

GRANT USAGE OF WATER RESOURCES IN THE ENVIRONMENTAL PROTECTION AREA AT MACHADO RIVER, IN THE SOUTH OF THE STATE OF MINAS GERAIS

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ABSTRACT

Water grant is an administrative act predicted by the Brazilian Water Resources National Policy that grants to the requester the right to water resources use according to the watershed plan guidelines ensuring the water multiples uses. The Environmental Protection Area of Machado river watershed is located in the southern of Minas Gerais State, and it has an intense land use diversity, demanded water for multiple productive process. This paper aims to evaluate the water permits granted by Minas Gerais Water Management Institute to the Environmental Protection Area of Machado river from 2002 to 2018. For this research was used cartographic data obtained in the scale 1:50,000, data of Minas Gerais State Forestry Institute, as well as the water permits database from Minas Gerais Water Management Institute. The treatments of spatial and non-spatial data were performed using geographical information system, electronic sheets and R statistical packages applications. Results show there is an increase in grant concessions in the study area in 2014, and the higher density of water permits is located at the middle and lower Machado river watershed due to the use by irrigated agriculture, which uses 70.8% of the consumed flows.

Keywords: Right of use. Multiple uses. Hydrology. Spatial analysis.

OUTORGAS DE USO DOS RECURSOS HÍDRICOS NA ÁREA DE PROTEÇÃO AMBIENTAL DO RIO MACHADO, SUL DE MINAS GERAIS

RESUMO

A outorga de água é um ato administrativo previsto pela Política Nacional de Recursos Hídricos, que concede ao solicitante o direito de uso dos recursos hídricos, vinculando diretrizes do plano de bacias, garantindo o uso múltiplo do mesmo. A Área de Proteção Ambiental da Bacia Hidrográfica do rio Machado, localizada no Sul de Minas Gerais, possui um mosaico de intenso uso da terra, demandando água para diversos processos produtivos. Objetiva-se avaliar por este artigo as concessões das outorgas emitidas pelo Instituto Mineiro de Gestão das Águas para a APA do rio Machado no período entre 2002 a 2018. Para a realização desta pesquisa utilizaram-se dados cartográficos obtidos nas cartas topográficas na escala de 1:50.000, dados do Instituto Estadual de Florestas de Minas Gerais, bem como a base de dados sobre outorgas do Instituto Mineiro de Gestão das Águas. Os

tratamentos de dados espaciais e não-espaciais foram realizados via sistema de informação geográfica, planilhas eletrônicas e pelos aplicativos do software R. Resultados demonstram que há incremento nas concessões de outorgas na APA do rio Machado a partir de 2014, sendo que as maiores densidades de outorgas expedidas se encontram no médio e baixo rio Machado, em virtude da agricultura irrigada, que utiliza 70,8% das vazões consumidas.

Palavras-chave: Direito de uso. Usos múltiplos. Hidrologia. Análise espacial.

INTRODUCTION

The conservation units in Brazil have, since 2000, a specific legislation for its protection, Law n. 9,985 from July 18, 2000, which established the National System of Nature Conservation Units (Sistema Nacional de Unidades de Conservação da Natureza) (SNUC), by creating two groups of conservation units – Full Protection and Sustainable Use- having as their basic objectives the preservation of nature and the compatibility of nature conservation with the sustainable use, respectively.

In the scope of SNUC there were created 12 categories of conservation units, among them the Environmental Protection Area, being defined through Art. 15 as:

[...] “an area which is, in general, extensive, with certain level of human settlement, with abiotic, biotic, aesthetic and cultural attributes, which are especially important for the quality of life and well-being of human populations and, which have as their basic objectives to protect the biological diversity, to regulate the occupation process and to assure the sustainability of the use of the natural resources” (BRAZIL, 2000, p. 9).

In chapter III, About the Conservation Units, Art. 14, item I, the Environmental Protection Areas constitute the group of Units of Sustainable Use, aiming to reconcile the preservation of the environment, together with the sustainable use of natural resources, may they be public or private, and allowing the presence of traditional communities that had already been established in the place.

In 1999, the then governor of the State of Minas Gerais, Itamar Augusto Cautiero Franco, sanctioned the State Law n. 13,373, enacting the creation of the Environmental Protection Area in the watershed of Machado River (EPA of Machado River), which encompasses the municipalities of Espírito Santo do Dourado, Congonhal, Ipuiúna, Carvalhópolis, São João da Mata, Poço Fundo, Campestre, Machado, Alfenas, Paraguaçu and Fama, being attributed to the State Institute of Forests from the State of Minas Gerais (IEF), the management of this conservation unit (MINAS GERAIS, 1999).

Because of the population and economic growth of the municipalities that belong to the EPA at Machado River, in the last decades, together with the multiplicity of land use, may it be for agricultural, urban, industrial means, or for the generation of hydroelectric power, the demand for the use of water in the most diverse productive systems and user segments, is a factor that lacks space-time evaluation about the grant usage by the government, as well as the quantitative that had been granted to their respective expiration dates.

It is worth highlighting that in the Environmental Protection Area, the development of research is allowed, once for these means, there are permitted the sample taking, aiming to assist their management and preservation. And in this sense, according to the picture abovementioned, on the plurality of water user segments, efforts in the technical-scientific cooperation between the State Public Prosecution, IEF, the Non - Governmental Organization Regional Agency of Environmental Protection at the Watershed of Grande River (ARPA Rio Grande) and the Federal University of Alfenas (UNIFAL-MG) have been made for the understanding of socio-environmental systems in the help for the sustainable use of EPA at Machado river.

Nevertheless, this study aims to evaluate the grant usage of water resources, granted by the Minas Gerais Institute for Water Management (IGAM), inserted in the EPA at Machado River, in which refers to the temporal and spatial analysis, and by purposes of use from 2002 to 2018, in order to contribute with EPA Management Council and the Committee of the Watershed of the Surroundings of Furnas reservoir (GD3), in planning actions and management of water resources.

GRANT USAGE OF WATER RESOURCES

Water is a natural element, which is extremely important for the maintenance of life in the planet. Regarding the purposes of its use by the societies, water can be understood under two aspects: water while a natural element and water while a resource.

The conceptual aspect which adopts water as a natural element, concerns about the balance of ecosystems that interact with the hydrological cycle, promoting their preservation and conservation. The bias adoption as a resource, is aligned to the use of the natural elements, while support for the implementation of diverse practices, as for example the irrigation of crops, generation of electricity, human supply, watering of animals, industrial intake, dilution of effluents, navigation, aquiculture among others.

Based in this last conceptualization, water is then called a water resource that shall meet the demands of all the user segments, focusing in the present, but, above all, in the future. In this sense, it is inserted the concept on the relationship between supply X demand, reconciling the water availability to the needs by the use of this resource.

In Brazil, the National Water Resources Policy– Law n. 9,433/1997 (Waters Law) – is based in five management instruments, being that one of them, the Grant Usage of Water Resources establishes criteria for the grant (BRAZIL, 1997). Among these criteria, it is highlighted the need for maintaining the quality and quantity of water, beyond the grants being aligned to the directives of the plans of water resources in the watershed, privileging the multiple use of water.

The grant usage of water resources is a constitutional right, and it is endorsed by the Waters Law, and it is characterized by public domain and inalienable property. Grant usage shall be issued by the granting bodies in the spheres of Federal, State public administration and from the Federal District, in accordance with the hydrologic analysis on the water availability of the collection point and/or launch of interest, may it be in quantity or quality of the water, as well as by observing its dominance.

About water domain, the Federal Constitution from 1988, articles 20 and 26 regulate the dominance of superficial and underground waters in the national territory:

Art. 20. The following constitute property of the Union:

“III – lakes, rivers and any watercourses on lands that it owns; interstate waters; waters that serve as borders with other countries; waters that extend into or come from a foreign territory; as well as the bordering lands and river beaches” (BRAZIL, 1988, p. 25).

Art. 26. The property of the States includes:

“I – surface or underground waters, whether flowing, emerging or in reservoirs, with the exception, in the latter case, as provided by law, of those resulting from works carried out by the Union” (BRAZIL, 1988, p. 30).

Watercourses that have their springs and estuary in a same federative state are considered rivers of state domain, which does not happen for rivers that cross or border federative states or countries with federal dominance.

In this sense, for fluvial systems of the Union domain, the responsibility for the grant usage is given to the National Agency of Waters (ANA), being that for watercourses under State jurisdiction, such responsibility is given to managing bodies of State water resources. In the case of the State of Minas Gerais, the regulation of grants usage of water resources is in the

trust of IGAM, according to the State policy of Water Resources – Law n. 13.199/1999 (MINAS GERAIS, 1999).

The grant gives the user the right for the use of a certain amount of water that comes from the water abstraction (superficial or underground) or for the dilution of the effluent. About the superficial abstraction, one should pay attention to the water availability in the interest point which, most of the time, does not correspond to the place where the monitoring of flows is done.

In this question, it is of great importance the hydrometric monitoring network, because it is through it which, and through methods of hydrologic regionalization that there are estimated the reference flows that will subsidize the grant usage. It is for each federative entity which is legally qualified the grant usage of a choice because of a reference flow.

Reference flow is characterized for being the kind of flow in which the hydrologic analysis of the water availability will be held, always grounded on minimal flows, may they be through the permanence curve analysis or by probabilistic methods. The granted quantitative will be a percentage share of the reference flow.

In case of rivers which fall to the Union, ANA establishes as reference flow the Q_{95} , that is, the minimal flow with 95% of time permanence in the fluvial section of interest, having as maximum grantable percentage the value of 70% (ANA, 2013). If in a fluvial section the Q_{95} is $10 \text{ m}^3 \text{ s}^{-1}$, the grantable maximum flow for the meeting of all demands in that section, will be of $7 \text{ m}^3 \text{ s}^{-1}$.

In Minas Gerais, IGAM in a partnership with the Secretariat of State for Environment and Sustainable Environment (SEMAD), wrote the Joint Resolution SEMAD-IGAM n. 1.548/2012, which establishes the directives on the determination of reference flow for the calculation of grant usage of water resources.

Through the abovementioned Resolution, $Q_{7,10}$ was defined as reference flow, i.e., the minimum flow of seven consecutive days, with a return period of ten years, having as grantable maximum percentage, the value of 50%, in natural conditions. However, for the watersheds of Jequitaí, Pacuí, Urucuia, Pandeiros, Verde Grande, Pará, Paraopeba and Velhas rivers, the maximum grantable percentage is 30% of the reference flow $Q_{7,10}$ (IGAM, 2012).

In this bias, it must be guaranteed, in quantity and quality the needed water for the meeting of users' demands, always being guided by the Watershed Planning, and, especially, based on an information system on water resources that are able to guarantee, with acceptable precision and accuracy, the estimates of reference flows.

METHODOLOGY

Study area

The EPA of Machado River (Figure 1) is in the South of the State of Minas Gerais and it has a drainage area of 860.9 km^2 , being Machado river the main watercourse with approximate extent of 112.2 km , according to spatial data that had been extracted from the topographic maps of the Brazilian Institute of Geography and Statistics (IBGE, 1970). Their main tributaries on the right bank are Machadinho do Campo and Machadinho streams (that borders the city of Machado/MG) and Conceição creek.

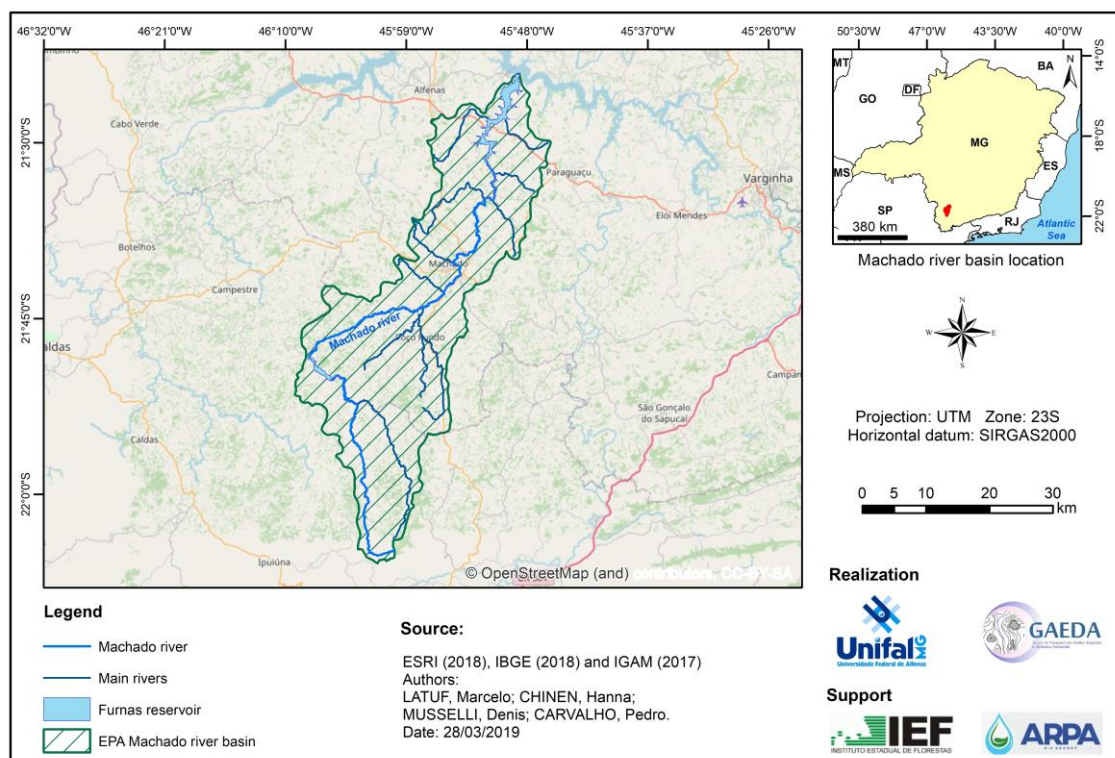
Machado river shows between the high and average course, expressive altimetric gradient, and, taking advantage of this characteristic, in 1949, Minas Gerais Energy Company (CEMIG), started the operation of Poço Fundo Hydroelectric Power Plant with $9,16 \text{ MW}$ and which is installed in a lake with 270.3 hectares and stored volume of 5.03 hm^3 (CEMIG, 2019).

In the geologic context, EPA is inserted at Varginha-Guaxupé Complex and it contemplates associations granite-gneiss, with associated lithotypes migmatite orthogneiss, paragneiss, biotite schists, migmatite, quartzite, peroxigen, granulite and granitoids that had been identified through a mapping in the scale of $1:1,000,000$ done by the Company of Economic Development of Minas Gerais (CODEMIG) and Company of Research and Mineral Resources (CPRM, 2014).

Geomorphologic Data from EPA show the presence of distinct morphological compartments, according to a research done by Gregório and Ferreira (2018),

“EPA’s morphological compartmentalization of the watershed at Machado river, showed the presence of six types of grouped topographies: types of dissection/degradation and types of accumulation/ aggradation. The ones about dissection are the hills, small hills, hills with soft slopes, mountains and, in the end, cliffs; and the types of accumulation are represented by the plains along the watershed of Machado River”. (GREGÓRIO; FERREIRA, 2018, p. 3).

Figure 1 – Environmental Protection Area of Machado River Location



Source – Authors (2018)

According to the soil mapping for the State of Minas Gerais, which was coordinated by the Federal University of Viçosa (UFV) in the scale of 1:650,000, the most representative pedologic classes in the EPA at Machado River are the Latosols, with 59.8%, followed by Cambisols with 33.7% (UFV, 2010).

The prevalent weather in the EPA at Machado River is the Tropical High – Altitude one (Cwa), according to Köppen-Geiger’s classification, which is characterized by having two well-defined seasons, a dry one that encompasses the months from April to September, and the other which is rainy, from the months from October to March (ALVARES et al., 2013; REBOITA et al., 2015). With annual fluviometric average of 1,597.2mm, the EPA records annual compensated average temperature of 19.8°C, being February the hottest month with monthly average maximum of 29°C. July is diagnosed as the coldest month, with monthly average minimum temperature of 8.8°C (INMET, 2018).

The major vegetation is characterized by Atlantic Rainforest, with transition for Savannah in some municipalities closer to the South of the Machado river watershed. However, data by Pisani et al. (2018) show that 41.7% of the area still has its original covering, and the class of

use by agricultural cultures gave the highest representativeness of the anthropized areas, reaching 350.4km².

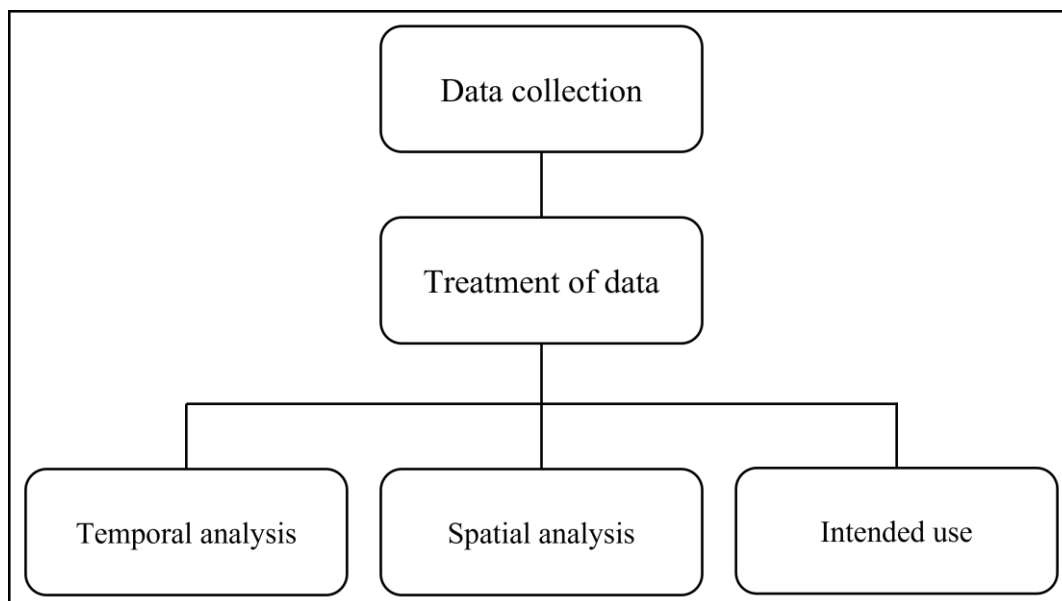
In the context of anthropized areas, the South of the state of Minas Gerais is mainly acknowledged by the coffee culture, of Arabic type (*Coffea arabica*), a product that is mostly made for export, followed by the cultures of sugar cane and corn, being the economic pillar of the mesoregion of the South/ Southwest of Minas Gerais followed by tourism, because of the proximity with Furnas reservoir, as well as the sectors of services and education.

Among the municipalities which are coffee producers from the South of Minas Gerais, the municipality of Machado is highlighted, with estimated population of 41,844 people in 2018 (IBGE, 2018, and with estimated production of 28,282.8 tons/year positioning itself as the biggest regional producer, according to data from the Agricultural Census – held by the Brazilian Institute of Geography and Statistics (IBGE, 2017).

Methodological procedures

For this research it was designed a methodological flowchart for the division of stages (Figure 2). The first one is named “*Data collection*” consisted in the elaboration of a digital cartographic base of the watershed of EPA at Machado River, as well as in the data collection on the grant usage.

Figure 2 – Methodological Flowchart of data collection and treatment.



Sources – Authors (2018)

The cartographic base was elaborated having as data source the ottocodified hydrography of the Rio Grande watershed, in the scale of 1:50,000, and it was gotten in the Portal Geospatial Metadata at ANA, which is compatible with the topographic maps from IBGE; EPA's limits at Machado River were obtained at IEF's website. Regarding grant data, they were obtained in the InfoHidro Portal of IGAM.

The grant data collection was divided into two strands: the first ones grant from before 2008; between 01/01/2009 - 25/02/2011 and 01/01/2014 - 31/12/2015, which were made available in electronic spreadsheets, which already showed data of latitude and longitude, which were further converted for decimal degrees.

In the second strand, in a hard effort of search – in every decree – in the identification of grants in the Planning Unit of GD3 Committee. Through the identification of grants which fit the abovementioned criteria, their data were fed in the electronic spreadsheet for further spatialization and selection of grants in the EPA at Machado River.

The second methodological stage, “*Treatment of data*”, branched out in other three sub-stages named “Temporal analysis”, “Spatial analysis” and “Intended use”, which consist in the annual evaluation of the grants and their respective expiry dates, in the spatial analysis of the distribution of grant points and in the diagnosis of user segments of the water resources, respectively.

The sub-stage “Temporal analysis” covered a more detailed evaluation of grant data, having as selection the criteria the civil year, i.e., the grants were filtered according to their dates of publishing in portals, and the base period was from 2002 to 2018. It is worth highlighting that the year of 2018 was taken into consideration until the date of the last access to the site with IGAM decrees, which was on May 09, 2018.

Then, data was differentiated according to the types of grants (underground or superficial), the quantitative of annual grants, granted annual flows (in liters per second), the relationship flow/grants and the analysis of the due date of the grants that had already been issued. About the granted issues, there were elaborated graphs of boxplot type, for the evaluation of descriptive statistics through the software RStudio version 1.0.153 (R CORE TEAM, 2018), which is supported in the method of interquartile range in the definition of *outliers* (BERALDO and SALDANHA, 2016).

The sub stage “Spatial analysis” comprehended the manipulation of spatial data through the System of Geographic Information ArcGIS® 10.5.1, aiming to do the data cut only for the interior of EPA at Machado River, and statement of the main watercourses, because of the modified Otto cycle of the hydrographic network.

Data spatial analysis was held through the methods of Euclidian Distance and the Kernel Distance, both of them which are enforced by the module *Spatial Analyst Tools*, so that the determination of spatial statistics in relation to proximity and density, respectively.

The last step from the methodological flowchart “Intended use”, had as its basis data of granted annual flows, having as reference the form of use of the water resource, defining the main water user segments in the EPA at Machado River, as well the quantitative of irrigated areas (in hectares).

RESULTS AND DISCUSSION

Because of the dominance of watercourses in the watershed at Machado River, IGAM is positioned as the body which is responsible for the grant of usage of underground and superficial waters.

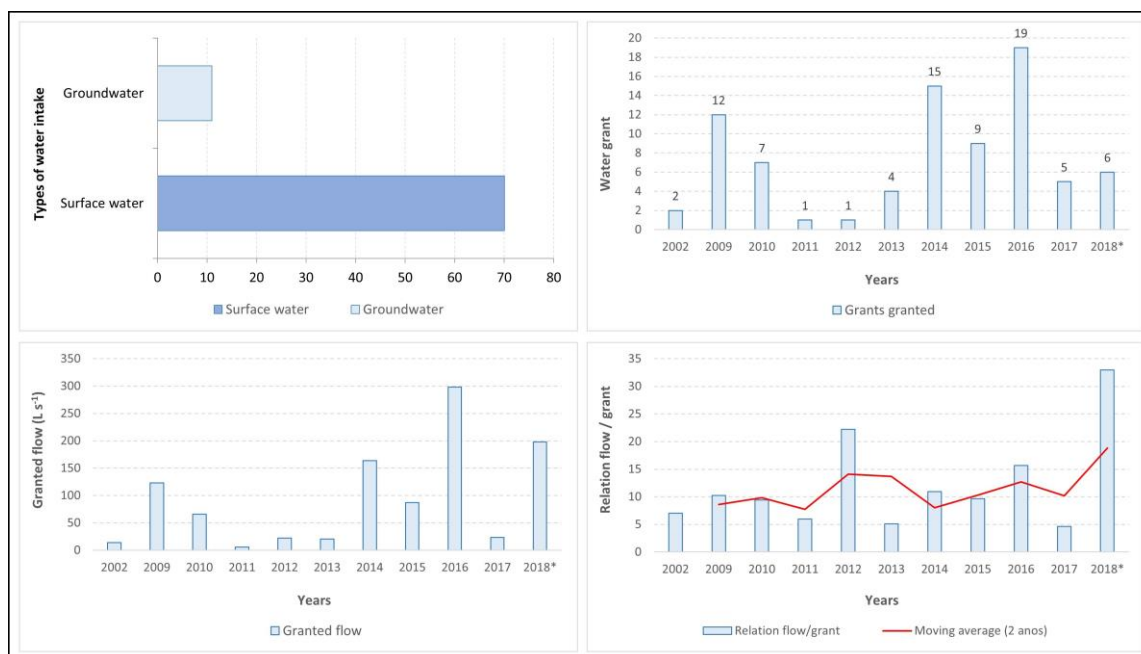
There was the data processing granted by IGAM in the EPA at Machado River, in the period from 2002 to 2018 (Figure 3), having as result the identification of 81 records of grants, mostly destined to superficial grants (86.4%) when compared to underground grants (13.6%) (Figure 3A).

About the analysis of annual grants (Figure 3B), it is observed that there is not ongoing increase of grants, a fact that was noticed in other places in the country, as for example the areas of agricultural expansion (RODRIGUEZ, 2004; SAMPAIO, 2012). What can be seen is an oscillating rhythm which is influenced, above all, by the validities of grants, which, in general, are of five years. Up to 2008 there had been recorded only two grants in the watershed, and this fact contrasts with the following years (2009 and 2010), with 19 grants.

This increase may have been influenced by some factors, such as the surveillance by environmental bodies, or by the obligation of users of water resources in the legalization of their collection, because according to Art. 12 in Decree n. 41.578/2001, which regulates the State

Policy of water Resources from the State of Minas Gerais (Law n. 13,199/1999), IGAM now has legal basis in the exercise of the surveillance of grants.

Figure 3 – Evaluation of the grant usage of water resources in the EPA at Machado River (2002 to 2018)



Source – IGAM (2018)

As the expiry dates of grants is, predominantly of five years, the period between 2011 and 2013 (six grants) can be considered a period of “off-season”, because the many users had already been regulated before the supervisory body.

In 2014, a “new cycle” of grants in the watershed started, because with the expirations of the grants from 2009, added of other ones, arising from the intensification of use and coverage of land, as highlighted by Pisani et al. (2018), the demand for the use of water resources increased in the EPA at Machado River; from this year on, there were issued 54 grant usage of water resources, accounting for 66% of all the grants.

It calls attention the triennium 2014/2016 with 43 grants (approximately 53% of the grants in EPA), being 2016 the year of higher expressiveness with 19 grants. It reflects an increasing demand for the use of water resources in the watershed, a fact that has been proven by the granted quantitative (Figure 3C), in which the numbers in liters per second (L s⁻¹) show a differentiation of 206% when compared in two periods (2002 to 2013 and 2014 to 2018), having the first one the sum of 251,6 L s⁻¹ and the second one of 769,9 L s⁻¹.

It was decided to hold the calculation of granted flow (Figure 3D) and, in these cases the years of 2012 and 2018, with 22,2 L s⁻¹ and 33 L s⁻¹, respectively, were highlighted. The uses destined to the maximum granted flows in the respective above mentioned years were for the irrigation of 11, hectares and the public supply in the city of Machado/MG, according to checked data (IGAM, 2018).

It should be noted that the adjusted moving average for Figure 3D shows trends of growth of the relationship flow/grant i.e., not only there is an increase in the number of requests and grant usage, but also in the demand for water in the watershed of EPA at Machado River. This fact highlights the need of the Committee GD3 of having its Plan of Watersheds to be updated, as well as to dispose of the further instruments for the management of operational type, with the purpose of satisfactorily manage the water resources in this watershed.

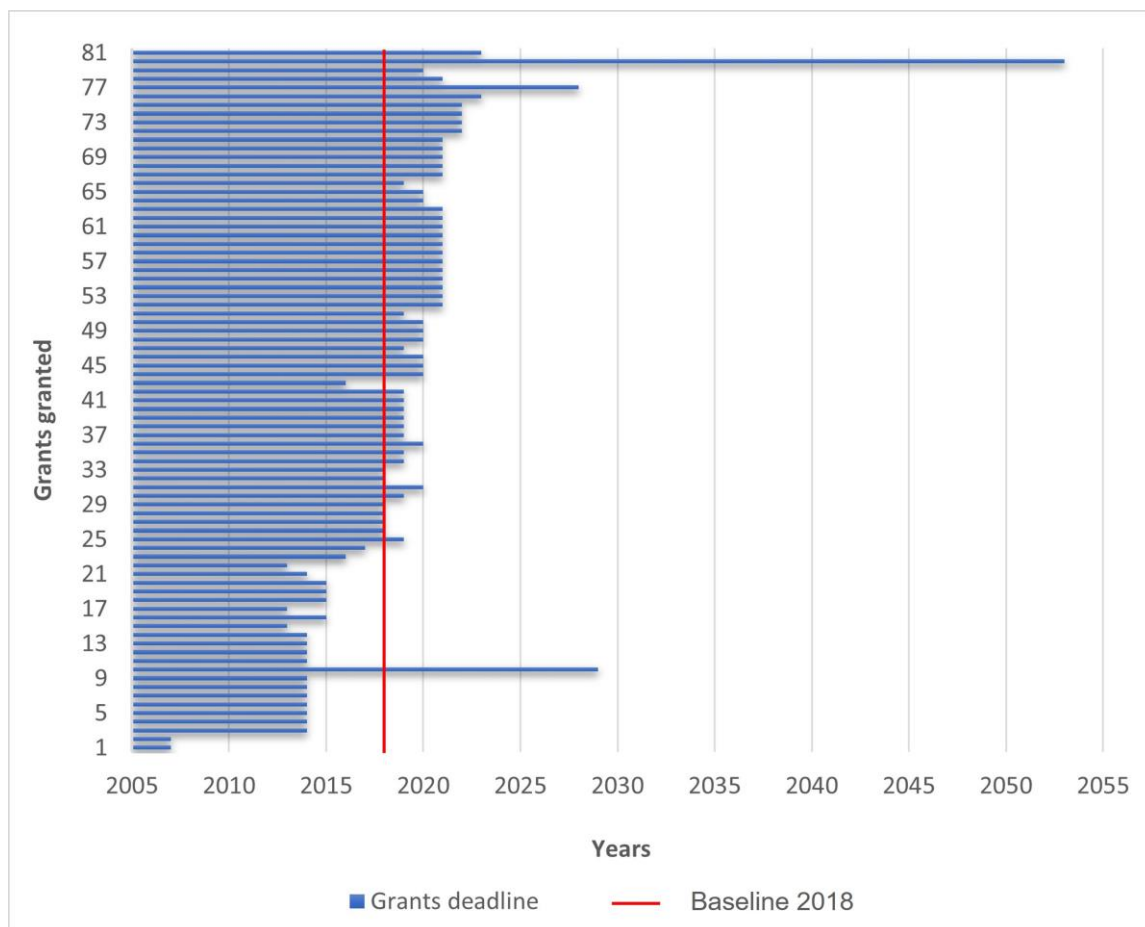
In the sense of evaluating the validities of the grant usage of water resources in the EPA at Machado River, there was done a temporal analysis of the due dates for each grant (Figure 4). In order to facilitate the understanding of this figure, it was decided to insert the base line of the present year (2018).

Three items are highlighted in the list of 81 grants, numbers 10, 77 and 80, and they can be viewed in the abovementioned figure. The grants number 10 and 80 are intended for the water supply of the cities of Fama/MG and Machado/MG, respectively. These grants will only expire in 2029 and 2053, having as capture values 15 L s⁻¹ and 145 L s⁻¹, respectively.

Grant number 77 is intended for use by the irrigation of 14.2 hectares, in the city of Espírito Santo do Dourado/MG, with expiry term of 10 years and the prediction for the end of the grant of 8.8 L s⁻¹ for 2028.

Out of the 81 grants that had been issued by IGAM for the watershed of EPA at Machado River, 57 of them are active until 2018, which represents 70.4% of the sampling universe. Out of this total, 48 grants will be expired in a scenery of four years (until 2021), and it provides a very timely planning horizon to Committee GD3, which will be able to expressively contribute for the recovery and preservation of this watershed, because it is a deadline which is able enough to establish the billing system by the use of water resources, fostering actions that had been deliberated by the Committee Plenary, with focus in the increase of hydric availability, quality of the water and, mainly that is designed for the multiple uses for the care with user segments.

Figure 4 – Due dates of grants in the EPA at Machado River



Source – IGAM (2018)

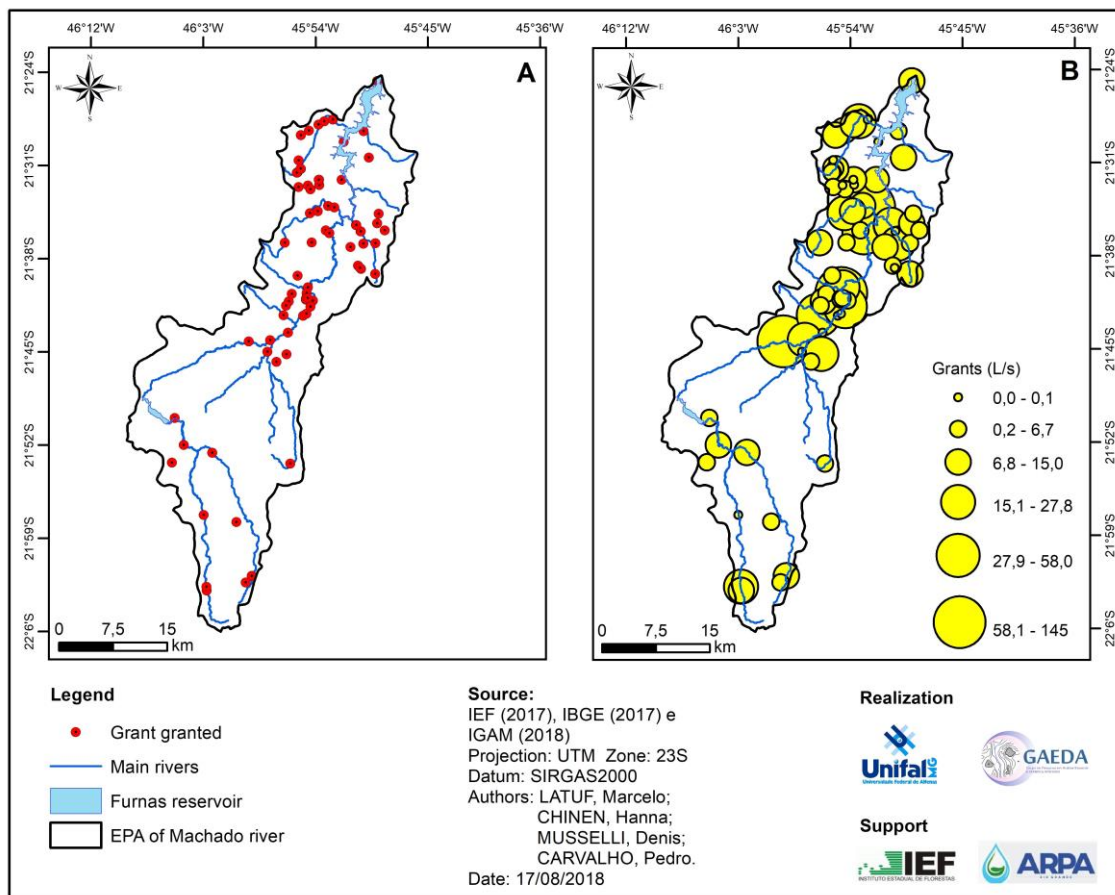
This picture reflects the need of the structuring of an information system on water resources, via Committee GD3, aiming to enhance a system of the type command – and – control (COLLISCHONN, 2014).

In which concerns the spatial analysis of the distribution of grants in the watershed in EPA at Machado River (Figure 5), there were elaborated two cartographic representations of the points of water abstraction (Figure 5A) and of their magnitude (Figure 5B).

Through the sectorization of the watershed at Machado River, in high, average and low courses, it is highlighted a bigger agglutination of grant points in the average and low courses, when compared to the grants in the passage of the high course of the watershed, which are characterized because they are more dispersed (Figure 5A).

This fact proves the highest demand for the use of water resources in the average course, but especially, in the lower course of Machado River, anthropized by agricultural cultures (coffee plantation - irrigated and dryland coffee) and cattle breeding (PISANI et al., 2018). It was also identified that near the city of Machado/MG, there are demands for the use of water, mainly because of urban and industrial needs (human supply and mineral extraction), as shown in the allocations that are granted by the checked decrees (IGAM, 2018).

Figure 5 – Spatialization of grants in EPA at Machado River (2002 to 2018)



Source – Authors (2018)

Figure 5B shows us the granted quantitatives, where the most expressive grants are located in the average and low Machado River, due to the demands by the use of water resources (superficial and/or underground, according to had been previously mentioned).

The descriptive analysis of the granted flows identified outlier records (Figure 6), i.e., records that show discrepancies regarding the sampling universe of observed data.

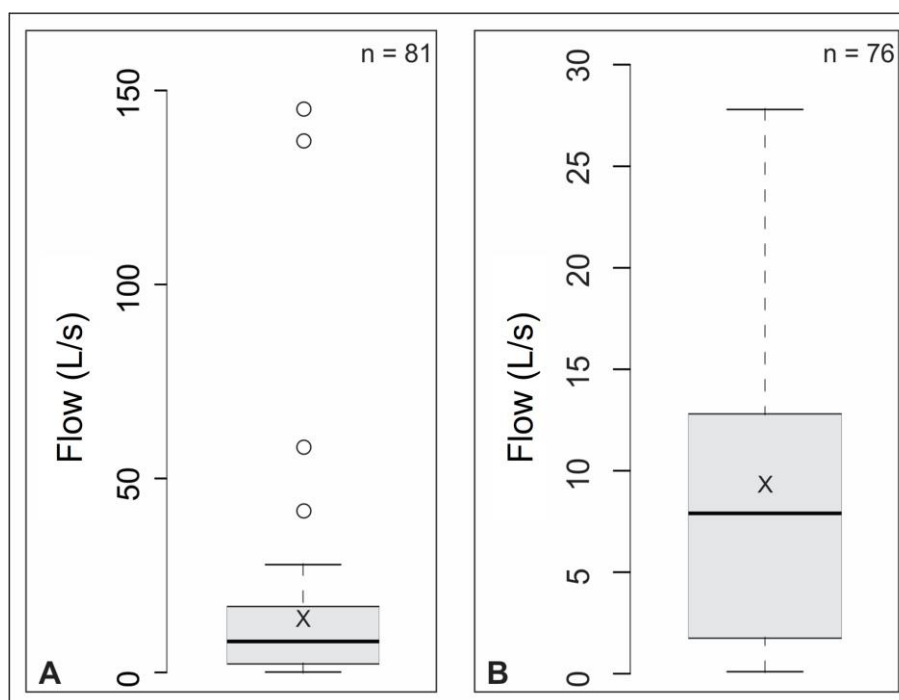
In Figure 6A, it was chosen the graphical representation of the 81 grants identified in the EPA at Machado River. It is observed that there is discrepant data (circular shape), accounting for five grants, in the values of 41.7 L s^{-1} , 58 L s^{-1} (twice), 137 L s^{-1} and 145 L s^{-1} , averaging 14.8 L s^{-1} , median of 8.0 L s^{-1} and amplitude of 144.9 L s^{-1} .

As highlighted by Beraldo and Saldanha (2016), the discrepant data significantly impact the descriptive statistics of the observed data, and it is recommended their split in another dataset, so that there is an analysis that is "closer to real" of the statistics of the sampling universe.

In this sense, data that was identified as discrepant were withdrawn, and it was, again, done the analysis of the descriptive statistics obtaining results for the average values of granted flows of 9.1 L s^{-1} , and the median had the value of 7.9 L s^{-1} , and amplitude of 27.7 L s^{-1} (Figure 6B).

With this procedure of reordering of data, there was not significant difference for the data of median (0.1 L s^{-1}), however, regarding the statistics of average and amplitude, there were diagnosed reductions of 38.5% and 80.9%, respectively.

Figure 6 – Boxplot of granted flow in the EPA at Machado River.

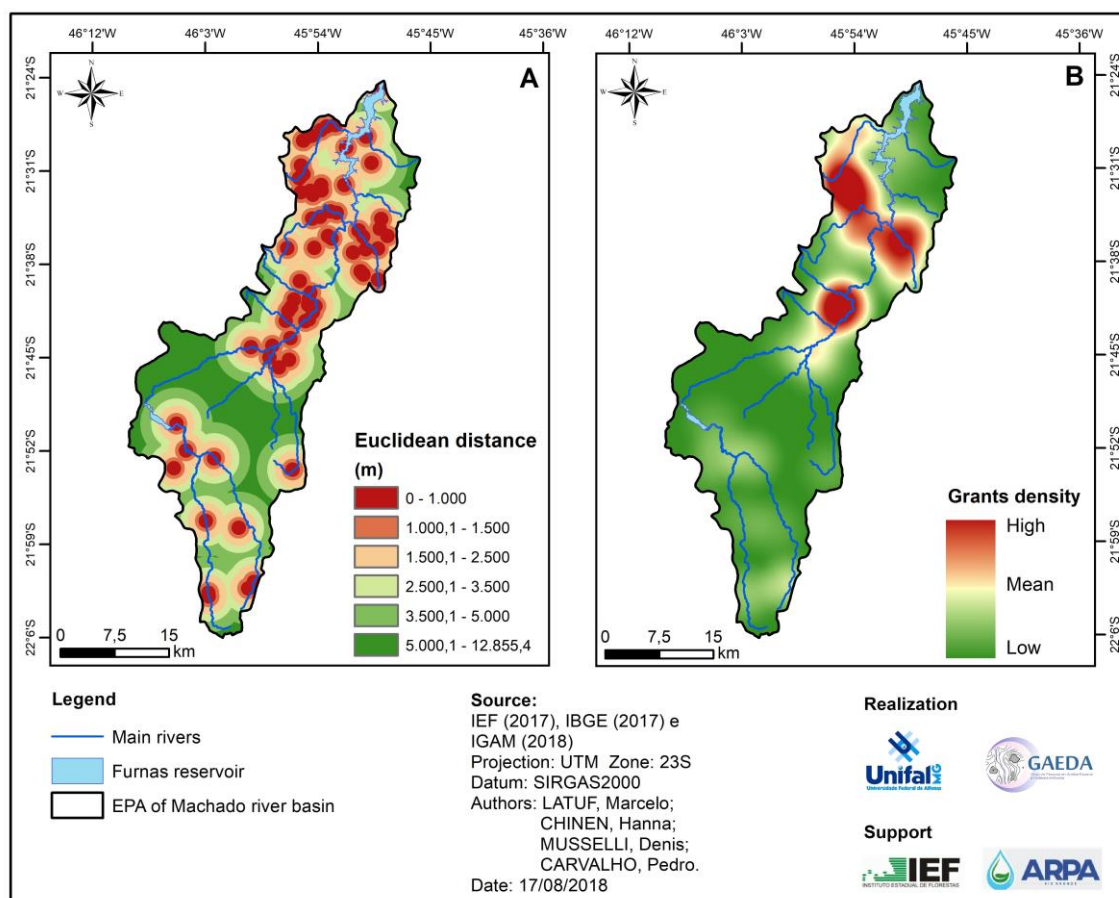


Source – IGAM (2018)

Regarding the spatial analysis of proximity and density, there were elaborated cartographic representations that can be observed in Figure 7. A similar procedure was also done by Fernandes et al. (2009) for the State of Rio de Janeiro, highlighting the benefits of the spatial analysis of the granted points.

The spatial analysis of the distribution of the granted points, of the amount of water, as well as its use, are key points for the diagnosis of the use of water resources in watersheds, once such products can contribute with the integrated analysis of the fluvial system, in order to guarantee the access of this resource to a multiplicity of users, by identifying areas with more pressure, to the use of water.

Figure 7 – Spatial analysis of grants in EPA at Machado River (2002 to 2018)



Source – Authors (2018)

About the proximity of water abstraction, Figure 7A highlights that in the sectors of average and low Machado River there are coalescences of about 1,000m, that is, regions where the Euclidean distance between the two grant points was lower than a thousand meters. This fact can cause restrictions of the use of water resources, in case the analysis of regionalization of flows for the grants, are not made based in a dense observation network.

They are stood out as regions and/or sub-regions that shall be analyzed as the biggest level of detailing: the proximities of the municipal headquarters in Machado/MG and the sub-watersheds in the riverside of Ponte Alta, and of the streams Coroado, Laje and Água Barrenta, as well as the low course of the riverside of Machadinho.

As characteristic of the EPA watershed of Machado River, about the proximity to capture points, there is the average distance of 3,052 meters and 12,855 meters for the maximum distance.

About the analysis of Kernel density (Figure 7B), there were identified two areas with higher concentrations of grants, which coincide with the abovementioned regions, in the analysis of proximity. The density relates the occurrence of capture, not by itself – as the analysis of the Euclidian analysis – but yet for the relation between their neighbors in a certain search area (CÂMARA and CARVALHO, 2004), a fact that can be observed in the high region of Machado River, where the occurrences of grants are the ones with higher spacing, when compared to the granted ones from the average and low regions at Machado River, resulting, then in a lower density.

The diagnosis shown by Figure 7B highlights the need for the compatibility of the relationship supply x demand, by the use of water resources in the EPA at Machado River, through the Plan of Watersheds in the Committee GD3, as well as by the Plan of Management in this unit of

State preservation, especially for the area in the vicinity in the city of Machado, and its downstream, always aiming the guarantee provided by the Federal Law (n.º 9,433/1997) and by the State Law (n.º 13,199/1999 - Art. 18, item V) to the multiple uses of this natural resource, without compromising the water availability and the quality of waters.

About the destinations of the in force captures in 2018 in the EPA at Machado River (Table 1), irrigation is seen as the biggest user segment, with 35 grants, representing 61.4% of the grants, followed by the user segments of human supply and animal watering, industrial use, mineral extraction, aquiculture and generation of electricity (PCH Poço Fundo).

Table 1 – User segments of granted water resources that had been granted when the in force of the EPA at Machado River.

User segment	Grants	Percentage
	(un.)	(%)
Irrigation	35	61.4
Human supply and watering of animals	9	15.8
Industry	6	10.5
Mineral extraction	4	7.0
Aquiculture	2	3.5
Generation of electricity	1	1.8
Total	57	100

Source – IGAM (2018)

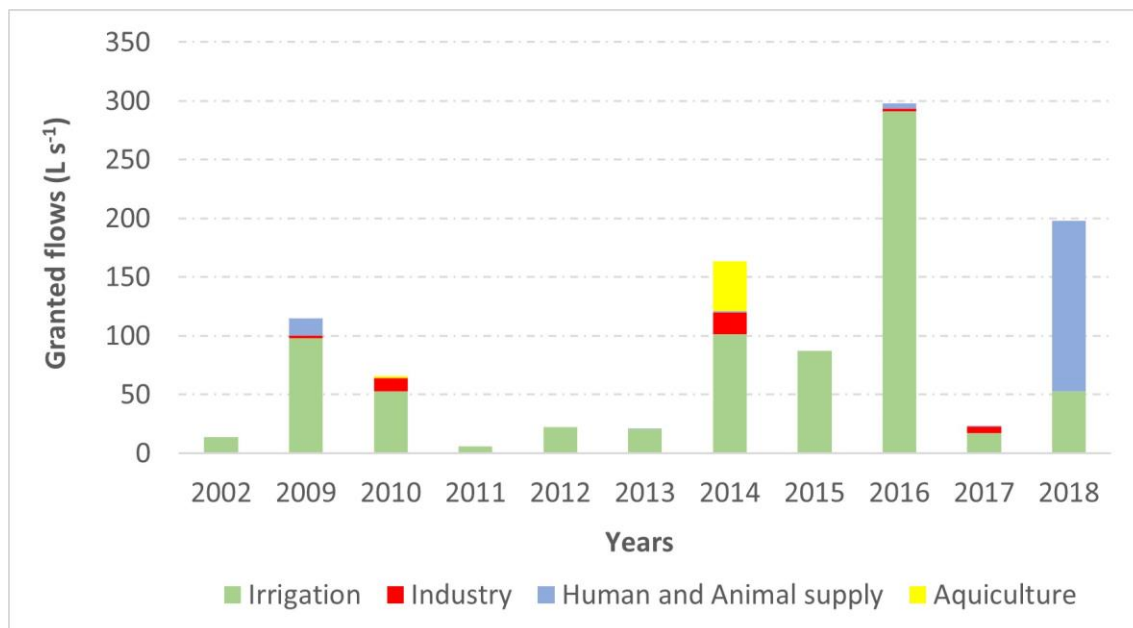
The picture that had been diagnosed in the EPA at Machado River for the user segment irrigation, calls attention because, according to data from the National Agency of Waters (ANA, 2017), it was evidenced the value of 32.9% above the national average. This fact needs special care from Committee GD3, in which refers to the grants and to the maintenance of the water availability to the further users in the watershed at Machado River.

As a last item to be approached by this research, but no less important, the quantification of granted flows to different user segments, provides essential data for the planning and management of water resources, once it characterizes the segments of higher demands for the use of the water in the watershed, enhancing policies, programs and projects by the Committee of Watersheds and Agency of Waters, aiming to guarantee the multiplicity of uses of this resource.

In this sense, the granted flows to the diverse user segments of water resources, in the watershed in the EPA at Machado River, can be viewed in Figure 8.

According to data obtained in the portals of grants issued by IGAM, irrigation is highlighted as the highest water consumer in the EPA at Machado River, in the period between 2002 and 2018. It is observed an increase of water consumption, based in the analysis of two distinct periods, being the first one from 2002 to 2013, and the second one from 2014 to 2018, with highlights for 2016. In 2016 there were 15 grants for this user segment, with quantitative of 291.3 L s⁻¹ in order to suppress the demand for 450.8 hectares (IGAM, 2018).

Figure 8 – Consumption of granted water resources in the EPA at Machado River



Source – IGAM (2018)

Regarding the in-force grants until the year of 2018 – 57 in total- irrigation consumes 569.9 L s⁻¹ (35 grants) for the irrigation of 1,030.9 hectares, totaling 70.8% of the consumed flows, comparing to the further user segments, a rate that exceeds the national average of 67.2% (ANA, 2017). Out of this total, the year of 2016 contributes with 51.1% of the grant usages for the use of water resources for this purpose.

The use of water for human consumption and watering of animals, reaches 166.3 L s⁻¹, characterized by the second biggest user segment consumer of water in the EPA at Machado River, followed by the aquaculture consumption (42.9 L s⁻¹) and industrial one (26.3 L s⁻¹).

FINAL CONSIDERATIONS

The knowledge on the granted usage in a watershed, may it be because of its localization or by the granted quantitative, aims to diagnose the demand by the use of water resources, in order to reconcile its use to all users, enforcing the right for the access to water, as well as fostering subsidies for the planning and management.

It was seen that in the EPA at Machado River, there is a more expressive of superficial grants, when compared to the underground ones, being that in the sectors of average course, in the proximity of the city of Machado/MG, and in the low course there are more demands for the use of water, which are especially motivated by the irrigated culture of coffee.

Irrigation characterized by the user segment of higher expressiveness in the consumption of water, followed by human supply and watering of animals. It is highlighted the tendency of the increase of water consumption by grant usage from 2014 on, and this fact proves the intensifying of the demand by the use of water resources in the EPA at Machado River.

It is expected that the results that are highlighted here can help the Committee GD3, as well as IEF, in the management of watershed in the EPA at Machado River. Even the cited bodies, with distinct attributions and competences in the management of the water resources, and the environmental agenda respectively, joint efforts through partnerships point out the path to be followed, always aiming the cooperation with the Civil Society and further entities.

In this bias, it is of significant importance that the Committee GD3 becomes integral part of the process for the grant request with IGAM, not only being informed by the former one, that grants took part in the watersheds of interest, in this case including the watershed of EPA at Machado River. This fact ratifies the need for the creation of the agency of Waters, which will expressively help the Committee GD3, as well as the Management Council, in which refers to the planning and management of water resources, because of the increase of the demand of water usage and the obligation in the attendance to multiple uses, which had been recommended by the National Policy of Water resources.

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