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Research and Applications in Geotechnologies: a Scientometric Study of the Midwest Region of Brazil

Pesquisa e Aplicações em Geotecnologias: um Estudo Cienciométrico Sobre a Região Centro–Oeste do Brasil

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Resumo

Este trabalho de cienciometria apresenta o estado da arte da produção científica enfocando o uso e a produção de geotecnologias por meio do levantamento dos Grupos de Pesquisa atuantes na região Centro-Oeste do Brasil. Neste estudo foram reunidas as informações de grupos de pesquisa cadastrados no Diretório de Grupos de Pesquisa do Conselho Nacional de Pesquisa Científica e Tecnológica - CNPq, utilizando-se os termos "Geotecnologias", "Geoprocessamento", "Sensoriamento Remoto", "Cartografia", "Geotecnologias Pantanal", "GPS" e "GNSS". Estes termos foram buscados integrando o nome do grupo de pesquisa, ou da linha de pesquisa, ou ainda como palavra-chave de linha de pesquisa. O levantamento mostrou que há na região um número considerável de grupos de pesquisa que utilizam as Geotecnologias atuando nas instituições de pesquisa e ensino da região e disseminados em diferentes áreas do conhecimento. Do número total de 117 grupos de pesquisa encontrados na região Centro-Oeste, 49 se declararam atuando em Sensoriamento Remoto, outros 48 em Geoprocessamento, 33 em Cartografia, 28 em Geotecnologias, 2 em Geotecnologias Pantanal, 6 em GPS e 1 em GNSS. Quanto às áreas do conhecimento, 22% estão concentrados área das Engenharias (Sanitária, Florestal, Agrícola e Civil), 19% na área da Geografia e 14% na Agronomia, sendo que as demais áreas do conhecimento reúnem de 1 a 5% dos grupos de pesquisa restantes. Identificou-se ainda, quanto às instituições às quais os grupos de pesquisa estão vinculados, que apenas 6 das 15 instituições da região respondem por 78% do total de grupos.
Palavras-chave: Cienciometria; Geotecnologias; Pantanal; Geoprocessamento; Sensoriamento Remoto; Cartografia; GPS; GNSS

Abstract

This scientometric study describes the state of the art of scientific production, with a focus on the use and production of geotechnologies, based on a survey of the research groups in the Midwest region of Brazil. Information on the research groups registered in the Research Groups Directory of the National Council of Scientific and Technological Research (CNPq) was collected using the terms, "Geotechnologies", "Geoprocessing", "Remote Sensing", "Cartography", "Pantanal Geotechnologies", "GPS", and "GNSS". These terms were searched as part of the name of the research group, the line of research, or as keywords in the line of research. The survey showed that there are a considerable number of research groups using Geotechnologies, both in research and in teaching institutions of the region, across different areas of knowledge. From the 117 research groups of the Midwest region of Brazil registered at CNPq, 49 reported working in Remote Sensing, 48 in Geoprocessing, 33 in Cartography, 28 in Geotechnologies, two in Pantanal Geotechnologies, six in GPS, and one in GNSS. With respect to the areas of knowledge, 22% are from Engineering disciplines (Sanitary, Forestry, Agricultural, and Civil), 19% are from Geography, and 14% from Agronomy, while the other areas of knowledge represent 1–5% of the remaining groups. Further, it was found that that 6 of 15 institutions in the region host 78% of the research groups.
Keywords: Geotechnologies; Geoprocessing; Remote sensing; Pantanal; GPS; GNSS

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1 Introduction

Scientometry is known as the quantitative study of scientific production, which allows a better understanding of the nature and outreach of research activities carried out in different areas of knowledge and countries, as well as by different institutions and researchers. In Brazil, scientific research information is assembled and monitored by the National Council of Scientific and Technological Development (CNPq), which holds the Research Groups Directory (RGD) in its database.

Geotechnologies is a very important issue and there is some misunderstanding about its meaning which deals with the gathering, editing and management of spatial data (Paranhos Filho et al, 2008). The term Geotechnologies has become to be used at the beginning of 2000's and according to Tommaselli (2016) the utilization of the geotechnologies by the mankind may be related to the human history itself, because since its beginning, man needed to know his position in the environment and many times needed to materialize this positioning. In this context, the term Geotechnologies has been used in the well concepted British Magazine, Nature (Gewin, 2004), where it has been affirmed that, at that moment, the geotechnologies were one of the three areas of the human knowledge with more growing. This proposition from Gewin (2004) about a world demand on professional with know how to deal with satellite images and geographic data is still current.

In Brazil, CNPq is an agency of the Ministry of Science, Technology, and Innovation (MSTI), which collects information on the scientific and technological research groups in Brazil. This information encompasses human resources (researchers, students, and technicians), lines of research, areas of knowledge, sectors of application, production (scientific, technological, and artistic), the partnerships established between research groups and institutions, and the companies in the productive sector (CNPq, 2016).

Based on this information, the RGD mission is to describe the limits and the general profile of the scientific-technological activity in Brazil. Interestingly, the research groups registered are mainly located in universities, higher education institutions with *sensu stricto* postgraduate courses, scientific research institutes, and technological institutes. The RGD provides a database on the internet where information can be continually updated by the professionals involved. In addition, biannual censuses are performed, in order to update the information on this database. CNPq does not require, however, the inclusion of institutions, researchers, and students in the RGD for participation in calls or programs (CNPq, 2016).

The high regional concentration of scientific production infrastructure in Brazil has been the subject of many reflections and debates. It results from a study on the quantitative indicators of scientific production and regional innovation systems in Brazil, indicated that the evolution of scientific production in Brazil is inhibited by a strong regional imbalance (Gusmão & Ramos, 2006). The concentration of resources and opportunities in the Southeast region of the country generates inequalities. These inequalities respond to a self-reinforcing mechanism whereby existing infrastructural conditions influence the flux of resources, which, in turn, are incorporated into the infrastructure itself, increasing the differentials of competitiveness among states, with respect to fundraising from government agencies. Figure 1 shows the domination of Southeast region, followed by South and Northeast, and then Midwest and North.

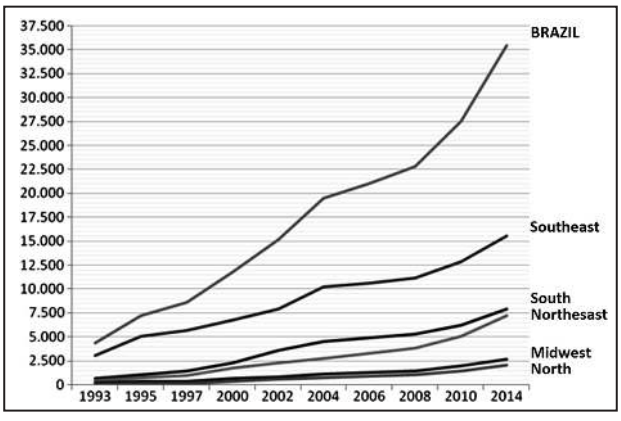

Figure 1 Temporal evolution of Research Groups in Brazil according to the geographic region.

The domination of the Southeast region of Brazil with regard to scientific production reflects directly on the number of research groups. Thus, although the Southeast region shows the lowest

growth in the number of research groups between 1993 and 2014, standing below all other regions (11 in the South, 17 in the Northeast, 15 in the Midwest, and 27 in the North; most recent data provided by the RGD in Brazil), in 2014, the Southeast region had 44% of the research groups in the country, twice the number in the South and Northeast regions, and more than six times the Midwest and North regions.

2 Objectives

The main goal of this study was to provide a contemporary picture on the use of geotechnologies in scientific research in the Midwest region of Brazil, based on the information available in the RGD/ CNPq database.

3 Materials and Methods

This study was based on surveys and online consultations involving the CAPES-CNPq-Lattes system (www.capes.gov.br; www.cnpq.br) and Research Groups Directory-CNPq (http://lattes.cnpq.br/web/dgp; www.memoria.cnpq.br/servicos/buscas.htm). The data was collected using a report-generating tool available in the system and the research groups were detected by searching entries by research terms, region, year of creation, and institution. The search of specific terms in the Research Groups Directory was performed by group, and applying the search in the fields, 'group name', 'line of research', and 'keyword of the line of research'.

First, information about every research group in Brazil was collected. Then a filter was applied to isolate those groups located in the Midwest region. The search of these two data sets was refined by searching for research groups associated with Geotechnologies, in both sets. The following search terms were used for this purpose: geotechnologies, geoprocessing, remote sensing, cartography, GPS, and GNSS. The specific term Pantanal geotechnologies was then also searched.

With respect to the historical series in the Midwest region, the tool "years of existence of the group" was used, each time selecting a time-window among those available (less than 1 year, 1 to 4 years, 5 to 9 years, 10 to 14 years, and 15 years or more). Because the search was performed for each of the terms mentioned above, and some groups could be associated with more than one term, it was also necessary to suppress duplicate groups produced by each parameter, in order to obtain an accurate number of research groups in the region. Based on this number, searches were then carried out by main area, by large area, by institution, and by type of institution.

4 Results and Discussion

The RGD is the official instrument for the evaluation of the scientific research in Brazil and a reference with regard to its intellectual production. The available data show that the number of groups registered in the RGD has been growing since 1993, both nationally and regionally. In 1993 there were 4,402 groups in the country, while the total number of groups found at the RGD in this study was 33,280.

Regarding geotechnologies, the general survey showed that of the 3,678 research groups registered and certified in the Central-West region of Brazil, 117 groups (3.18%) are working on geotechnologies. This is a relatively small number compared to the situation in Brazil, where, 1,521 (6.81%) of the 22,324 active groups, work and/or produce research in this area. It should be noted that the survey was carried out in October 2016, when the total number of groups was 33,280, and 10,956 groups were subtracted from that number, which is the number of groups excluded, non-certified, or undergoing an update process.

Regarding the frequency of specific terms among the research groups in Brazil, 79% of the occurrences are for remote sensing, geoprocessing, and cartography, while geotechnologies, GPS, and GNSS account for the remaining 21%, as shown in Figure 5. The graphics shows the percentual occurency of the terms in research groups; as more than one term may be occuring at the same group, then the group may be counted more than once (CNPq, 2016)

For the Midwest region, the first set (remote sensing, geoprocessing, and cartography) has a smaller participation than in Brazil overall, 77%, while Geotechnologies, GPS, and GNSS account for 23%. This difference may reveal a greater

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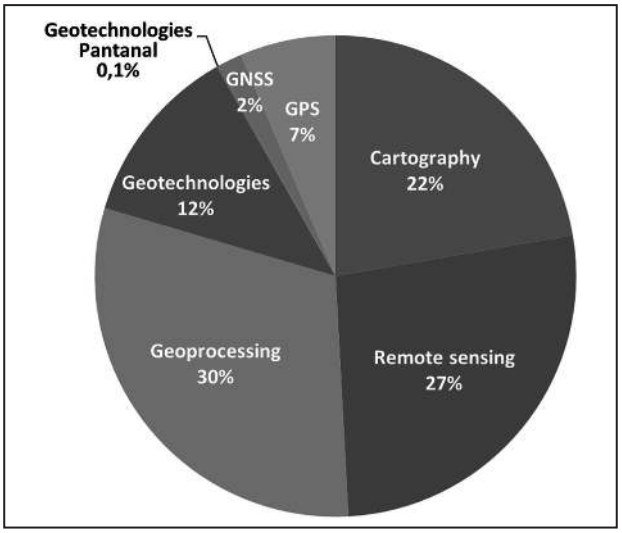

Figure 2 Research Groups in Geotechnologies in Brazil. Participation of the search terms as name of the group, or keyword or research line.

concentration of recent geotechnologies in the Midwest region, when compared to Brazil. In addition, the Midwest region hosts all the groups working in Pantanal Geotechnologies.

With respect to the terms related to research in Geotechnologies in Brazil, compared to the Midwest region, the latter is responsible for 12%, on average, of the terms. However, while most of the terms contribute with percentages of 4–11%, the terms 'Geotechnologies' and 'Pantanal Geotechnologies' show quite prominent values (Figure 7). The study reveals that, of 184 groups, lines of research, or keywords in research groups in Brazil that work in Geotechnologies, 28 (15.2%) are in the Midwest region, which also accounts for 100% of the occurrences of the term 'Pantanal Geotechnologies'.

Pantanal is the largest wetland in the world, with its vast majority in the state of Mato Grosso do Sul, but it also extends into Mato Grosso in Brazil and also into Paraguay and Bolivia. As such a vast tropical wetland, the Pantanal is a very precious environmental resource of Brazil, home to an array of plant and animal species. In fact, up to 12 sub-regional ecosystems have been identified within the Pantanal, each of which has its own unique identity and characteristics. It covers a total area of almost

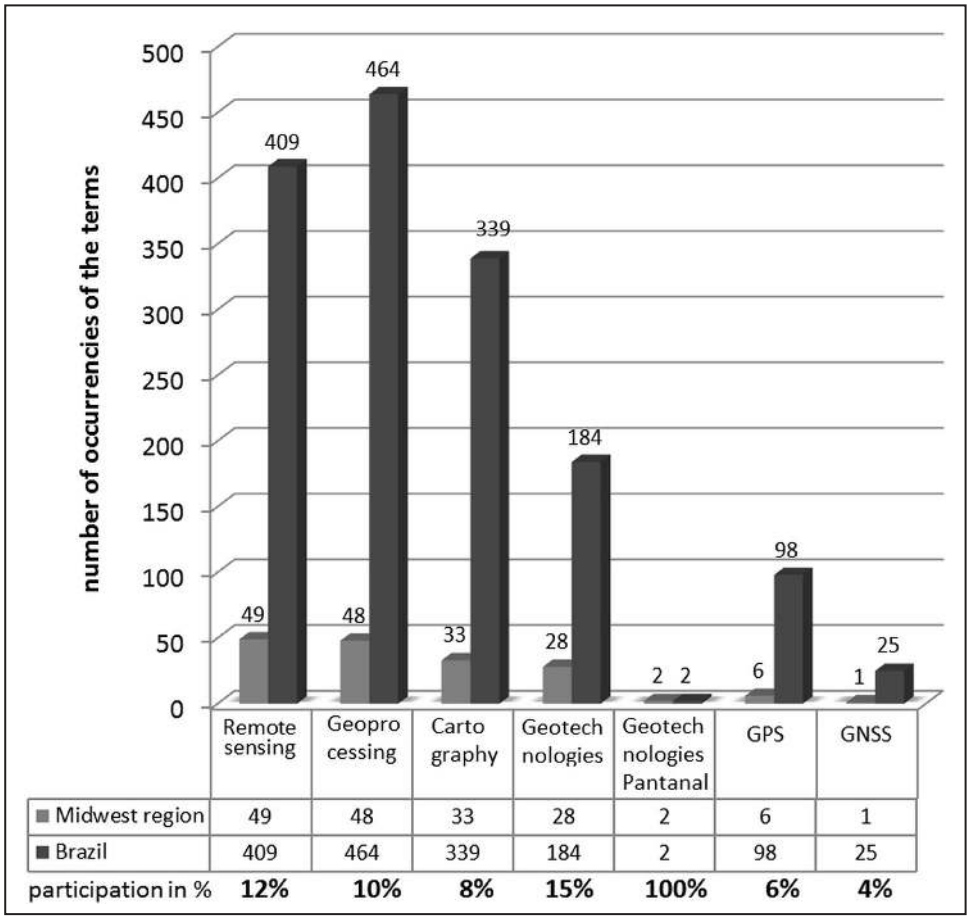

Figure 3 Participation of the search terms of the Midwest region related to Brazil. The search terms were done as the name of the group, the research line or the keyword (CNPq, 2016).

195,000 square kilometers (or 75,000 square miles), with about 80% of the wetlands submerged during the wet season up to five meters risen also being declared by UNESCO a World Nature Heritage site and Biosphere Reserve. The biomes (which include semi-arid woodland, tropical Amazonian rainforest and savannah) are home to approximately 3,500 known plant species, 1,000 bird species, 300 mammals and 9,000 invertebrates, in addition to countless fascinating insects and other species, some of them endangered or under extinction risk.

The lifetime of the research groups is one of the tools provided by the Research Groups Directory of the Lattes Platform. The collected information allowed visualizing the increments in time of existence intervals of 4–5 years, as follows: groups with less than 1 year, groups with 1 to 4 years, groups with 5 to 9 years, groups with 10 to 14 years, and groups with more than 15 years of existence (Figure 4).

Concerning the development of research in Geotechnologies in the Midwest region, it was observed that the most significant quantitative increases occurred between 2006 and 2011, with a significant growth of the number of research groups in this area. The largest increase occurred in remote sensing, with 20 new groups, in addition to geotechnologies and geoprocessing, with 16 and 15 new groups, respectively. Added to the values of the other search terms, this period contributed 63 new occurrences, the largest increase between any of the periods observed in the RGD.

In second place, were the groups with 1 to 4 years of existence, that is, those created between 2011 and 2015, showing an increase of 40 new occurrences, the largest being related to geoprocessing, with an increase of 12 occurrences, remote sensing with 11, and geotechnologies, with 9.

With respect to the search of groups by areas of knowledge, the identification of the distribution of research groups in the different areas of knowledge meets the purpose of understanding which scientific fields are applying geotechnologies to the development of science in Brazil. According to the Capes portal (CAPES, 2016), classification of the Areas of Knowledge has an eminently practical purpose, namely, to systematize information on research projects and human resources, for managers in the areas of science and technology. In this study, two of the hierarchy levels of the areas of knowledge were considered: 'large area' and 'area'. 'Area of knowledge' was defined as the "interrelated set of knowledge, collectively built and assembled according to the nature of the object of research, for purposes of teaching, research, and practical applications" (CAPES, 2016).

The Geotechnologies research groups in the Midwest region were organized here by the predominant area of knowledge, as shown in Figure 5. From the 117 research groups that work in Geotechnologies in the Midwest region, half are concentrated in only three of the 23 areas of knowledge reported as being the main research areas of the groups. These are Geography, Geosciences, and Agronomy (19, 17, and 14) %, respectively. The next areas are Engineering, Ecology, and Urban and Regional Planning, with number of groups 4–9. Finally, the other 18 areas of knowledge were shared among the rest of the research groups (with one to two groups each).

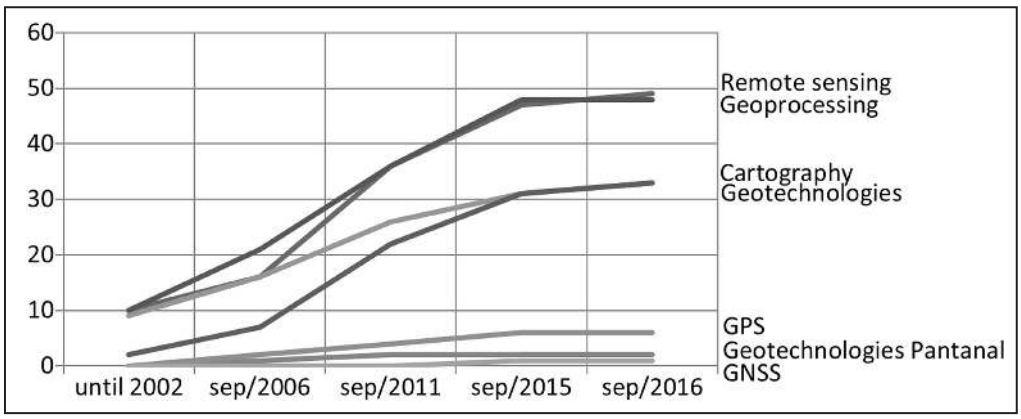

Figure 4 Distribution of the search terms by years of existence of the group (CNPq, 2016).

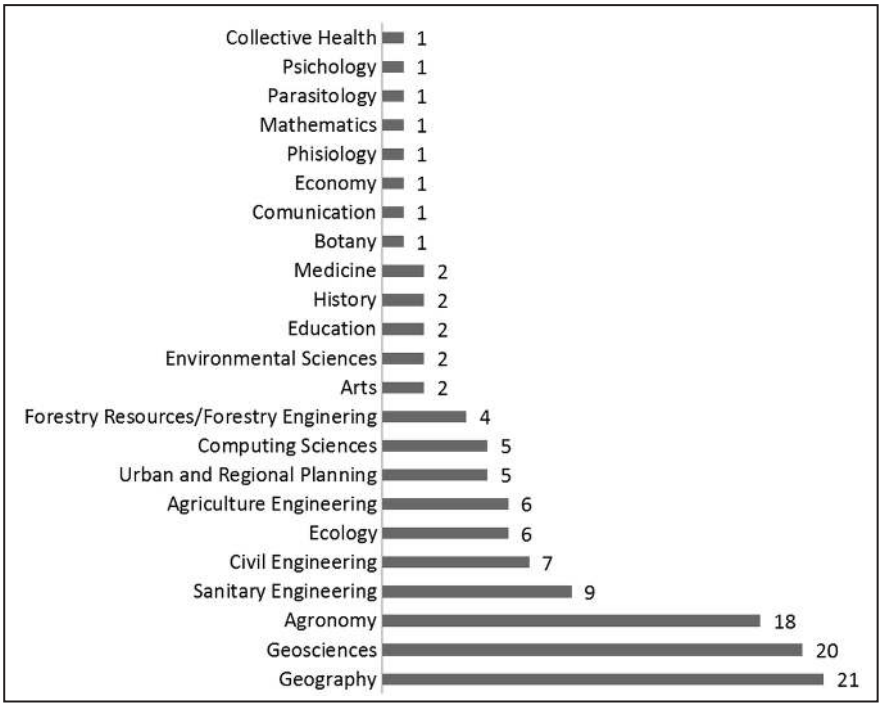

Figure 5 Number of research groups in Geotechnologies at the Midwest region by predominant area of knowledge.

When the Geotechnologies research groups were analyzed by great areas of knowledge, defined by Capes as the, "agglomeration of several areas of knowledge due to the affinity of their objects of study, cognitive methods, and instrumental resources, reflecting specific sociopolitical contexts" (CAPES, 2016), the distribution of the Geotechnologies research groups in the Midwest region took the form in Figure 6.

The largest number of research groups is concentrated in the Agricultural Sciences, Exact and Earth Sciences, and Human Sciences (28, 26, and 26 groups, respectively), adding up to 80 groups, or 67% of the total number of groups in Geotechnologies. These are followed by the Engineering disciplines, with 16 groups, or 13% of the total. It should be stressed that Forestry and Agricultural Engineering, which make the greatest research contributions in

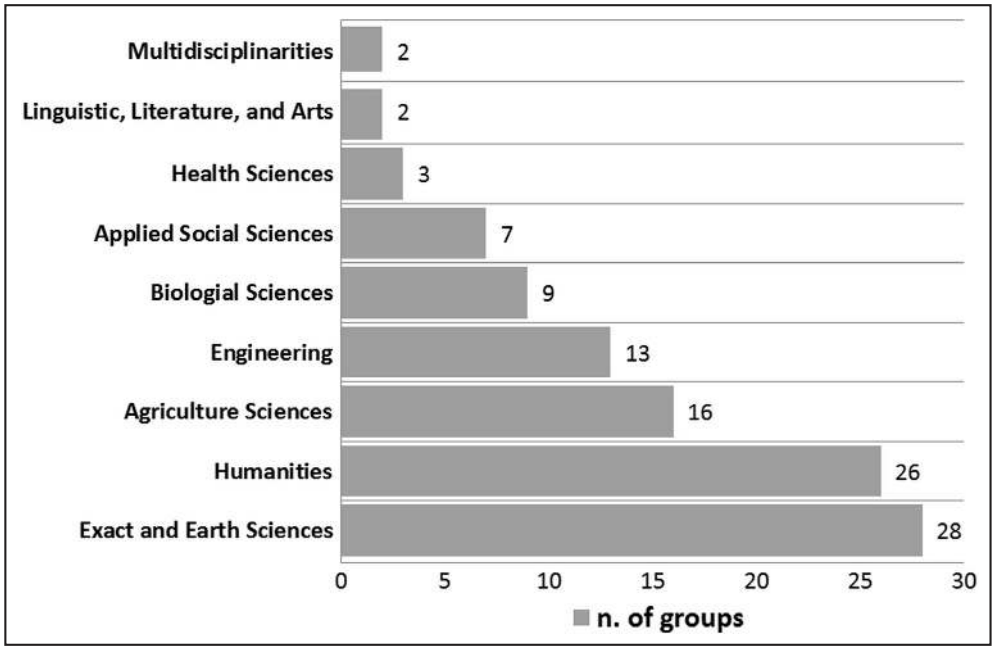

Figure 6 Number of research groups in Geotechnologies at the Midwest region by large area of knowledge. At the area Geosciences are also included the subareas Physical Geography, Hydrogeography and Photogeography.

Geotechnologies, among the different Engineering disciplines, are not included in this large area, but rather in the Agricultural Sciences area.

Another specificity of this classification concerns the area of Geography. This belongs to the large area of Human Sciences, which occupies third place regarding the number of research groups, while in the classification by areas it is the one that contributes the most with respect to geotechnologies. This may be due to the fact that although Geography is included in the Human Sciences as an area, it belongs to the Geosciences as a subarea (Physical Geography, Hydrogeography, and Photogeography) (CAPES, 2016).

Regarding the participation of the institutions in the groups that work and produce geotechnologies, it was observed that 16 institutions in Brazil host groups in this area, with extremely variable participation. Thus, six of them are responsible for 80% of the groups: UFMT (Federal University of Mato Grosso), UnB (University of Brasília), UFMS (Federal University of Mato Grosso do Sul), EMBRAPA (Brazilian Agricultural Company), and UFG (Federal University of Goiás). With the exception of EMBRAPA, these are all federal research and teaching institutions. The number of groups and percentages are shown in Fig. 7.

As can be seen from Figure 7, in addition to the predominance of federal institutions, federal institutes, through the benefit of governmental incentives, are gaining relevance, showing a number

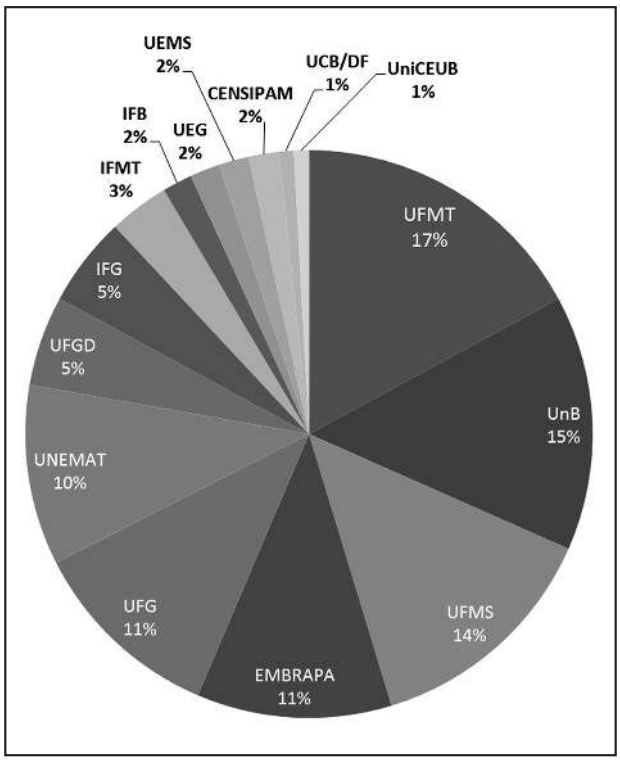

Figure 7 Research groups in geotechnologies at the Midwest region by research institution.

Brazil. Large areas of knowledge Predominant areas of the research groups	Groups/ area	Groups/ large área	%
5.00.00.00-4 Agricultural Sciences			
5.01.00.00-9 Agronomy	18	28	23
5.02.00.00-3 Forest Resources and Forestry Engineering	4		
5.03.00.00-8 Agricultural Engineering	6		
1.00.00.00-3 Exact Sciences and Earth Sciences			
1.01.00.00-8 Mathematics	1	26	22
1.03.00.00-7 Computing Sciences	5		
1.07.00.00-5 Geosciences	20		
7.00.00.00-0 Humanities			
7.05.00.00-2 History	2	26	22
7.06.00.00-7 Geography*	21		
7.07.00.00-1 Psichology	1		
7.08.00.00-6 Education	2		
3.00.00.00-9 Engineering			
3.01.00.00-3 Civil Engineering	7	16	13
3.07.00.00-0 Sanitary Engineering	9		
2.00.00.00-6 Biological Sciences			
2.07.00.00-8 Phisiology	1	9	8
2.13.00.00-3 Parasitology	1		
2.05.01.00-5 Ecology	6		
2.03.00.00-0 Botany	1		
6.00.00.00-7 Applied Social Sciences			
6.03.00.00-0 Economy	1	7	6
6.05.00.00-0 Urban and Regional Planning	5		
6.09.00.00-8 Comunication	1		
4.00.00.00-1 Health Sciences			
4.01.00.00-6 Medicine	2	3	2
4.06.00.00-9 Public Health	1		
8.00.00.00-2 Lingüistics, Literature, and Arts			
8.03.00.00-6 Arts	2	2	2
9.00.00.00-5 Multidisciplinar			
9.05.00.00-9 Environmental Sciences	2	2	2
TOTAL	117	**117**	100

Table 1 Number of research groups in Geotechnologies at the Midwest region by large area of knowledge. At the Geosciences area, the sub areas Physical Geography, Hydrogeography and Photogeography (Physical-Ecological) are also included.

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of research groups even larger than that of state universities. From the perspective of the type of research institution, the federal universities host 72 research groups, which represent 61% of the total number of groups in the region.

Next (although far below) appear the state universities and, almost with the same number of groups, the federal public research institutions and the federal institutes, with, respectively, 16, 15, and 12 research groups. Finally, the private universities, UCB/DF (Catholic University of Brasilia) and UniCEUB (University Center of Brasília), share the remaining 2% of the groups. Among the government public research institutions, (marked with *) which represent 15 of the Geotechnologies groups, 13 groups are based in EMBRAPA.

5 Conclusions

This scientometric study allowed quantification of the participation of a Brazilian region in recent scientific and technological growth, in a research area of great relevance: geotechnologies. A total of 117 research groups working in geotechnologies were identified in the Midwest region. Half of these are concentrated in only three of the 23 CAPES areas of knowledge: Geography (19%), Geosciences (17%), and Agronomy (14%). Next, with number of groups ranging from 4 to 9, were Engineering, Ecology, and Urban and Regional Planning. Finally, one to two groups each of the remaining research groups are spread among the remaining 18 areas of knowledge. Furthermore, 16 institutions with variable participation in the groups involved in research activities in Geotechnologies were observed, of which six are responsible for 80% of the groups: UFMT, UnB, UFMS, EMBRAPA, and UFG. With the exception of EMBRAPA, these are all federal teaching and research institutions.

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