

Geoenvironmental Analysis Under the Perspective of Geographic Information System (GIS) and Landscape Archaeology: Guarani and Kaingang Sites in the Anhumas Stream, Lower Paranapanema Region, SP



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Abstract The relationship of society with the environment in past times shows the relevance of interdisciplinary studies between Geography and Archaeology. In this case, we discuss the landscape of Guarani and Kaingang archaeological sites located near the banks of Ribeirão Anhumas, Municipality of Narandiba, SP. Cartography and the logic used in GIS for spatial analysis were carried out with emphasis on location, distribution of archaeological remains, as well as to demonstrate the form of implantation of the indigenous site Guarani or Kaingang in the relief, thus contributing to the analysis of geoenvironmental contexts in interdisciplinary research, especially by the triad—Geography, Landscape Archaeology, and Cartography, through the study of material culture and the form of implantation of archaeological sites.

1 Introduction

In the twenty-first century, contemporary geographers and archaeologists are approaching, especially in research into the organization of past occupations (KORMIKIARI 2000). Boado (1993) emphasizes that archaeology, when used as a research strategy, includes the study of all social and historical processes in its spatial dimension or, rather, intends to interpret areas of archaeological sites and the objects that specify them, either by recording the archaeological culture or material of a spatial matrix and then converting space into the object of archaeological research.

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Thus, the new technologies that enable professionals in the area to make maps linked to technologies with the use of software in order to represent the geographic space.

(...) society, when appropriating nature, imprints on this objectivity an order that is expressed by geographical principles. And the appropriated nature becomes geographical environment, from then on the relation becomes society/geographical environment. In fact, the process of subjectivation/objectivation in the construction of the geographical environment is realized through the geographical principles as a dimension of existence, both of the subject and the object, embodying a process of totalization. Here is the geographic as an expression of the existence of totality. And between the geography of man and the environment are built the mutual geographical determinations in the objectification/subjectivation relationship (Martins 2016, p. 62).

Archaeological studies in Pontal do Paranapanema are scarce in relation to the establishment of Guarani, small-sized, and Kaingang sites, which are always small compared to the Guarani. According to Faccio (1998) the archaeological records are identified in different contexts and extensions. The denomination of small sites refers to archaeological sites of smaller extension, with low density of artifacts and distant from navigable rivers, located near springs, streams, and/or creeks. The small and medium-sized sites located in Pontal do Paranapanema is close to small watercourses (streams and creeks).

The pottery groups of the Pontal do Paranapanema, such as the Guarani, inhabited the terraces and mid-slope areas, passing through river channels and tributaries where they entered the Paranapanema River area. The possibility of contact between Guarani and Kaingang is evidenced by the analysis of pottery from Guarani sites, mainly in the Lower Paranapanema Valley area (Faccio 2011). The Kaingang of São Paulo, together with the Kaingang of the state of Paraná, constitute the largest southern Jê group. In the state of São Paulo, they occupied valleys and spurs in the interior of the state, bordering the Tietê, Peixe, Feio-Aguapeí, Paranapanema Rivers, and their tributaries. In southern Brazil, the Kaingang inhabited the valleys of the Tibaji, Ivaí, Iguaçu and Uruguai rivers (Pinheiro 1999).

The regional farming systems of the Paranapanema were dismantled by the various fronts of the Iberian invasion in the sixteenth century (Morais 2002). Regarding the regional farming systems in the Paranapanema River area, formed by sedentary communities originating from the Southwest and the South, they migrated through the Paranapanema and its tributaries along the left bank of the river (Morais 2002). Archaeological data reveal that these migratory fronts were occupied around the beginning of the Christian era, marked mainly by archaeological records of remnants of the villages of the regional Guarani system (Pallestrini and Morais 1982).

This paper presents the preliminary results of the spatial analysis of archaeological sites located near the banks of the Ribeirão Anhumas, from the description of their geoenvironmental components. They are indigenous Guarani and Kaingang archaeological sites: Santa Cruz do Anhumas II, Santa Cruz do Anhumas III, Santa Cruz do Anhumas IV, Santa Cruz do Anhumas V, São Saprino, Santa Helena, Tatu Galinha, Córrego da Boa Vista I and Córrego da Boa Vista II.¹

¹ The Preventive Archaeology research carried out in the sugarcane plantation area of COCAL, Narandiba Unit, under the coordination of the archaeologist and Professor Neide Barrocá Faccio,

2 Study Area

The pottery groups of the Pontal do Paranapanema, such as the Guarani, inhabited the terraces and mid-slope areas, passing through river channels and tributaries where they entered the Paranapanema River area. The possibility of contact between Guarani and Kaingang is evidenced from the analysis of pottery from Guarani sites mainly in the Lower Paranapanema Valley area (Faccio 2011). The municipalities of Narandiba, Anhumas, and Taciba are located in the western part of the State of São Paulo, bordered to the south by the Paranapanema River and to the west by the Paraná River.

The Pontal do Paranapanema was occupied by groups of migrants from Minas Gerais and the Northeast Region of the country, between the late nineteenth century and early twentieth century, when the coffee cultivation consolidated in other regions of the State of São Paulo expanded, which resulted in an extraordinary demand for “land” by farmers (Abreu 1972). This occupation process, according to Abreu (1972), Monbeig (1984), and led to an intense process of environmental degradation (deforestation and soil degradation), followed by the extermination of the traditional indigenous and caboclo populations.

The delimitation for the region known as Pontal do Paranapanema is called Water Resources Management Unit (UGRHI-22) and is considered the 10th^o Administrative Region of the State of São Paulo, according to the governmental administrative delimitation (Fig. 1).

According to Faccio (2011) in the Paranapanema Project (ProjPar) area, Kaingang archaeological sites were evidenced in the middle valley area; however, in the Baixo Paranapanema Paulista area, although Ethno-History reports point to the presence of Kaingang Indians and Guarani Sites have presented ceramics with brunidura (blackening technique of ceramics, recognized as Kaingang). Robrahn (1988) and Chmyz conducted an archaeological assessment in the middle Ribeira de Iguape area and detected Kaingang sites with dates between 600 and 270 BP.

Araújo (2001) reported that in the Alto Taquari basin, a tributary of the Paranapanema River, near the city of Itapeva, 60 km from the Paraná border and only 40 km upstream from the Middle Ribeira sites, he found 39 Kaingang-related archaeological sites, including open-air ceramic sites, in shelters, mounds, and underground houses, which confirm the preference of this indigenous group for areas of high relief.

The geomorphology of the Paranapanema River basin favored the occupation of these human groups, as it presents in its relief an abundance of resources such as silicified sandstone, basalt, and also clay, thus making it easier for the indigenous groups to obtain raw materials for the manufacture of lithic and ceramic materials. The distinction of the occupation mode of indigenous groups in the Paranapanema River basin was influenced by the relief morphology and settlement pattern since in the upper basin of the Paranapanema River, the implantation of these

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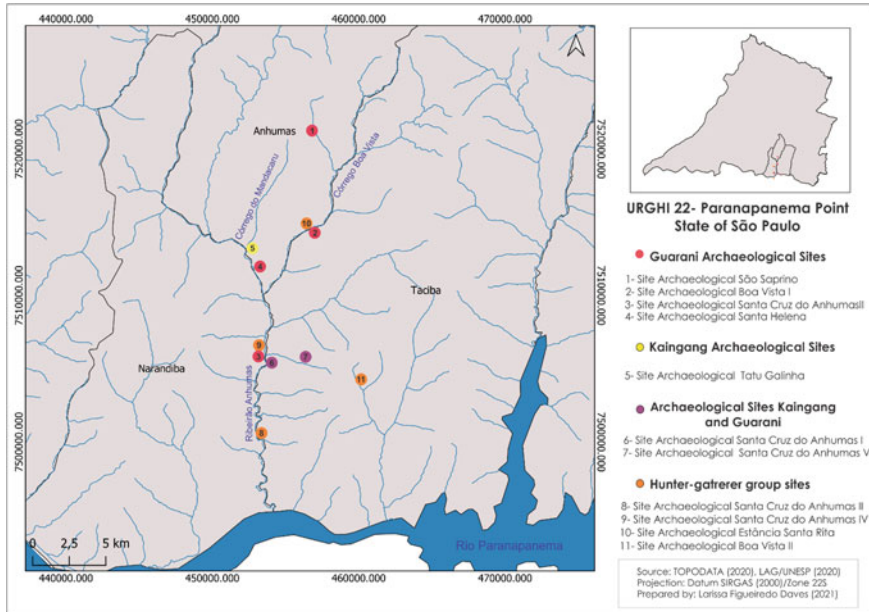


Fig. 1 Location of the archaeological sites located near the banks of Ribeirão Anhumas, Ponta do Paranapanema region (URGHI-22). Municipalities in the study area: Narandiba, Anhumas, Taciba, State of São Paulo. *Source* Google Earth Pro Landsat Image. IBGE (2021). **Organization:** Larissa Figueiredo Daves

archaeological sites occurred in the hills interspersed by small drainage channels (Upper Paranapanema). In the middle basin, on the other hand, the settlement pattern continues to be amplified by a network of camps and chipping workshops along the large hydrographic channels (Middle Paranapanema).

3 Methodology

3.1 *Theoretical Assumptions: The Concept of Landscape and Landscape Archaeology*

Landscape Archaeology is an interdisciplinary knowledge with a vast amount of theories and methodological approaches to other sciences. When used as a research strategy, Landscape Archaeology includes the study of social and historical processes, in order to interpret landscapes and archaeological remains in their temporality in the spatial dimension.

The space is produced, resulting from this interaction and uses of nature, mediated by technique (artifacts) and also production of a landscape. Thus, the man does not

occupy the space, he produces the space, and the landscape is the result of this dynamic interaction, as Bertrand (2009) puts it.

The postulate that bases the analysis of the landscape then can only be social: "it is the production system in the broad sense, i.e., producing material and cultural goods, which, within a defined social group and in a given space, draws the material and cultural content of a landscape". (Bertrand and Bertrand 2009, p. 221).

The investigation of the settlement pattern makes it possible to relate geographical characteristics, such as topographic use and use of vegetation types; the social structure, inferring about its organization in the territory and, finally, the changes through time, with a view to relating the characteristics of the materials for comparisons (Vogt 1956). Thus, we have a method the Landscape Archaeology, in order to analyze the elements of the physical and cultural environment in an integrated way.

Because it understands the landscape in a dynamic way and is related to the integrative and polysemic debate, bertrand's proposal (2009) is used as the main approach, in which he states that "Landscape Archaeology should be apprehended as an attempt to refine the vestige of the historical relations established between society and nature." (BERTRAND 2009, p. 171).

As an example of this debate, we have the GIS (Geographic Information Systems) that presents extremely relevant potential for spatial analysis, researchers use such tool for cartographic production in social and/or environmental studies, in addition to computational systems for management of spatial data (Ferreira 2006).

GIS can be defined in two categories—1st GIS is a field of research that contains a **broad set of spatial analysis issues and** is known as the science of geographic information; 2nd **GIS is a toolbox of multiple technical uses** -set of techniques ancillary to the sciences in general (Goodchild 1992). In the first definition, GIS is geared to the paradigms of geographic information science—*GISystem* by *GIScience*. At this level, it presents functions of map analysis with theoretical-methodological basis, which were established by spatial analysis. At the second level, the GIS is seen as a set of techniques at the service of a science, either by the image processing system or by the system and access to database (Ferreira 2006).

The interdisciplinarity allows showing that the landscapes examined by the collaborators form a subjective perspective, locally situated, as something that not only shapes but is shaped by human experience (Bender 1993). The interpretation of archaeological data and interpretation of the landscape by spatial logic is fundamental to the study of human groups who inhabited the territory in past times, such perspective refers us to the "spatial turn," definition used in the human sciences for understanding in the function of images in the context of knowledge by imagery language (Fonseca 2007).

It is noted the intense use of GIS in archaeological research. According to Llobera (2003) the theme of GIS in archaeology has the purpose of representing the occupation of human groups in past times, as stated in the article "Exploring the topography of the mind: GIS, social space and archaeology". It is verified that from the visibility in the landscape and the topographic space it is possible to find evidence of the past occupation. Llorera (2003), and Gaffney and Stancic (1995) emphasize that the use of GIS for landscape analysis in archaeological sites makes it possible to represent

the memory of occupation in a given place in the past, from evidence rescued in the current landscape.

3.2 Methodological Procedures

To analyze the Kaingang and Guarani settlement pattern in Pontal do Paranapanema on a local scale, the methodology proposed by Morais et al. (2000), called Regional Occupation System, is used as a starting point. Comparative studies are used to identify the settlement pattern. The intrasite spatial analysis has several objectives, both at the inferential level, which takes into consideration the reconstruction and explanation of past behaviors and unobservable activities and at the operational level of the relations between archaeological observations. In this context, the landscape analysis and the settlement pattern are fundamental for the discussion of the context of the archaeological sites, both in the cultural scope and in its relation to the physical aspects of the area (Carr 1984).

The data systematization was performed in three steps: a) Obtaining and manipulating SRTM data, by the pre-processed image with spatial resolution of 30 m from the letter 22S52RSN extracted by INPE—TOPODATA Project, for slope and altitude analysis. Such maps were prepared through the raster model, in order to perform the mapping of archaeological sites and their situation in the relief, in order to discuss the settlement pattern; b) The analysis of the spatial distribution of archaeological remains was performed based on the maps of vector model, initially, the data were entered into the software Q.GIS 3.18.2, classified by type and amount of archaeological material (ceramics and chipped lithic), with their respective coordinates in KML format—UTM coordinates (file compatible with GoogleEarth Pro).

The concentrations of the vestiges were represented by means of the graduated method in proportional circles (percentage %). c). The mapping was performed through the analysis of panoramic photographs and satellite images (Google Earth Pro- Image 2020 CNES/Airbus and Image Landsat 8). In the realization of the mapping was extracted geomorphological features (drainage, floodplains, and terraces, characterization of valley bottoms, and areas with presence of geoindicators) for a digital planialtimetric base, through juxtaposition of these features on a topographic sheet (from the IBGE, title of Esperança do Norte- SF-22-Y-B-VI-1, scale: 1:50 000, year 1973), according to drainage network—(Scale-temporal map of the Paranapanema River watercourse: years 1973 and 2021).

After the elaboration of vector data according to the concentration of traces in the perimeter of each archaeological site, we perform the treatment from symbols (triangles, pentagons, arrows) for representation of chipped lithics, polished lithics, and indigenous migration of each ethnic group with ethnohistorical survey basis

according to the ethnologist Curt Nimuendajú (1943),² in order to show migratory flows of the Guarani and Kaingang in the twentieth century with the archaeological data of each tradition (Tupiguarani, Jê).

The fieldwork was conducted between 21 and 25 September 2020, by means of exploratory research in the study area, as well as landscape analysis of physical-geographic characteristics (relief, soil, vegetation, and hydrology). The methodology used was based on the levels of treatment proposed by Ab'sáber (1969), with emphasis on topographic compartmentalization, geomorphological features, and archaeological remains.

4 Results and Discussions

Cartography assists the representation of space in Landscape Archaeology through the preparation of maps, from the use of aerial photos, topographic charts (altimetry and planimetry of the terrain and contour lines), being fundamental to topographic representation, one of the ways of apprehending reality, because it is a quantitative apprehension of reality: the morphology through the slopes, altitudes, lengths and breaks of a ramp, slope (Crosby 1999).

The remote sensing through the analysis of satellite images, besides the elaboration of slope maps, in this case in studies of slope morphology and landscape dynamics (Cassetti 1989; Ab'Sáber 1969). For possible discussion regarding the material culture and dispersion of archaeological materials on the perimeter of archaeological site, having probable interpretation of the settlement pattern and/or occupation system of these human groups, in time and space, together with data obtained by the dating of archaeological remains (environmental geoindicators and operating chain) (Faccio 2011; Morais et al. 2000).

Ab'sáber (1969)³ made use of three levels of treatment for geomorphological research, with respect to the structuring of landscapes in the past and their evolution. According to Cassetti, the understanding of the choice of the geographic position of the archaeological site offers auxiliary elements for the analysis of evidence of later colluvial settlements, by the physical-chemical characteristics of the correlative deposits. Thus, the analysis of the surface structure allows the researcher to prove the chronogeomorphological studies, from the dating of the archaeological remains and geoindicators with evidence of habitation in past times.

² from ethno-historical reports and field research, the ethnologist Curt Nimuendajú (1943) elaborated a map of the linguistic families of the State of São Paulo in the first half of the twentieth century.

³ The first level studies the **compartmentalization of the regional topography**, with characterization and description, as exact as possible, of the relief forms of each of the studied compartments. The second level of treatment seeks to obtain systematic information about the **superficial structure** of the landscapes referring to all the observed compartments and relief forms. The third level seeks to understand the current morphoclimatic and pedogenetic processes in their full action in order to understand the **physiology of the landscape**.

From this mapping, we had the delimitation of the morphology of the relief and deployment of archaeological sites by spatial analysis and their location on the relief. The visual interpretation was listed by the visualization and quantification, laws of the two natures. In this sense, the cartographic representation is both a representation and a construction. From these elements were extracted geomorphological features (drainage, floodplains and terraces, characterization of valley bottoms and areas with presence of geoindicators) for a digital planialtimetric base, through juxtaposition of these features on a topographic chart, according to the drainage network, in this case, the watercourse of the Paranapanema River, Ribeirão Anhumas, near the area of the archaeological sites.

Thus, we contributed a historical approach to the landscape in order to represent by Cartography the occupation of the sites in question, mainly the pottery groups, in the area of Pontal Paranapanema, besides analyzing the landscape transformation and approaching the scenario in two moments: 1°-occupation of the landscape by the Guarani and Kaingang groups 2°-after the impact on the environment and its change in the landscape.

In this sense, the logic used in GIS for prehistoric spatial analysis on location, distribution of archaeological remains, and the implantation of archaeological sites in the relief show the relevance of landscape studies in archaeology. Thus, the application of GIS in archaeological research allows the analysis of archaeological attributes associated with geographic ones, and “this presents the possibility of tracking distribution and movements, as well as interactions between archaeological cultures” (Csáki and Jerem 1995, p. 85).

The physical-geographical characteristics of the Paranapanema River, especially its morphology and lithology, conditioned the way in which the geographic space was appropriated by pottery groups, mainly by the Guarani group. The area where the archaeological sites are located presents fluvial terraces and sloping surfaces of colluvial-aluvial deposits, predominance of sedimentary rocks of the Bauru Group (Adamantina Formation), and volcanic rocks of the São Bento Group (Serra Geral Formation). The macroleivo is formed by the Peripheral Paulista Depression (Depression of the Paranapanema) and the morphoculture of the Paulista Western Plateau. The mesorelevo is characterized by broad hills of hilly relief with the presence of soils of the type: Red Latosolo (VL) and Red Podzsolos (RW) (Fig. 2).

The union of such a study allows us to understand the current physiognomy and reflect on its transformation over the history of use of the researched environment. The analysis emphasized the location for delimitation of the morphology and implementation of the archaeological site (relief compartmentalization). Table 1 shows the archaeological materials evidenced during the prospective diagnosis for the Guarani and/or Kaingang occupations in western São Paulo (Table 1 and Fig. 2).

Such physical-geographic characteristics, mainly the morphology and lithology, conditioned the way of appropriation of the geographic space by ceramic groups, mainly the Guarani and Kaingang groups. The concentration of ceramic material is found near the course of this stream, in an area of medium/low slope, with altitudes ranging from 340 to 430 m.

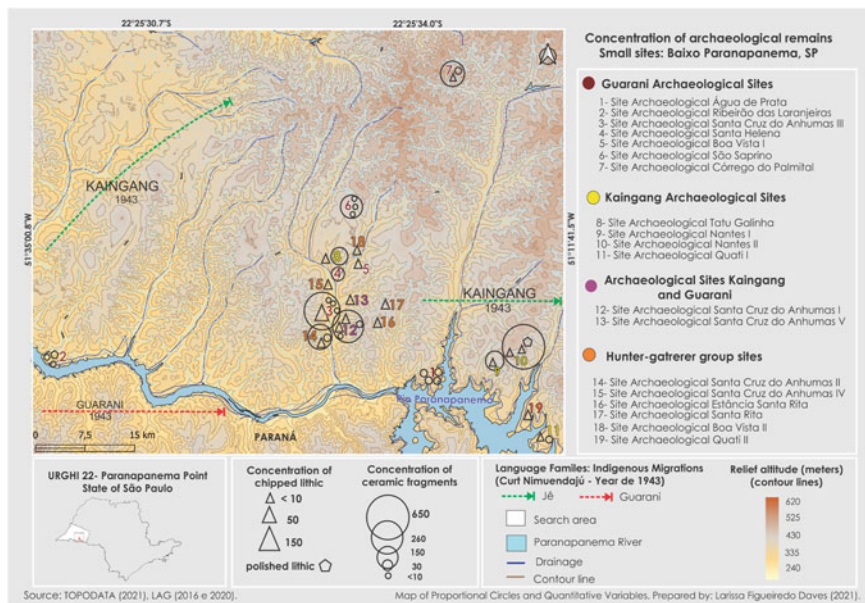


Fig. 2 Concentration of archaeological remains on the perimeter of the sites located near the banks of the Paranapanema River, Paulista side—Ribeirão Anhumas tributaries, Boa Vista Stream, Mandacaru Stream, Laranja Doce River. State of São Paulo. *Source* TOPODATA (2020). LAG/UNESP (2020). **Elaboration:** Daves

The archaeological survey on Kaingang archaeological sites shows the form of occupation on the relief, their preference for hilltop areas, although it presents the existence of sites located on low slopes near valley bottoms, while Guarani sites present location in medium/low slope areas near large navigational rivers (Araújo 2001; Fig. 3).

We found that the Kaingang and Guarani sites with the presence of ceramics are located on soft and/or undulated terrain, in areas of wide hills, while the lithic sites occupy the flat terrain, near the Ribeirão Anhumas fluvial terrace, near possible rocky outcrops with the presence of silicified sandstone pebbles and silixite, while the possible clay sources are located in areas of sand deposition in marginal dikes of the Ribeirão Anhumas.

The archaeological sites Tatu Galinha, Santa Helena, São Saprino, Boa Vista I and II, Santa Cruz do Anhumas I, II, III, IV, and V are located in the municipality of Narandiba, situated in the area of medium/low slope, near the confluence of the Mandacaru Stream with the Anhumas Stream, tributary of the Paranapanema River. The landscape of the Ribeirão das Laranjeiras site shows that it is located on a low slope, approximately 30 m away from the Paranapanema River, with the same characteristic as the Água de Prata site (Taciba municipality) and the Quati II site (Iepê municipality).

Table 1 Archaeological Sites located near the Ribeirão Anhumas, Boa Vista Stream and tributaries of the Paranapanema River, Municipality of Nandubá, SP

Archaeological sites	Lithic materials	Ceramic materials	Lytic polite	Site classification	Occupation in relief	Altitude (m)	Hydrography	Distance from the nearest body of water
Saint Cross of Anhumas I	35	61	1	Tupiguarani/Itararé	Medium/low strand	341	Anhumas Stream	220 m
Saint Cross of Anhumas II	5	-	-	Lithic Site	Medium/low strand	312	Anhumas Stream	380 m
Saint Cross of Anhumas III	-	17	-	Tupiguarani	Medium/low strand	340	Anhumas Stream	290 m
Saint Cross of Anhumas IV	5	-	-	Lithic Site	Low strand	340	Anhumas Stream	1,5 km
Saint Cross of Anhumas V	-	11	-	Tupiguarani/Itararé	Medium/low strand	404	Anhumas Stream	410 m from the spring 3 km from Ribeirão Anhumas
Boa Vista Stream I	-	37	-	Tupiguarani	Low strand	354	Boa Vista Stream	75 m of the Boa Vista stream
Boa Vista Stream II	7	-	-	Lithic Site	Low strand	365	Boa Vista Stream	120 m of the Boa Vista stream
Saint Saprino	-	9	-	Tupiguarani	Medium/low strand	407	Anhumas Stream	140 m from boa vista stream
Chicken Armadillo	8	40	-	Tupiguarani/Itararé	Low strand	360	Anhumas Stream	360 m

(continued)

Table 1 (continued)

Archaeological sites	Lithic materials	Ceramic materials	Lytic polite	Site classification	Occupation in relief	Altitude (m)	Hydrography	Distance from the nearest body of water
Saint Helena	-	10	-	Tupiguarani	High and medium strand	380	Anhumas Stream	630 m

Source Faccio et al. (2016). **Organization:** Larissa F. Daves

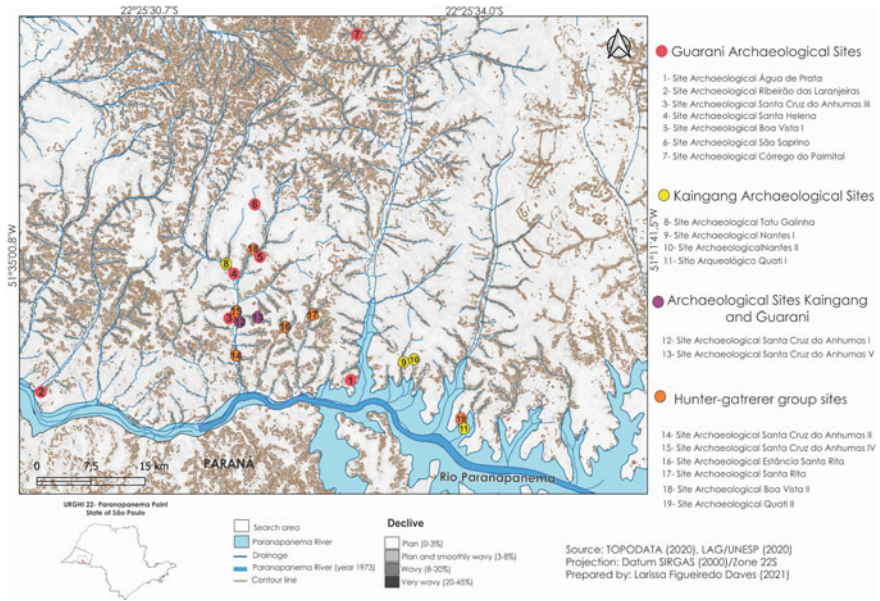


Fig. 3 Occupation in the relief of the lithic, Guarani, and Kaingang sites in the study area, Lower Paranapanema River course. *Source* TOPODATA (2020). *Elaboration:* Daves

These sites presented the presence of Guarani pottery, and in some cases also Kaingang pottery. The Nantes I and II sites are situated on the middle and lower slopes of a wide hill, approximately 50 m away from the Coroado Stream, also a tributary of the Paranapanema River, located in the Municipality of Nantes. They present blackened black ceramics as a result of the presence of burnishing (Fig. 4).

The archaeological sites located near the banks of the Ribeirão Anhumas make it possible to characterize the indigenous settlement pattern of Guarani and Kaingang groups far from the banks of the Paranapanema River.

In the Lower Paranapanema area, the large Guarani sites are characterized by occupation on hilltops and villages near the large marginal terraces of the Paranapanema River.

The Santa Cruz do Anhumas I archaeological site is located in an area of medium/low slope, 200 m west of the Anhumas stream and 12 km away from the Paranapanema River watercourse. We found the presence of a clay source (fluvial neosolo), being a possible geoinicator (highlighting floodplain and terraces) for pottery making in prehistoric times, located 300 m away to the west of the Santa Cruz do Anhumas I site (Fig. 5).

Analyzing the Paranapanema River watercourse, having as parameter the current context (2021), a new delineation can be noticed, leaving evident the present modification in the drainage with the submersion of the terraces and plains in the low concavity areas, besides the landscape transformation during the years, from 1973

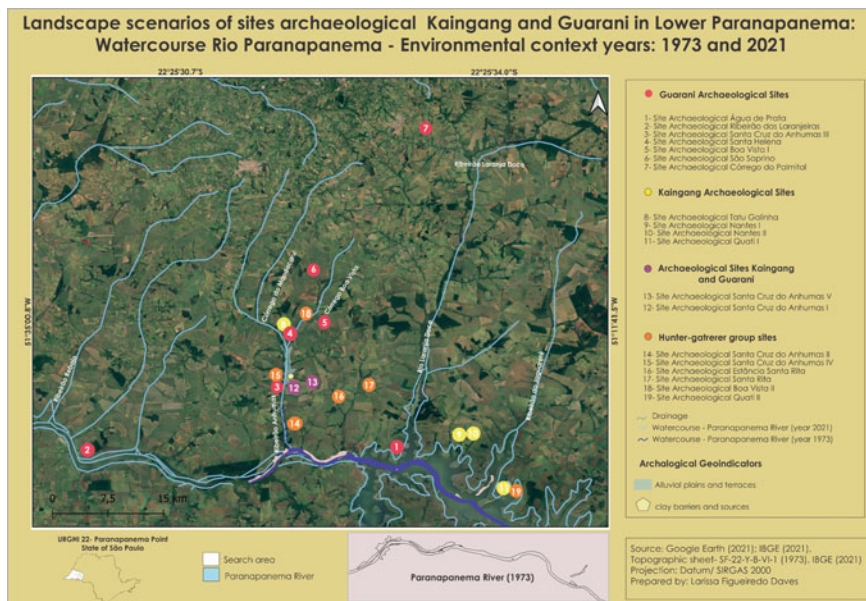


Fig. 4 Landscape of archaeological sites, Guarani and Kaingang course of the Lower Paranapanema River. Time scale 1973 and 2021. *Source* Google Earth (2021); IBGE (2021). Topographic sheet (1973), IBGE

to 2001, with the disappearance of the archaeological geoinicator sites, due to the formation of the Ada Usina Capivara lake, in the municipality of Iepê, SP.

5 Final Considerations

The cartographic representation of the geoenvironmental context of Guarani and Kaingang archaeological sites in the area surrounding the Ribeirão Anhumas allowed us to understand the spatial distribution of the phenomena studied, both in their vertical stratification and in their horizontal structure. From this cartographic representation, it was possible to indicate the dynamics of these indigenous groups, who lived in the period from 370 to 570 AP, which can be identified in the landscape of the present and in the logic of the location of the remains and materials collected from the past.

We conclude that from the landscape analysis, the settlement pattern of the archaeological sites located in Ribeirão Anhumas can be characterized by the presence of ceramics—Guarani, and Kaingang—in areas of gently undulating and/or undulating relief in areas of wide hills. The lithic sites occupy the flat relief near the low slope, on the fluvial terrace of the floodplain of this tributary of the Paranapanema River.

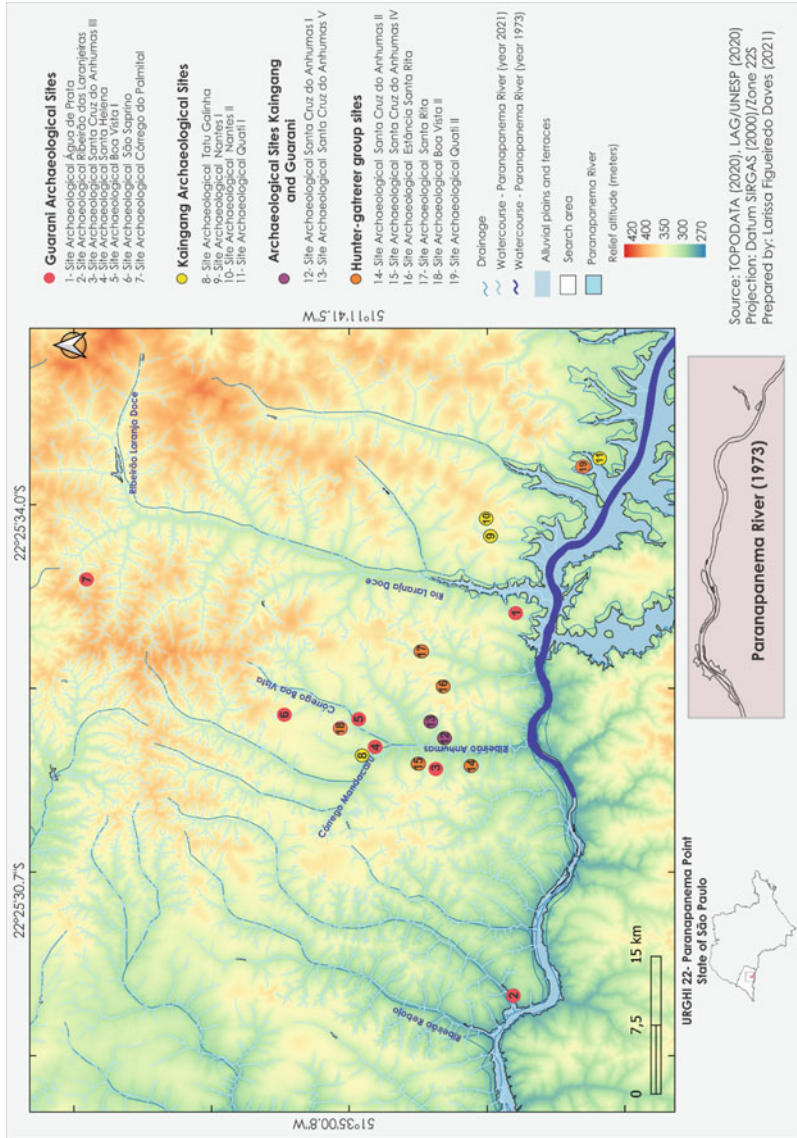


Fig. 5 Hypsometry map of the Guarani and Kaingang archaeological sites of the Lower Paranapanema River. Time scale 1973 and 2021. *Source* Google Earth (2021), IBGE (2021). Topographic sheet (1973), IBGE

The relevance of the analysis of geoenvironmental aspects in interdisciplinary research is noted, especially by the triad—Geography, Archaeology, and GIS, through the study of the material culture of archaeological sites and landscape analysis. This involves the mapping and elaboration of cartographic products about their occupation in the relief, in order to highlight the reasons that led these groups to establish settlement in this particular area.

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