (the second most efficient), expropriation lost strength. Yet one cannot fail to mention that expropriation prevails in almost all states and mandates;



**Fig. 6** Ways of creating rural settlements. *Note* the size of the circles is proportional to the number of settlements created in each state

3. During the tenure of President Lula, the Northeast region was characterised by keeping expropriation as the predominant policy for the creation of settlements, unlike what happened in some states in the South and Southeast regions, such as Rio Grande do Sul, Santa Catarina and Minas Gerais;
4. Also in the Northeast region, there was a significant increase in recognition under President Lula's government, and it was only in Sergipe that expropriation grew, which led to greater efficiency in President Lula's last term;
5. During Lula's first presidential term, recognition increased and went on to occupy the second most expressive position;
6. Maranhão, which had a high efficiency, was one of the states with the lowest expropriation percentage in all presidential terms;
7. In the second term of Lula's government, Piauí, which was the most efficient state, prevailed in settlements by purchase, given that in previous mandates, when it was inefficient, expropriation prevailed;
8. Expropriation is not significant in the northern region of the country;
9. In the State of Rio Grande do Sul during FHC governments, the expropriation policy shared predominance. However, during President Lula's governments there was both a reduction in the creation of settlements as well as a reflux of desapropriation policies, leading to their almost non existence in the second term. It is worth noting that the State of Rio Grande do Sul is renowned for being the birthplace of MST before its creation in 1984, and this movement, marked by intense struggles, publicly defended an agrarian reform policy by expropriation;
10. During the four presidential terms the gathering policy prevailed in a few states. The Northern region concentrates most of these, particularly in Rondônia, Pará and Acre; and
11. Despite the massive growth of the recognition policies under President Lula's governments, the Midwest region, especially the state of Mato Grosso do Sul, stood out for expansions of the purchasing policy.

Comparing Figs. 5 and 6, it can be noted that in both mandates of Lula's government, the areas with the highest Triple Index did not have the creation of settlements supported predominantly by an expropriation policy, as expropriation was losing intensity and regulation was increasing. This situation reflects a change in strategy in how to promote the creation of settlements.

The main argument today is supported by the different understandings of agrarian reform, and currently there are two predominant analyses and insights on the topic: (a) one understands that land reform should reach agrarian concentration; and (b) one characterised by considering agrarian reform as a broader set of policies. In this sense, Pacheco (2009), representatives of the first concepts, conduct a severe critique regarding the current creation of rural settlements, because in recent years the federal government, through the Ministry of Agrarian Development (MDA) and INCRA, have recognised settlements that were previously created by the states, regularising squatters and traditional communities, and declaring this to be land reform. In other words, they point out that recognition does not decentralise the agrarian structure and therefore cannot be considered land reform.

In regards to the limitations and possibility for future studies, the authors recommend that other techniques such as stochastic efficiency frontiers be applied to a larger set of parameters to consider the implications of land grabbing in the agrarian structure.

## References

- Antunes, R. (2001). Global economic restructuring and the world of labor in Brazil: The challenges to trade unions and social movements. *Geoforum*, 32(4), 449–458.
- Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30(9), 1078–1092.
- Bernini, C., Guizzardi, A., & Angelini, G. (2013). DEA-like model and common weights approach for the construction of a subjective community well-being indicator. *Social Indicators Research*, 114(2), 405–424.
- Brannstrom, C. (2001). Producing possession: Labour, law and land on a Brazilian agricultural frontier, 1920–1945. *Political Geography*, 20(7), 859–883.
- Carboni, O. A., & Russu, P. (2014). Assessing regional wellbeing in Italy: An application of Malmquist—DEA and self-organizing map neural clustering. *Social Indicators Research*, 122(3), 677–700.
- Chaaban, J. M. (2009). Measuring youth development: A nonparametric cross-country ‘youth welfare index’. *Social Indicators Research*, 93(2), 351–358.
- Charnes, A., Cooper, W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2(6), 429–444.
- Cherchye, L., Moesen, W., Rogge, N., & Puyenbroeck, T. V. (2007). An introduction to ‘benefit of the doubt’ composite indicators. *Social Indicators Research*, 82(1), 111–145.
- Cooper, W. W., Seiford, L. M., & Tone, K. (2000). *Data envelopment analysis: A comprehensive text with models, applications reference and DEA-solver software*. Dordrecht: Kluwer Academic.
- Dasgupta, S., Mamingi, N., & Meisner, C. (2001). Pesticide use in Brazil in the era of agroindustrialization and globalization. *Environment and Development Economics*, 6(4), 459–482.
- DATALUTA. (2011). Dataluta: Banco de dados pela terra - relatório brasil 2011. Tech. rep., DATALUTA
- Debnath, R. M., & Shankar, R. (2014). Does good governance enhance happiness: A cross nation study. *Social Indicators Research*, 116(1), 235–253.
- Deibel, E. (2012). Open variety rights: Rethinking the commodification of plants. *Journal of Agrarian Change*, 13(2), 282–309.
- Despotis, D. K. (2004). A reassessment of the human development index via data envelopment analysis. *Journal of the Operational Research Society*, 56(8), 969–980.
- Domínguez-Serrano, M., & Blancas, F. J. (2011). A gender wellbeing composite indicator: The best–worst global evaluation approach. *Social Indicators Research*, 102(3), 477–496.
- Doyle, J., & Green, R. (1994). Efficiency and cross-efficiency in DEA: Derivations, meanings and uses. *Journal of the Operational Research Society*, 45(5), 567–578.
- Fernandes, B. M. (2000). A formação do MST no Brasil. 853262345X, Vozes, Rio Grande do Sul.
- Fernandes, B. M., Welch, C. A., & Gonçalves, E. C. (2010). Agrofuel policies in Brazil: Paradigmatic and territorial disputes. *Journal of Peasant Studies*, 37(4), 793–819.
- Giambona, F., & Vassallo, E. (2013). Composite indicator of social inclusion for European countries. *Social Indicators Research*, 116(1), 269–293.
- Hammond, J. L. (1999). Law and disorder: The Brazilian landless farmworkers’ movement. *Bulletin of Latin American Research*, 18(4), 469–489.
- Hashimoto, A., & Ishikawa, H. (1993). Using DEA to evaluate the state of society as measured by multiple social indicators. *Socio-Economic Planning Sciences*, 27(4), 257–268.
- Hashimoto, A., & Kodama, M. (1997). Has livability of Japan gotten better for 1956–1990?: A DEA approach. *Social Indicators Research*, 40(3), 359–373.
- IBGE. (2006). Censo agropecuário. Tech. rep., IBGE.
- Jurado, A., & Perez-Mayo, J. (2012). Construction and evolution of a multidimensional well-being index for the Spanish regions. *Social Indicators Research*, 107(2), 259–279.
- Kloppenborg, J. (2010). Impeding dispossession, enabling repossession: Biological open source and the recovery of seed sovereignty. *Journal of Agrarian Change*, 10(3), 367–388.
- Leta, F. R., Soares de Mello, J., Gomes, E. G., & Meza, L. A. (2005). Métodos de melhora de ordenação em dea aplicados à avaliação estática de tornos mecânicos. *Investigação Operacional*, 25(2), 229–242.
- Lopes, M. N., & Camanho, A. S. (2013). Public green space use and consequences on urban vitality: An assessment of European cities. *Social Indicators Research*, 113(3), 751–767.
- Lopes Soares, W., & Firpo de Souza Porto, M. (2009). Estimating the social cost of pesticide use: An assessment from acute poisoning in Brazil. *Ecological Economics*, 68(10), 2721–2728.
- Mariano, E. B., & Rebelatto, D Ad N. (2013). Transformation of wealth produced into quality of life: Analysis of the social efficiency of nation-states with the DEA’s triple index approach. *Journal of the Operational Research Society*, 65(11), 1664–1681.

- Mariano, E. B., Sobreiro, V. A., & Rebelatto, D Ad N. (2015). Human development and data envelopment analysis: A structured literature review. *Omega*, *54*, 33–49.
- Martín, J. C., & Mendoza, C. (2013). A DEA approach to measure the quality-of-life in the municipalities of the Canary Islands. *Social Indicators Research*, *113*(1), 335–353.
- May, J., Stevens, T., & Stols, A. (2002). Monitoring the impact of land reform on quality of life: A South African case study. In *Assessing quality of life and living conditions to guide national policy: The state of the art*, Social Indicators Research Series (Vol. 11, pp. 293–312). Springer, New York.
- Morais, P., Miguéis, V. L., & Camanho, A. S. (2013). Quality of life experienced by human capital: An assessment of European cities. *Social Indicators Research*, *110*(1), 187–206.
- Murias, P., Martínez, F., & Miguel, C. (2006). An economic wellbeing index for the Spanish provinces: A data envelopment analysis approach. *Social Indicators Research*, *77*(3), 395–417.
- Ondetti, G. (2015). Social movements, law and the politics of land reform: Lessons from Brazil. *The Journal of Peasant Studies*, *42*(1), 236–239.
- Pacheco, P. (2009). Agrarian reform in the Brazilian amazon: Its implications for land distribution and deforestation. *World Development*, *37*(8), 1337–1347.
- Reig-Martínez, E. (2013). Social and economic wellbeing in Europe and the Mediterranean Basin: Building an enlarged human development indicator. *Social Indicators Research*, *111*(2), 527–547.
- Silveira, J Qd, Meza, L. A., & JaCCBS, Mello. (2012). Identificação de Benchmarks e Anti-Benchmarks para companhias aéreas usando modelos DEA e fronteira invertida. *Produção*, *22*(4), 788–795.
- Vergara-Camus, L. (2012). The legacy of social conflicts over property rights in rural Brazil and Mexico: Current land struggles in historical perspective. *The Journal of Peasant Studies*, *39*(5), 1133–1158.
- Wang, Y. M., & Chin, K. S. (2010). Some alternative DEA models for two-stage process. *Expert Systems with Applications*, *37*(12), 8799–8808.
- Welch, C. (2009). Camponeses: Brazil's peasant movement in historical perspective (1946–2004). *Latin American Perspectives*, *36*(4), 126–155.
- Wield, D., Chataway, J., & Bolo, M. (2010). Issues in the political economy of agricultural biotechnology. *Journal of Agrarian Change*, *10*(3), 342–366.
- Wittman, H. (2009). Reframing agrarian citizenship: Land, life and power in Brazil. *Journal of Rural Studies*, *25*(1), 120–130.
- Wolford, W. (2003). Producing community: The MST and land reform settlements in Brazil. *Journal of Agrarian Change*, *3*(4), 500–520.
- Wolford, W. (2010). Participatory democracy by default: Land reform, social movements and the state in Brazil. *Journal of Peasant Studies*, *37*(1), 91–109.
- Wu, P. C., Huang, T. H., & Pan, S. C. (2013). Country performance evaluation: The DEA model approach. *Social Indicators Research*, *118*(2), 835–849.
- Yamada, Y., Matui, T., & Sugiyama, M. (1994). New analysis of efficiency based on DEA. *Journal of the Operations Research Society of Japan*, *37*(1), 158–167.
- Zhou, P., Ang, B. W., & Zhou, D. Q. (2010). Weighting and aggregation in composite indicator construction: A multiplicative optimization approach. *Social Indicators Research*, *96*(1), 169–181.