# Water demand and availability for livestock in the microregion of Alto Teles Pires – MT, Brazil

# Demanda y disponibilidad de agua para la ganadería en la microrregión de Alto Teles Pires - MT, Brasil

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## ABSTRACT

The present study aimed to estimate the water demand and availability for livestock in the municipalities of the Microregion of Alto Teles Pires, Mato Grosso, Brazil. The historical series of flows obtained from the National System of Information on Water Resources (SNIRH) were used in the research. At the same time, several vector files were acquired from the continuous cartographic databases of the Brazilian Institute of Statistics and Geography (IBGE). In addition, on this site data referring to the livestock in the municipalities of the Microregion of Alto Teles Pires were obtained. To account for all species of animals and quantify the water demand in livestock in the mentioned Microregion with greater efficiency, the methodology suggested by the Paraná State Water Resources Plan (PERH) was applied. The data from the historical series of flows were analyzed with the R program, determining the reference flows Q95 of the fluviometric stations of this micro-region. In the elaboration of thematic maps, the QGIS program was used. The methodology applied in the research was adequate to evaluate the

relationship between water demand and availability for livestock in the Alto Teles Pires Microregion. The water availability estimated in the micro-region was higher than the water demand required for animal watering and cleaning the facilities, meaning that livestock activities in the Micro-region did not compromise water availability, therefore, this was not a limiting factor for its development. In the geographical area studied, there was a high spatial variability in the number of animals, expressed through the EBWD unit, and it was not possible to establish a direct proportion between water availability and the area of the municipalities.

**Keywords:** Equivalent cattle, animal watering, reference flow.

**RESUMEN**

El presente estudio tuvo como objetivo estimar la demanda y disponibilidad de agua para la ganadería en los municipios de la Microrregión de Alto Teles Pires, Mato Grosso, Brasil. En la investigación se utilizaron las series históricas de caudales obtenidas del Sistema Nacional de Información de Recursos Hídricos (SNIRH). Al mismo tiempo, se adquirieron varios archivos vectoriales de las bases de datos cartográficas continuas del Instituto Brasileño de Estadística y Geografía (IBGE). Además, en este sitio se obtuvieron datos referentes a la ganadería de los municipios de la Microrregión del Alto Teles Pires. Para contabilizar todas las especies de animales y cuantificar la demanda de agua en la ganadería de la mencionada Microrregión con mayor eficiencia, se aplicó la metodología sugerida por el Plan de Recursos Hídricos del Estado de Paraná (PERH). Los datos de las series históricas de caudales fueron analizados con el programa R, determinando los caudales de referencia Q95 de las estaciones fluviométricas de esta microrregión. En la elaboración de los mapas temáticos se utilizó el programa QGIS. La metodología aplicada en la investigación fue adecuada para evaluar la relación entre la demanda y la disponibilidad de agua para el ganado en la microrregión del Alto Teles Pires. La disponibilidad de agua estimada en la microrregión fue superior a la demanda de agua requerida para el abrevado de los animales y la limpieza de las instalaciones, lo que significa que las actividades ganaderas en la microrregión no comprometieron la disponibilidad de agua, por lo tanto, ésta no fue un factor limitante para su desarrollo. En el área geográfica estudiada, hubo una alta variabilidad espacial en el número de animales, expresada a través de la unidad EBWD, y no fue posible establecer una proporción directa entre la disponibilidad de agua y la superficie de los municipios.

**Palabras clave**: Ganado equivalente, abrevadero de animales, caudal de referencia.

## 1 INTRODUCTION

In livestock farming, in general, water is used for the production of food and inputs, animal watering, animal slaughter, processing of animal products, and cleaning of facilities, where it helps remove waste (feces, urine, leftover food, and bedding). In addition, water can contribute to the improvement of animal thermal comfort conditions, i.e. the ambience of the facilities. Depending on the vocation of the watershed, the demand for water for animal watering, specifically for cattle, may represent a very high percentage of its water availability.

In rural watersheds with agricultural aptitude, water consumption can account for up to half of the water availability or the grantable flow (ALMEIDA et al., 2017). In Brazil, the rational use of water is based on Law 9.433/97, through several management instruments, among them, the allocation and charging. The allocation refers to the mandate and control of demand in water bodies, while charging refers to the allocation of economic value. These instruments require accurate information about the available potential and water demand in the system to promote the effective control of the water balance based on criteria (MEDEIROS et al., 2006; ALMEIDA e CURI, 2016).

The estimation of water demand for each user group is essential for the definition of criteria for granting and/or charging for the use of water resources. Given the problems of water scarcity, the livestock production chain has been one of the most affected sectors. Thus, water quantities below the minimum limit for both desedentation and for indirect uses in vegetation and species consumption have provided a drop in the nutritional values of forage, favoring low productivity and seasonality in animal production (ALBUQUERQUE, 2012). In this condition of frequent scarcity, high rates of evaporation (above 5%) and critical situation of volume in much of the dams have been derived, further highlighting the need for water management (AESA, 2016).

According to the 2020 Municipal Livestock Survey - PPM conducted by the Brazilian Institute of Geography and Statistics - IBGE, the State of Mato Grosso has the largest cattle herd in the country, the fifth largest pig herd and the eighth largest poultry herd, with 32.7 million, 2.6 million and 47.1 million animals, respectively (IBGE, 2020). It is also noteworthy that the Microregion of Alto Teles Pires in Mato Grosso presents a high concentration of cattle herds (ORLANDI and LIMA, 2012).

In relation to animal water demand, respectively, cattle, pigs, poultry, horses and bubalines, as well as goats and sheep demand 88%, 5%, 2%, 2% and 2% of the total volume. Although cattle demand the most water, they cause less risk of water imbalance, because their geographical distribution is regular. However, the herd of pigs and poultry, even with the low water demand, present greater risk of causing an imbalance in the water balance, due to the high concentration of animals in some regions (ANA, 2019; PALHARES, 2021).

In this context, knowing the flow of watercourses is an element of paramount importance for the management of water resources, in which the technical criteria and strategies needed to balance the demands and supply of water in the basin must be defined with the purpose of using this natural resource in a rational and sustainable way, without

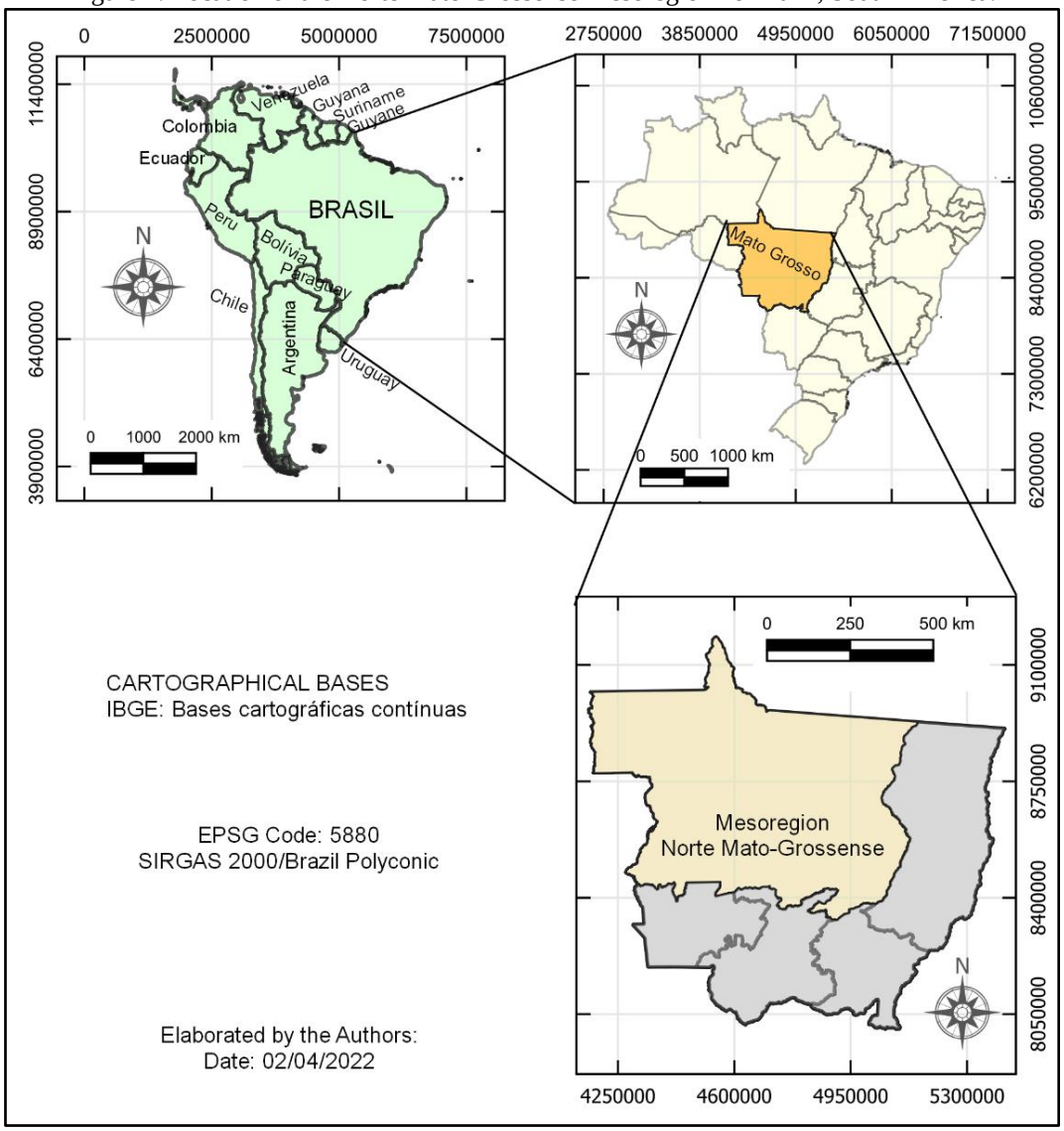
compromising the environment. To achieve this purpose requires the processing of information obtained over the years about the hydrological behavior of the area in question. In this sense, the study of the relationship between consumption and watercourse flow presents itself as a valuable tool to assist decision making, in relation to the use of water resources.

In view of the relevant presence of cattle-raising in the Microregion of Alto Teles Pires and the high potential for generating significant profits, observing the hydrological behavior of this area deserves special attention in order to avoid future water shortages. This research is based on the hypothesis that the estimation of water demand and availability can serve as a tool for the rational use of water in animal production systems, aiming to avoid that the minimum flow values are not able to meet the need. Thus, the main objective of the present study was to estimate water demand and availability for livestock in the Microregion of Alto Teles Pires - MT, Brazil.

## 2 MATERIAL AND METHODS

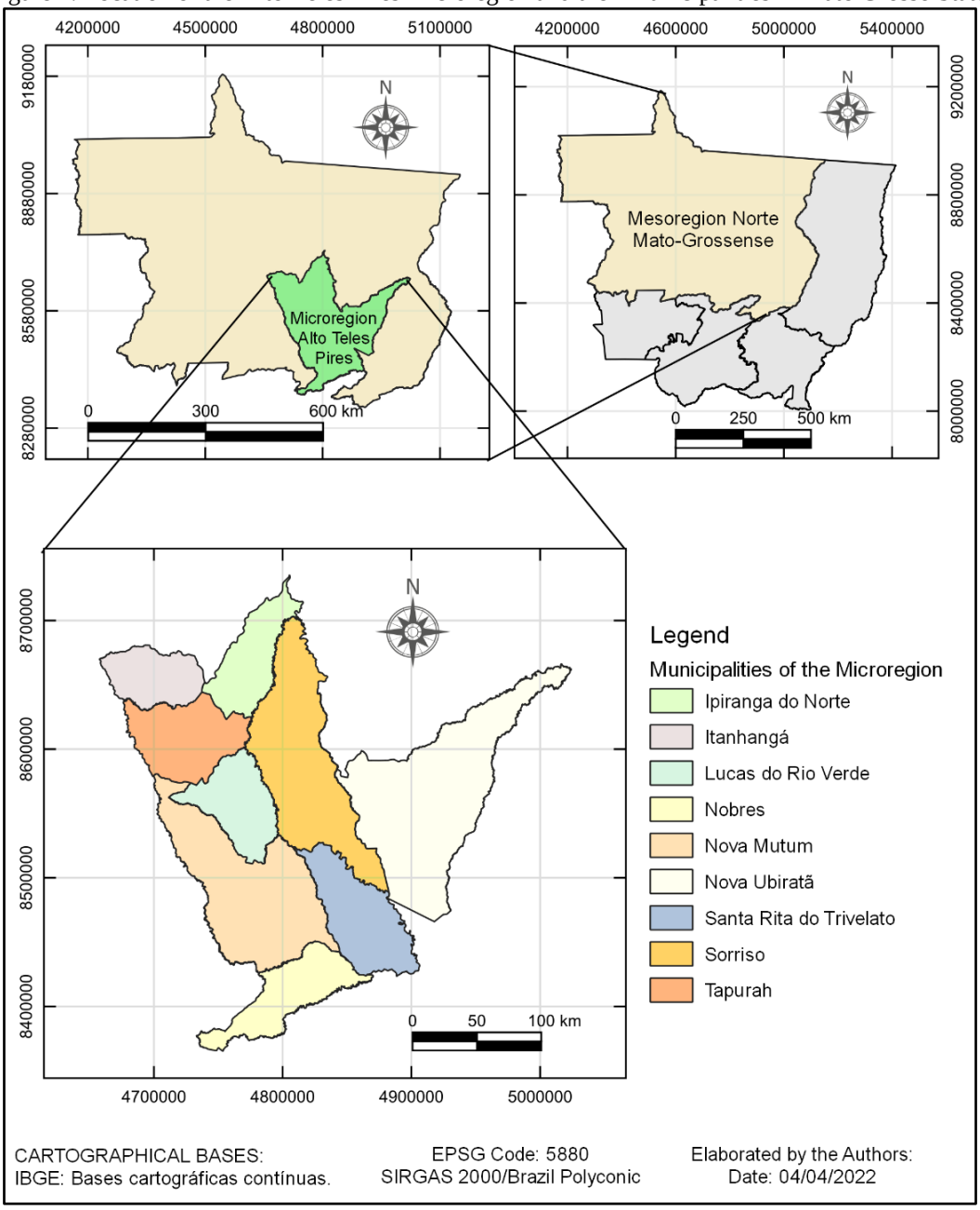
In this study the Microregion of Alto Teles Pires - MT was selected. This geographical area is located in the Mesoregion Norte Mato-Grossense, Mato Grosso, Brazil and comprises nine (9) municipalities (Figure 1). In the Microregion predominates the climate Am or tropical monsoon climate, called humid tropical climate or tropical climate of monsoons and trade winds, which is characterized by having two well-defined seasons, hot and dry (PEEL et al., 2007; ALVARES et al., 2013).

Figure 1. Location of the Norte Mato-Grossense Mesoregion no Brazil, South America.




The average annual temperature in this geographical area varies between 19 °C and 33 °C, while the total annual rainfall ranges from 1472 to 1894 mm (INMET, 2022). The research used the historical series of daily flows, obtained from the National System of Information on Water Resources (SNIRH), managed by the National Agency for Water and Basic Sanitation (ANA), open data portal HidroWeb (ANA, 2022a). Data regarding the number of livestock herd in the municipalities of the Upper Teles Pires Microregion were obtained from the Municipal Livestock Survey conducted by the Brazilian Institute of Geography and Statistics (IBGE, 2017, 2020 and 2021). In addition, several vector files ("Shapefiles") were acquired to represent the study area, available in the continuous cartographic bases, geosciences portal (IBGE, 2022). Figure 2 presents the location of this geographical area and its municipalities.

Figure 2. Location of the Alto Teles Pires Microregion and their municipalities in Mato Grosso State.



To make all the animal species compatible and quantify the use of water in cattle-raising in the Microregion of Alto Teles Pires with greater efficiency, we applied the methodology suggested by the Paraná State Plan for Water Resources (PERH), based on the Plan for Integrated Utilization of the Northeast's Water Resources - PLIRHINE (SUDENE, 1980; PERH, 2006). This methodology adopts a unit called Bovine Equivalent for Water Demand (BEDA), which estimates the unit water demand of each species in relation to the bovine by means of several coefficients, according to the equations described below:

$$\text{EBWD} = \text{Bovines} + \text{Buffaloes} + \frac{\text{Swine}}{5} + \frac{\text{Rabbits}}{200} + \frac{\text{Avins}}{250} + \text{A} + \text{B}$$

Where,

EBWD: Equivalent Bovines for Water Demand;
Bovines, Buffaloes, Swine, Rabbits, Avins: Animals of these species.

$$\text{A} = \frac{(\text{Equines} + \text{Mules} + \text{Donkeys})}{1{,}25}$$

Where,

A: Total number of Equines, Mules and Donkeys;
Equines, Mules and Donkeys: Animals of these species.

$$\text{B} = \frac{(\text{Sheeps} + \text{Caprines})}{6{,}25}$$

Where,

B: Total number of Sheeps and Caprines;
Sheeps, Caprines: Animals of these species.

The coefficients used in the estimation of the water demand required for the desiccation and cleaning of zootechnical facilities were selected based on the research carried out by Benedetti (1986), Dado and Allen (1995), Perissinotto et al. (2005), Campos (2006), Carvalho et al. (2011), Guerra et al. (2011), Palhares (2013, 2021), Oliveira et al. (2016), ANA (2019), and Borges et al. (2022). According to these studies, the coefficients of water demand in cattle showed high variability, finding the minimum 20 L·dia-1·animal-1 and the maximum 150 L·dia-1·animal-1. However, the average demand for cleaning the facilities was estimated at 26.8 L·dia-1·animal-1.

It is worth noting that the variation in daily water demand is directly related to several factors among them we can mention weight, breed, productive aptitude, diet, management, and climatic conditions that interfere in animal performance, mainly, temperature and relative humidity of the air, as well as solar radiation. In this study, the values presented in the literature citations above were used as reference in estimating water consumption. Therefore, to determine the daily water demand for animal watering and cleaning of the facilities, associated with the consumption of equivalent cattle (BEDA), the equation given by

$$WD_{EBWD} = \frac{NU_{EBWD} \cdot CLV_{EBWD}}{1000}$$

Where,

$WD_{EBWD}$: Water demand of the EBWD units ($m^3 \cdot day^{-1}$);
$NU_{EBWD}$: Number of the EBWD units for municipality (dimensionless);
$CLV_{EBWD}$: Limits values for animal consumption and cleaning ($L \cdot day^{-1}$);
Constant 1000: Factor for volume unit conversion ($L^{-1} \cdot m^3$).

The consumption values adopted as reference in this study were:
Minimum limit value for the water consumption by the animal: $CLV_{EBWD}$ = 20 $L \cdot day^{-1}$;
Maximum limit value for the water consumption by the animal: $CLV_{EBWD}$ = 150 $L \cdot day^{-1}$;
Consumption water value for cleaning: $CLV_{EBWD}$ = 26,8 $L \cdot day^{-1}$.

The water availability in the micro-region was calculated taking into account Article 4 of Resolution No. 7 of July 9, 2009, of the State Council of Water Resources of Mato Grosso - CEHIDRO, which states that: "For the analysis of water availability of surface water bodies of the State domain, the permanence flow rate for 95% of the time will be adopted as the reference flow rate Q95" (CEHIDRO, 2009). According to CEHIDRO (2009), the maximum limit for individual withdrawal is 20% of the reference flow rate. However, this limit can be exceeded for animal watering. Thus, in this study we adopted the value of 20% of the permanence flow rate (Q95), calculated by the following equation:

$$W_{Avail} = 0{,}20 \cdot PF_{95} \cdot 86400$$

Where,

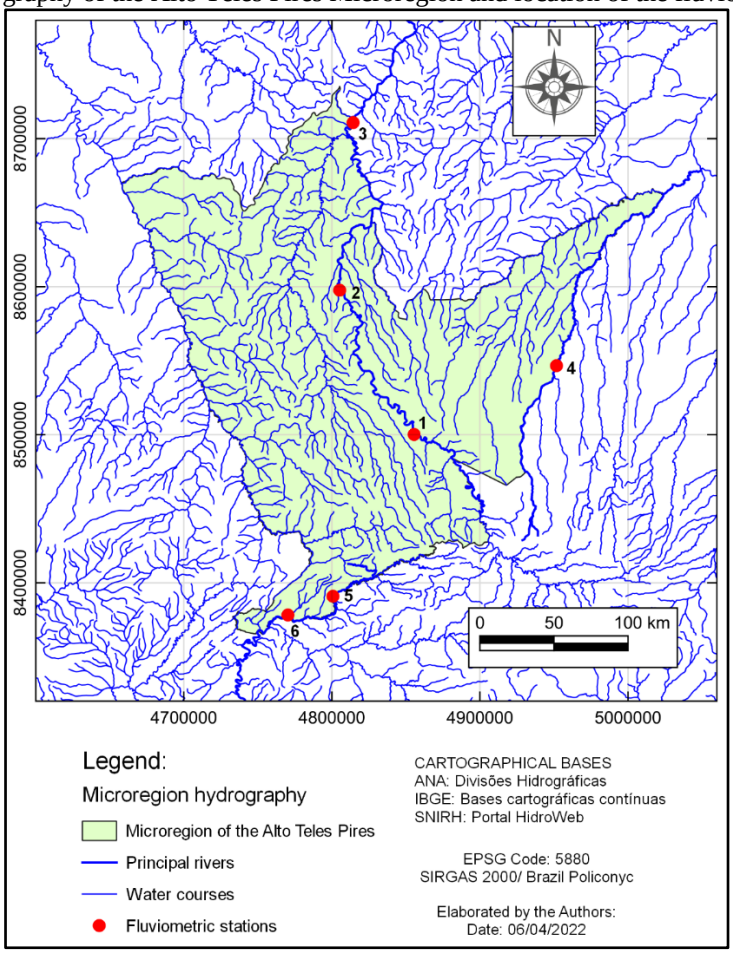
$W_{Avail}$: Water availability ($m^3 \cdot day^{-1}$);
$PF_{95}$: Permanence flow equaled or exceeded 95% of the time ($m^3 \cdot s^{-1}$);
Constant 0,20: Factor for the maximum grantable funding limit (20%);
Constant 86400: Factor for unit conversion ($s \cdot day^{-1}$).

The data corresponding to the historical series of daily flows were analyzed by the R program (R CORE TEAM, 2021). In this sense, the reference flow rates Q95 of the river gauge stations of the Upper Teles Pires micro-region were determined with the probability function ("quantile") and a stacked bar graph was prepared. In addition, the Geographic Information Systems program QGIS, version 3.16.14 (QGIS, 2021) was used. With the aid of this system, thematic maps were generated to illustrate the hydrography, the location of the fluviometric stations and the spatial distribution of the equivalent cattle units for water demand in the Microregion of Alto Teles Pires, Mato Grosso, Brazil.

## 3 RESULTS AND DISCUSSION

Figure 3 presents the hydrography of the Microregion of Alto Teles Pires MT, as well as the geographic location of the river gauge stations. According to this Figure, 50% of the stations are in the central part of the mentioned Microregion, two in the South and only one in the East, lacking this facility in the West.

Figure 3. Hydrography of the Alto Teles Pires Microregion and location of the fluviometric stations.



The general information on the river gaging stations located in the micro-region of the Upper Teles Pires is shown in Table 1. In this table it can be seen that three stations are installed on the Teles Pires River, which has the largest drainage area in this geographical area. It is noteworthy that all stations, except Quebó (Code 66160000) on the Cuiabá River, provided historical flow series with more than 30 years, making it possible to obtain more accurate results.

Table 1. Information of the fluviometric stations located in the Upper Teles Pires Microregion.

| Number* | Code | Name | River | Drainage area ($km^2$) | Geographic coordinates (°) | |
|---|---|---|---|---|---|---|
| | | | | | Latitude | Longitude |
| 1 | 17200000 | Porto Roncador | Teles Pires | 10800 | -13,5575 | -55,3347 |
| 2 | 17210000 | Teles Pires | Teles Pires | 13900 | -12,6742 | -55,7928 |
| 3 | 17280000 | Cachoeirão | Teles Pires | 34600 | -11,6517 | -55,7025 |
| 4 | 18420000 | Fazenda Ita-guaçu | Ronuro | 3840 | -13,1408 | -54,4453 |
| 5 | 66140000 | Marzagão | Cuiabá | 2320 | -14,5417 | -55,8489 |
| 6 | 66160000 | Quebó | Cuiabá | 4260 | -14,6536 | -56,1322 |

Source: Elaborated by the authors, based on the Metadata Catalog (ANA, 2022b).
* Corresponds to the station number in the map of Figure 3.

Table 2 shows the number of animals per species in each municipality in the Microregion of Alto Teles Pires. The species with the highest number of animals were cattle, pigs and poultry, with the municipalities of Nova Mutum, Nobres and Nova Ubiratã highlighting the bovine herd. The municipalities of Nova Mutum and Tapurah showed superiority in the quantitative aspect of pig farming. In relation to poultry, only the municipality of Nova Mutum was characterized as supreme. It should also be emphasized that there is an ample activity in sheep-raising in the mentioned Microregion, as significant quantities of this species were accounted for in all the municipalities, varying from 2,005 to 14,629 animals, respectively, in Itanhagá and Sorriso.

Table 2. Number of animals by species for each municipality in the Microregion of Alto Teles Pires.

| **Species** | Ipiranga do Norte | Itanhangá | Lucas do Rio Verde | Nobres | Nova Mu-tum | Nova Ubiratã | Santa Rita do Trivelato | Sorriso | Tapurah |
|---|---|---|---|---|---|---|---|---|---|
| Bovines | 13.858 | 57.485 | 44.789 | 114.619 | 114.942 | 105.205 | 41.055 | 88.161 | 50.401 |
| Buffa-loes | 0 | 5 | 8 | 122 | 39 | 23 | 0 | 0 | 6 |
| Equines | 261 | 1.130 | 813 | 3.085 | 2.401 | 1.741 | 742 | 1.731 | 1.162 |
| Donkeys | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 |
| Mules | 0 | 9 | 9 | 61 | 98 | 0 | 17 | 49 | 0 |
| Caprines | 340 | 568 | 149 | 283 | 268 | 203 | 169 | 1.041 | 92 |
| Sheeps | 2.783 | 2.005 | 4.069 | 2.157 | 9.192 | 6.436 | 4.665 | 14.629 | 3.915 |
| Swine | 139.560 | 3.927 | 149.307 | 5.632 | 369.066 | 65.651 | 29.461 | 269.989 | 336.796 |
| Avins | 21.240 | 35.300 | 4.901.000 | 48.288 | 8.550.000 | 206.200 | 40.743 | 5.360.000 | 5.315.131 |
| **Total** | **178.042** | **100.429** | **5.100.144** | **174.254** | **9.046.006** | **385.459** | **116.852** | **5.735.600** | **5.707.503** |

Source: Elaborated by the authors, based on data from the Brazilian Institute of Geography and Statistics (IBGE, 2017).

The number of Equivalent Cattle Units for Water Demand (BEDA), the corresponding total water consumption and the average daily water availability in the municipalities of the Upper Teles Pires micro-region are presented in Table 3. It can be seen that the number of BEDA units showed high variability, ranging from 42,563 to 226,507 in the municipalities of Ipiranga do Norte and Nova Mutum, respectively. From the Table itself it is deduced that, the water availability had a very variable behavior, estimating the lowest value of 90,22.34 m³·dia-1 in the fluviometric station of Marzagão, municipality of Nobres and the highest value of 5,855,701.25 m³·dia-1 in the station Porto Roncador, located on the border of the municipalities Santa Rita do Trivelato and Sorriso.

Table 3. Water demand and availability for ranching in the Microregion of Alto Teles Pires.

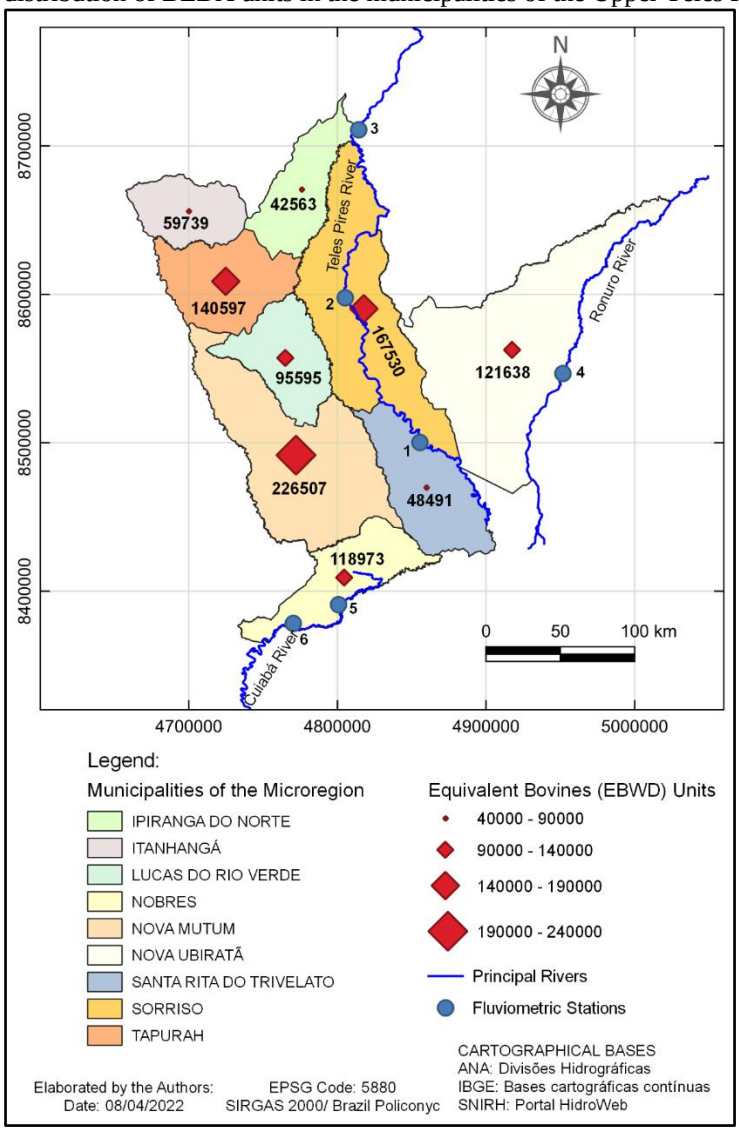
| **Municipality** | **EBWD Unit (dimensionless)** | **Water Demand ($m^3 \cdot day^{-1}$)** | | | **Water Avail-ability ($m^3 \cdot day^{-1}$)** |
|---|---|---|---|---|---|
| | | **Animal watering** | | **Cleaning** | |
| | | **Minimum** | **Maximum** | | |
| Ipiranga do Norte | 42.563 | 851 | 6.384 | 1.141 | 5.855.701,25 |
| Itanhangá | 59.739 | 1.195 | 8.961 | 1.601 | 90.222,34* |
| Lucas do Rio Verde | 95.595 | 1.912 | 14.339 | 2.562 | 90.222,34* |
| Nobres | 118.973 | 2.379 | 17.846 | 3.188 | 175.457,03 |
| Nova Mutum | 226.507 | 4.530 | 33.976 | 6.070 | 90.222,34* |
| Nova Ubiratã | 121.638 | 2.433 | 18.246 | 3.260 | 738.626,69 |
| Santa Rita do Trivelato | 48.491 | 970 | 7.274 | 1.300 | 834.411,46 |
| Sorriso | 167.530 | 3.351 | 25.130 | 4.490 | 1.184.321,95 |
| Tapurah | 140.597 | 2.812 | 21.090 | 3.768 | 90.222,34* |

Source: Elaborated by the authors. *Adopted value from the near municipality because it has no fluviometric station.

In the Microregion of Alto Teles Pires in the state of Mato Grosso, it can be seen that there was no direct relationship between the number of BEDA units, and consequently water consumption, and water availability. Thus, it was not possible to establish a functional dependence between these variables for this territory (Table 3). Similar results were obtained by Borges et al. (2022), evaluating the total water consumption required for dairy cattle farming and water availability in the Microregion of Aripuanã, state of Mato Grosso.

The spatial distribution of equivalent units for water demand (BEDA) in the municipalities of the Upper Teles Pires Microregion can be seen in Figure 4. In this Figure one can see the definition of four groups of BEDA units to identify the municipalities with the lowest and highest herds in the territory, as well as their location in relation to water courses.

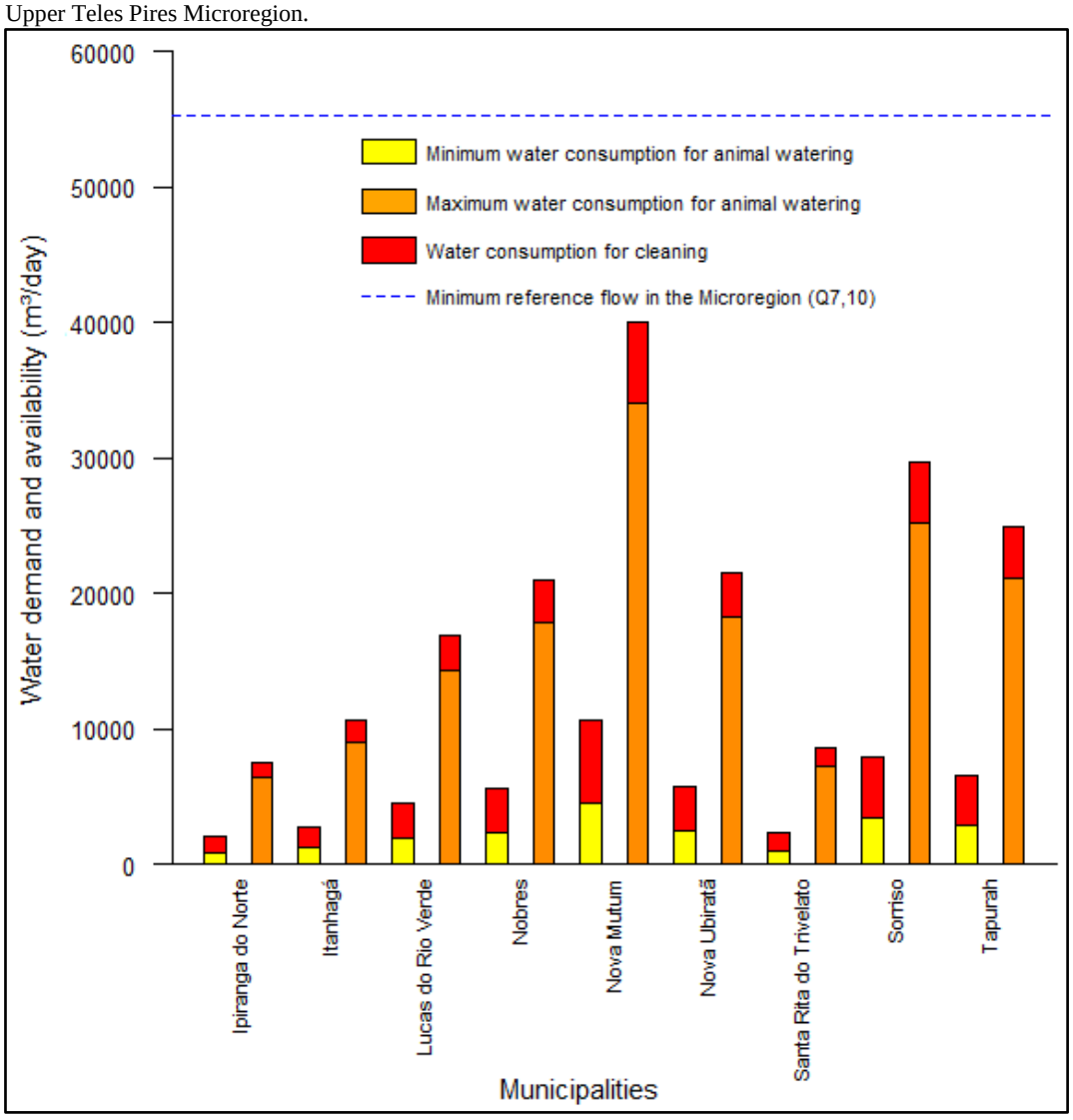
Figure 4 - Spatial distribution of BEDA units in the municipalities of the Upper Teles Pires Microregion.



As shown in Figure 4, the municipalities of Ipiranga do Norte, Itanhangá and Santa Rita do Trivelato belonged to the first class. In the second group were included Lucas do Rio Verde, Nobres and Nova Ubiratã. In turn, the third category was formed by the municipalities of Sorriso and Tapurah. However, only the municipality of Nova Mutum occupied the fourth stratum, which has the largest number of BEDA units.

Figure 5 presents the relationship between water consumption by livestock and water availability in the Microregion of Alto Teles Pires. It can be seen that in all the municipalities the demand was lower than the minimum reference flow selected to prepare this graph. The greatest proximity was evidenced for the municipality of Nova Mutum, however the difference was close to 37.5%.

Figure 5: Limits of water consumption by livestock and minimum reference water availability in the municipalities of the Upper Teles Pires Microregion.



It should be noted that in the municipality of Nova Mutum it was not possible to estimate the true hydric availability, because it had no accessible historical series of flows, and the minimum value of the Upper Teles Pires Microregion was adopted. Therefore, there is a need for fluviometric stations in this municipality, given the high number of animals accounted for. However, the municipality possesses an ample drainage network to supply the demand for water for livestock (Figure 3). This network is considered to provide a flow rate equal to or greater than the minimum reference flow determined for the geographical area studied.

As illustrated in Figure 5, we adopted a minimum flow of seven (7) days duration and ten (10) years of return (Q7,10), which means a 10% risk for values lower than or equal to this one to occur in any year. However, the state of Mato Grosso opted for the permanence flow rate equaled or exceeded 95% of the time (Q95) as a reference and 20% of this value for individual capture, which can be exceeded for animal watering (CEHIDRO, 2009).

In Table 3 it can be seen that the value of the minimum reference flow rate for 95% of the time in the studied micro-region was higher than the value of seven days with a 10-year return period, that is, this value has greater reliability to assess the relationship between demand and water availability. In addition, the seven-day reference flow rate with a 10-year return period is based on a probability density function, in this case Weibull, while the 95% time reference flow rate is estimated from a frequency distribution, therefore, it has a lower statistical validity to infer about the future hydric behavior in the region.

In summary, it should be noted that the municipalities of the Upper Teles Pires Microregion do not fit into the category of insignificant uses for livestock activities, according to Resolution No. 27, of July 09, 2009, issued by the State Council of Water Resources - CEHIDRO of Mato Grosso (CEHIDRO-MT, 2009). According to the provisions of Article N° 8, second paragraph, in the watercourses it was verified a flow superior to 0.2 $m^3 \cdot s^{-1}$ (17280 $m^3 \cdot dia^{-1}$) and the minimum hydric demand was greater than 0.0005 $m^3 \cdot s^{-1}$ (43.2 $m^3 \cdot dia^{-1}$). Therefore, rural producers responsible for livestock herds and zootechnical facilities, should carry out the granting process for the use of surface water resources in this region over the domain of the state of Mato Grosso.

## 4 CONCLUSION

The methodology applied in the research was appropriate for evaluating the relationship between water demand and availability for ranching in the Upper Teles Pires Microregion. The estimated hydric availability in the micro-region was higher than the hydric demand required for animal desedentation and cleaning of the installations, meaning that the ranching activities in the micro-region did not compromise the hydric availability, therefore, this did not constitute a limiting factor for its development. In the geographical area studied we observed a high spatial variability of the amount of animals, expressed through the BEDA unit, not being possible to establish a direct proportion between water availability and the area of the municipalities. Based on this study it was confirmed a deficiency in the availability of data and information regarding hydric resources, mainly daily flow rates due to the low number of fluviometric stations in relation to the extension of the territory and drainage network. For future work it is recommended to include the analysis of the monthly ratio between water demand and availability, in order to identify the possibility of critical periods in water consumption by livestock throughout the year. Another relevant aspect to be considered in subsequent studies is the trend of water demand and availability, presented in recent decades, which allows inferences to be made about the behavior of the cattle herd and the probability of conflicts arising over water use.

## ACKNOWLEDGMENTS

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