

Real Estate Market Prices and Floods in Rio Do Sul (Santa Catarina, Brazil): Evidences of Correlations under a Territorial Perspective

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Abstract

The city of Rio do Sul, State of Santa Catarina, Brazil, is marked since its colonization in the last years of the 19th century from frequent and intense floods that shaped its urbanization and relation of its residents with the environment. After the 1983 floods that reached the historical record of 13.56 meters over the riverbed and the 2011 events, the second-highest ever, researchers argued that the local, territorial dynamics of spatial segregation and real estate market changed and became attached to the floods quotas. However, none of them ever showed these conclusions by empirical data, what is the objective of this research. After collecting data from 200 terrain properties to sale on this city, the researchers applied geostatistical (specially kriging) and geoprocessing methods with Geographic Information Systems to identify if there is a relation of cause-effect with the different flood quotas reaching the properties with its market value. The results are that this association exists, but is not the only variable that explains value variations in Rio do Sul, with relevant weight from the city's centrality to real estate market prices. However, the premise is true for the neighborhoods far away from the city center, where the lowest prices are in floodable places. In the same analysis, the researchers identified that the highest values are from properties free from floods and close to the central area, but not widely enough to confirm the hypothesis, considering its methodological limits.

Index terms— urban planning; spatial analysis; real estate market values; territorial relations; natural disasters.

1 Introduction

The Rio do Sul municipality location (Picture 01) is in the region known as Alto Vale do Itajaí (Itajaí's High Valley, in a free translation), at Santa Catarina state, southern Brazil. Its territorial limits are with the municipalities of Agrônômica, Lontras, Laurentino, Presidente Getúlio, Ibirama, and Aurora, totalizing an area of 260,82 square kilometers, with an estimated population of 70 thousand inhabitants (IBGE, 2019).

The city has a past and present of urban floods that, in historical terms were also responsible for reflecting in its urban development characteristics, concomitantly interfering in its territorial relations and real estate market prices dynamics (COLAÇO & KLANOVICZ, 1999; ESPÍNDOLA & NODARI, 2015; BOGO, 2020).

With the knowledge about its geographical characteristics and its socio-spatial formation, this research sought to analyze, with data collected from real estate market values, how the realty prices fluctuate according to some aspects. In this matter, we tried to understand how the variables (a) flood occurrence risk, (b) altitude/relief (that also determines the flood risk) and (c) urban centrality (what has relevant aspects such as better infrastructure,

41 commerce flows and, services being a variable that interferes in real estate market values) can influence land values
42 and economic segregation in this urban space.

43 Therefore, from the use of geoprocessing technics and its methods of data manipulation and visualization,
44 the researchers realized kriging processes and made cartographical products that sought to provide a better
45 understanding and interpretation of this case of study.

46 2 II.

47 The Rio Do Sul's Floods and its 48 Relations with Urbanization

49 Whenever we treat about a study object that demands the use of the geographical science's principles, the two
50 dimensions that compose must be present, being at a minimum stage contextualized in a way to understand the
51 reality to be discussed and analyzed. As widely described by Massey (2005), these two dimensions are time and
52 space, that must be understood together in every scientific investigation that applies the presets of Geography,
53 composing the researchers "mind", as the author stated in a posterior paper (MASSEY, 2017).

54 So, this is valid also to study cities and their dynamics, with its variable scales (from small municipality centers
55 to global megalopolis). Understanding its spatial and temporal processes that are part of wider national and
56 regional socio-spatial formations are needed aspects for the urban studies, even when only for contextualization,
57 as presented here.

58 In consequence, the Brazilian urban space is full of heterogeneous phenomena that vary regionally and
59 according to the temporal processes that compose them. Even if the common sense thinking establishes that
60 Brazilian cities never had any kind of urban planning, we know that a lot of nodal points that became urbanization
61 cores were deliberately chosen with strategic purposes, accompanied by pre-made urban designs, representing
62 each historical context and ideological zeitgeist of the governors from each period. This is real for cities of large
63 dimensions as Salvador, Aracaju, Macapá, Belo Horizonte, Goiânia, Brasília, and Palmas, among others; for
64 the territorial occupation by small and medium-sized cities in the Centro-Oeste (midwest) and Norte (north)
65 regions of the country; and also for the planned cities promoted by private institutions like industrial ones (Volta
66 Redonda and Ipatinga, for example) or created by colonization companies (like the Londrina and Maringá region,
67 in Paraná state's north) (VILLAÇA, 2019).

68 However, as argued by the same author, these spatial acts previously planned and executed in the territory,
69 such as infrastructure maintenance and the population needs didn't characterize by it some kind of national or
70 even regional urban planning. Still, only punctual interventions and projects, without an effective integration
71 or realization of long or very long term planning ?? According to Santos (2013) analysis, Brazil, predominantly
72 rural until half of the 20th century, had internal migrations that had never occurred before and passed through
73 a demographical explosion in the big cities . Some consequences of this effect were the lack of thinking about
74 the metropolitan reality that would become the norm in Brazil (over the municipality chambers) and the own
75 disorderly growing of cities, in other scales.

76 3 2

77 As discussed before, the urban phenomena that occur in Brazil are consequences of its socialspatial reality, but
78 manifest itself differently in each specific context, being in regional or local scales. As argued by Tucci (2007),
79 there is an intense relationship between urban settlements in Brazil and the rivers that compose the country, being
80 in the surroundings of river sources, valleys, or mouths, especially in coastal cities. Goularti Filho (2014) considers
81 this phenomenon as , that became the focal point of a wide range of social phenomena of Brazilian space, with
82 spotlight to social-spatial inequalities. This ends up overlapping with other urban problems and turns to evidence
83 the different accesses to amenities from certain demographic groups. As a consequence of these inequalities, that
84 occur especially from the territorialities practiced from spatial agents such as the Estate or the private market
85 (like the real estate one) (CORRÊA, 1986), factors that involve the relation between marginalized populations
86 and the environment tend to become costly for both sides: the human occupation is made in inadequate and
87 polluting ways, interfering in its quality of life, and in the same time different ecosystems suffer from unregulated
88 interference (DE PAULA, 2015). ?? As characterized by Souza (2010), urban planning must treat about long
89 or very long periods, differently from the urban management, focused on short or medium prompts. ?? Process
90 that already occurred starting on the 1930 decade but became more intense with the centralization tradition
91 imposed by the civil-military dictatorship that ruled in Brazil between the 1960 and 1980 decades (VILLAÇA,
92 1999.) natural for the colonization and urban network consolidation processes since the rivers can be a source
93 of potentially drinkable water, irrigation, energy generation, effluent discharge and, commodities and, people
94 transportations. According to the author, this is notably strong in the Brazilian case since there is a huge
95 hydrological network in most regions, excluding the dry northeast (that has the São Francisco basin, with high
96 flow competence).

97 However, Grangeiro, Ribeiro & Miranda (2020) shows that this dynamic had (and still has) direct consequences
98 on these cities urban planning and in the quality of life of its inhabitants, composing an unsustainable relation,
99 resulted from the disorganized growing of urban spaces and the absence of integrated urban management. The
100 authors criticize the public administration structure about themes evolving the urbanizations around the rivers

101 in Brazilian reality. So, it is a context that there is no proper metropolitan management to deal with the
102 urban conurbations that exist in urban centers of variable dimensions (as argued by Souza [2010] and Santos
103 Júnior & Montandon [2011]), together with the segmentation of civil defense among the municipalities and the
104 low deliberative capacity of the Agência Nacional de Águas (National Agency of Waters, in a free translation)
105 hydrological basins committees, managements scale that could raise the quality of the above-mentioned scenario.

106 This isn't different for Santa Catarina state, where is located the municipality discussed here. This city has
107 historical variations on the development of its regions, either by different forms of territory occupation and land
108 use 3 However, the Itajaí-Açu river valley, the biggest basin entirely in the state (SANTA CATARINA, 1986),
109 receives a special spotlight for its dimensions and relatively huge urban network that formed there. Some of the
110 most populous and economically relevant cities are on its stream way, forming dense and dynamic population
111 cores, that maintain direct relations with other centers of higher dimensions of the country, like Florianópolis,
112 Curitiba and São Paulo (SIEBERT, 1997; IBGE, 2020). Analyzing from a hypothetical longitudinal line from the
113 coast to west, there are three regional , either by the significant environmental conditions, expressed especially
114 by the local geomorphology, that impacted the occupation and dispersion models on the territory. However,
115 considering the differences, Maar, Peron & Netto (2011) and Goularti Filho (2014) show the importance that the
116 hydrological basins had to the colonization, production and, capital accumulation on the geographical space of
117 Santa Catarina, on all its regions. 3 A classic example is the difference between the subsistence occupation that
118 started with the Azoreans on the coast, the large farms model of the uplands and the characteristically small
119 properties of European colonization in the South, West and Vale do Itajaí regions (GOULARTI FILHO, 2014).
120 divisions: first, the river's mouth region, that has the Itajaí city as its center. This city 4 After, distant a little
121 bit more than 40 km to the west, in the river's midway, there is the city of Blumenau, the first point of the
122 valley's colonization by European immigrants and today the third most populous Santa Catarina municipality
123 (almost 360 thousand inhabitants), being a regional core of textile industry and services with relevant dimension
124 and center of a conurbation that extends itself to others cities like Indaial, Gaspar, Timbó e Pomerode. On its
125 surroundings, still forming what is known as "Médio Vale" , with an estimated population of almost 220 thousand
126 inhabitants, 6º most populous of the state has its most important port and is the center of an urban conurbation
127 that includes of economically and demographically relevant municipalities, such as Balneário Camboriú, Itapema,
128 Camboriú e Navegantes, among others (IBGE, 2019; 2020).

129 4 5

130 What the above paragraphs show is that the urban network that developed on this hydrological basin is historical
131 and geographically dependent on its major rivers, with the urban center of relevant density located specially on
132 its flood plains or the hills around them. There is, therefore, a combination of disorganized space occupation
133 and natural dynamics that generates a context where there is a high susceptibility to environmental disasters.
134 This factor, present in most of the state, something showed by the researches of Maar, Peron & Netto (2011)
135 and Nodari, Espíndola & Lopes (2015), intensifies itself even more in the Vale do Itajaí, (Intermediate Valley,
136 in a free translation) is the city of Brusque, with its urbanization around the Itajaí-Mirim river (Itajaí-Açu's
137 affluent), today has more than 130 thousand inhabitants, 12º most populous of Santa Catarina, that specialized
138 itself also in the textile industry, presenting integration (and also dependency) with both the above-mentioned
139 urban centers (GOULARTI FILHO, 2014; IBGE, 2019; 2020). Finishing the regional divisions, about 70 km to
140 the west relatively to Blumenau, we find the third "region" that forms the Itajaí-Açu's hydrological basin, known
141 as Alto Vale and has as its "capital" the municipality of Rio do Sul. This city, emancipated in 1930, formed its
142 urbanization around the junction between the Itajaí do Oeste and Açu rivers (located at 337 meters above sea
143 level), what Colaço & Klanovicz (1999) call its "structural node". Today with about 70 thousand inhabitants and
144 conurbated in different levels with the municipalities of Agronômica, Lontras, Aurora e Laurentino, it became
145 an industrial and services core for a region composed of around 30 municipalities, besides still being dependent
146 of bigger centers such as Florianópolis and Blumenau (IBGE, 2019; 2020). by the correlation between anthropic
147 elements and regional environmental conditions, like rain indexes, rock substratum, soils types, river dynamics,
148 among others (DE PAULA, 2015; BOGO, 2020).

149 5 Volume XX Issue IV Version I

150 Discussing specifically Rio do Sul, part of the above-mentioned context and target of this research, it's possible
151 to understand that its position isn't different from the regional norm, knowing that the spatial agents as the
152 private sector, the State and the own civil society (regarding urbanization, considering migrations and self-
153 building) generated interventions without territorial ordering in an unsustainable way, being the environment
154 only a resource provider.

155 In institutional terms, it is well known from researches in the urban planning field that the making, approving
156 and, application processes of the local participatory master plan (PMP) took too much time to be made and
157 also hit low-quality standards. As described by authors like Poleza (2013), Lapolli (2013) and specially Bogo
158 (2016, 2019, 2020), some general characteristics were identified about to two master plans presented since the
159 publication of the Estatuto da Cidade (Cities Statute, in a free translation) law, being these published in 2006
160 and 2014: composition process made "by the book" not following the local needs, especially the 2006 edition,

161 approved close to the deadline established by the federal law; low level of participation and distribution through
 162 the local population, that had minimal interference in its production; besides the technocratic model, the own
 163 municipality chamber dedicated lack of resources and funds to the PMP, made by a small group of its employees;
 164 and, the most relevant factor, both planning documents were not restrictive to urbanization in risk areas and
 165 almost didn't consider the city's relation with the floods, with minimal interference in the established reality.

166 But, after all, why the criticism of the lastmentioned element above is so relevant to the case of Rio do Sul?
 167 Because the city presents a long record of relation with urban floods that, in a dialectic understanding, were
 168 influenced by its urbanization at the same time that shaped it, interfering the territorial dynamics that happen
 169 there (COLAÇO & KLANOVICZ, 1999; ESPÍNDOLA & NODARI, 2015; BOGO, 2020). With colonization made
 170 by Europeans that began at the 19th -century end, becoming a municipality in 1930, the whole urbanization
 171 process and the anthropization escalation 6 ,occurred on the Itajaí-Açu's river flood plains or on the hills
 172 surrounding it, according to the norm for the biggest cities that form Vale do Itajaí's urban network.

173 However, the parallels between the natural river floods and the human occupation on its surroundings are
 174 notably strong for this city and date back to before its foundation as a municipality. From historical records of
 175 the Municipal Chamber of Rio do Sul (PMRS, 2019) and from researchers such as Colaço & Klanovicz (1999) e
 176 Espíndola & Nodari (2015), we know that intense flood events already happened in the 19th century's end 7 It
 177 is in this context that occurred the 1983 floods, hitting 13.58 meters over the riverbed, highest ever recorded in
 178 the city's history (PMRS, 2019), causing ruinous consequences in social and economic terms by reaching about
 179 80% of the population and 95% of the industries. Beyond the material damages, this event became a historical
 180 symbolic mark for the locals and became a source for news even for the national media. After this event, an
 181 already weakened community and recovering from what happened the year before suffered again with the 1984
 182 floods that, even though smaller , as well as on 1910, 1930 and, 1950 decades. However, this wasn't enough to stop
 183 the local economy and demographical growth that reached prosperity with the timber industry that reigned over
 184 most state regions between the 1950 and 1970 decades (GOULARTI FILHO, 2014; ESPÍNDOLA & NODARI,
 185 2015; BOGO, 2016).

186 This fact takes us to the 1980s, when the population was already almost entirely urban, while the economy was
 187 showing clear signs of weakness, as results from the confluence between national economic crisis and restrictions
 188 to the wood cutting, then the major local source of economic goods. At this moment, there wasn't any relevant
 189 flood since 1958, which intensified the urbanization around the river, with permission from the municipal chamber
 190 government (COLAÇO & KLANOVICZ, 1999; ESPÍNDOLA & NODARI, 2015). Sul another period of growth,
 191 becoming a regional center focused on industries and services, being among the top 20 economies in the state and
 192 one of the best cities of Santa Catarina to live in terms of quality of life. However, these facts didn't prevent the
 193 2011 floods that reached 12.56 meters above the riverbed (2^o highest ever), causing massive material and social
 194 prejudices again, with estimated values of R\$ 283 million 9 Differently of other huge flood events, that weren't or
 195 had just one following new consecutive occurrence (like the 1983-1984 cases), the 2010 decade marked the city for
 196 the atypical happening of floods, probably a result of more intense and unregulated raining combined with space
 197 anthropization. Besides 2011, other huge floods . Beyond that, this occasion was marked by criticism about the
 198 public power (municipal chamber and civil defense) inoperability in reference of preventing and managing the
 199 disasters (BOGO, 2016; 2020). 10 9 Close to 168.5 million US dollars at the time. 10 It is also important to take
 200 note about the small scale floods that happen with more frequency and reach areas closer to the river, normally
 201 occupied by lower standards buildings (BOGO, 2019). happened in 2013, 2015 and, 2017, turning the already
 202 severe city's relation with environmental disasters in something even worse (BOGO, 2020). With this scenario,
 203 there is a question about the city's territorial relations and the public power's role: in which degree the more
 204 frequent floods (in different scales) interfere in the real estate market prices? To answer it is this research goal.

205 The process of land use devaluation of floodable areas that causes socio-spatial segregation insofar as the
 206 frequent urban floods turn the areas that are free of these disasters overvalued was already identified by other
 207 researches, something evident on the following citation In Rio do Sul, it is possible to identify, in the last years,
 208 by the buildings and by the real estate market, the displacement of urban activities toward the higher areas,
 209 after its initial installation. This happened, especially, after the 1983/1984 floods, that changed the city's urban
 210 scenario deeply, inducing the opening of a lot of new neighborhoods and demographic transferences from upper
 211 areas to the lower and viceversa. In general, the members of wealthier classes transferred themselves to upper
 212 areas, free from the floods, occurring the inverse with populations of lower-income. [...] So it is impossible to, in
 213 current days, work with construction in Rio do Sul not considering the floods as a variable. The possibility or not
 214 of a flood reaching a building redefines the form of volumetric and its market value. [...] The floods were always
 215 perceived as a serious problem, event that they affect, more directly, the residents of lower quotas, where people
 216 with lower incomes are living. (ESPÍNDOLA & NODARI, 2015, 74-76 pp.) However, the above-mentioned
 217 authors and others that point the same phenomenon, as Colaço & Klanovicz (1999) e Bogo (2019; 2020) didn't
 218 show empirical evidence that there are spatial differences between higher and lower-income groups because of the
 219 floods in Rio do Sul 11

220 6 III. Collection and Discussions about

221 Rio Do Sul's Real Estate Market Data

222 . We believe that this phenomenon occurs in this city, being considered as this research hypothesis. To test

223 it, we build a methodology focused on geostatistics and the use of geographical information systems (GIS), from
224 the real estate data compilation and its prices.

225 This research sought to define, from the already known knowledge about the spatial frame discussed here,
226 that it is possible to obtain evidence to show if there is spatial and economic segregation happening from some
227 correlation with the urban floods upon the application of geoprocessing tools and methods.

228 The ground is, has been and is going to be one of the main needed resources for the cities' existence and
229 the development of urban life -"is where the civilizations unroll happen". Beyond being the physical support for
230 elements, flows and processes that give form, movement and life to cities, the ground must be served with a net
231 of services, transportation infrastructure and several types of buildings so the urban activities can happen -"at
232 this point the use and change values surge" (BAER, 2013, p. 221).

233 On property evaluation engineering, there are two central terms on discussions: value and price. Value is the
234 monetary expression of a property. At the same time, price is the amount of cash needed to buy a property, being
235 that by property we mean something that has a value, that can be used or become a thing with legal guarantees.
236 In this context, there is a difference between market value, being this the more likely amount of money to be
237 spent in a voluntary and conscious trade in a referenced data, following norms current in the market (ABNT,
238 2001) and, arbitrary value.

239 The last is obtained through property evaluation techniques to identify value, cost, produces and rights,
240 together with viability indexes and its use for certain situations, goals and, dates, being the adopted value as the
241 evaluation result, inside the limits established by the norms (15% more or less) (ABNT, 2011). It concerns a group
242 of variables and characteristics that compose a property, that when measured and added together, represents how
243 much a property value, being a movable or immovable one. This, however, doesn't represent what necessarily
244 is going to be paid in a trade, but how much the property value with its characteristics, considering location,
245 benefits, or even the absences of it.

246 To this is added the venal value, being it an estimative gave by the public power that serves as reference for
247 tax purposes. Also composed by its characteristics, is directly related to the generic values plant. This one is
248 the basis for collection and calculation of taxes, as described by Silva (2006). As elements of the venal value, we
249 spotlight position towards the street, area, building area, the property typology and, age (when it's relevant).

250 In terms of conceptualization, they are different nouns, even if used by common sense as synonyms. However,
251 price means what is indeed paid for a property in a trade. So, it's not necessarily connected with the market
252 value of a property, since that, considering the market dynamics, the will of both sides, together with the occasion
253 needs, a property can be traded for thousands of dollars more or less beyond its value.

254 With this presentation, we worked with the real estate market data sample collected, focusing especially in
255 data that expressed the properties' value, being that these contain some accountable attributes, with a spotlight
256 to its geographical location. The methodology adopted follows the precepts stipulated by the ABNT (2001, 2011)
257 norms and Silva's (1999, 2006) proposals. The NBR 14.653-1 (ABNT, 2001) norms predict the use of one out of
258 four methods of property evaluation, being these: the involutive method; the evolutionary method; the income
259 capitalization method; and the method base on direct comparison among the market's data. While we have
260 followed the last, we are not going to value the properties, but to analyze the real estate market dynamics. We
261 describe the data sample next.

262 The data sample collected is formed by 200 properties (only ground ones, without any building) on sale ??? .
263 We filtered only the announcement of terrain properties, as well as its characteristics (Picture 03). The sources
264 were real estate agents (local and regional sized real estate offices 13) and announcements found on aggregator
265 websites like Zap Imóveis and OLX. The following variables were collected as the following picture shows.

266 7 Source: By the authors

267 Picture 03: Characteristics collected for every property When some essential characteristics for the data analysis
268 couldn't be added to the list, the property got excluded.

269 8 a) Materials used

270 We used the following software as support tools for the data analysis: QGIS, on its 2.18.20 Las Palmas and
271 3.8.1 Zanzibar versions, open source software distributed by OSGeo; Google Earth Pro, 7.3.0 version, with free
272 distribution by Google. For tabular data manipulation, we worked with Google Spreadsheets. At last instance,
273 for the kriging applications together with the histometric analysis, we used SAGA, 2.1.3 version.

274 With the selling announcement data of the offered properties in the real estate office website and other sources,
275 we prepared a spreadsheet with the data, with every case composed of eight columns. To every property, we gave
276 a number as an identifier (id, as Picture 03). Then, geographical coordinates were included on the columns to
277 include the properties on the Geographical Information System (GIS) for the geographical analysis.

278 We obtained the coordinates with the help of Earth Pro software, open to free access offered by Google.
279 Searching for addresses available on the announcements, the software finds the property location, marking it on
280 the map, then we gave it an id, crossing it with the spreadsheets. This identifier method allows the properties
281 spatialization in a simplified manner.

282 The data analysis and also the cartographic products are from QGIS software application. This one has
283 a simplified graphic interface for attributes edition, linking and, manipulation, chosen to the final print layout
284 production. QGIS plugins permitted the use of base maps that allowed raster overlap from remote sensing images
285 from Bing or Google Satellite. These base maps are used for map compositions manners and graphic support on
286 the flood quotas analysis. The vector data about parcels, streets, neighborhoods, hydrology, and, floods shapes
287 were provided by Rio do Sul's Municipal Chamber and it's Civil Defense, considering the scientific purpose of
288 this research.

289 9 b) Method

290 The data collection followed the activities flow presented on Picture 04, below.

291 10 Source: By the authors

292 Picture 04: Activities flowchart In the context of this flowchart application, we worked with the above-mentioned
293 GIS software, characterized as geoprocessing tools that allow complex geographical analyses, crossing diverse data
294 from N including the creation of georeferenced databases (CAMARA et al., 2001). Today they offer different
295 plugins that ease statistical analysis; among them, we can spotlight the important allowance of spreadsheets
296 upload, like the Google ones. When a GIS software like QGIS, imports spreadsheets it is possible to interpret
297 columns that can be of different types, like integer, date/time, string, and real (decimal numbers).

298 With the data collected and uploaded to QGIS we filtered them and proceeded to the analysis phase, focusing
299 on obtaining a spatial product that could reflect the local real estate market dynamics. Then, we calculated
300 the square meter (m²) value through the division: sale value/total dimension for every property. This way we
301 obtained the value for each property, comparing it to others between characteristics and geographic position.

302 So then it was possible to link the properties with the spreadsheets, crossing, merging and aggregating more
303 than one table at a time. On the process of working with the properties price data, we ran validation tests,
304 eliminating outliers, and preparing data for the last step of the analysis.

305 In this context, some concepts created by statistical scientists are useful for geographers in some research
306 fields, where its methods allow the construction of visual layers from data samples together with geostatistics
307 proceedings like kriging, which is helpful for associating uncertainty measures (CAMARA et al., 2001).

308 The graphical analysis that translates punctual data to raster can be done by different methods. The GIS
309 application allows the projection of numerous hypothetical scenarios with some methods like closer neighbor,
310 distance pattern, lines/areas length amounts, and kriging interpolation.

311 By kriging we mean a validgeostatistical method for finding a hypothetical value for the analyzed properties,
312 been characterized as (...) this method allows the interpolation of non-sampled variable values from sampled
313 neighbors. The quota of some point of interest is calculated by the weighted average of the neighbor samples,
314 determined by geostatistical analysis, which provides coefficients that describe the spatial variability of the
315 analyzed data. (VALERIANO, 2008, apud BRITO et. al., 2013) Volume XX Issue IV Version I

316 11 (B)

317 Kriging is based on the regionalized variables theory, having a polynomial equation in its fundamentals, through
318 a multiple regression process between the properties market values and its locations (geographic coordinates).
319 And this method has its divisions. There is the "simple kriging", in which the estimative are based upon an
320 already known and constant average (m) value. However, in the "ordinary kriging" there's no need for previous
321 knowledge of the m value.

322 To compare possible analysis methods, we know that in simple linear interpolation, the weights are all the same
323 (1/N), defining in which the N variable under the distance's square inverse that separates interpolated values and
324 collected values. In kriging, the proceeding is close to the interpolation by weighted moving average, except that
325 is this case, the defined weights come from spatial analysis. With this process, it provides non-biased estimations
326 and with minimal variance. Therefore, the difference between kriging and other interpolation methods is the way
327 how the samples receives its weights. Values obtained by this method in blocks are smoother than punctual ones
328 (VALERIANO, 2008 apud BRITO et al., 2013), justifying its application for real estate market analysis.

329 The steps needed for a scientific work that applies kriging techniques, according to Druck et al. (2004), are
330 (I) exploratory data analysis; (II) structural analysis (spatial correlation models); and (III) statistical surface
331 interpolation. Thus, with QGIS support, we analyzed the collected values seeking outliers, very high or very low
332 prices, with the sample distribution histogram. Following it, we proceeded to data filtering and outlier exclusion,
333 seeking a better data distribution and homogenization, looking for higher quality in the analysis.

334 12 c) Results obtained

335 The properties' spatialization was created by GIS tools, allowing the different layers overlapping, with themes that
336 describe some variables of Rio do Sul's urban elements. The following Picture (05) shows the overlapping between
337 properties values with the flood quotas. They are divided into four classes, for analysis purposes: 7 meters quota
338 14 ; 9-9.50 15 meters; 10.71 meters (from the 2015 floods); and 13.56 meters (from the historical record of 1983),
339 being these measured from the riverbed. © 2020 Global Journals 14 According to Bogo (2019), this quota has the

340 most frequent flood occurring, tending to reach low-income populations, in most cases attached to the "informal
341 city". 15 From PMRS (2019) data, it's one of the most frequent flood quotas. 16 For interpretation purposes,
342 every Brazilian Real (R\$) equals 0.2 US Dollar (US\$). This exchange rate must be read through the rest of the
343 paper.

344 Besides that, values obtained by "block kriging" are smoother than "punctual kriging", what made our choice
345 for the first. So, for the error diminish, it is needed to use a m number of samples. The vast application of the
346 ordinary model can be explained by its simplicity (weighted average), which uses structural information provided
347 by a variogram model, supplying de uncertainty connected to estimation (YAMAMOTO & LANDIM, 2013).

348 Seeking a better visualization, we generated a group of maps that show the areas reached for each class,
349 together with the properties and value distribution. The following Picture 06 shows this information. Through
350 the collected properties, we can identify more density of high-value ones (classes with darker tons and marked
351 in the map inside the green circle) on the central region, especially in Centro, Jardim América, and Sumaré
352 neighborhoods, including some of flood reachable ones. In the maps that form the picture, it is possible to see
353 the unitary flood classes.

354 13 Source: By the authors

355 Picture 06: Unitary flood quotas, overlapped with the properties collected Applying SAGA's software tools, it
356 was crafted interpolation between properties values and its m² values, from the ordinary kriging method, focusing
357 on data distribution analysis. The results are available in Picture 07.

358 In the analysis, properties over 2,500 m² (26 cases) and prices over R\$ 350.000 were discarded, which could
359 show distortions in the results, setting the already mentioned outliers. Therefore, 152 properties served for the
360 total value kriging process. The resulting values histograms can be seen, in sequence, in the Pictures 08 and 09.
361 With the kriging done, QGIS and its plugins served as tools to the process of extrapolating the pixel values (in
362 m²) for the lots (parcels) polygons. We adopted the square meter (m²) as variable to this research step based
363 upon that the total values can present some distortions since the price of a property is composed of various
364 characteristics. That heterogeneity is an inherent factor to the real estate market analysis. In this sense, the
365 estimated m² value based on the samples showed itself as the suited alternative for the analysis.

366 As the last graphic result, two maps (Figure ??1 and 12) were made, with the m² value extrapolated to the
367 lots and with the punctual collected data, both overlapped with the floods layers (respectively separated and
368 together), seeking to identify from the spatial analysis if the flood quotas influence in the properties averages m²
369 value and if in some way the prices change for being located in areas reached by floods (or if they are free of
370 them), influencing the local socio-spatial segregation.

371 Source: By the authors Picture 12: Correlation between overlapped flood quotas and properties values Even
372 if we consider that the maps above are our last product and are also self-explicative, a brief analysis is needed to
373 help our comprehension before the final remarks.

374 What the pictures 11 and 12 show are two clear tendencies. The first one is about the fact that there is
375 a strong property evaluation tendency as a result of its relationship with the central area, pointing that the
376 more distant neighborhoods (Santa Rita, Rainha, Barragem, Barra do Trombudo, among others), both to the
377 northeast or southwest, contain most of the lower market value properties collected. In these cases, the lower
378 classes presented in the maps, containing m² values between R\$ 180 to R\$ 240, prevail among these areas samples
379 and in the estimations after them.

380 Thus, it is possible to see about higher value classes is the prevalence of it around the city center, including
381 neighborhoods like Centro, Jardim América, Sumaré, and Eugênio Schneider. The collected points and the
382 extrapolation related to that are between R\$ 270 to R\$ 1,000 per m² are found only in these regions, what can be
383 understood as evidence of how the "structural urban node" that formed already in the 1950 decade (COLAÇO &
384 KLANOVICZ, 1999) still being the major focus of the services private market and the city's amenities aggregator,
385 raising the prices of the available terrain properties on its surroundings.

386 The second tendency involve this research's objective, being the values relations with floods. What can be
387 seen from the graphic products is that there is relevant evidence that the floods have an influence on real estate
388 market prices, with the spotlight to where the waters hit more often. It is possible to assume that because some
389 of the most valuable properties collected are reached just by the higher quota ever (from 1983) and not by the
390 others. Besides that, not just only the investigation identified that the most valuable m² (and its extrapolations)
391 are in general located close to the city's center and free from floods, in areas where the public power supports
392 long term urbanization (BOGO, 2016; 2020), but also how the lower prices can be seen especially in farther
393 neighborhoods that are hit by the waters, including the ones that happen more often.

394 So, what we can understand is that the real estate market values (and prices) are guided by the following
395 "equations": free from floods + close to city center = higher prices; reached by floods + away from the city
396 center = lower prices. So, there is a tendency of intensification of the current socio-spatial segregation because
397 of this phenomenon.

398 However, the research doesn't entirely confirm the affirmations from Colaço & Klanovicz (1999) and Espíndola
399 & Nodari (2015), as the floods aren't the only factor to influence the real estate market prices and dynamics.
400 The central neighborhoods, due to its access to services, amenities and better infrastructure are still responsible
401 for properties' high evaluation, making residents and, shop owners to continue dealing with the floods, not being

402 responsible for such an intense displacement of local activities as the authors argue. But, we consider that we
403 have hit some methodological limits considering that the lower areas on the central neighborhoods as well as on
404 the "informal city" cases tend to have a higher number of buildings (so, lower terrain properties available), that
405 aren't included in this scientific investigation, what is again discussed in the following final remarks.

406 IV.

407 14 Final Remarks

408 After the application of the methods presented on this research (geoprocessing techniques together with kriging),
409 we ascertained some spatial correlations about the real estate market values concerning its spatial locations,
410 being reached by floods or not, concluding that this factor has territorial relevancy. However, it is not the only
411 and excluding variable on this matter.

412 Especially in areas that are reached by 7 and 9 meters' floods, in other words, areas that the river waters hit
413 more often, we identified the decrease of property values. But, this factor is not so relevant in the city center and
414 its close neighborhoods, with the spotlight to Jardim América, Centro, Sumaré and, Eugênio Schneider. From
415 these findings, we believe that this phenomenon occurs because the central region has an urban core of complex
416 nature, centering in it the most important commercial structures, businesses, among others, causing consequences
417 on the tendencies of properties evaluation.

418 Therefore, this causes some kind of partial "neutralization" of floods risk influence, considering the character-
419 istics marked on this case of study. Oppositely, the neighborhoods located in floodable areas that are also far
420 away from the city center present a deeper tendency of properties devaluation when these are reached by the
421 waters.

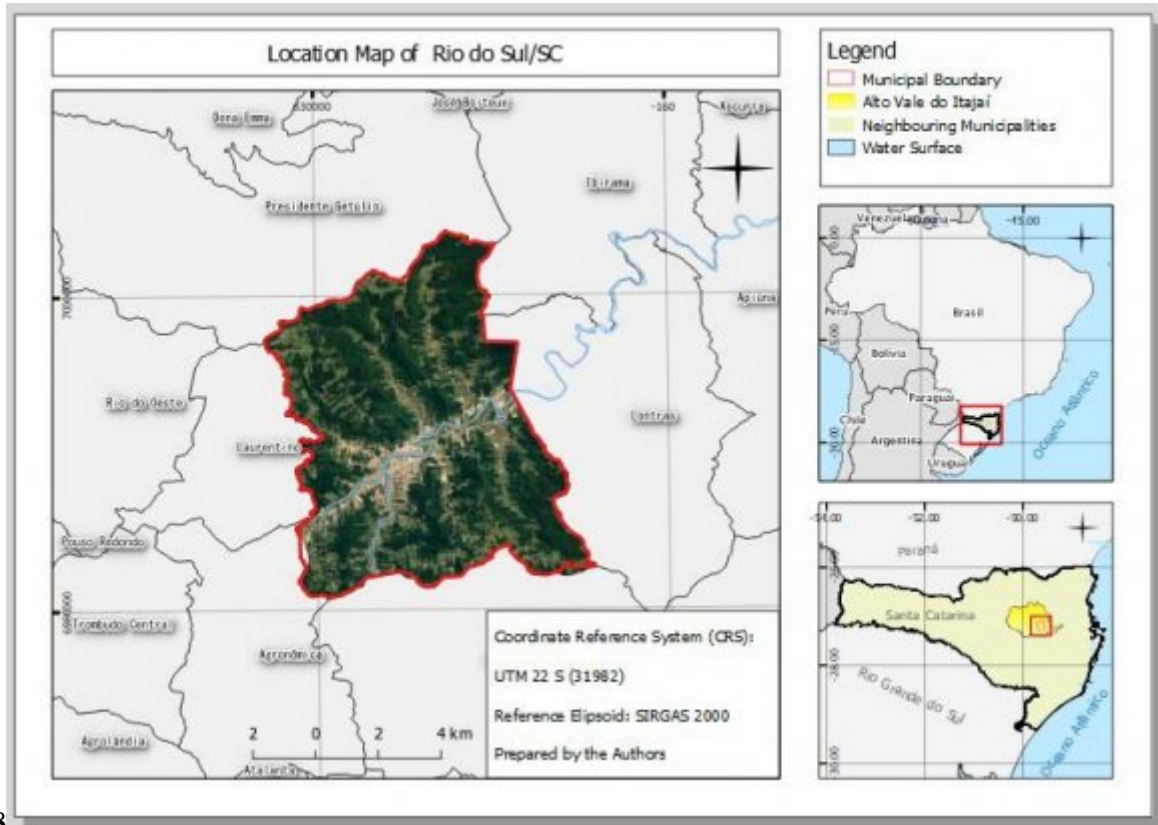
422 That is, in a first general analysis: (I) it is possible to understand that the altitude factor -that reflects in
423 less flood risk in comparison with lower areas -demonstrated itself as a relevant factor to variations among the
424 properties prices in Rio do Sul; (II) About the neighborhoods centrality -regarding its connection with better
425 infrastructures and more services available presents itself as a variable that guides a small "neutrality" of the
426 cause-effect relation between floods and properties prices.

427 Considering the maps made, they show these variations through the city's territory, deepening the evidence
428 about the floods influence in real estate market dynamics, also on the central region, where the highest prices
429 are seen in flood free places.

430 Partially, the attributes that appear as more relevant in the analysis are the degree of "centrality" and "flood
431 risk". A critical analysis together with the historical descriptions and field knowledge showed that the above-
432 mentioned variables influence a possible fragmentation among economic classes in Rio do Sul's socio-spatial
433 dynamics, considering that the properties with the highest prices, both close and far from the city center, seem
434 more protected to floodable areas.

435 The case of study object complexity suggests that the research and its methods attended its expectations
436 and brought information to craft others and more complex discussions about this territory. From that, other
437 scientific investigations can take advantage of this "window of opportunity" to identify and analyze which other
438 variables could complement the correlations between properties value/price on this regions, collecting data, for
439 example, of rent prices, buildings for sale or real estate market prices for already built places. These variables
440 could complement the current analysis from the method presented here and expand the comprehension about
441 the territorial transformations of Rio do Sul municipality, also opening new interpretations about the acts of its
442 spatial agents.

443 Therefore, the affirmative that "how higher the flood risk, the lower the property values" showed itself partially
444 correct, considering that the variable "urban centrality" have relevant influence in prices, making that the cause-
445 effect relation of the floods devaluating the properties raised on the hypothesis before is not entirely true, even
446 that we identified that most of the expensive properties are located in areas free from the river waters. But,
447 specifically in the cases of the distant neighborhoods the premise above was confirmed as true. However, we
448 believe that the research's central problem isn't entirely resolved and new scientific investigations, using other
449 variables together with flood studies must be done, seeking for the confirmation or refutation of the hypothesis
450 proposed here.



8

Figure 1: 8 than

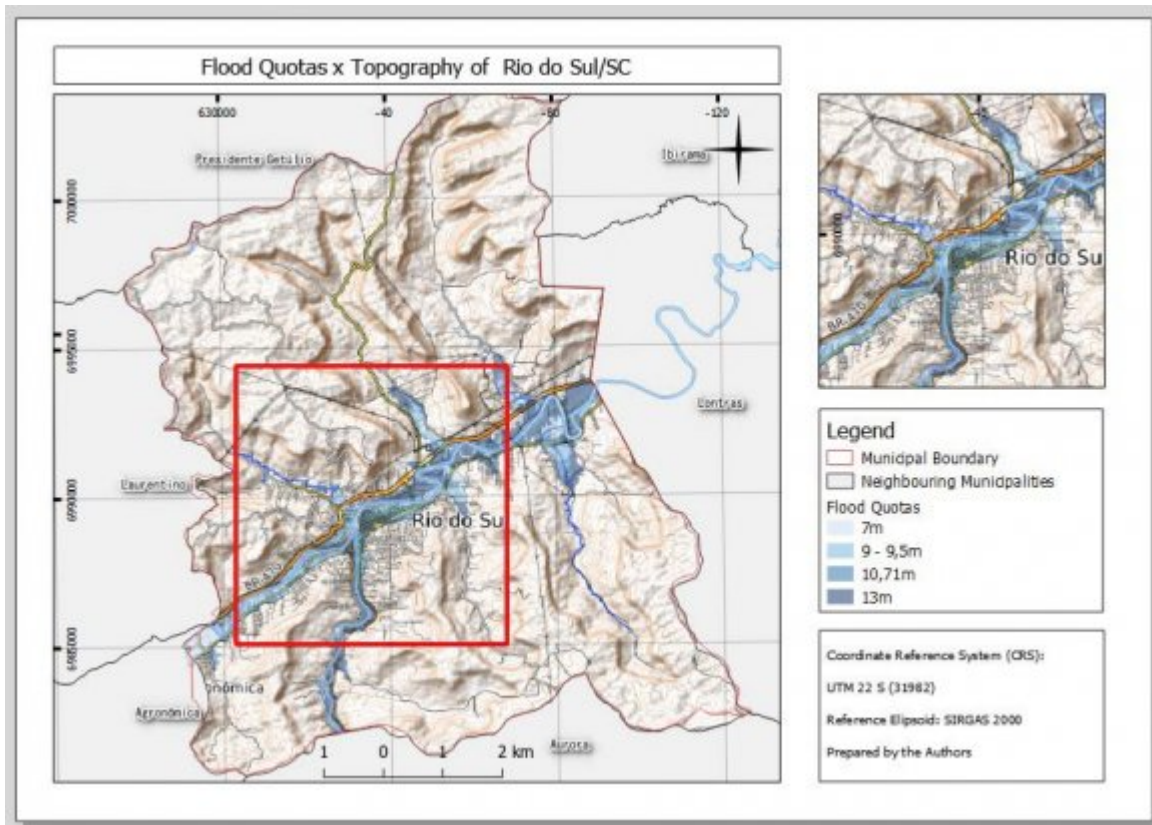


Figure 2:

Variable characteristics	Id	Font	neighborhood	Address
	Unique identify assigned to the ad that allows it to link with geometry	Identification of the ad source, allowing to know which advertiser offers the market event	Attribute that allows future filtering in analyzes by neighborhoods and zones	Location where the property is
Variable characteristics	east	north	area_tot	value_tot
	Latitude coordinate that allows the unequivocal location of the property	Longitude coordinate that allows the unequivocal location of the property	Property's total area, consisting of the lot's width x length dimensions	Price at which the market event is being offered

Figure 3:

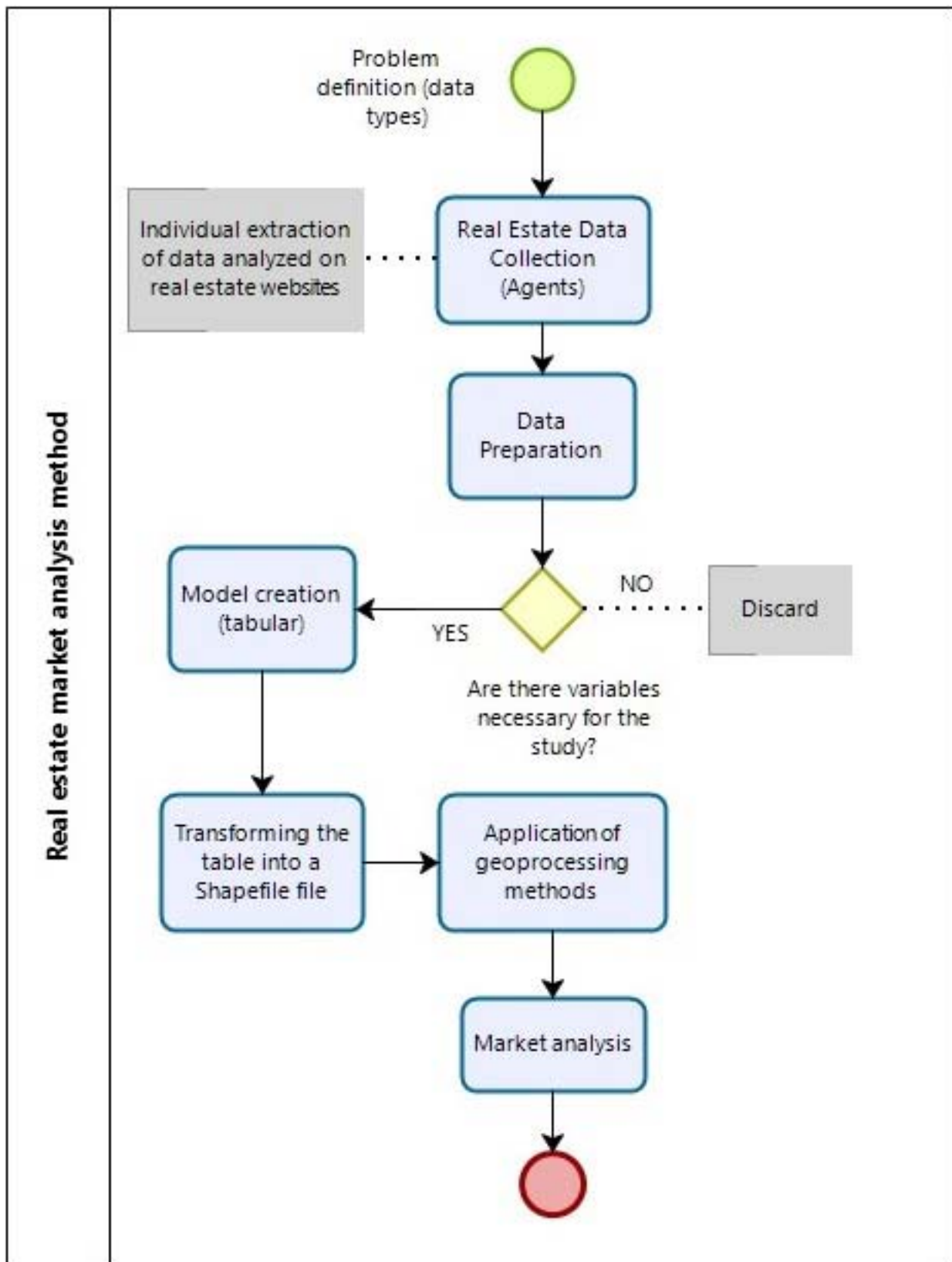


Figure 4:

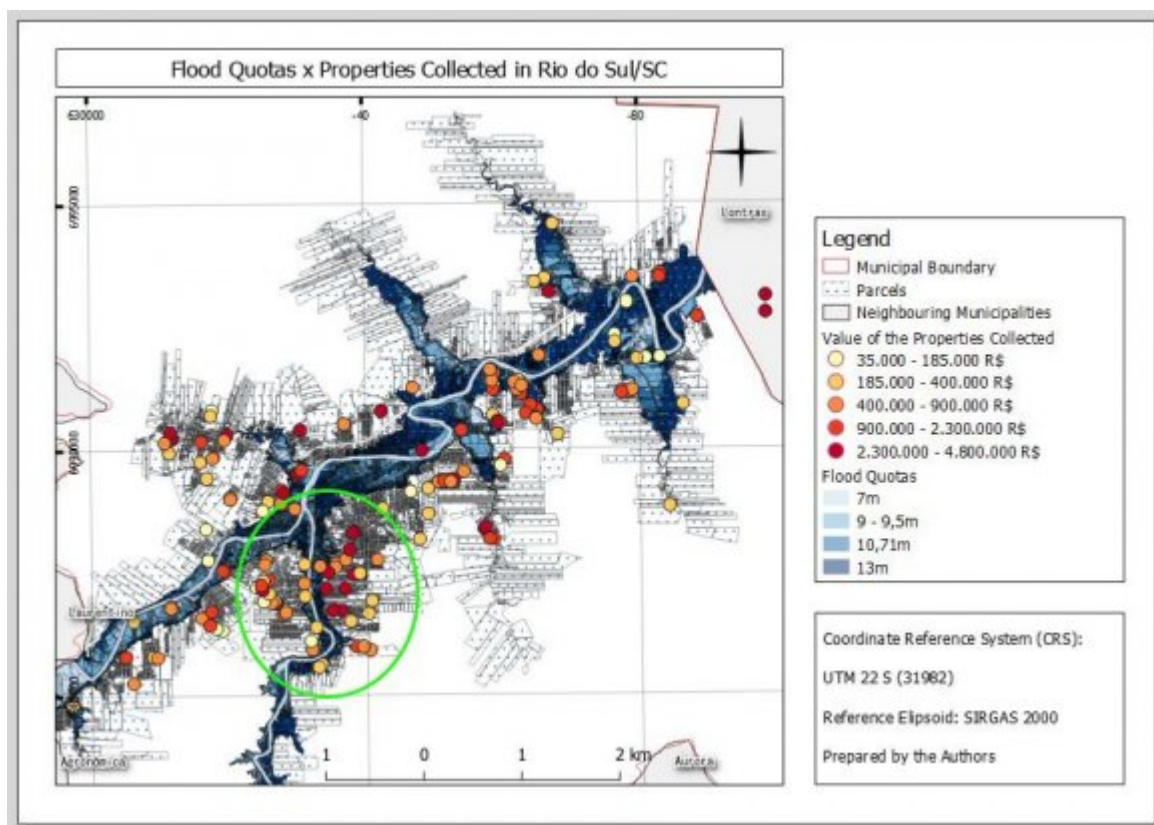


Figure 5:

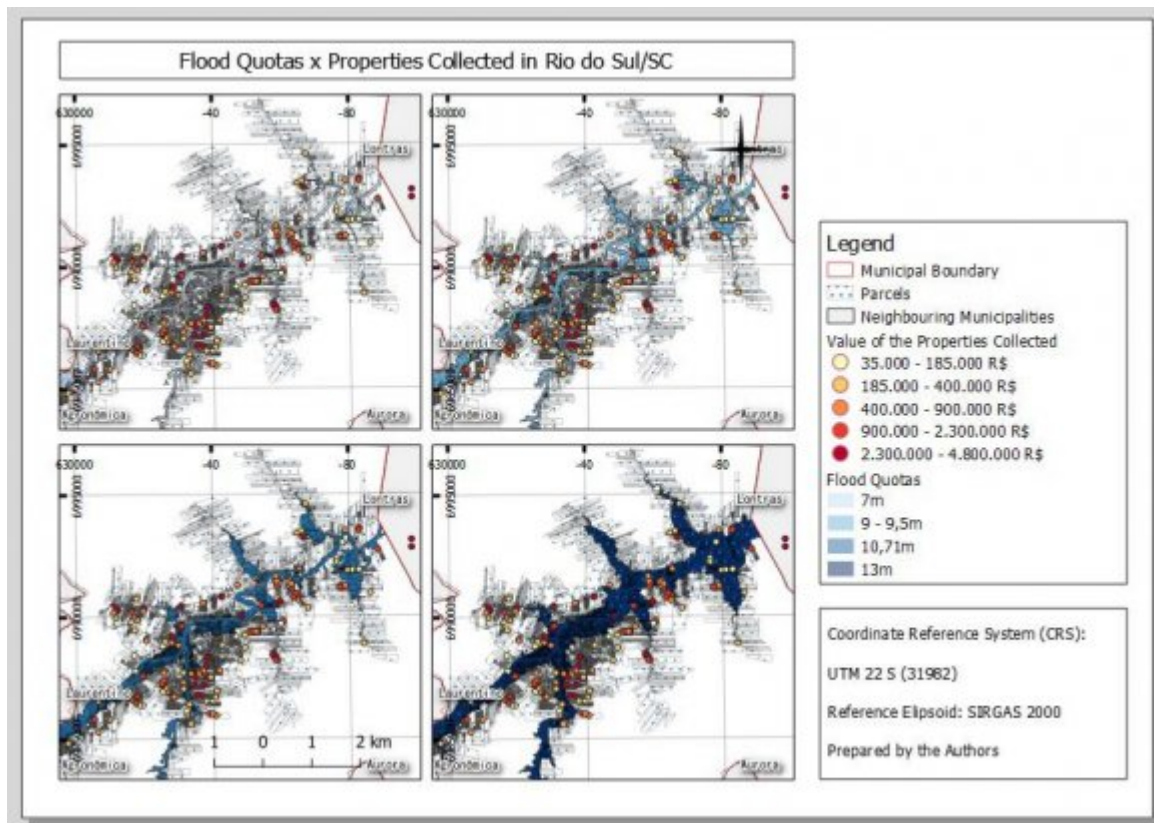


Figure 6:

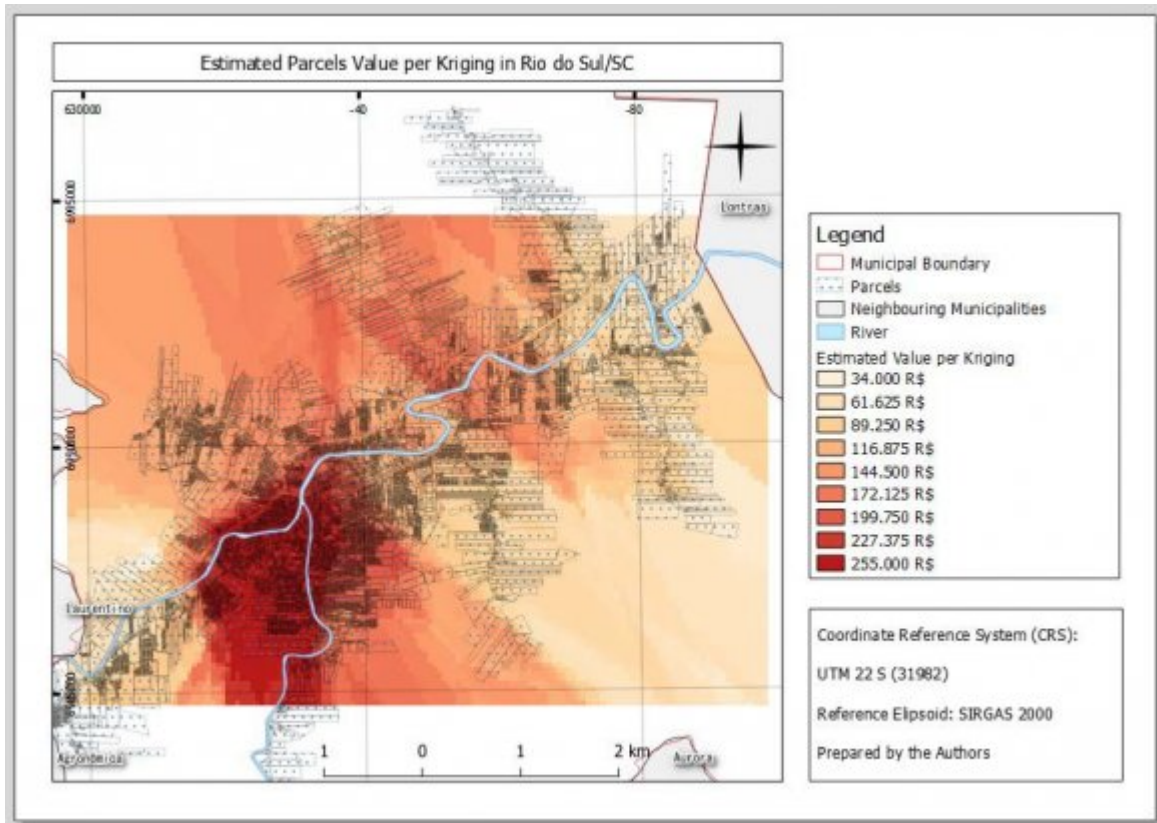


Figure 7:

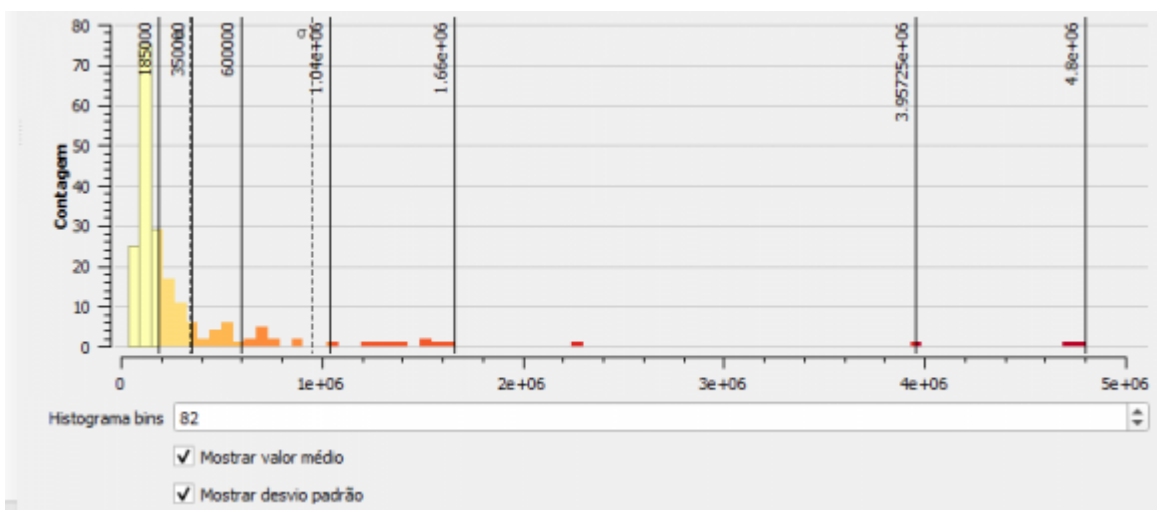


Figure 8:

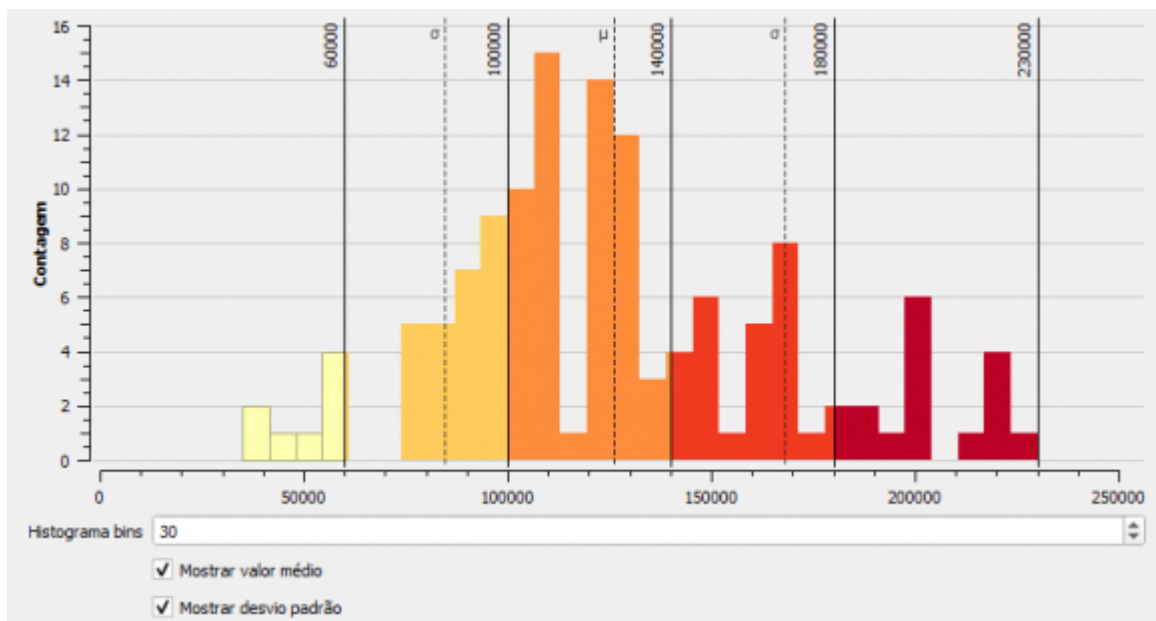


Figure 9:

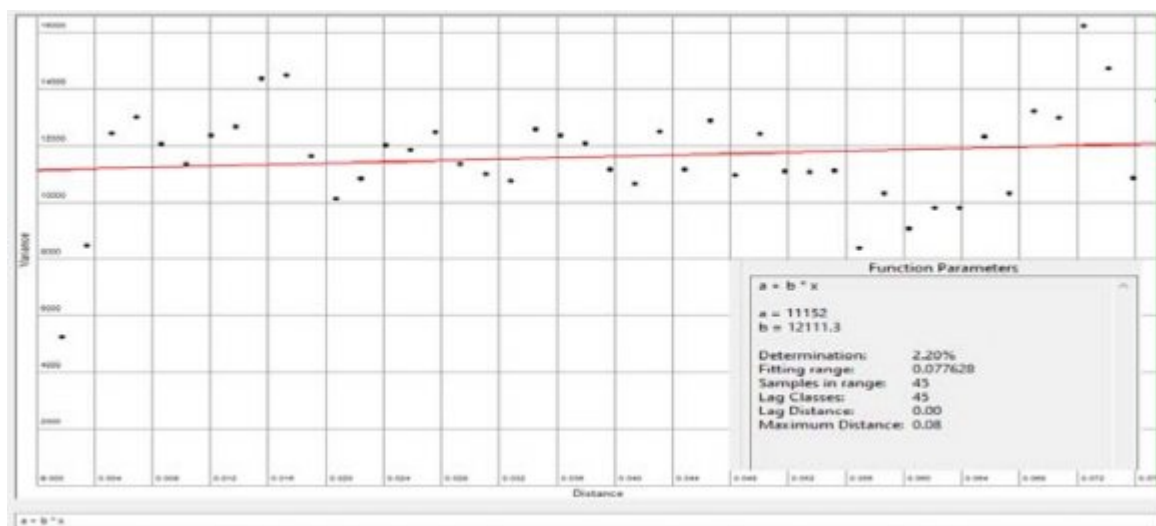


Figure 10:

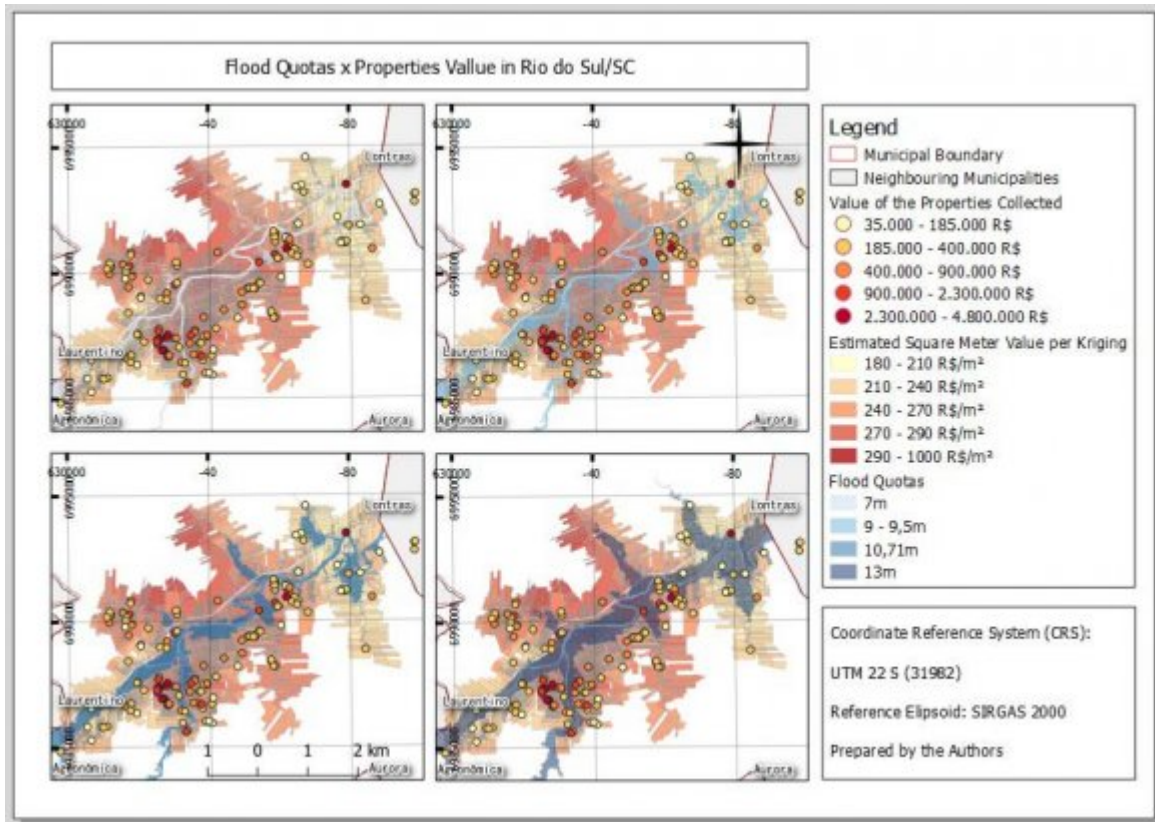


Figure 11:

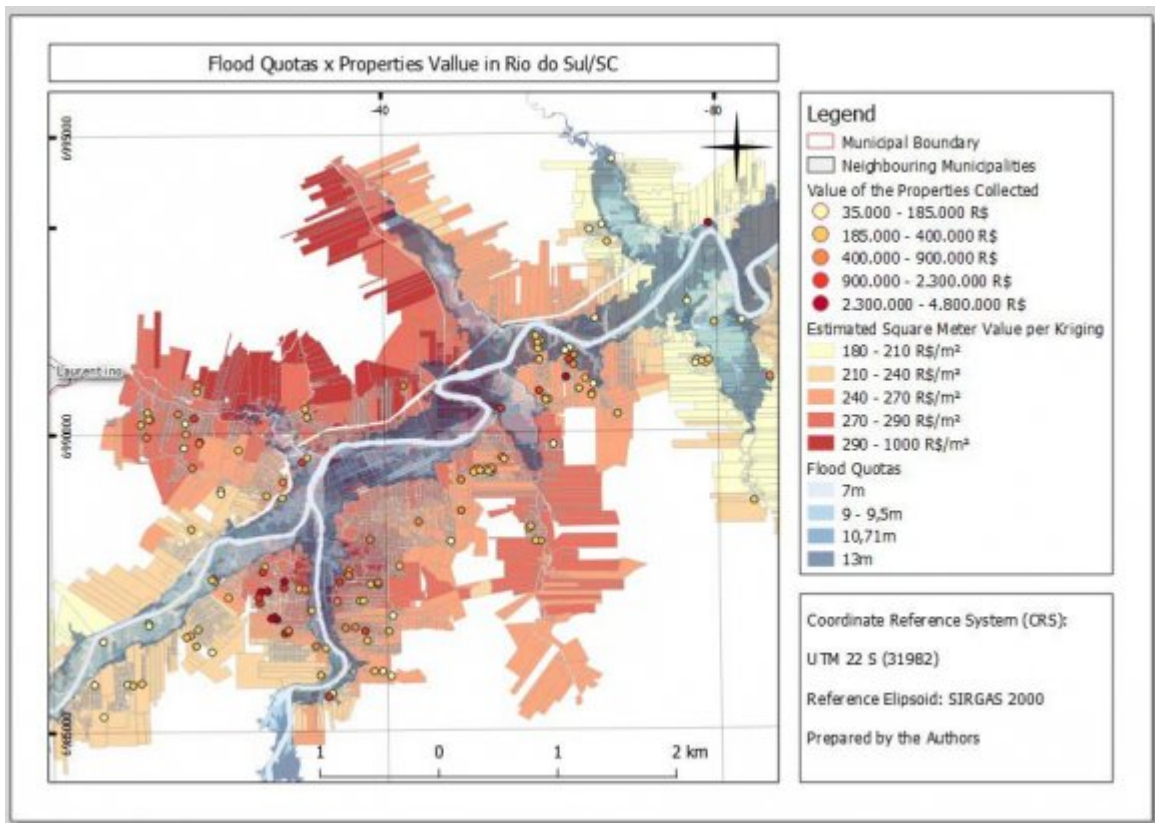


Figure 12:

¹According to the IBGE (2020), in terms of urban influence, Itajaí connects itself to Balneário Camboriú, forming an urban binary that is one of the main state centralities.⁵ This is the very well-known name beside the city's center being only 16 meters above sea level.

²The effects resulted were the river's silting up, impermeability raise, riparian forest deforestation and margins occupation (ESPÍNDOLA & NODARI, 2015).

³This fact also happens in Blumenau, with colonization that started before and, located down the river basin (DE PAULA, 2015).

⁴In Blumenau, De Paula (2015) says that the socio-spatial inequalities resulting from floods took the poor to displace themselves to the uphill, marked in this city by higher slopes and chances of mass movements events than Rio do Sul.

⁵The sampled data were collected remotely, using internet announcements (institutional or private ones).¹³ The agents are Dalfovo real estate office; San Genaro real estate office; Habiterra properties; Habivale real estate office; Carneiro properties; Charles Cimardi realtor; Metropolitana properties; and Pacher real estate office.

⁶Real Estate Market Prices and Floods in Rio Do Sul (Santa Catarina, Brazil): Evidences of Correlations e under a Territorial Perspective

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