Acta Scientiarum
http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8621
Doi: 10.4025/actasciagron.v42i1.44440
CC BY

Analysis of static and dynamic capacity in Paraná State, Brazil

Elizabeth Giron Cima[1*], Miguel Angel Uribe-Opazo[1], Jerry Adriani Johann[1], Weimar Freire da Rocha Junior[2] and Willyan Ronaldo Becker[1]

[1]Programa de Pós-Graduação em Engenharia Agrícola, Universidade Estadual do Oeste do Paraná, Rua Universitária, 1619, 85819-170, Cascavel, Paraná, Brazil. [2]Programa de Pós-Graduação em Desenvolvimento Regional e Agronegócio, Universidade Estadual do Oeste do Paraná, Toledo, Paraná, Brazil. *Author for correspondence. E-mail: egcima74@gmail.com

ABSTRACT. This study had two objectives - firstly, to analyze the total static and dynamic capacity of agricultural storage in Paraná State, Brazil and secondly, to verify if the storage followed the growth of grain production. The study was performed by mesoregion for the 2013/2014 and 2014/2015 crop years. The methodology used was descriptive from an agricultural database of the Secretariat of Agriculture and Supply (SEAB), of the National Register System of Storage Units (SICARM), interviews were also made with agroindustrial cooperatives and official agencies. It was identified that in Paraná State there is an insufficiency of 17.75% of total static capacity of warehouses to comply with the total grain production (soybean, 1st and 2nd corn crops, and wheat). The results showed that the total dynamic capacity of warehouses is sufficient in the mesoregions of Eastern Center, Southern Center, Northern Center, and Metropolitan. Therefore, storage units vary uniformly in most municipalities, not following the growth of total grain production in the state of Paraná.

Keywords: agribusiness; deficit; georeferencing; spatial analysis; warehouse.

Received on September 4, 2018.
Accepted on January 12, 2020.

Introduction

Agribusiness is the pillar of the Brazilian economy and follows a promising trajectory with a dynamic that has the potential to expand over time if some challenges are overcome, as is the case of a lack of adequate grain storage infrastructure, which may inhibit the virtuous cycle deficiencies in the logistics of storage, transport and commercialization of grains that is configured.

In this way, understanding how grain production and storage infrastructure behave, planning and developing strategies for storing the grain production is a relevant condition for producing food and generating food security qualitatively and quantitatively (Patino, Machado, Nascimento, & Alcantara, 2013).

According to the criteria adopted by the Food and Agriculture Organization of the United Nations (FAO), the minimum acceptable in the static storage of a region must exceed its total production by 20%, so that there is no storage deficit in the event of overproduction. However, despite the great advances in Brazilian agribusiness in the areas of production, management and technology, it faces the storage deficit, which considerably limits the efficiency of the system by raising processing costs (Cicolin & Oliveira, 2016).

Brazil will probably have a high grain storage deficit in the next few years if actions are not taken to contain the static storage capacity deficiency (Baroni, Beneti, & Seidel, 2017). This is aggravated since only 14% of domestic agricultural production is stored in the rural area or agricultural property, while in countries like the United States and Argentina, this amount varies from 30 to 60% (ACEBRA, 2012).

In the United States, Canada, and Australia, the predominant agricultural scenarios are static storage capacity with percentages between 50 - 86% located within the rural property (USDA, 2015).

It is emphasized that in Storage Units (SUs), total static storage capacity (TSSC) and total dynamic storage capacity for grain (TDSC) are considered.

The TSSC is the quantity of grain that can be stored in the physical structure of the warehouse or garner. And the TDSC is the turnover of the grain, that is the storage capacity of grains in the period of one year. The use of the universal stock turnover factor, which indicates a dynamic capacity of 1.5 times the static capacity of the warehouse, considers the dynamic capacity based on the product between the static capacity. If this grain turnover factor is equal to 1, it means that no portion of the stock will be renewed throughout

the year. And a rotation factor equal to 2 means that all grain stock will be renewed throughout the year (Nogueira Junior & Tsunechiro, 2005). The stock rotation or *turnover* is justified considering that crop variations among agricultural products are differentiated, not occurring full coincidence of crop times (Nogueira Junior, 2008).

Regarding the SU locations, there are four types according to the classification of warehouses in Brazil: farm, collector, intermediate and terminal (Brasil, 2011).

The survey carried out by Silva Neto, Aruda, and Bastos (2016) showed that in the mesoregions of Goiás State, Brazil, the static storage capacity of grains in 2013 had a deficit of approximately 38% in relation to grain production. Oliveira and Cicolin (2016) verified that the static storage capacity in Mato Grosso State, Brasil in 2014 was insufficient to comply with the production of grains. However, this problem also occurs in other countries. Studies by Said and Pradhan (2014) evaluating India's static grain capacity in 2014 through an aeration system and hermetic system and confirmed the need for investment in low-cost storage infrastructure that was considered effective to preserve food grains safely to avoid post-crop inefficiency. Sharon, Kavitha Abirami, and Alagusundaram (2014) and Chaturvedi and Raj (2015) studied the agricultural storage deficiencies in India between the years 2005 to 2013 verified that government public policy needs to improve the static storage capacity of grain to avoid post-harvest grain losses.

Schewe, Otto, and Frieler (2017) evaluated the role of the dynamic storage capacity of wheat associated with annual grain marketing prices in the last 40 years in Germany through a descriptive analysis of the supply demand. They verified that the variation in grain prices interferes with the static storage capacity and the inclusion of new warehouses is necessary to meet the growth of agriculture.

This study has two objectives - The first one will be to analyze the total static capacity and the total dynamic storage capacity in Paraná State, Brazil and the second one was to verify if the storage followed the growth of grain production of Paraná State, Brazil. The study analyzed the total static warehouse capacity and the total dynamic warehouse capacity for years 2013/2014 and 2014/2015 by mesoregion in relation to total grain production (soybean, 1st and 2nd corn crops, and wheat) in the same crop period, which production and storage process is aimed at_commercialization, domestic consumption and export of soybean, maize, and wheat.

Material and methods

The study area comprised three hundred and ninety-nine counties of Paraná State, Brazil, which are subdivided into 10 mesoregions (Figure 1).

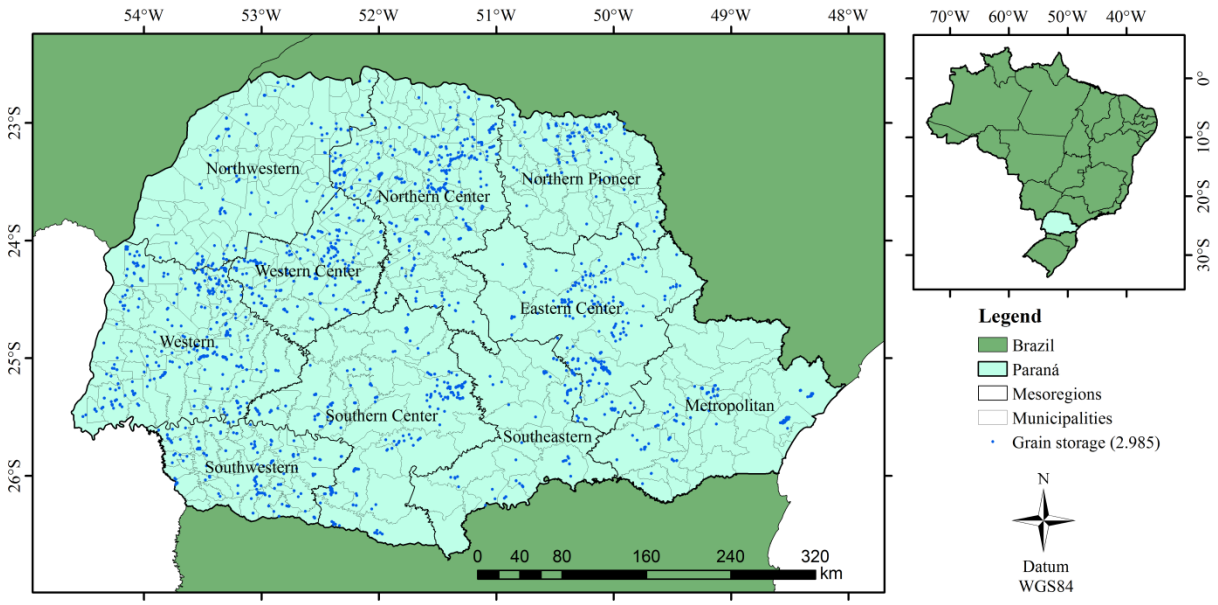

Figure 1. Paraná State, Brazil with 399 counties, 10 mesoregions, and grain storage units.

Georeferenced data were used of Total Static Storage Capacity (TSSC), in thousand tons of the storage units (SUs) from the Sistema de Cadastro Nacional de Unidades Armazenadoras (National Register System of

Storage Units) (SICARM), of Companhia Brasileira de Abastecimento (Brazilian Supply Company) (CONAB, 2015). This database has the following data - Warehouse Code (WC), Warehouse, Address, County, States, Warehouse Type, Telephone, Email, Static Total Storage Capacity and the UAs geographical coordinates (Latitude and Longitude).

Data from the Total Grain Production (TGP) was also used, in thousand tons of soybean, 1st and 2nd corn crops, and wheat, obtained from the Secretaria da Agricultura e do Abastecimento do Paraná - Departamento de Economia Rural (Secretariat of Agriculture and Supply of Paraná - Department of Rural Economy) (SEAB/DERAL, 2015). The study period comprised the crops for years 2013/2014 and 2014/2015.

For the creation of the spatial database it was necessary to perform a verification of all the database, approximately 900 geographic coordinates were corrected manually, because they presented a geolocation error, reported the location of the storage unit in a municipality when it was actually located in another, and then proceed with the sum of Total Static Storage Capacity per county, for later use in comparison with the TGP of each county.

The Normative Instruction No. 29/2011 of the Ministério da Agricultura Pecuária e Abastecimento (Ministry of Agriculture Livestock and Supply) approves the mandatory or recommended technical requirements for certification of storage units in natural environment and the Conformity Assessment Regulation of Storage Units. The operation of storage units generally appears in two large groups of conventional warehouses and bulk carriers (Brasil, 2011).

The normative of the MAPA (Normative Instruction No. 29/2011) was used to validate the organization of the types of warehouses and garner according to the database (CONAB and SICARM) studied. Therefore the information was standardized according to this Standard.

The storage units studied were classified according to their location and their operational characteristics in four levels. At the unit - producer or rural property, collector, intermediary and terminal (Brasil, 2011). The warehouses were classified according to the maintainer entities in public warehouses and private warehouses which were used to analyze the grain use characteristics (soybean, maize, and wheat) (Figure 2).

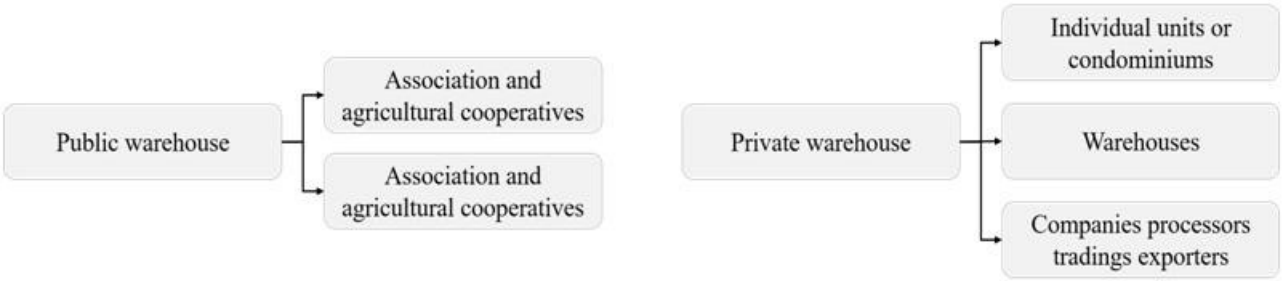

Figure 2. Classification of warehouses in Brazil according to maintainer entities.
Source: Elaborated by the authors with data from Brasil (2011).

The data of the Storage Units provided by the Companhia Nacional de Abastecimento (National Supply Company) - CONAB, for the agricultural year 2013/2014 and by the Sistema de Cadastro Nacional de Unidades Armazenadoras (National Register System of Storage Units) (SICARM), for the agricultural year 2014/2015, both are different database, the CONAB presented information on the quantity and static capacity of warehouse by mesoregion and SICARM was by location, storage companies, address, by counties, characterizing the storage units with the following typology - Conventional and Bulk by mesoregion according to the regulative norms.

Data on Total Static Storage Capacity were tabulated and the total dynamic storage capacity (TDSC) was calculated considering the grain turnover rate of 1.5 proposed by Nogueira Junior and Tsunechiro (2005).

It was also used for the methodology proposed by Maia, Pinto, Marque, Lyra, and Roitman (2013) (Figure 3) which used the ratio between Total Grain Production and Static Total Storage Capacity to infer the storage situation and obtain the total dynamic storage capacity. Thus, the turnover of the stock can be interpreted as the lowest value for the turnover factor which causes the dynamic capacity to be greater or equal to the total grain production. Therefore, the ratio of total grain production to total static capacity provides the lowest value for the turnover factor and suggests that the storage network is sufficient.

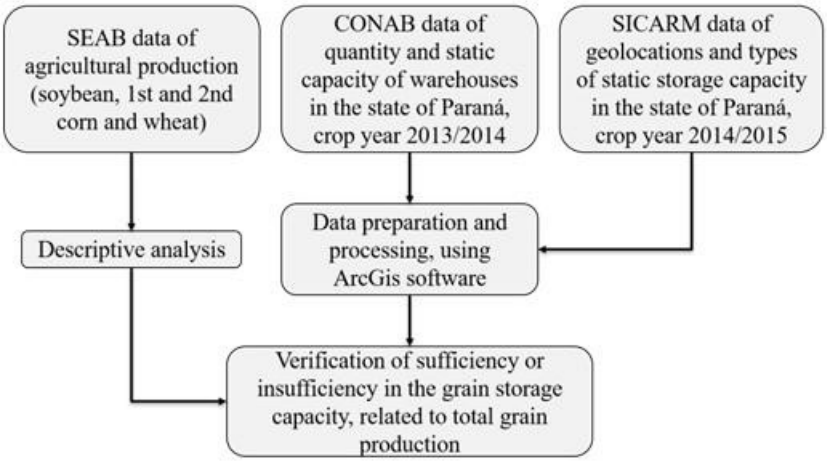

Figura 3. Flowchart of the study methodology.

The analysis of Total Grain Production, Total Static Capacity of Storage, and Total Dynamic Storage Capacity was performed by mesoregions of Paraná State, Brazil. A survey was made of the spatial distribution of TSSC and SUs by property (private, cooperative and government) and by location (Urban, Rural, Farm, and Port).

By typology of SUs, the analysis of the quantity and static capacity by type of grain storage (conventional, garner set, bulk carrier, garner, rodent-proof cap, structural and deposit) in Paraná State was carried out.

Four CI, CIE, CICOOPT, and CIECOOPT groups were organized with the purpose of characterizing storage units regarding the commercialization for usage and export of grains. CI storage units are cerealist, traders and rural producers who store and commercialize the grains (soybean, maize, and wheat) for domestic usage only; the CIEs are cerealists, tradings and companies that commercialize the grains for usage in the domestic and foreign markets; the CICOOPT are the cooperatives and agroindustries that commercialize or transform the grains (in vegetable oil and bran) only for the domestic market and the CIECOOPT are the cooperatives and agroindustries that commercialize or transform the grains for usage in the domestic and external market.

These groupings were proposed based on the visits made to the companies and cooperatives through interviews with their respective representatives, besides the interviews with rural producers and managers of public agencies who are involved in the process of storage of cereals. The period of interviews took place between January 2016 and January 2017, to understand the management of the routine regarding the logistics of receiving, storing and processing the grains, contextualizing the routine of the process and improving the information pertinent to the study. The software ArcMap 10.0 was used for the construction of the maps which represent the regional storage profile of Paraná State.

Results and discussion

Descriptive analysis of TSSC and TGP of the crop years 2013/2014 and 2014/2015 in Paraná State

The results of the descriptive statistics analyze for the total static storage capacity between the years 2013/2014 and 2014/2015 and total grain production for the crop years 2013/2014 to 2014/2015 are presented in Table 1. Presented high heteroskedasticity relation to their averages (CV > 30%). The non-homogeneity of TSSC indicates the uniform unavailability of the total static storage capacity of the warehouse in the 399 counties of Paraná State as can be seen in Table 1.

The results presented in Tables 1 could be related to the inexistence or the insufficiency of warehouses as well as the high oscillation of the TGP in the different counties.

Table 1. Descriptive Statistics of Static Total Static Storage Capacity - TSSC (thousend tons) and Total Grain Production - TGP (thousand tons) of the State of Paraná in the years 2013/2014 and 2014/2015.

Variables	Years	n	Min	$\bar{x}$	Md	Max	Sd	CV(%)	Total
TSSC	2013/2014	3091	0.252	94.84	32.598	2878	252	266	28262
	2014/2015	2985	0.091	10.051	3.996	2658	242	229	30001
TGP	2013/2014	399	0.016	86.58	54.374	828	105	121	34371
	2014/2015	399	0.015	92.50	60.07	884	111	120	36607

n: number of warehouses or counties; Min: minimum; $\bar{x}$·: average; Md: median; Max: maximum; Sd: standard deviation; CV: coefficient of variation; TSSC: total static storage capacity; TGP: total grain production.

According to SEAB/DERAL (2015) TGP presents a gradual increase in Paraná State, which varied from 34371 thousand tons to 36607 thousand tons. The total static storage capacity for the year 2013/2014 when compared to the total grain production for the 2014/2015 crop year had a deficit of 17.78%. For the year 2014/2015 this deficit was higher rising to 18.04%.

Patino et al. (2013) when analyzing soybean production and predicting storage needs in Brazil in the years 2012 to 2016, found minimum and maximum values ranging from 64981 to 94987 thousand tons which indicated a deficit of static storage capacity (TSSC) of soybeans in Brazil.

Santos and Pelentir (2016) when analyzing the quantity of stored soybeans and the static storage capacity in the period from 2011 to 2015, at Cooperativa Grão Norte in Roraima State, Brazil, they found deficit in static capacity of the storage.

Grain receiving flow in the two main agroindustrial companies in the TSSC from the years 2013 to 2015 in Paraná State

Table 2 presents the grain receiving flow (GR) (soybean, maize, and wheat) in the data collection performed with the total static storage capacity (TSSC) in the two main storage units (SU1 and SU2) of Paraná State. When analyzing the grains receiving (GR) observed in the storage units SU1 and SU2 of the Western Region of Paraná State the results showed that they were superior to their TSSC this characterizes the reality experienced daily in the agroindustrial systems due to the need to consume the grain. By analyzing from SU1 it remained constant which may characterize that not always a same volume of storage is able to comply with the receiving of grain supply it is observed TSSC insufficiency. It is suggested that the incoming grain supply is necessary for service and domestic supply, but the existing TSSC is currently limited one of the factors may be the increase in demand for grains.

Table 2. Grain receiving flow in relation to the total static storage capacity of the region in the two main storage units in Paraná State.

	SU1			SU2		
Year	GR (thousand tons)	TSSC (thousand tons)	Deficit	GR (thousand tons)	TSSC (thousand tons)	Deficit
2013	515	335	-180	869	620	-249
2014	487	335	-152	909	740	-169
2015	567	335	-232	1069	860	-209

GR: Grain receiving (soybeans, maize, and wheat); TSSC: total static storage capacity; SU1: storage unit 1; SU2: storage unit 2; thousand tons: one thousand tons. Source: Data collected by authors obtained in cooperatives (2018).

We observed a critical deficiency of CEA in SU1 and SU2 with values varying between 20 and 41%, which shows the daily challenge of agroindustries regarding grain reception planning.

The grain receiving for the SU2 Storage Unit presented great variation over the years studied, since the TSSC appears to show low variability this suggests that the demand for grain in the cooperative is high, thus necessitating a storage infrastructure that comply with its grain supply since the storage of grains appeared insufficient.

Stock Flow in relation to the entry and exit of grains in the two main agroindustrial companies for the year 2013/2014 and 2014/2015

The stock flow related to the grain input and output (soybean, maize, and wheat) in the SU1 storage unit investigated for crop year of 2013/2014 and 2014/2015 is presented in Figure 4a and c. The soybean and maize stored stock determined by the research was low related to the grain output, this behavior is indicative of grain turnover inside the warehouse. However, the amount of wheat stored is much lower when compared to soybeans and maize, since the wheat is not processed by the cooperative but is commercialized in the market. In the research it was verified that the stock of wheat is equivalent to 2.7 thousand tons while the soybean and the maize are above 50 thousand tons.

Analyzing Figure 4b and d, it can be observed that the input of the grain in the storage unit SU2 is larger than its output, because it depends on several factors among which we can mention the decision of the rural producer in choosing the best time to commercialize its crop which reflects in the total static storage capacity.

The results found in Figure 4b, grain input and output were high suggesting the grain turnover inside the warehouses consequently generating a low stock. It is suggested that the release of new space in the warehouses depends on this rotation. Grain turnover is also required to ensure grain biosecurity. Burkot (2014) when analyzing the grain biosecurity during its reception and exit in an agroindustrial company in the region of Ponta Grossa, Paraná State, Brazil, in the year 2014 verified that the management and rotation of the stock allows a better quality of the grain during process in the warehouses.

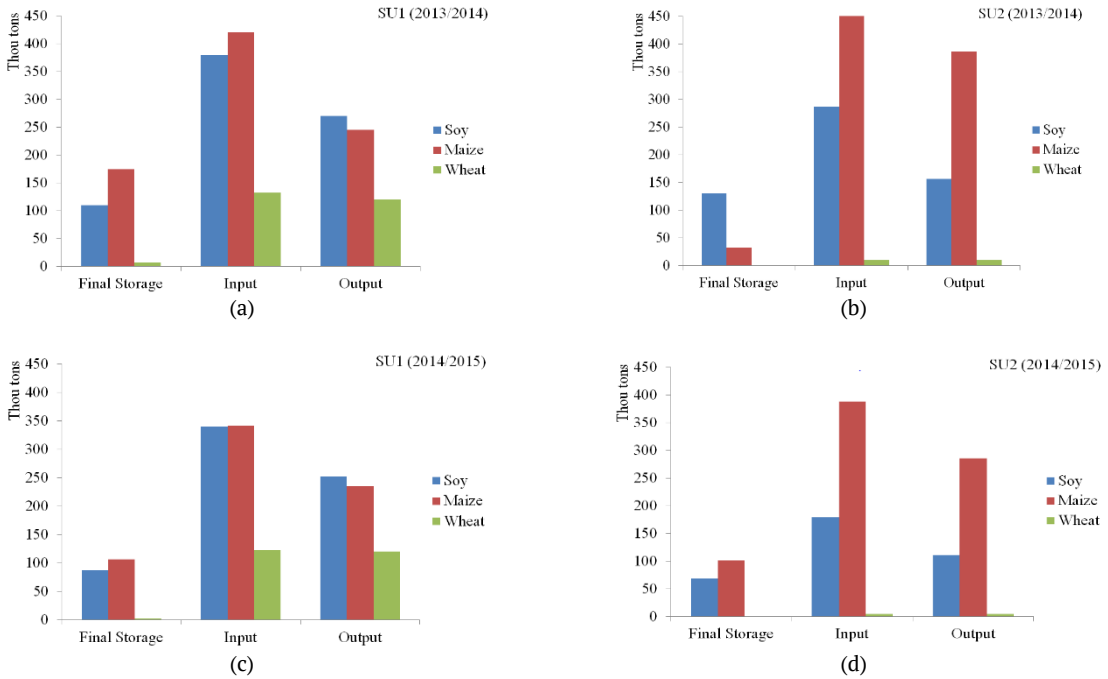

Figure 4. Stock flow of grain input and output in storage units SU1 (a), (c) and SU2 (b) and (d).

By analyzing together Figure 4a, b, c, and d, it is observed in SU1 and SU2 the final stock and the output of the grains vary, this behavior suggests the grain turnover inside the warehouses in some periods the outflow of some crops were greater than others such as soybeans and maize. However, the wheat does not follow this pattern in SU2 it is received by agroindustrial companies only for commercialization purposes the agroindustrial company buys the grain from the rural producer and sells it in the consumer market.

Spatial Analysis of TGP, TSSC and TDSC by means of Nogueira Junior and Tsunechiro (2005) methodology and Maia (2013) for the years 2013/2014 and 2014/2015 by county of Paraná State

According to Figure 5a and b, the maps constructed by the Nogueira Junior and Tsunechiro (2005) methodology, which show the joint insufficiency of TSSC and TDSC in 42 counties (10.5%) (red); presented only TSSC insufficiency in 152 counties (38.1%) (pink); are sufficient of TSSC in 58 counties (14.5%) (light green) and joint sufficiency of TSSC and TDSC in 46 counties (11.5%) (dark green) and 101 counties with no TSSC and TDSC.

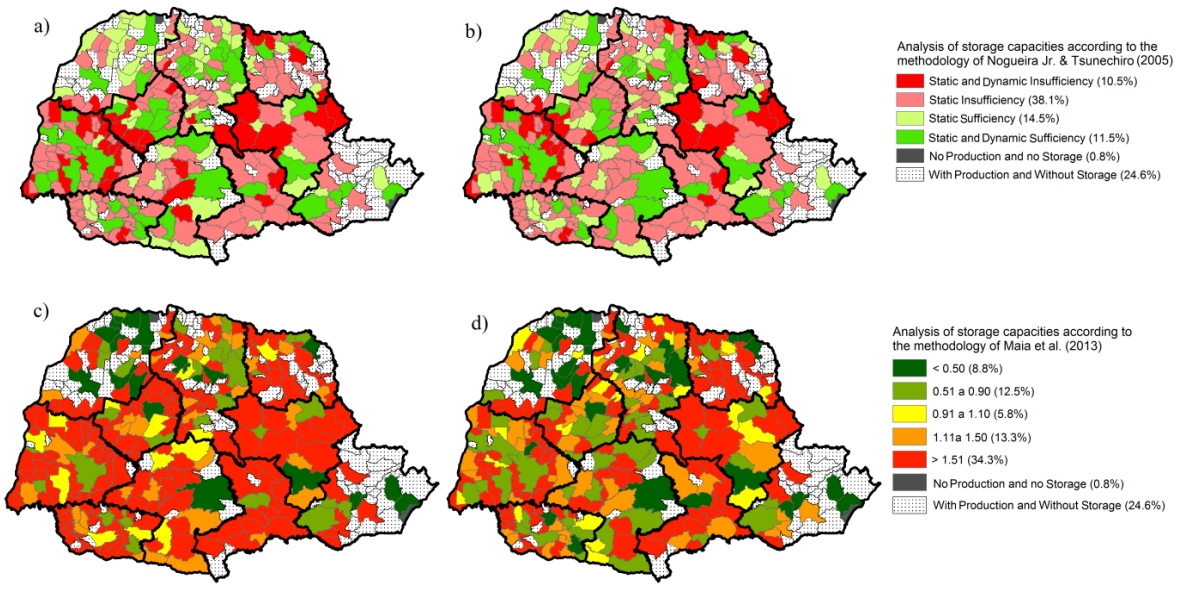

Figure 5. Descriptive map of the TSSC and TDSC by means of Nogueira Junior and Tsunechiro methodology (a) 2013/2014 and (b) 2014/2015 and Maia et al. (2013) (c) 2013/2014, and (d) 2014/2015 by county of Paraná State.

According to Figure 5a and b, the maps constructed by the Nogueira Junior and Tsunechiro (2005) methodology, which show the joint insufficiency of TSSC and TDSC in 42 counties (10.5%) (red); presented only TSSC insufficiency in 152 counties (38.1%) (pink); are sufficient of TSSC in 58 counties (14.5%) (light green) and joint sufficiency of TSSC and TDSC in 46 counties (11.5%) (dark green) and 101 counties with no TSSC and TDSC.

It occurred in three counties absence of TGP and TSSC totaling 0.8% of counties studied (399) they are: Santo Antonio do Caiuá located in the Northwestern, Matinhos and Pontal do Paraná mesoregion, located in the Metropolitan mesoregion (black).

The same pattern is observed in Figure 5a and b of the TSSC and TDSC for the year 2014/2015, but there was a higher deficiency of TSSC, 166 counties, representing 41.6% of the total counties in Paraná State. The counties of the Western mesoregion were the ones that presented the most deficiency of TSSC and TDSC. Because the Western region presents a great agricultural production, considering the state and this volume of grain can not be stored due to the insufficiency of warehouses.

The maps of Figure 5c and d constructed with the Maia et al. (2013) methodology, present in the intervals between 0.5 and 1.5 TDSC sufficiency in the counties of Paraná State, Brazil (dark green, light green, yellow, and orange).

However, in the interval greater than 1.5 (red), there was insufficiency of TDSC this pattern was common in most counties in Paraná State with a higher presence for the year 2013/2014 (Figure 5c).

Analysis of TGP, TSSC, and TDSC by mesoregion in the Nogueira Junior and Tsunechiro (2005) methodology

The total dynamic capacity of storage units in the 399 counties of Paraná State in the years 2013/2014 and 2014/2015 proposed by the Nogueira Junior and Tsunechiro (2005) methodology were 42393 and 45002 thousand tons respectively.

Due to the total dynamic storage capacity the result indicated sufficient grain turnover for both the year 2013/2014 and the year 2014/2015, compared to the total grain production for the same period in the general evaluation of Paraná State.

According to Table 3 the TGP in the mesoregions respectively: Western, Northern Center, Western Center, Southern Center, and Eastern Center represent 50% of Paraná State. The other mesoregions were similar. In these same mesoregions the total dynamic storage capacity was insufficient for Western Paraná State, once the total grain production was higher. There was found insufficient total storage dynamic capacity in the mesoregions: Northwestern, Northern Pioneer, Southeastern, and Southwestern. It should be noted that the Metropolitan mesoregion was the one that presented the least TGP and had its total dynamic storage capacity higher due to the port regions in this mesoregion.

Table 3. Total grain production (TGP), Total storage static capacity (TSSC) and total dynamic storage capacity (TDSC) according to the mesoregion.

Mesoregion	TGP (thousand tons)		TSSC (thousand tons)		TDSC (thousand tons)	
	2013/2014	2014/2015	2013/2014	2014/2015	2013/2014	2014/2015
Western Center	4235	4224	2934	2924	4401	4386
Eastern Center	3066	3219	3788	3962	5683	5943
Southern Center	3203	3018	2711	3566	4066	5349
Metropolitan	967	1092	3842	3910	5763	5865
Northwestern	1224	1472	688	944	1032	1416
Northern Center	5988	6786	5781	5674	8671	8511
Northern Pioneer	2964	3501	1179	1361	1769	2042
Western	8393	9001	4994	5553	7492	8330
Southeastern	1702	1683	686	637	1029	956
Southwestern	2623	2629	1655	1466	2483	2200

TGP: Total Grain Production; TSSC: Total Static Storage Capacity; TDSC: Total Dynamic Storage Capacity.

The storage profile for the 2014/2015 crop year was similar to the crop year 2013/2014. From the ten mesoregions of Paraná State - Western, Southeastern, Southwestern, Northwestern, and Northern Pioneer presented insufficiency in the total static storage capacity.

Analysis of TGP, TSSC, and TDSC by mesoregion of the crop years 2013/2014 and 2014/2015 according to Maia (2013) methodology

The variation ratio of total grain production and TSSC for the year 2013/2014, showed in the ten mesoregions studied, insufficiency in total storage static capacity for the mesoregions - Western Center, Northwestern, Northern Pioneer, Western, Southeastern, and Southwestern, respectively. The most unfavorable situation for storage occurred in the Northern Pioneer mesoregion, followed by the Southeastern mesoregion (Figure 6).

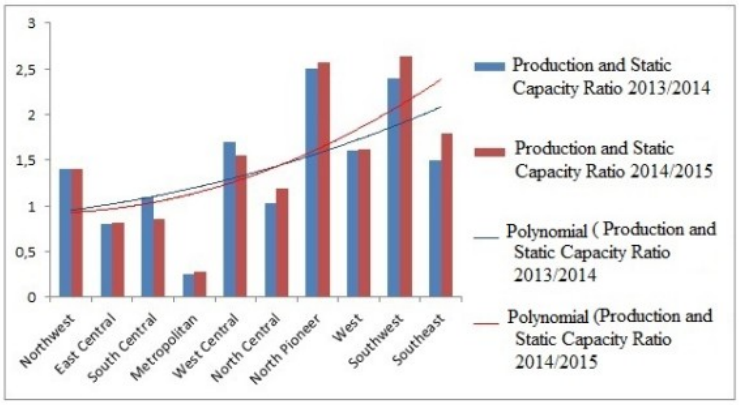

Figure 6. Ratio between TGP and TSSC of grains, from the year 2013/2014 and 2014/2015. Sources: SICARM total static capacity data extracted from CONAB (2015) and total grain production data, SEAB/DERAL (2015).

For the years 2014/2015 the ratio obtained between TGP and TSSC was high in the mesoregions respectively - Western Center, Northwestern, Northern Pioneer, Western, Southeastern and Southwestern characterizing the inadequacy of storage systems. The supply of total grain production was greater than the availability of storage networks.

The storage profile of total grain production for the 2014/2015 crop year was similar to the year 2013/2014. The Northern Pioneer mesoregion again suffered the most from the lack of storage and presented a high ratio of 2.57 (ratio of total grain production to total static storage capacity). For the Southeastern mesoregion the storage table was considered the second most critical, presenting a high ratio between total grain production and total static storage capacity, being this ratio of 2.64. This same pattern of insufficiency was identified in the mesoregion Western, Southwestern, and Northwestern.

Distribution and TSSC Spatial Location for the year 2014/2015

Table 4 presents the distribution of TSSC by location for the year 2014/2015, and for the year 2013/2014 CONAB did not provide data regarding the location of TSSC. Although many rural properties have storage structures installed the portion of the overall TSSC is small. This seems to suggest that rural producers prefer to turn to cerealists, cooperatives and among others instead of storing on the property. However, this choice is coherent since the relationship with cerealists and cooperatives should involve low cost of storage making it more viable for rural producers to use this form of storage.

It is also observed in Table 4 that the total static storage capacity distribution and the storage units are concentrated around 70% in the urban area.

Table 4. TSSC distribution by location of the year 2014/2015 – Paraná State, Brazil.

	Urban (%)	Rural (%)	Port (%)
TSSC	68.56	21.74	9.30
SUs	70.52	24.36	4.86

Source: Elaborated by the authors with data from CONAB (2015).

However, the highest percentage of TSSC (68.56%) is in the urban location and this is further away from the grain producing regions. In the rural area only 21.74% of the TSSC was found which corroborates Conteh, Yan, and Moiwo (2015) who studied grain storage systems in Sierra Leone (Africa) and identified that rural producers have low purchasing power and thus do not invest in storage in rural property for the additional costs.

Although the private sector holds 62.45% of the storage units the quantity stored in grains is similar to the quantity stored by the cooperatives, which presents 33.57% of the SUs in Paraná State, Brazil.

Table 5. Distribution of TSSC by property for the year 2014/2015 – Paraná State, Brazil.

	Private (%)	Cooperative (%)	Government (%)
TSSC	48.70	46.0	4.86
SUs	62.45	33.57	3.59

Source: Elaborated by the authors with data from CONAB (2015).

Georeferenced mapping of the types and percentages of SUs and TSSC for the year 2014/2015

Figure 7 presents the map resulting from the georeferenced analysis of the SUs types and TSSC percentages for the year 2014/2015, and for the year 2013/2014 CONAB did not provide data regarding the location of coordinates by type of SUs and TSSC, in Paraná State. According to the SICARM database 2014/2015 for the analysis of TSSC and SUs presenting the types of storage in different locations in the same counties.

The types of SUs in Paraná State differ among them the garner set (1,138 units) are the most relevant, which represent 43% of the TSSC followed by bulk carriers (588 units) that represent 40% of the TSSC. Conventional types represent 12% of TSSC (1,001 units) and garner 3% of TSSC (227 units).

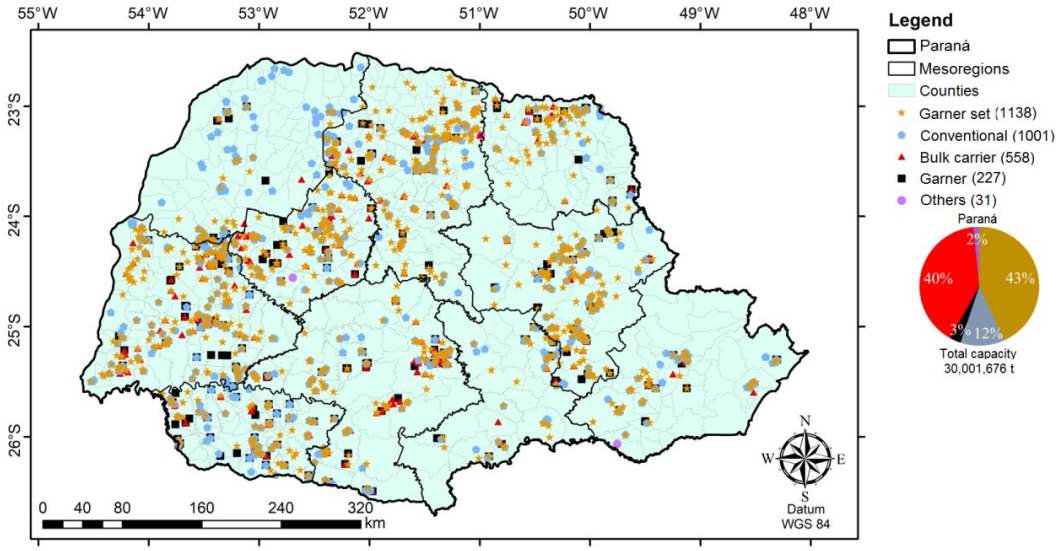

Figure 7. Map of SUs quantities by type of warehouse in Paraná State, Brazil.

Table 6 presents the types of SUs and TSSC and percentages by mesoregion in Paraná State for the year 2014/2015. The Western mesoregion was the one with the highest SUs (163) in Paraná State with a TSSC of 392 thousand tons followed by the Northern Center mesoregion (161 SUs) with 634 thousand tons (TSSC). In relation to Paraná State the mesoregions Western, Northern Center, Metropolitan, and Northwestern present the highest quantities of SUs. TSSC was higher in the Metropolitan, Northern Center, Western, and Northwestern mesoregions. The types of garner, conventional and bulk carriers were the most present SUs in Paraná State.

Table 6. SUs and TSSC (thous tons) of the types of warehouses per mesoregion of the year 2014/2015.

Meso	Conventional				Garner Set				Bulk Carriers				Garner			
	SU	%	TSSC	%	SU	%	TSSC	%	SU	%	TSSC	%	SU	%	TSSC	%
W. C	80	2.7	268	0.8	120	4.0	1353	4.5	62	2.0	1239	4.1	19	0.6	61	0.2
E. C	90	3.0	219	07	180	6.0	1810	6.0	54	1.8	1567	5.2	33	1.2	76	0.2
S. C	90	3.0	172	0.5	122	4.0	2034	6.7	90	3.0	1203	4.0	32	1.0	156	0.5
Met	140	4.6	1164	3.9	51	1.7	753	2.5	48	1.6	1836	6.2	10	0.3	155	0.5
Nw	102	3.4	229	0.8	36	1.2	424	1.4	15	0.5	272	0.9	9	0.3	19	0.6
N. C	161	5.4	634	2.1	227	7.6	2777	9.3	88	3.0	2109	7.0	20	0.7	84	0.3
N. P	37	1.2	236	0.8	70	2. 3	681	2.3	23	0.8	282	0.9	17	0.6	81	0.3
W	163	5.4	392	1.3	214	7.1	2095	7.0	155	5.1	2938	9.8	36	1.2	127	0.4
Se	43	1.4	67	0.3	40	1.3	385	1.3	8	0.3	148	0.6	12	0.4	42	0.1
Sw	95	3.2	193	0.7	78	2.6	645	2.1	45	1.5	39	1.6	39	1.3	105	0.4
Total	1001	33.0	3574	11.0	1138	38.1	12957	43.2	588	19.7	12089	40.3	227	7.6	906	3.0

Meso: mesoregion; W. C: Western Center; E. C: Eastern Center; S. C: Southern Center; Met: Metropolitan; Nw: Northwestern; N. C: North Center; N. P: Northern Pioneer; W: Western; Se: Southeastern; Sw: Southwestern; SUs: storage units; TSSC: total static storage capacity. In Paraná State these types of storage units are evident, especially in the West.

Western Center and Eastern Center mesoregions, where several cooperatives are presented processing the grain (Table 7) for domestic consumption and the surplus destined for the export.

The Western mesoregion concentrates the most SU with 19% of the total, followed by the Northern Center mesoregion with 16.81% and they are still insufficient when compared with the TGP.

In general, the mesoregion Southeastern, Northwestern, Northern Pioneer are those that presented smaller amounts of SUs and TSSC, considering that they are promising in the TGP and the presence of cooperatives and agribusiness is very present.

Georeferenced analysis of the Characteristics of usage of the grain in relation to TSSC for the year 2014/2015

Figure 8 presents the Map of the characteristics of grain usage in relation to TSSC for the year 2014/2015, and for the year 2013/2014 CONAB did not provide data regarding the location of coordinates by type of SUs and TSSC in which the SUs were classified according to maintainer entities it is public and private warehouses, in the public classification are the cooperatives, farming and state bodies. In the private warehouses are the general warehouses, the processing companies and exporting companies. The CI and CIE characteristics were more present in private warehouses. The CICOOPT and CIECOOPT in cooperatives.

The characteristics of grain usage (soybean, maize, and wheat) are associated to different segments of markets which agroindustrial systems operate.

Of the 2,985 SUs, 1,879 of them (42% of the TSSC) of Paraná State have internal usage (CI) of the TGP, that is, they are composed of cerealists, commerce and rural producers who store the grain for consumption in the domestic market. Regarding to storage units, 363 represent 23% of Paraná State TSSC have characteristic of use CIECOOPT, are cooperatives that store the grain, for domestic consumption and the excess for exportation. The 20% of the TSSC of grains (360 storage units) presented characteristics (CIE) that are those represented by *tradings*, cerealists, and commerce, that store the grain for consumption in the internal and external market.

By mesoregion, it was observed that the characteristic of use of the grain CICOOPT, CIECOOPT, and CIE, were more present in Northern Center, Western, and Southwestern. This result makes sense, since the largest cooperatives and tradings are located in these regions.

In the Eastern Center mesoregion, the largest presence was cereal farmers, traders and farmers selling grain for use in the domestic market (CI), the same is observed in the Metropolitan mesoregion also with the presence of *tradings*.

The agroindustrial companies with CICOOPT characteristics, that is, the cooperatives that receive and transform the grain only for internal consumption responds for 15% of TSSC (383 storage units).

It can also be observed in Figure 8 that in the Western mesoregion of Paraná State are located the large cooperatives that leverage the national agribusiness economy evidence of this is in the cooperatives that commercialize, industrialize the grain surplus, soybean, maize are exported to others countries.

In the Northern Pioneer, the same characteristics of grain use are observed, with emphasis on cooperatives and use grain for consumption in the domestic market and cereals and tradings, in the Southeastern the predominance is CI.

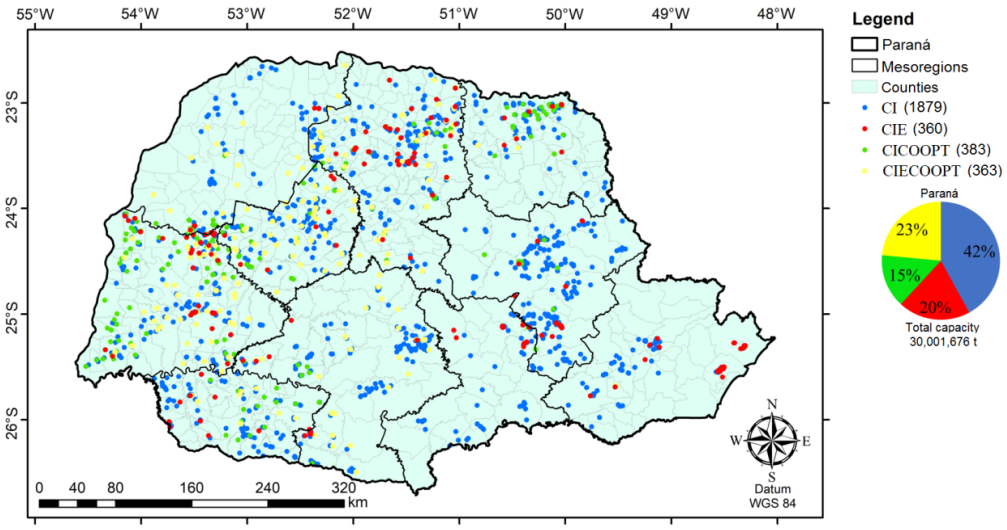

Figure 8. Map of grain usage characteristics without relation to TSSC.

The cerealists and trades that store grain for domestic usage represent 33% of TSSC. In the Western region this characteristic is very present, since the demand for grains to supply the cooperatives and agroindustry is quite evident.

Table 7 presents the characteristics of the type of grain usage by mesoregion in Paraná State for the year 2014/2015. Grain usage Characteristic (CI) was predominant in the Northern Center, Eastern Center, and Western mesoregion and the characteristic CICOOPT and CIECOOPT were very frequent in Western Paraná State. It is perceived in a general way the very strong presence of cerealists and cooperatives especially in the Western of Paraná State which commercialize most of the grains for domestic usage to supply their chains of agroindustrial production.

In the characteristics of grain usage, one fact draws attention in the study developed. Many cooperatives industrialize all their production of soybeans, maize, and wheat. Maize is all converted into animal protein all soybean goes through the crushing process for the production of soybean meal, on average 50% of this soybean meal is consumed internally and the rest is exported mainly to the Asian continent, presenting the characteristic CICOOPT on average 36% of the TSSC of the SUs. Wheat is processed to supply the starch derivative industries, flour and meal are commercialized in the domestic market. According to the interviews carried out in association with the market profile other cooperatives present differentiated grain usage characteristics which represents 23% of the total static capacity of the storage units with this characteristic of usage - they industrialize part of the receiving maize (poultry food), trades in the domestic market and the surplus is exported (CIECOOPT).

Table 7. Grain usage characteristics of SUs and TSSC (thousand tons) per mesoregion for the year 2014/2015.

Mesoregion grain usage characteristic	CI	CIE	CICOOPT	CIECOOPT	CI	CIE	CICOOPT	CIECOOPT
	Quantity	%	Quantity	%	Quantity	%	Quantity	%
Western Center	147	4.9	9	0.3	42	1.10	85	2.9
Eastern Center	296	10.0	40	1.3	27	0.90	0.0	0.0
Southern Center	263	8.8	8	0.3	8	0.3	57	1.9
Metropolitan	126	4.3	120	4.0	0.0	0.0	4	0.1
Northwestern	104	3.6	5	0.2	32	1.1	21	0.70
Northern Center	319	11.0	69	2.31	39	1.3	75	2.5
Northern Pioneer	96	3.4	15	0.50	39	1.30	3	0.10
Western	263	8.8	49	1.64	156	5.2	100	3.3
Southeastern	80	2.8	20	0.70	3	0.10	0.0	0.0
Southwestern	185	6.3	25	0.8	37	1.2	18	0.60
Total	1879	63.0	360	12.0	383	12.8	363	12.2

Grain usage Characteristics by mesoregion of Paraná State.

Through commercialization logistics and usage of the grains, it is clear that in the Western region the need for total static storage capacity is high which in fact the study showed this necessity promotes the great movement of the grains in the crops periods and intercrops which leads the cooperative managers to seek strategic alternatives to store the entire crop that is entering.

It is remarkable in Paraná State the Western mesoregion is a large grain consumer mainly maize and soybeans, it needs to keep reserves stocked until the next crop, due to this large demand for grain consumption.

In interviews with public agencies, as a result, there is a positive trend in the growth of SUs and TSSC in recent years in Brazil and in Paraná State, where the federal government launched the PCA line (Program for Construction and Expansion of Warehouses) with interest rates of 4% per year, in this period the process of construction of the warehouses in the Southern Center and in the Western Center of Brazil began. In Paraná State, cooperatives invested the most and TSSC was expanded by about 2.5 million tons between 2013 and 2015.

Conclusion

There was a total static storage capacity (TSSC) and total dynamic storage capacity (TDSC) insufficiency in most of the Paraná State counties. The study evidenced the difference in the storage situation in the mesoregions. Some mesoregions presented the total grain production substantially larger than the TSSC. The results presented here have fundamental importance and can contribute in the analysis of the agricultural scenario in Paraná State. It is also to suggest to the regulatory agencies to define a legal form

verification that will commit the processing agro-industries, cerealist and rural producers to update the information inherent to the warehouse geolocation.

Acknowledgements

The authors would like to thank the anonymous reviewers for their helpful and constructive comments that greatly contributed to improving the final version of the research. They would also like to acknowledge the Coordination of Superior Level Staff Improvement (CAPES), Brazilian National Council for Scientific and Technological Development (CNPq) and State of Paraná Research Foundation (Araucária Foundation) for financial support, and the Western Paraná State University (UNIOESTE) for technical support.

References

Associação das Empresas Cerealistas do Brasil [ACEBRA]. (2012). *Armazenagem do Setor Cerealista*. Retrieved on Aug. 12, 2018 from http://www.agricultura.gov.br / arq. . . /App_Armazenagem_Insumos. pdf.

Baroni, D. G., Beneti, H. P., & Seidel, J. D. (2017). Cenários prospectivos da produção e armazenagem de grãos no Brasil. *Revista Thema*, *14*(4), 55-64. DOI: 10.15535-thema.14.2017.55-64.452

Brasil (2011). Ministério da Agricultura, Pecuária e Abastecimento. *Instrução Normativa 29/2011*. Lei do Sistema Nacional de Certificação de Unidades Armazenadoras. Brasília, DF. Retrieved on Sep. 16, 2017 from http://www.agricultura.gov.br/assuntos/politica-agricola/infraestrutura-e-logistica/documentos-infraestrutura/29-2011.pdf

Burkot, R. C. (2014). A qualidade desejada na secagem e armazenagem de grãos em uma cooperativa no município de Ponta Grossa - PR. *Revista de Gestão e Organizações Cooperativas*, *1*(2), 39-50. DOI: 10.5902/2359043215479

Chaturvedi, B. K., & Raj, A. (2015). Agricultural storage infrastructure in India: An overview. *Journal of Business and Management*, *17*(5), 37-43. DOI: 10.9790/487X-17513743

Cicolin, L. O. M., & Oliveira, A. L. R. (2016). Avaliação de desempenho do processo logístico de exportação do milho brasileiro: uma aplicação da análise envoltória de dados – DEA. *Journal of Transport Literature*, *10*(3), 30-34. DOI: 10.1590/2238-1031.jtl.v10n3a6

Companhia Nacional de Abastecimento [CONAB]. (2015). *Geosafras*. Brasília, DF. Retrieved on Jan. 25, 2018 from http://geoweb.conab.gov.br/conab/

Conteh, A. M. H., Yan, X., & Moiwo, J. P. (2015). The determinants of grain storage technology adoption in Sierra Leone. *Cahiers Agricultures*, *24*(1), 47-55. DOI: 10.1684/agr.2015.0733

Maia, G. B. S., Pinto, A. R., Marque, C. Y. T., Lyra, D. D., & Roitman, F. B. (2013). Panorama da armazenagem de produtos agrícolas no Brasil. *Revista do BNDES*, *40*(4), 161-194.

Nogueira Junior, S. (2008). Investimentos na Armazenagem de grãos. *Analises Indicadoras do Agronegócio, 3*(4). Retrieved on Sep. 20, 2017 from http://www.iea.sp.gov.br/ftpiea/mercado/HP-31-2008.pdf

Nogueira Junior. S., & Tsunechiro, A. (2005). Produção agrícola e infra-estrutura de armazenagem no Brasil. *Informações Econômicas*, *35*(2), 7-18.

Oliveira, A. L. R., & Cicolin, L. O. M. (2016). Evaluating the logistics performance of Brazil's corn exports: A proposal of indicators. *African Journal of Agricultural Research*, *11*(8), 693-700. DOI: 10.5897/AJAR2015.10653

Patino, M. T. O., Machado, M. F., Nascimento, G. T., & Alcantara, M. R. (2013). Analysis and forecast of the storage needs of soybeans in Brazil. *Engenharia Agrícola*, *33*(4), 834-843. DOI: 10.1590/S0100-69162013000400022

Santos, V. F., & Pelentir, M. G. S. A. (2016). Análise da estrutura física de armazenagem de soja em grãos na cooperativa grão norte no município de Boa Vista-RR. *Revista de Administração de Roraima*, *6*(3), 718-737. DOI: 10.18227/2237-8057rarr.v6i3.4061

Said, P. P., & Pradhan, C. R. (2014). Food grain storage practices: A review. *Journal of Grain Processing and Storage*, *1*(1), 1-5.

Sharon, E. M., Kavitha Abirami, C. V. K., & Alagusundaram, K. (2014). Grain storage management in India. *Journal of Postharvest Technology*, *2*(1), 12-24.

Schewe, J., Otto, C; & Frieler, K. (2017). The role of storage dynamics in an annual wheat prices. *Environmental Research Letter*, *12*(2), 1-14. DOI: 10.1088/1748-9326/aa678e.

Secretaria da Agricultura e do Abastecimento do Paraná, Departamento de Economia Rural [SEAB/DERAL]. (2015). *Banco de Dados da Produção Agropecuária no Paraná*. Situação mensal de plantio, colheita e comercialização de produtos agrícolas no Paraná. Retrieved on Jan. 25, 2018 from http://www.agricultura.pr.gov.br/arquivos/File/deral/pss.xls

Silva-Neto, W. A., Aruda, P. N., & Bastos, A. C. (2016). O déficit na capacidade estática de armazenagem de grãos no estado de Goiás. *Gestão & Regionalidade*, *32*(96), 151-169. DOI: 110.1330037/gr.vol32n96.22944

United States Departament of Agriculture [USDA]. (2015). Grain storage capacity affects transportation Tuning and Patterns. *Grains Transportation Report*. DOI: 10.9752/TS056-10-15-2015