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Integrative Teaching Activity in the Field of Water Resources: A Proposal for Environmental Engineering

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ABSTRACT

This article proposes an Integrative Teaching Activity (ITA) that encompasses the interrelation of disciplines in the field of water resources based on a current scenario: the use of water in the Alto Paranapanema Basin (BALPA). The mentioned scenario raises a fundamental theme in the training of professionals who will work in natural resources management: the water crisis. The objective is to "analyze the dynamics of land use and its implications on water availability in the Alto Paranapanema Basin." The research methods focus on developing a diagnosis of water availability in BALPA and its relationship with land use through the following strategies: analysis of secondary data related to land use and water demand for identified uses, calculation of the climatological water balance of the basin, and consultation of institutional documents. All suggested sources are publicly available. The results describe the developed activity, which integrates content from eight disciplines and includes 11 stages that support students in answering six questions that guide the activity. It is concluded that, in terms of learning outcomes, ITA is considered capable of driving the development of competencies expected for graduates of the environmental engineering course, including cooperation, creativity, autonomy, and above all, the ability to learn how to learn. Additionally, the activity will promote the consolidation of knowledge from different curricular units necessary for water resources management at the watershed scale, while suggesting ways to develop assessment rubrics and implement ITA.

KEYWORDS: Interdisciplinarity. Water Resources. Engineering.

1 INTRODUCTION

The discussion on interdisciplinarity is not new in the academic and educational context. The debate on the subject spans the last decades and different areas of knowledge in an attempt to overcome the limits of disciplinarity (AMBONI et al., 2012).

When discussing interdisciplinarity, Japiassu (1994) emphasizes that, based on the traditional paradigm, knowledge has been taught in a fragmented manner. In the 1990s, the same author admitted that "interdisciplinarity appears as a new principle for the reorganization of scientific disciplines and the reformulation of pedagogical structures in their teaching" (JAPIASSU, 1994, p. 1). In the context of engineering education, interdisciplinarity may face resistance as it is somewhat challenging and surpasses traditional ways of working with disciplines and their content.

According to Cezarino and Corrêa (2019), the goal of interdisciplinarity is to integrate content, promoting a chaining of knowledge to solve a problem. This application of knowledge, even if allocated in different disciplines, aims to understand reality through a problem for which a solution is sought, or, if there is no single solution, encourages a comprehensive view of possibilities. According to Pombo (2012), it involves the combination of disciplines aiming at understanding any object through the convergence of different perspectives.

In the context of undergraduate engineering programs, the inclusion of interdisciplinarity or the integration of content emerges modestly in the National Curricular Guidelines (BRASIL, 2019). The third chapter, which deals with the organization of undergraduate engineering courses, article 6, paragraph 4, instructs that throughout the entire undergraduate course, from its beginning, activities promoting integration and interdisciplinarity should be encouraged. It is also emphasized that there should be coherence between such activities and the curricular development axis, integrating different dimensions such as scientific, environmental, economic, social, and ethical (BRASIL, 2019).

The need for "chaining of knowledge," "combination of disciplines," or even the integration of knowledge arises in the form of challenging scenarios awaiting graduates, including environmental engineers. One of these critical contemporary situations was reported in 2021, based on research results from the MapBiomas project. They indicate that between 1985 and 2020, Brazil lost 15% of its water surface (MAPBIOMAS, 2021). The data also show a clear trend of reducing this surface in all the country's watersheds, encompassing all Brazilian biomes. Among the various factors contributing to this reduction is the dynamics of land use, guided by the conversion of forests into agricultural and pasture areas. In the midst of this scenario, the training of professionals who will work in natural resource management plays a crucial role.

However, the curricular content supporting the professional development of these students in the field of water resources management is addressed in separate curricular units distributed throughout the course. This configuration of the curriculum structure does not always favor a comprehensive training of the student for the mentioned management. Nor does it lead to the development of timely strategies for the rationalization of water use in different contexts. Lanna (2001) establishes a connection between interdisciplinarity and water management. In his work, the author highlights the knowledge involved in this task and asserts that it is impossible for an individual, or even a small group, to have the necessary mastery of these disciplines. This realization gives rise to the need for the formation of interdisciplinary groups to carry out the mentioned management.

Even when working in a team, the author emphasizes that it is necessary for each professional to have basic knowledge covered in their education. Among these, some are part of the curricular units in environmental engineering courses: hydraulics, hydrology, environmental sanitation, basic sanitation, erosion and sedimentation, geoprocessing, statistics, and economics. Additionally, some of the topics presented by Silva et al. (2017), extracted from Barth's work (1987), are related to water resources in different aspects, including: a) water use, mentioning irrigation, hydroelectric power, rural, urban, and industrial supply; b) user sectors, highlighting agriculture, forestry, and energy; and c) natural resources, including agricultural soil, flora, and fauna.

Seeking to integrate knowledge from different disciplines in the environmental engineering course and promote an interdisciplinary view of a common problem, this work was developed with the following objective: "analyze the dynamics of land use and its implications on water availability in the Alto Paranapanema Basin." Through this activity, the specific objectives sought to provide students throughout the course, considering the specificities and the level of complexity inherent in each period in which the disciplines that make up the ITA are allocated, the opportunity to consult, select, and use different hydrological and meteorological databases; analyze the evolution of land use in the basin using images, agricultural data, and consultation of institutional documents; identify potential critical factors in water availability in the basin through the integrated analysis of the information obtained.

Among the expected learning outcomes is the development of competencies expected of environmental engineering graduates. The concept of competence adopted by Silva and Tonini (2018) is considered, in which the authors define it, among other aspects, as a set of knowledge, skills, and attitudes that take shape in practical action.

2 METHODOLOGICAL PROCEDURES

2.1 Study proposition

The ITA is titled: "Analysis of the Dynamics of Land Use and Its Implications on Water Availability in the Alto Paranapanema Basin." The choice of the Water Resources Management Unit (UGRHI) was made due to the availability of data on the website of the Center for Studies in Spatial Ecology and Sustainable Development (NEEDS), Federal University of São Carlos, Lagoa do Sino Campus (NEEDS, 2021a).

2.2 Questions to guide the ITA

1. Obtain a representative series of monthly precipitation and temperature data for municipalities in the Alto Paranapanema Basin. At least ten municipalities should be represented.
2. Generate the monthly normal water balance (BHN) using the Thornthwaite and Mather method (1955) for each municipality with the data series.
3. Develop a textual synthesis of the hydrological scenario of the Alto Paranapanema Basin using the BHN results: average, minimum, maximum values, periods with deficits and surpluses, municipalities with more critical values.
4. Compile information on land use in the Alto Paranapanema Basin: present the evolution of the area occupied by the main economic activities based on data provided by NEEDS.
5. Identify water demands for the main economic activities in the Alto Paranapanema Basin.
6. Identify potential conflicting uses of water demands in the Alto Paranapanema Basin

2.3 Format of the material to be delivered

It is suggested that the results of the activities be delivered in the format of a technical report, following ABNT standards.

2.4 Definition of ITA development stages

The necessary stages for the development of the ITA were defined, and then the curricular units and their associated programmatic contents were identified. This information is available on the website of the Federal Technological University of Paraná (UTFPR, 2021) (Table 1).

Table 1 - Development Stages, Curricular Units, and Encompassed Programmatic Contents

Development Stages	Curricular Units Covered	Encompassed Programmatic Contents
Research of Databases	Hidrology, Climatology	Climatic elements: temperature; Precipitation measurement.
Combination and Selection of Different Databases	Hidrology, Climatology	Precipitation measurement; Climatic elements: temperature; Climatological series.
Consultation of Agritempo Database – Temperature Data Retrieval	Climatology, Probability and Statistics	Climatic elements: temperature; Statistical inference: sample size.

Consultation of DAEE Database - Precipitation Data Retrieval	Hidrology, Probability and Statistics	Precipitation measurement; Statistical inference: sample size.
Consultation of NURMA Database - Estimation of Monthly Normal Water Balance (BHN)	Hidrology, Climatology	Climatic classification criteria: Thornthwaite; Climatology and Environmental Engineering; Geographic factors of climate: latitude, altitude influence; Estimation of evapotranspiration.
Combining Data and Elaborating the BHN	Probability and Statistics	Random variables: Exploratory data analysis - importance of mean and standard deviation.
Consultation of NEEDS Database - Land Use	Geoprocessing	Definitions and applications of geoprocessing; Techniques for environmental analysis of landscapes.
Consultation of NEEDS Database – Irrigation Pivots	Geoprocessing	Definitions and applications of geoprocessing; Techniques for environmental analysis of landscapes.
Use of NEEDS Data - Maps/Geoprocessing	Geoprocessing	Import and processing of vector and raster data in a Geographic Information System (GIS).
Reading and Obtaining Additional Information (UGRHI Reports)	Water Resources Management, Applied Ecology, Natural Resources Management	Multiple uses of water resources; Principles of Water Resources Management; Legal and institutional aspects of water resources management; Planning and management instruments of water resources policy; Examples of environmental services from forest ecosystems; Use and management of natural resources - water.
Preparation of Technical Report	Research Methodology	Research methods and techniques; Standards for preparing academic papers; Scientific communication; Organization of scientific text; Organization of scientific text according to ABNT standards.

Source: From the author (2021).

2.5 Description of the tasks in each stage of the ITA

It is noteworthy that the activity was planned for students to develop all stages throughout a semester. The following describes the tasks in each stage to facilitate their application with suggested data or adaptation to different regional conditions and data sources.

A research on meteorological data was conducted for the municipalities within the Alto Paranapanema Basin using official databases, namely: Integrated Agrometeorological Information Center - CIIAGRO (CIIAGRO, 2021), Department of Water and Electric Energy - DAEE (DAEE, 2021), Agrometeorological Monitoring System - Agritempo (AGRITEMPO, 2021), and Agroclimatic Monitoring Center - NURMA (SENTELHAS et al., 2021). The objective of this research was to find reliable data sources with extensive historical series and the broadest possible coverage of municipalities. The competence inherent in this stage of the activity involves identifying research sources and reflecting on the reliability of these sources.

Combinations were performed among different databases to harmonize the necessary data for the monthly Water Balance Normal (BHN) development for the municipalities in the BALPA, considering the historical series interval and the covered municipalities. Based on these combinations, the time frame for data series analysis (2001-2020), the covered municipalities, and the databases to be used in this study were defined. Precipitation data were provided by DAEE, temperature data by Agritempo, and BHN spreadsheets by NURMA. Reflecting on appropriate ways of utilizing research sources, mastering spreadsheet software, organizing, and tabulating a set of data were the competencies that characterized this stage, which we elaborate on below:

- Consultation of Agritempo Database – Temperature Data Retrieval: Obtained temperature data from Agritempo, extracted and analyzed according to the study period. Competences developed: spreadsheet software proficiency, data organization, tabulation, interpretation, and statistical knowledge application.
- Consultation of DAEE Database - Precipitation Data Retrieval: Obtained precipitation data from DAEE, extracted and analyzed according to the study period. Competences developed: similar to the previous stage.
- Consultation of NURMA Database - Estimation of Monthly Normal Water Balance (BHN): Obtained BHN estimates for selected municipalities based on precipitation and temperature data. Competences developed: similar to the previous stages, with application of hydrology and climatology knowledge.
- Combining Data and Elaborating the BHN: Organized data from different databases to elaborate the monthly BHN for each selected municipality. Competence developed: understanding and using Thornthwaite and Mather's climatological water balance technique, applying hydrology knowledge.
- Consultation of NEEDS Database - Land Use: Obtained land use data in the Alto Paranapanema Basin from the NEEDS platform. Used QGIS for spatial analysis and Excel® for tabulated data of main economic activities. Competence developed: spatial data manipulation, GIS software mastery.
- Consultation of NEEDS Database – Irrigation Pivots: Obtained data on the quantity and distribution of irrigation pivots in the Alto Paranapanema Basin from the NEEDS platform. Used QGIS and Excel® for analysis. Competences developed: similar to the previous stage.

- Use of NEEDS Data - Maps/Geoprocessing: Used QGIS to create maps illustrating the correlation between irrigation pivots and economic activities in the Alto Paranapanema Basin.
- Reading and Obtaining Additional Information (UGRHI Reports): Conducted research to obtain additional information from UGRHI reports regarding the Alto Paranapanema Basin. Competences developed: identifying research sources, reflecting on their reliability, applying them appropriately, and evaluating the applicability of water use rights.
- Preparation of Technical Report: Organized, analyzed, correlated, and presented all information in the format of a technical report following ABNT standards. Competence developed: organizing and communicating knowledge in writing, following the structure of a technical report, meeting ABNT standards, and applying research methodology knowledge.

Throughout the entire ITA development process, students have the opportunity to develop competencies related to critical and reflective thinking, cooperation, creativity, and autonomy. These competencies are crucial for meaningful learning and understanding real-world problems in their future professions. It's important to note that these competencies evolve as students progress through different periods of the course, ranging from activities in the Applied Ecology discipline (third period) to the optional Water Resources Management discipline (ninth period).

Each discipline contributes to varying degrees of cognitive development required for knowledge mobilization in different stages of the activities. Each participant in the team, depending on the period of participation in the ITA, will develop distinct competencies.

3 RESULTS

3.1 Obtaining monthly temperature and precipitation series

To obtain meteorological data for municipalities in the Alto Paranapanema Basin, a survey was conducted in four official databases, considering the number of municipalities covered, the type of data available, and the historical series' length (Table 2).

Table 2 - Characterization of Meteorological Databases

Database	Data Type	Historical Series Range	Number of BALPA Municipalities Covered
Centro Integrado de Informações Agrometeorológicas (CIIAGRO)	Temperature and Precipitation Data	8 to 29 years	13
Departamento de Águas e Energia Elétrica (DAEE)	Precipitation Data	49 to 84 years	20
Sistema de Monitoramento Agrometeorológico (Agritempo)	Temperature and Precipitation Data	20 years	25
Núcleo de Monitoramento Agroclimático (NURMA)	Monthly Estimate of Normal Water Balance (BHN)	-	28

Source: From the author (2021).

It was observed that the NURMA database, providing BHN estimates and allowing estimations through data input, covers the highest number of BALPA municipalities (28), followed by the Agritempo database (25), which provides meteorological data for temperature and precipitation. Concerning the historical series' length, the DAEE database offers the most extended series, with over 30 years, followed by the Agritempo database with a series spanning approximately 20 years.

Combinations between different databases were also conducted to align the necessary data for the monthly BHN, including temperature, precipitation, and BHN estimate spreadsheets (Table 3).

Table 3– Combination of Databases

Databases (Data Types)	Number of BALPA Municipalities Covered
CIIAGRO (Temperature and Precipitation) + NURMA (BHN Spreadsheets)	10
Agritempo (Temperature and Precipitation) + NURMA (BHN Spreadsheets)	17
DAEE (Precipitation) + CIIAGRO (Temperature) + NURMA (BHN Spreadsheets)	6
DAEE (Precipitation) + Agritempo (Temperature) + NURMA (BHN Spreadsheets)	11

Source: From the author (2021).

Based on these combinations, it was possible to verify that the combination of the Agritempo and NURMA databases had the broadest coverage of BALPA municipalities (17). Thus, considering the satisfactory data series interval provided by Agritempo (20 years), the number of municipalities (17), and the spatial distribution of municipalities covered by the combination of Agritempo and

NURMA databases, these were selected for use in the development of monthly BHN.

Subsequently, a monthly BHN was developed for each of the 17 selected municipalities, using the monthly temperature and precipitation averages obtained from Agritempo over the last 20 years as a basis. However, the obtained water balances did not present an annual precipitation distribution consistent with the region's reality, leading to the need for a new analysis of the databases.

A comparison was made between water balances developed using precipitation data provided by the DAEE and Agritempo databases. As a result, a difference between the results obtained by the different databases was observed, and due to this discrepancy, the decision was made to use DAEE data. This choice was made because these data are also used by the Alto Paranapanema Hydrographic Basin Committee in the preparation of the Water Resources Situation Report (CBH-ALPA, 2020). However, due to this choice, it was necessary to reduce the number of selected municipalities while maintaining the minimum number requested in the proposed questions.

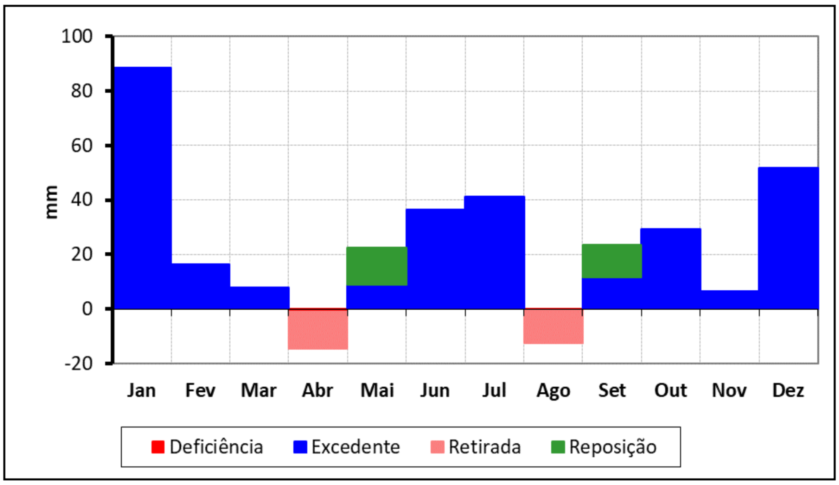
Thus, considering the criteria of the minimum number of covered municipalities and the historical series span of the data sources, the combination of Agritempo, DAEE, and NURMA data sources was selected for the development of water balances for eleven municipalities in BALPA: Angatuba, Avaré, Itaberá, Itapetininga, Itapeva, Itatinga, Pilar do Sul, São Miguel Arcanjo, Sarutaiá, Tapiraí, and Taquarituba.

3.2 Development of the monthly normal water balance by the Thornthwaite and Mather (1955) method for each municipality

A monthly normal water balance was developed by the Thornthwaite and Mather (1955) method for each of the 11 selected municipalities, using the monthly precipitation averages provided by the Department of Water and Electric Energy (DAEE) of the state of São Paulo and monthly temperature averages obtained in the Agrometeorological Monitoring System (Agritempo) for the 20-year interval, defined between 01/01/2001 and 12/31/2020.

For each municipality, a spreadsheet containing BHN estimates obtained from the NURMA database was used. The spreadsheets were populated with monthly precipitation and temperature average data, from which graphical representations of water balance excerpts and complete water balances were generated in both line and bar chart formats (Figure 1).

Figure 1– Example of a complete graphical representation of the climatological water balance in bar chart format, showing deficiencies, surpluses, water withdrawal, and replenishment throughout the year



Source: Adapted from Sentelhas et al. (2021).

3.3 Elaboration of textual synthesis on the hydrological scenario of the Alto Paranapanema Basin using BHN results

The average monthly temperature among the selected municipalities was 21.4ºC. The month with the lowest average temperatures was July, with the lowest recorded temperature being 15.9 ºC in the municipality of Itapeva. The month with the highest average temperatures was February, reaching 25.7 ºC in the municipalities of São Miguel Arcanjo and Tapiraí.

Monthly precipitation ranged from 35.9 mm to 298.6 mm, with August being the least rainy month and January having the highest recorded precipitation. The annual average precipitation among the studied municipalities was 1438.7 mm. Itapeva had the lowest annual average precipitation (1201.0 mm) for the studied period, while Tapiraí had the highest (2039.0 mm).

The months with the highest occurrence of water deficit for the studied municipalities were April and August. São Miguel Arcanjo recorded the highest water deficit value (-5.7 mm) for the month of April, and Tapiraí was the only municipality that did not show water deficit.

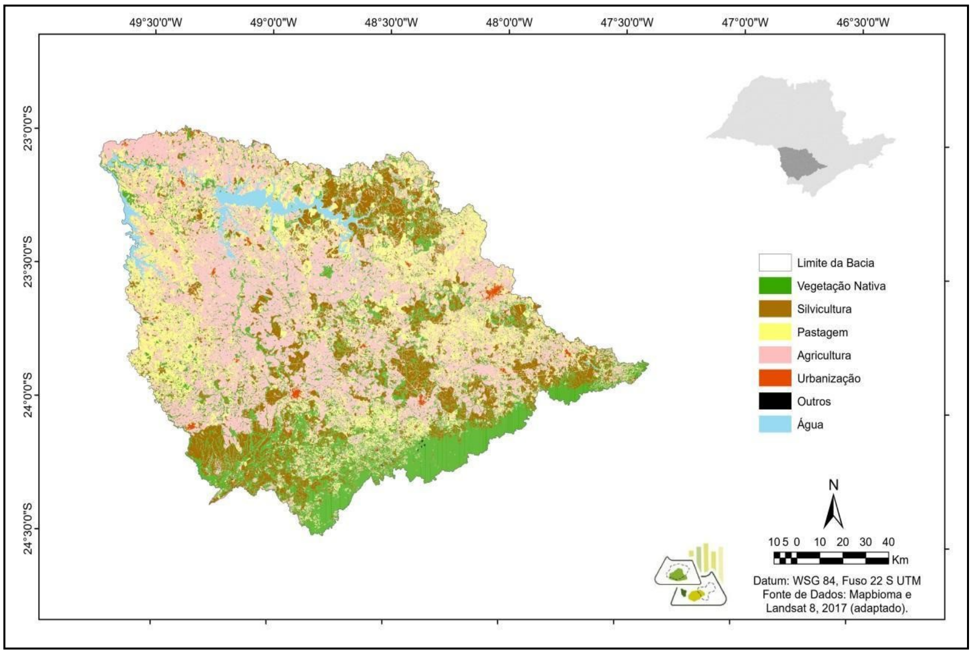
January was the month with the highest water surplus, and Tapiraí had the highest monthly water surplus (162.3 mm), standing out as the only municipality with a water surplus in every month of the year.

3.4 Compilation of information on land use in the Alto Paranapanema Basin

According to data provided by the Center for Studies in Spatial Ecology and Sustainable Development – NEEDS (NEEDS, 2021a), the main economic activities in the Alto Paranapanema Basin are agriculture, pasture, and silviculture. From 1987 to 2017, there was a 150.74% increase in areas used for agriculture and an 85.21% increase in areas allocated for silviculture. Pasture areas, however, experienced a 58.26% reduction during the same period. The total number of cattle also decreased, but the animal density increased by 73.57% in the analyzed period, indicating a transformation from extensive pastoral activities to a more intensive form with a greater number of animals in a smaller area.

Between 1987 and 2017, there was a substitution of a significant portion of areas previously used for pasture to agricultural areas. According to a survey conducted in 2017, agricultural areas covered 850,376.56 ha, pasture areas covered 465,638.41 ha, and areas used for silviculture covered 329,449.43 ha, together encompassing more than 70% of the total area of the Alto Paranapanema Basin (Figure 2).

Figure 2– Land Use in the Alto Paranapanema Basin in 2017



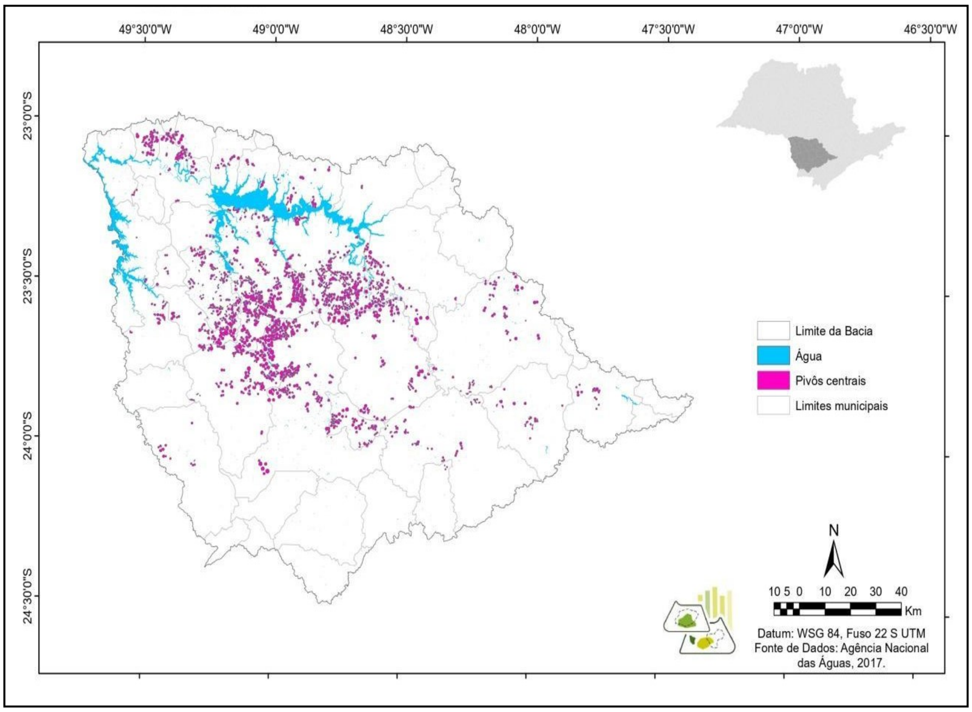
Source: NEEDS (2021b).

3.5 Identification of water demands for economic activities in the Alto Paranapanema Basin

Agriculture is the economic activity that occupies the largest area in the Alto Paranapanema Basin and also the activity that experienced the greatest growth in the occupied area (150.74%) between 1987 and 2017. Similar to agriculture, the central pivot irrigation system, used on a large scale in irrigated agriculture, also showed significant growth between 1985 and 2017.

In 1985, there were only three central pivots in the municipalities of Piraju, Itapeva, and Itapetininga. In 2017, this number increased to 1,805 central pivots, distributed across 28 municipalities in the Alto Paranapanema Basin (Figure 3).

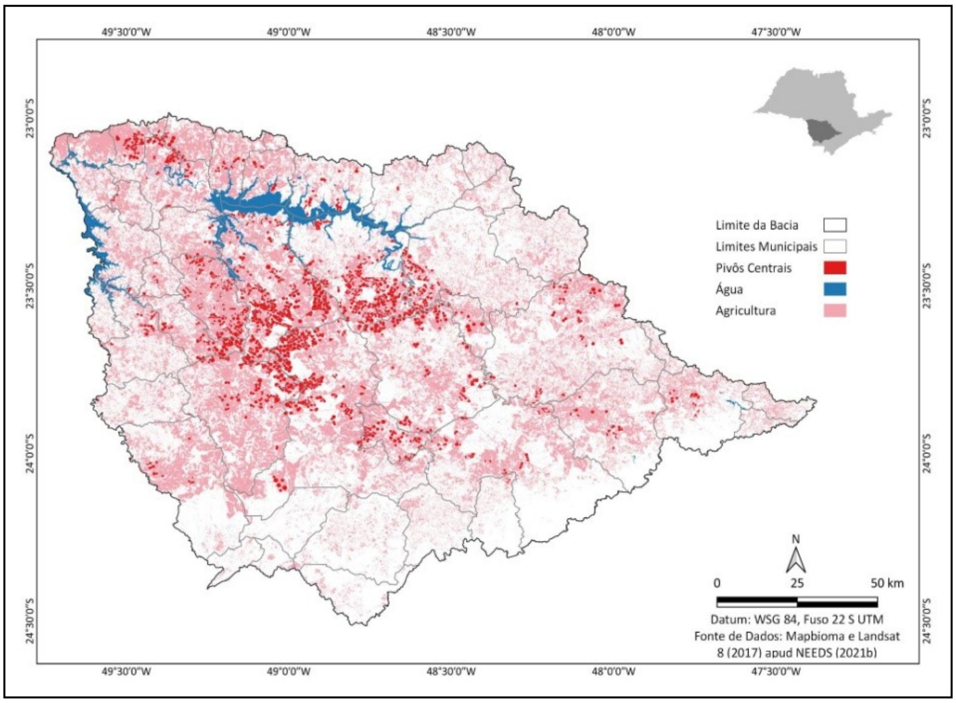
Figure 3– Distribution of Central Pivots in the Alto Paranapanema Basin in the year 2017



Source: NEEDS (2021b).

It is evident that there is a significant concentration of central pivots in the central region of the basin, where agricultural activities are also predominant (Figure 4), particularly in the municipalities of Itaí (335), Paranapanema (291), Itapeva (225), Taquarituba (169), Itaberá (138), and Buri (103). The surface water demands in the region encompassing these municipalities represent an allocated flow of 16.85 m³/s (CBH-ALPA, 2020).

Figure 4– Distribution of Central Pivots and Agricultural Activities in the Alto Paranapanema Basin in the year 2017



Source: Adapted from NEEDS (2021b).

Central pivots are equipment that mobilize large water flows, and their high concentration poses significant pressure on water resources, potentially causing demand to exceed water availability in the region. This is already happening in some locations in the basin, especially in the central area, where water catchment demand surpasses 50% of $Q_{7,10}$ (minimum average flow over 7 consecutive days with a 10-year return period) (TCA; IPT, 2016).

3.6 Identification of potential conflicting water uses in the Alto Paranapanema Basin

The water criticality observed in the Alto Paranapanema basin is closely related to the substantial water demand for rural use. Areas considered in critical condition regarding water availability are located in rural areas of the municipalities of Paranapanema, Itaí, and Itapeva, where there is an intense concentration of agricultural activities requiring extensive use of central pivots (TCA; IPT, 2018).

Another water demand in the basin is from hydropower dams. There are four hydropower plants (UHE) in the basin: UHE Paranapanema, UHE Chavantes, UHE Piraju, and UHE Jurumirim. UHE Chavantes has a drainage area of 400 km² and an average annual flow of 310.00 m³/s; and UHE Jurumirim has a reservoir area of 449 km² and a daily average flow of 54 m³/s (TCA; IPT, 2016).

With the increased use of central pivots in irrigated agriculture, there was also a considerable increase (110.97%) in the number of hydropower dams from 2007 (401) to 2015 (846) (TCA; IPT, 2016). Starting in 2016, changes in the hydrological regime of the basin occurred due to a scarcity of rainfall, and in 2019, shifts in the rainfall pattern led to the lowering of reservoirs used by hydropower plants, such as the Jurumirim reservoir, which reached a useful volume of 40% in May 2019 (CBH-ALPA, 2020).

After analyzing the results, some initiatives are suggested for the rational use of water in the BALPA: a) study the volume captured by pivots using granted water usage data; b) conduct a survey of possible ungranted water intakes; c) identify priority areas for forest restoration through property compliance with the Native Vegetation Protection Law - Law 12.651/2012 (BRASIL, 2012), aiming to boost the recovery of hydrological ecosystem services, especially streamflow regularity in the BALPA, following the studies of Honda and Durigan (2017).

4 CONCLUSIONS

The research conducted will allow students to consult and evaluate four meteorological databases, selecting those that proved suitable. Through the proposed activities, it will also be possible to analyze land use evolution in the basin using images and agricultural data, consolidating knowledge related to geoprocessing disciplines. The determination of the monthly normal water balance will require basic concepts in hydrology. The same will happen during the spatial location of irrigation pivots, as well as the analysis of granted totals, also encompassing geoprocessing knowledge. The final evaluation of the obtained data associated with information extracted from institutional documents will enable the consistent exercise of the curricular unit "Water Resources Management."

On the other hand, the proposal of actions for the rational use of water and the favoring of the provisioning ecosystem service through forest restoration aligns with the contents of Applied Ecology and Environmental Restoration. Regarding the suggestion of studies to identify possible ungranted intakes, this procedure will allow the application of contents of Water Resources Management, more precisely those related to instruments of the National Water Resources Policy. Finally, the preparation of the technical report will enable the application of procedures and technical standards with which students had initial contact in the Research Methodology discipline.

Consulting institutional documents will support the critical analysis of the current water availability scenario in the basin, developing one of the expected competencies in environmental engineering graduates: "being able to recognize user needs, formulate, analyze, and solve engineering problems creatively." This competency is provided for in the National Guidelines for the Undergraduate Course in Engineering (BRASIL, 2019, p. 1).

Through the execution of the work and discussion within the group, students will develop the ability to identify potential factors of criticality in water availability in the basin, based on the integrated analysis of the obtained information. In this way, they can simultaneously develop another expected competency and provided for in DCN 2019: "adopt multidisciplinary and transdisciplinary perspectives in their practice" (BRASIL, 2019, p. 1).

The application of the integrative teaching activity has the potential to drive the development of competencies expected for graduates of the environmental engineering course, including cooperation, creativity, autonomy, and above all, the ability to learn how to learn. To achieve this potential, it is suggested that the activity be developed in groups formed by at least one student from each discipline.

Each student can contribute to the group's dynamics by mobilizing knowledge inherent to their discipline, which is a unique condition for interaction between peers with different levels of knowledge development.

The offer of an evaluation rubric can be made, for example, by individualizing the development stages (according to Table 1) or even using the "questions for guiding ITA" as a reference.

ATIVIDADE DIDÁTICA INTEGRADORA NA ÁREA DE RECURSOS HÍDRICOS: UMA PROPOSTA PARA ENGENHARIA AMBIENTAL

RESUMO

O artigo propõe uma atividade didática integradora (ADI) que contempla a inter-relação de disciplinas da área de recursos hídricos com base em um cenário atual: o uso da água na Bacia do Alto Paranapanema (BALPA). O referido cenário suscita um tema fundamental na formação de profissionais que atuarão na gestão de recursos naturais: a crise hídrica. Temos como objetivo: "analisar a dinâmica do uso do solo e suas implicações sobre a disponibilidade de água na bacia do Alto Paranapanema". Os métodos de pesquisa orientam-se no desenvolvimento de um diagnóstico da disponibilidade hídrica da BALPA e de sua relação com o uso do solo por meio das seguintes estratégias: análise de dados secundários referentes ao uso do solo e demanda de água pelos usos identificados, cálculo do balanço hídrico climatológico da bacia e consulta a documentos institucionais. Todas as fontes sugeridas estão disponíveis ao público. Nos resultados descreve-se a atividade desenvolvida, sendo que ela integra conteúdos de oito disciplinas e contempla 11 etapas, que subsidiam os acadêmicos para responder a seis questões que norteiam a atividade. Conclui-se que, em termos de resultados de aprendizagem, considera-se que a ADI pode impulsionar o desenvolvimento de competências esperadas para o egresso do curso de engenharia ambiental, dentre as quais destaca-se a cooperação, criatividade, autonomia e sobretudo, a capacidade de aprender a aprender. Adicionalmente, a atividade promoverá a consolidação de conhecimentos oriundos das diferentes unidades curriculares, necessários para a gestão dos recursos hídricos na escala da bacia hidrográfica ao mesmo tempo em que são sugeridas formas de elaboração de rubricas de avaliação e de aplicação da ADI.

PALAVRAS-CHAVE: Interdisciplinaridade. Recursos Hídricos. Engenharias.

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