

Urban Projects and New Territorialities: The Itá Case - Santa Catarina State - Brazil

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Abstract

The development of the town of Itá is an unusual case because 16,000 people had to move from where they used to live and be relocated to another area defined by an urban project developed by the Itá hydroelectric power station team, which started to be built in 1967 and, for that reason, an artificial lake had to be created, flooding the original town in 2000. This research focuses on the original town of Itá, on the project implemented in 1989 and its current urban configuration. Existing indicators that were tested in several real cases will be used to obtain a reliable overview of the collected data, and will allow the comparison of the three phases of the urban system listed for the study. Besides the evolution of spatial configuration and urban form, we will study which socioeconomic impacts caused by the implementation of the hydroelectric power plant on the population of Itá and region are present, as well as the town's later urban development.

Keywords: urban spatial dynamics, socioeconomic relations, urban development

Introduction

Located on the border of the municipal districts of Itá (in the State of Santa Catarina) and Aratiba (in the State of Rio Grande do Sul), the Itá Hydroelectric Power Plant case has a singular story, because, for its total implementation, 16,000 people were displaced from the place they used to live and where they had their lives spatially settled. The construction of Itá Hydroelectric Power Plant starts in 1967, in the Alto Uruguay region (the Uruguay River basin), therefore demanding the expropriation of many properties. Considering that the construction was finally finished in 2000, 33 years have passed for this process to evolve.

During all this time, the population of Itá was in doubt and uncertain about their destiny. For the engineers who planned the power plant it was more a place where some land would be flooded, but, for the people who lived there, that land was much more than an area to be flooded for the creation of an artificial lake. The land meant their daily lives and the tranquility of planned work, as well as it was a social and historical place, that is, those people were forced to leave the place where they had built their lives and where they planned their future and were forced to reconstruct their social, economic and spatial relations.

In this study, we will explore Itá's spatial configuration then and now. In this context, we will present the behavioral, socioeconomic and cultural impacts caused by change ,spatial configuration and the implementation of the power station on the population of the town and region from 1967to 2012. The town is seen as system in constant evolution in this study, even being the new Itáa planned town that continues da new evolutionary process, creating new characteristics.

The town change and the impacts caused by the location of the dam provide a rare case to study, due to how quick events happened and also by the dramatic changes for the population, such as: change of location, change of neighborhood; impacts caused by the new spatial configuration, change in socioeconomic status, creation of new networks due to the items mentioned above. Thus, we intend to evaluate the initial situation of the town(before the flood), comparing it with the first planned town and its current situation using an evolutionary approach based on an investigation of its spatial form, socioeconomic activities, age group of the population, besides unusual behaviors that have occurred due to the growth of the town.

In this context, we will analyze changes in the urban system taking into account its spatial configuration and socioeconomic networks, evaluating the structure of the original town and the planned one and also the way the actual occupation that will be used to compare the design intent and the actual results with the following objectives:

- Analyzing socioeconomic changes in the town and region as a result of the new established relations.
- Analyzing the spatial configuration of the former town, the planned one and the current Itá, concerning complex networks.
- Analyzing the spatial distribution of the population.

With these analyses, indicators will be established in order to compare the three moments of the town. The main hypothesis of this study considers that the town's change caused a series of impacts not only related to spatial change, but also to socio economic changes and the creation of new self-organizing networks (**PORTUGALI and HAKEN, 1995**). These changes are reflected in the development of the new town, bringing out new behaviors and properties in a systemic and continuous way.

The object of this study, in this case, the town of Itá, allows the investigation of new network formation concerning neighborhood relations and geography of opportunities created by the development of the new town, which turned out to modify the original project. According to this hypothesis, the socio economic relations act as "incident forces" on the urban system and may be the cause of variations in its structure and development.

Approach

Concerning urban geography, the urban structure results from the decision on where to locate social and economic activities. Each decision is taken considering the existing urban structure and it limits the decisions of other agents by the use of space or the relations that are established, therefore assuming a systemic behavior. Three describing models of the urban structure formation process are shown next.

Economic Theory

Since the classic models of the locational theory, such as Von Thünen's Isolated State Theory (1826), Weber's Industrial Location Theory (1909), Christaller's Central Place Theory (1933) and the models firstly developed in the 60's, the economy contributions to urban modeling have been important.

The assumptions that guide this approach are typical of the neoclassical economy, based on the paradigm of perfect competition, which leads to a state of the greatest possible welfare and it is close to the consumer theory. The space is conceived as an isotropic plain, where location differences are reduced to only one variable: CBD distance. Families decide possible combinations of three kinds of goods: compound goods, space use and CBD distance. Individuals satisfaction is limited by the resources they possess, that is, the maximization of utility is restricted to its available resources.

As CDB distance increases, there is a reduction in income offer per space unit and there is an enhancement of compound goods consume and transportation expenses. According to Abramo (2001) there are basically two ways of reaching family balance in the neoclassic synthesis: firstly Alonso, who studies spatial balance having income offer notion as a starting point (true to Thunenian tradition), and later Muth, who based his studies in the market partial balance.

The principal limitation of the economic theory is that it is based on the idea that the system reaches a balance point, a perfect competition scenario ruled by offer and demand, a condition that is rare in the real world. Another limitation is the impossibility of dealing with external events and the imperfect rationality of the decision agents (SCHUMPETER, J. 1976). According to Abramo (2001), residential density and verticality are used by the market's capitalist demand as a means of spatial innovation, unlike the image of the missing owner and of the building industry presented by the neoclassical approach. This theory does not consider the speculative nature and the income accumulation frequently sought by owners and construction industries.

Functionalistic Approach

The functionalistic approach presents its concepts of empiric observations on regularities that manifest under the spatial interdependence in the distribution of social and economic activities in the urban space. These interdependences appear as people's, goods' and information flow, among the several places of urban activities called spatial interaction. Spatial interaction models compare cities or urban areas to gravitational or electromagnetic force fields (concepts linked to Newton's Theory). Cities are formed by distinctive elements (human beings), "that place and move themselves through space, communicate, attract and pull themselves mutually" (Lynch, 1981).

One of the first models formulated using this theory was Lowry's (1964). The objective of this theory was to trace work locations and residential areas and the existing relations between these two variables. Other model examples are Wilson's (1970) and Wingo's (1961). Spatial interaction models made it possible to explain the urban form, therefore describing the spatial and economic interactions. Today, there are several transportation models that use principles from the gravitational model to predict urban flows, showing good and realistic results.

The major criticism to this model highlights the lack of consideration regarding economic issues, such as land market and building constructions. According to Krafta (1995), the basis of most of the models of spatial interaction is the theory of random use, of general balance (work net and soil use) and more than a half of the models use Lowry's (1964) as a basis. The approaches on Spatial Interaction Models Economics are two complementary ways to analyze the urban spatial structure, mainly on a high level of aggregation. Both are based on economic relations and use the neoclassic economic theory as a starting point: the urban structure components would start to interact with themselves, restricting the possible changes in each one, reaching the system's balance.

Self-Organization and Urban Development Dynamic

Since the 80's and 90's geography has been applying the theory of self-organization to explain the behavior of the spatial, physical, urban and regional system. Complexity science sees the world as a collective of components that interact among themselves, assuming characteristics that are called emerging properties of systems. According to Haken (1983), the system is ruled by a certain number of collective variables which form the "order-parameter". During instability moments, many parameters coexist and compete among themselves until one of them "wins" and "enslaves" the system's components through its movement.

This process is called "enslaving-principle" and considers that the complex system generates reproductive relations among its components, enslaving its movement. Besides, in some moments, the competition can be solved by using the cooperation among its components. Portugali (1994) considers that in a city, the enslaving process is visible in cases of invasion-repulsion, invasion-succession, as well as in the "gentrification" phenomenon (Smith, 1982), because "segregating" individuals prefer to live among neighbors of their kind. This process happens both in choosing where they will work and in evaluating the place already used by them.

This situation suggests the existence of a social and economic urban cultural mosaic where some order-parameters can attract the attention of individuals orienting the dynamics of the system's transformation. This can be considered a "deterministic chaos" (Portugali, 1997), which appears when many individual parts are suddenly attracted by a small amount of attractors or enslaved by some order-parameters that may seem chaotic macroscopically speaking. Order-parameters compete among themselves and only one is able to enslave the system and lead to order. Likewise, different groups take over determined spaces and, after competing for them, the winner is the order-parameter. With this, an identity of urban and regional space is established and it modifies the city and/or region structure.

Attractiveness

The urban macrosystem, due to its complexity, have many buildings that possess functions that enable attractiveness and, through that, move people and goods that perform complementary activities there (spatial interaction). The urban state system is perceived by the activity units that will act on it based on the available information about its general condition. This information is never complete, but it enables only a partial view of the system, giving a certain uncertainty concerning the obtained results.

The transformations occurred in urban subsystems originated from the allocation process of urban activities can be:

- **Strengthening:** when activities related to subsystems are attracted to the areas from which they belong or there is more land use with the same kinds of activities;
- **Weakening:** when social and economic activities suffer the process of deactivation;
- **Movement:** when there is transition of social and economic activities to areas that offer more locational advantages to these functions or are "expelled" from previous locations.

Since we consider the urban macrosystem a result of the interaction among urban subsystems, any of the situations mentioned above would cause instability within the urban macrostructure, therefore modifying its spatial structure and morphology.

Competition and Urban Space Configuration Process

The urban space is heterogeneous concerning the available site characteristics in order to enable, urban growth and also to the resources necessary to develop social and economic activities. Among these we can name the physical factors, location related to the service net and public facilities and the transportation system technology that reflect in advantages of urban areas to the development of activities. Each change generated by an external agent to the subsystem through the addition of a new building, modification of an existing one, closing or substitution, promotes the internal restructure of social and economic subsystems, affecting everything.

From these little changes, the attraction forces that modify the relations of the activities of a determined area with the city structure, causing unbalance in its development may behave as follows:

A - cooperation among compatible activities: as, for example, business-home that start to coexist in the same urban area using the same facilities offered there;

B - competition among incompatible activities: start to coexist in the same space, derived from the addition of a new element that modifies the social and economic inter-relations of the subsystem in relation to the urban macrosystem.

It is considered that the possibility of change would happen due to factors that unstabilize its social and economic complementarity relations, causing a new adaptation of its components to adjust to this new established order. The “winners”, that is, those that are able to obtain the necessary resources to their survival and reproduction will be selected, the others will be eliminated. The structural functionalist approach sees the development of urban areas as necessary spatial relations and functions for the development of society. Considering urban and regional space as geography of opportunities, we have, consequently, the generation of inter-relations between places and functions, creating processes of spatial interaction, forming an urban system whose structures hierarchical and highly organized.

We will use a structural-functional approach, therefore, systemic. It allows the construction of models and performance indicators that will permit a more objective comparison of the three phases of the urban and regional system, which will be the object of this study, and the transformations generated by the construction of Itá Dam and its change of territory during three defined phases for the development of this research:

1. The original town was flooded by the waters of the Lake in 2000.
2. The original project of the town of Itá, that exists since 1989.
3. The actual occupancy of Itá since the moving of the population to the new location.

The modifications of the urban structure can be identified by physical characteristics, such as building volumetry, intensity of urban occupation, and infrastructure. Agents commonly define the location where they will live, considering their needs and the activities that are complementary, and those that would be unwanted in their neighborhood. This information causes changes in the urban structure, defining areas of higher occupancy and density, areas connected to different activities and also the flows caused by different types of attractiveness.

The methodology aims to apply existing indicators, as well as the ones developed during this research in order to identify the main socioeconomic impacts and the spatial configuration after changing the location of Itá and its subsequent development linking Urban Structure, Spatial Interaction, Attractiveness, Socioeconomic Analysis and Spatial Statistics.

Characterization of mile stones used as Basis for research

The transformation of the landscape after implementing Itá Hydroelectric Power Plant defined the town relocation to another site planned for such event.



Itá Hydroelectric Power Plant started to work in 2000, with a flooded area of 103km² forming a large lake on the original town. Source: own creation from the photo by the author and Itá Town Hall website: <http://www.ita.sc.gov.br>

The evaluation on the original town was based on a direct survey with its inhabitants, involving Sociology, Economy, Architecture and Urbanism professionals as well as representatives of the town's administration. The beginning of the original occupancy happened in the twentieth century, when drovers coming from Rio Grande do Sul State arrived there. The occupation takes place around the 1920s, when Companhia Luce Rose created a housing development occupied by settler descendants of Italians and Germans, coming from the "colonies" of Rio Grande do Sul. In 1956 there is the emancipation of the municipality, after the separation from the town of Seara.

Itá's territory was in rugged relief and headed from East to West, with very significant land unevenness; it was defined as a valley town. The agricultural and livestock production, especially poultry, soybean and corn farming, was composed of small autonomous production units and became the main economic activity of the town. The lack of jobs can be considered the most difficult aspect of old Itá. By 1980, job offers were barely sufficient for the rate of natural increase. It was a 200-family town; those families kept their descendants true to past traditions. A distinctive feature of social relations is the significant role played by the idea of kinship, where all residents considered themselves neighbors and there was a low intensity of flows in the urban center, both of vehicles and pedestrians.

The urban planning of the new town was developed by the Planning Division of Eletrosul's Department of Building Projects, with the participation of the local administration and community representatives, besides state government technicians. During the process, Itá Relocation Task Force (Grupo Operacional para Realocação de Itá – GORI) was created. In 1984, the group produced the document named "Municipal Headquarters Relocation: Change Plan" to establish guidelines that would relocate the town.

Describing the Original Project

The main concern of the proposed plan for the town of Itá was to provide space and equipment that allowed the population to keep practicing their activities, addressing any upcoming deficiencies in order to stimulate the development both of individuals and also the community in social, economic, cultural and physical ways. The new town was designed aiming to understand how much the population, being forced to be relocated, would lose affective landmarks.

The principal restrictions were the large-gap to topography, the elongated shape of land, native vegetation causing that had to have preservation areas and the search for identity among inhabitants and urban facilities. The New Itá, founded in 1996, is a place where landmarks are important for bringing back what public buildings previously meant. The project intent shows the concern with the characterization of the town by its public buildings, creating strong references for its inhabitants. We tried to install the main equipment for community usage in the urban center. These facilities were arranged centrally in relation to the various residential and ecological areas. The square and the side walk can be characterized as the meeting place for social and political purposes, leisure and cultural and religious activities

Concerning house building, we point out the relations established between architects and dwellers. The immigrant background present in the region, as well as its architectural expressiveness, encouraged architects to seek a local vernacular architecture, using strong elements between the old and the new residences

General Identification of Itá Today

Itá is located in western Santa Catarina, in the micro region of Upper Uruguay in Santa Catarina, described by IBGE [Brazilian Institute of Geography and Statistics] Census (2000) as micro region of Concórdia. It borders the municipalities of Seara, Concórdia and Paial, having as southern border the Uruguay River, the natural border between the states of Rio Grande do Sul and Santa Catarina. It borders the municipality of Seara-SC on the north, and the municipality of Aratiba-RS on the south, the municipalities of Aratuã and Concórdia-SC on the east, and west with the municipality of Paial-SC. The microregion comprises 16 municipalities, being Concórdia its center. Itá is 550 Km far from Florianópolis, the capital of the State of Santa Catarina.

It has 165 km² as land area and an average elevation of 520 meters above sea level. The land in the region notably folds into the valley of the Uruguay River. The downstreams, arrangement in layers, are responsible for the presence of levels, with the predominance of basaltic rocks. The climate is humid mesothermal with hot summers and average temperature of 33°C, while in winter the average temperature is 18°C, reaching minus 2°C. There are three vegetation types in the municipality: primitive forest (native vegetation), the secondary forest (natural restoration, including high *capoeira* vegetation); and planted forest (reforestation). The main rivers that run through the town are: the Uruguay River, The Engano River, the Jacutinga River and the Ariranhazinha River, which are tributaries of the Uruguay River.

The urban structure of the new town, due to the morphological characteristics of the site is defined by an axis road that crosses the town (residential area/urban center/residential area) by directing heavier pedestrian and car flows. The access to Itá power plant is by means of a parallel highway in relation to the structural axis, in order to prevent heavy traffic in the city. Secondary and tertiary streets complement the urban road system, being 95% of these streets paved.

Socioeconomic Analysis

Since the 1980s, researchers on Urbanism have considered the urban structure as the result of a dynamic process that can be modified through time. **Krugman (1997), Krugman, Fujita and Venables (1999)** use the theory of complexity and self-organization to analyze the New Economic Geography.

In this case, the territory affects the different networks where there are urban activities and it is also affected by this process. This concept is suitable for this research in order to define a new representation of the process of spatial transformation and the use of urban land generated from this particular process of urban development. Although the planned town had provided, "a priori", locations for urban activities at Itá, the ongoing urban development can bring up a different network structure from the ones available initially.

The weight of the action of the attractiveness of each activity on the others is able to bring up significant changes in a city, especially when there is a change in its Economic Base. According to **Krugman (1997)**, the other firms depend on these activities and behave according to the location the economy of agglomeration, establishing relationships of spatial dependence in the urban structure and spatial interaction (**Wilson, 1970**). The combination among these concepts of conceiving urban structure results in an analysis that takes into consideration spatial dependence and a hierarchical and competitive system.

When there is the construction of a dam and the entire infrastructure needed for that, new requirements arise in the region, as well as more jobs offers, besides a lot of expectations about it. These elements start to be a part of activity resizing and the everyday life of the people who are located close to construction sites. On one hand, this increase in population represents an increase in cash circulation, creating the need for services; on the other hand, this temporary population participates not only of the profile and the sizing of the urban demand, but they represent a responsibility to local authorities, that are responsible for providing equipment and services for the basic collective usage of regional populations.

The possibility of new job offers and the opening of new professional areas in town are understood as a positive aspect enabled by the construction of the dam, bringing "progress" to the region. Professionals strongly associate this open professional perspective to the construction of the dam, with the possible creation of a diversified demand for accounting, law and health services, among others. Many young people who used to leave the town looking for new opportunities in bigger cities tend to become freelancers and stay in town, because of these job offers. Economic progress is important for businessmen. Since the beginning, they point out the town's increasing income as people come to work and live there, as well as it increases local employment. In 1993, it was prominent perspective.

The first change was the development of construction companies. With the "auto-relocation", there were bigger opportunities for local contractors. The presence of a big company influences and modifies the salary relations established in the place. The salary paid to temporary workers is relatively higher than the average in town, especially for low-skill jobs. Rent and food price rise is one of the factors that affected the population the most. The presence of Eletrosul [a subsidiary of Eletrobrás Energy Company] is identified as one of the causes for the high price rise in trading, fact that starts to be experienced mostly by people with lower economic income.

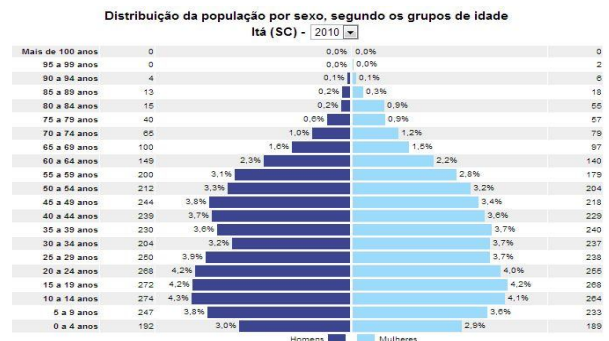
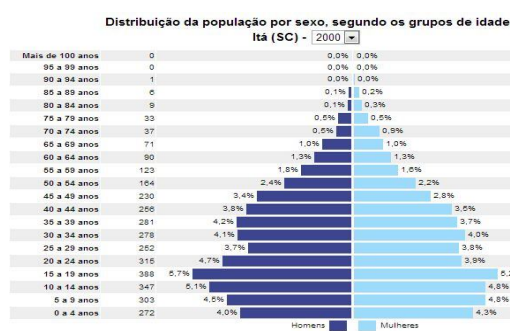
In this context, it can be observed that when there was profit, it was not evenly distributed among its population. Some areas have far more chance of immediate profit with population growth, while others split costs ranging from increased demand for services and public space, up to the rising cost of living. The town's economy fluctuated depending on the construction pace. When there is a stop due to lack of resources, there is a decrease in population and consumption, hence, retail sales decrease. While there is an increase in income, of cash flow, there is the increase of demand for certain public services such as: infrastructure increase in education, health and public safety, and the need to adapt the economy of the town for the departure of the affected farmers.

After the construction of the dam, when the seasonal economy was cooled off in the region due to the many flooded fertile estates, the population started to worry. It was also a topic for discussion between the town's administration and some local leaders. After 2000, when the dam began its activities, the Government attracted some industries to the town offering tax exemption. A lot of work has been done to transform Itá into a tourist attraction and the municipality is doing it in a firm and solid way. In the near future, it intends to have, besides its industry, tourism as a major business activity for the town to grow.

Itá's population changed significantly regarding the number of inhabitants.

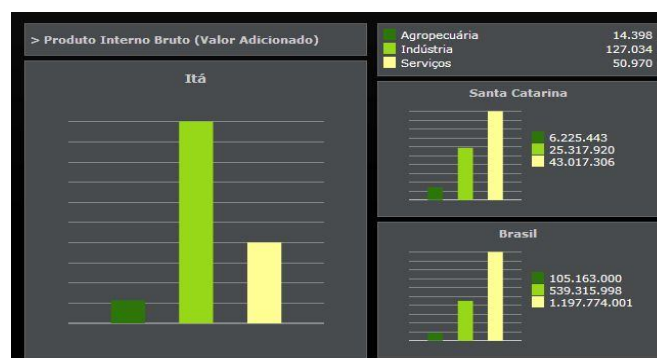
The first change happened from 1970 to 1980 due to the beginning of the studies for the construction of the Power Plant. From 1980 to 1990, with the construction already in progress, a large number of people begin to live in town. In the third phase, from 1990 to 1995 there was a reversal regarding the population living in rural and urban areas. The rural population moved to the urban area supposedly looking for jobs at the construction of the plant that was offered to the region inhabitants. Before that, most people lived in rural areas and, from that moment on, most of them move to urban areas. From 1995 to 2002 we see a significant decrease in population in Itá, probably due to the construction of the plant in 2001.

Nowadays, its population is 6,755 inhabitants being 3,418 in the central urban area and also in six other neighborhoods. In the rural area, there are 3,337 people distributed in 24 communities. Itá went through three economy cycles: agricultural (corn and beans), cane spirit (having about 30 stills), wood (taken by ferry across the Uruguay River to Argentina). It produces beans and corngrains; it is also famous for its poultry and pork production.



Distribution by age groups. Source: 2000 and 2010 IBGE [Brazilian Institute of Geography and Statistics] Census

Today, the town has the industry as its main economic activity, which considers the hydroelectric enterprise as a large scale industry and it is developing fast in terms of tourism.



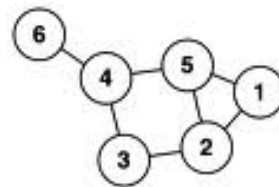
Itá's GDP [Gross Domestic Product]. Source: IBGE Cities@**Configurational Analysis: Complex Networks Analysis**

The study of network as complex systems has been effective to understand the structure and the function of various natural and artificial systems. This type of relationship is used for several areas of knowledge, such as computer science, information theory, social networks and others.

"An important feature regarding complex networks is the presence of community structures. "Communities are also called" clusters" or groups, and are formed by groups of vertices that probably share common properties, such as functional entities, for example, including their role in the structure of the graph.

The three phases of this research will be analyzed using PAJEK software for analysis and representation of networks(1996, 2010V.Batagelj, A.Mrvar) to show the topological relations of spatial, social and economic elements of a region having different measures of centrality, revealing its structure, such as the identification of centers, important areas of connection, etc.

In this context, it is necessary to change the way of describing the system so that the analyses related to networking can be applied. With this purpose, spatial relationships are often related to mathematical representation by means of graphs that reflect topological relations of spatial systems using a mathematical language.

**Geometric representation of a graph. A graph is usually represented as a set of points (vertices) connected by lines (edges).**

Within Urban research, we can point out Hillier and Hanson's "The Social Logic of Space" (1984), where convex spaces are represented as axial lines and their connections form a network where classical measures are generated, such as Integration, that measures how "deep" or far an axial line is from all other system lines, streets, corners etc. More "shallow" paths are closer to each other, therefore, it is said that they are more integrated. "Deeper" paths in relation to others are said to be segregated.

Another important contribution is the Centrality Model (Krafta, 1994) which analyzes the morphological properties of the urban system using two basic categories: public spaces and built forms, aiming to describe the space differentiation of the urban structure. It is considered that each elementary portion of built forms, being mediated by an interconnected system of public spaces, is reachable from any other portion.

Graph Theory

Graphs representing self-organizing systems are not regular, that is, they are objects where order coexists with disorder. Based on this assumption, we define the property of self-organizing networks that do not produce random graphs, but do heterogeneous ones revealing a high hierarchy. The distribution degree is broad and is usually characterized by many low-degree vertices and other high-degree ones.

Moreover, the connection distribution is not global but produces high concentrations of connections between special vertices groups and a low concentration between them. This study will use four properties of complex networks.

Closeness Centrality

Self-organizing networks are not random graphs and, furthermore, they are heterogeneous, revealing hierarchy. The analysis of this process can be performed using topological features of the network such as centrality measures. The dimension of the vertices comes from values obtained at the different centrality measures that, in this case, are only determined by the spatial configuration of grid plan of the town.

The "closeness centrality" of a vertex is the number of vertices divided by the sum of all distances between the analyzed vertex and all the others. This measure can be used to detect continuities of the structural characteristics present in the studied networks in different stages of the simulation. The goal is to verify if the vertices occupied in the early stages of the simulation remain with high centrality values along iterations, thus preserving its structure. This is called "mutual information", in a process called "path dependency".

Betweenness Degree

Betweenness is measured by considering the amount of times a vertex is part of the shortest path between any given pair of vertices of the system. This property is used in vertex classification according to their topological position within communities. It is used to identify groups and their boundaries. Inter communicating vertices can be detected and community formation gets clearer than in the "closeness centrality" measure.

Detecting Centers

Vertices with a central position in their clusters may have an important role concerning control and stability within the group. They may also have a critical role in mediating relationships and exchanges between different communities. Moreover, in some cases, they can be part of different groups in a network overlay. Graph center detection using PAJEK software is based on the "stealing algorithm": high degree vertices are considered more "powerful" than the neighbors; therefore, they can "steal" from them.

At the beginning of the detection, vertices are given values according to their degree, or they get the minimum value. (1996, 2010 V. Batagelj, A. Mrvar) When "weak" vertices are identified, neighbors steal from them according to their weight in the system. This measure points out not only the most central areas of the overall system, but it also makes local important points visible. They tend to create centrality in clusters. Defining centers detects a clear hierarchy and the formation of islands that are detected by this centrality measure.

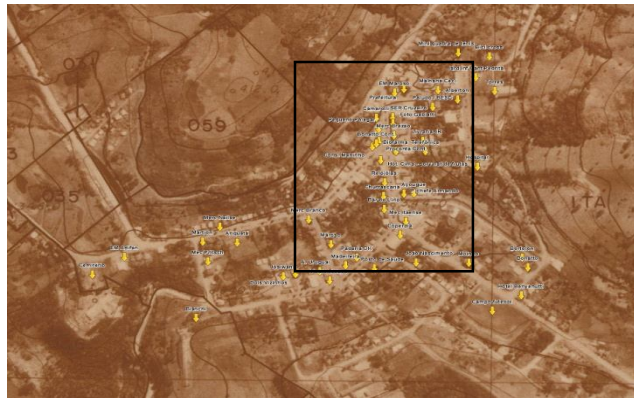
Vertices with Maximum Neighborhood

The neighborhoods of a set X of vertices of a graph G are the set of all vertices that have a neighbor in X . This set is denoted by $\nu(X)$. The neighborhood of a vertex v is the set $\nu(v)$. This index shows which vertices with the largest number of high degree vertices are connected to it, that is, it demonstrates the best connected places within a network.

Original Town

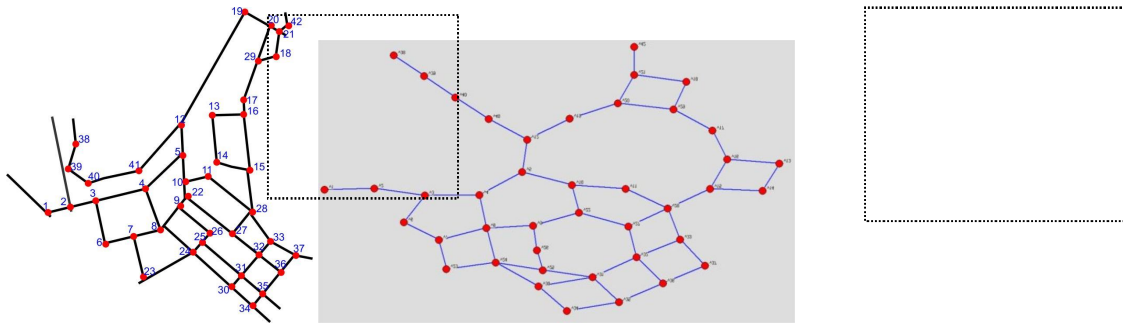
The original town (Figure 1) displayed a traditional urban fabric, commonly seen in small towns in the countryside of the southern region of Brazil, with its main uses distributed along Main Street that used to pass through the whole city, having a more developed center near the main square and the Catholic Church.

The main church in town, which is shown below, is identified with the name *Torres* [towers] due to its preservation as the town's memory even after the flood.



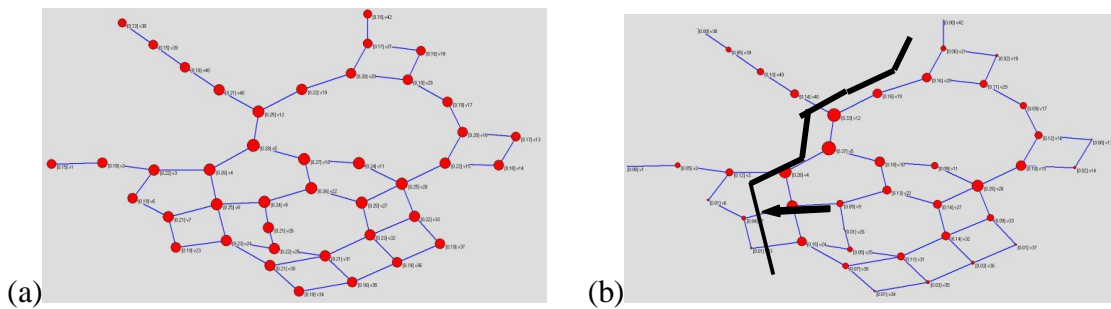
The Original Itá, before being demolished and the place turned into a lake.

In this case, the displacement of the center happened due to topography and agricultural land grants, the economic base of the region before the construction and occupancy of the new Project. The original design was a model for the creation of the axial map of the town that was built representing the corners of the town with dots and the connecting lines representing convex segments of streets. As we can see, this is a very simple layout consisting of 42 points. This axial map enabled a description process of the network that started to be represented more abstractly, fact that allowed the analysis of the town's grid plan from a purely topological point of view and the analysis within the context of complex networks, as shown next:



The highlighted areas in both graphs correspond to the same central area

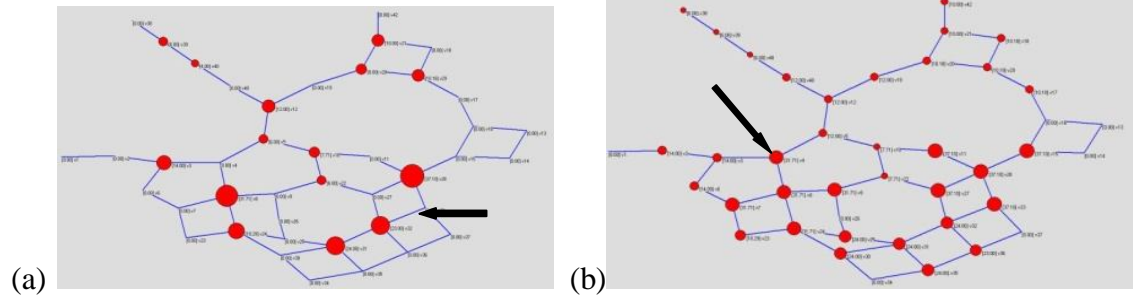
The area that contains the largest number of activities heads towards Main Street, but it is dislocated from the other points. Yet, the distribution of "Closeness Centrality" demonstrates a high degree of urban fabric with little variation of its values, as we can see in the Graph and the Standard Deviation of the values of each Vertex measured in this Topological Property. Standard Deviation indicates here, and in all the cases below, the spatial differentiation generated at each vertex by each applied measure.



(a) Closeness: Standard Deviation: 0,03989 (b) Betweenness Centrality. Standard Deviation: 0,0908

Despite the simplicity of the original urban fabric, some differentiations appear when we consider the "Betweenness Centrality" of its vertices. The grid design, presenting a considerable discontinuity inside itself causes some vertices to be essential for connecting others. These areas, shown below, reveal discontinuities and indicate the formation of clusters in the urban grid of Itá in its original design. Points with higher values correspond precisely to the main street, where the main activities were located, indicating a distribution closer to the classic "herringbone" structure, although it maintains a good part of its grid with a high degree of connectivity as the Graph with higher degree of neighborhood vertices shows.

As previously mentioned, the urban grid of the original town had some discontinuity points of its urban fabric that are now highlighted after detecting its centers. These points clearly appear internally to the most connected area of the town, occupied by most of the Urban Population at the time.



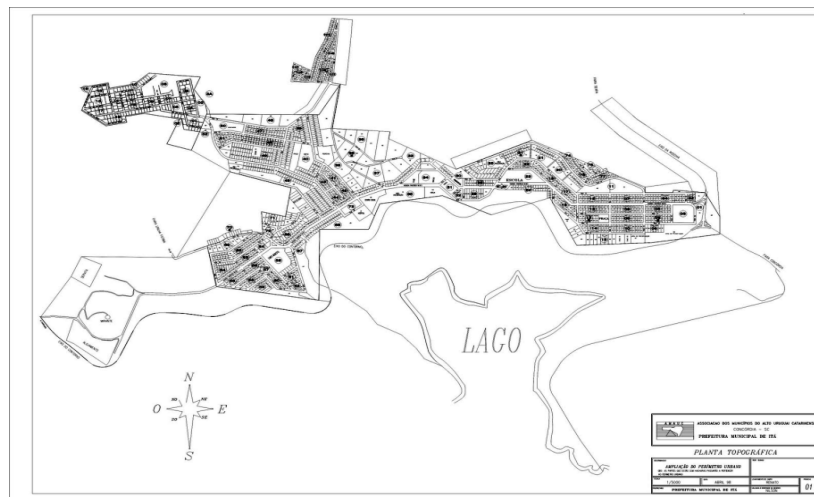
(a) Detecting Centers. Standard Deviation: 9,2149 (b) Higher Neighborhood Degrees. Standard Deviation: 12,4363.

The High Standard Deviation in the distribution of central vector values shows great spatial differentiation and a tendency to form clusters because the alternative route started by vector 28 (pointed out in the two preceding paragraphs) could prove to be the beginning of cluster formation connecting the most occupied area to the one defined by the population as the center, identified mainly by the church and a larger number of businesses located there.

The urban grid behavior of the original town of Itá is uncommon, since vectors with higher neighborhood degrees are displaced from the main points and have higher allocation of commercial activities, except for the town entrance, as shown above. Another singular aspect of the grid is the existence of "Levels" with many vectors with the same value, distributed in the Urban Grid.

The Original Project

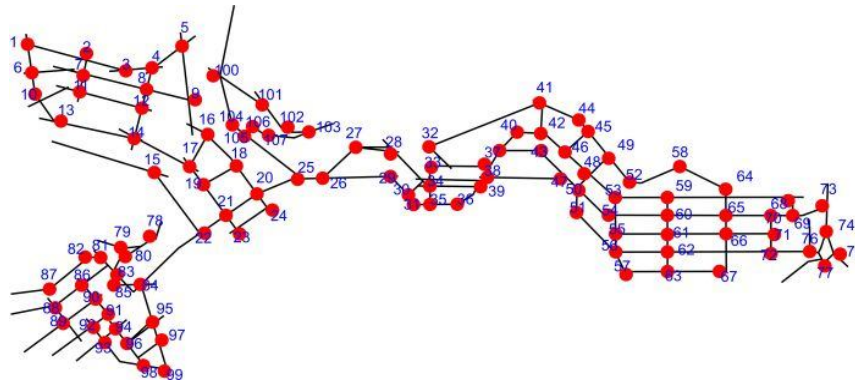
The Original Project defined an axis road that goes through the town and organizes the most intense flows of vehicles and pedestrians. There is the town hall, a shopping arcade and the church around the square. The square and the main street promenade are the structuring spaces of the city center, where there are the main public buildings.



Original Sketch of the Town: drawn in 1998

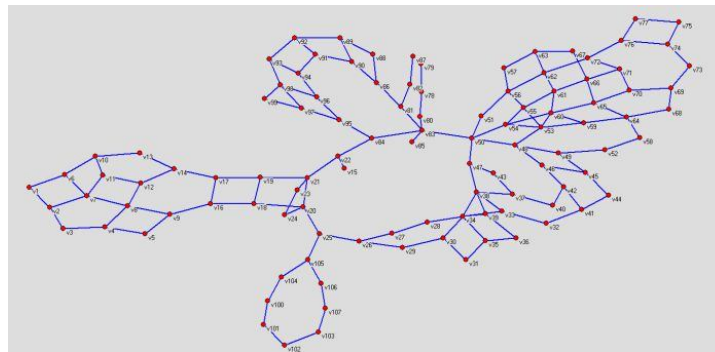
The intention of the designers to form a town whose structure had identifiable connections with the original one is already seen in the original design, and also in the axial map based on it.

Furthermore, being its topography so extreme increases grid discontinuities. The definition of a town center with the location of the major collective activities and the need to "arrange" the new town according to the preservation areas and the uneven terrain form three well-defined areas that are shown as clusters in the various analyses presented below.



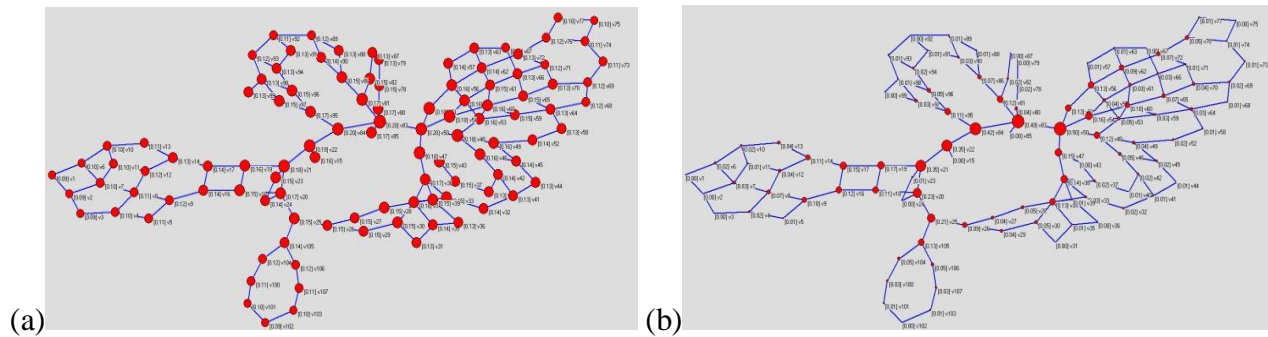
Axial Map of the Original Plan

In the graph below we can see important discontinuities in the urban fabric that lead us, since the making of the project, to a typical feature of self-organizing complex networks: the formation of communities. In this case, designers, regarding natural and cultural factors, replicate characteristics of the original urban system.



Base Axial Map using Pajek Software

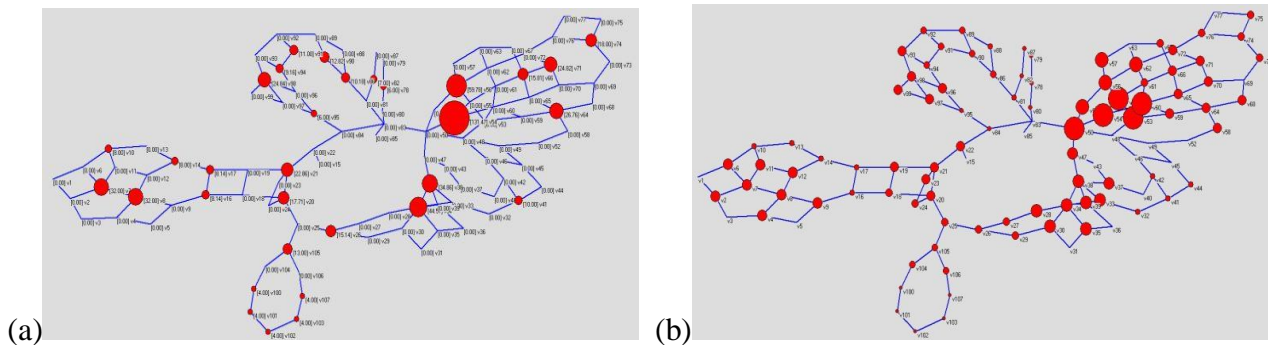
The image below and the low Standard Deviation in the Distribution of Closeness Centrality values demonstrate a highly connected system. The Project has the property of limiting the spatial differentiation, enabling similar accessibility to all the system, even considering the site's topology.



(a) Closeness Centrality. Standard Deviation: 0,022860 (b) Betweenness Centrality. Standard Deviation: 0,094874

The Project, similarly to the original design, highlights some vertices that have their importance connected to the passage place among the three most integrated centers. These vertices form the main structural path of the town.

The existence of Clusters in the project is clearly seen at the process of detecting centers, as shown below.



(a) Detecting centers. Standard Deviation: 15,9861 (b) Higher Neighborhood Degrees. Standard Deviation: 28,3800

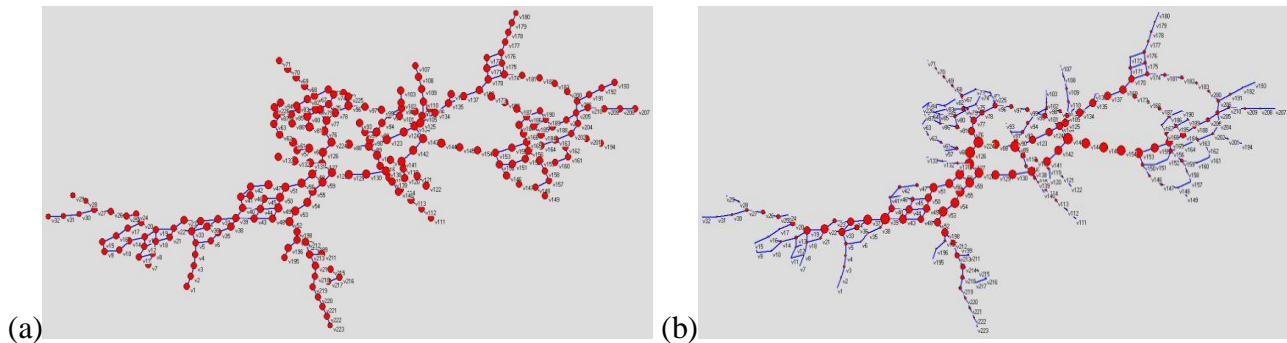
The Standard Deviation regarding vertex value distribution in this property demonstrates cluster formation and is complete by observing the Higher Neighborhood Vertices that appear inside or on the borders of the three major agglomerations of the Project. Nevertheless, the highest concentration of values remains in the "entrance" of the town, where the project defines, since the beginning, the Urban Center.

The City Today

This part of the analysis aims to highlight the continuity and the differentiation of the urban grid properties of the New Itá Project and its current occupation. That can be analyzed using spatial configuration, which happens spontaneously, even this being a planned town.

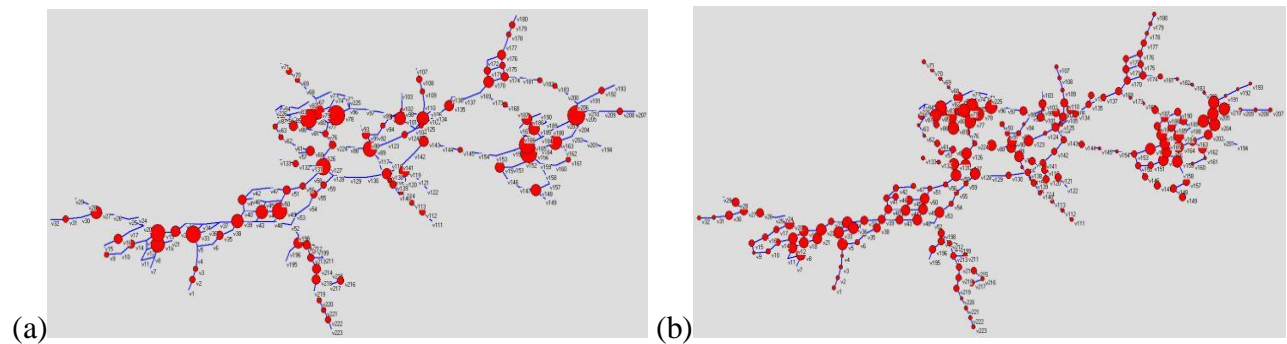
Base Axial Map using Pajek Software

Then, the population occupied this area the same way they used to, since they shared the same idea that everyone is close neighbors. This is the first place where it happened. Nevertheless, besides the three main existing areas in the Original Project, we now find a number of new growing areas, almost all linear regarding the urban grid configuration. Just like on earlier days, previously analyzed here, Closeness Centrality is distributed evenly throughout the town area that has low Standard Deviation in this property.



(a) Closeness Centrality. Standard Deviation: 0,0127; (b) Betweenness Centrality. Standard Deviation: 0,080

Yet, Betweenness Centrality clearly indicates the structural paths of the town. One can see that the same linear growth implied in the design of the new town strengthened, and continues to be present until today, still indicating the original center.



(a) Detecting centers. Standard Deviation: 8,955; (b) Higher Neighborhood Degrees. Standard Deviation: 12,602

Today, the city has a strong tendency to form clusters and "lines" that head to different directions, as shown in the Detecting Centers Graph. We can also see that when we only consider spatial configuration, forgetting about the location of the main equipment as a reference value of the vertices, the area originally intended to be the urban center (highlighted in the graph) weakens due to the rise of new centralities. The topography has a strong influence on this property for it defines an "arrangement to the site" causing discontinuities in the grid plan, directing the formation of communities that connect to a general structural axis even more.

An important behavior of the current urban system is the emergence of Higher Neighborhood Degree areas in different locations of the Original Project. The areas that have this property in the original plan were close to the town entrance, at the beginning of the Structural Path. This area still has a strong concentration of vertices with higher neighborhood degree values but, together with this maintenance structure, today we see vertices with higher neighborhood degrees in the internal areas of the clusters formed from previous and new occupations.

Morphological Analysis: Fractal Geometry

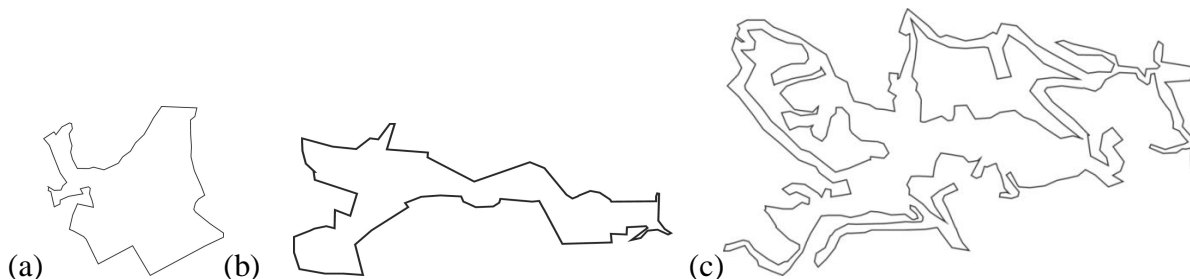
Benoit Mandelbrot coined the term *Fractal* in 1975 to refer to a special class of curves defined recursively, which produced real and surreal images. A geometrical or physical structure that has an irregular or fragmented shape at all scales of measurement. Fractal Geometry studies complex subsets. In geometry of deterministic fractals, the objects studied are subsets generated by simple geometric transformations of the object itself in itself, that is, the object is composed of reduced parts of itself (Mandelbrot 1977).

Currently, Fractal Geometry, especially Fractal Dimension, has been used in several study areas of chaotic systems such as pattern of cloud formations; object characterization; analysis and recognition of image patterns; texture analysis and measurement of curve length. Unlike what happens with "perfect" Euclidean objects, each object has its own dimension concerning fractals. Irregular curves have a dimension that varies between one and two, so that an uneven surface has a dimension between two and three.

The most important characteristic that defines a fractal is the "Fractal Dimension". Contrary to what is observed in Euclidean Geometry, where the value of the dimension represents the dimensionality of the space in which a certain object is inserted, fractal dimension represents its irregularity degree. In order to include fractal dimension in this paper, it was used Fractalyse software.

It was developed by the research group "City, mobility, territory" at Thema (Théoriser et pour Modéliser Aménager - Université de Bourgogne) research center. Its research coordinators are Pierre Frankhauser and Cécile Tannier. In the graphs below, the X axis of the graphs represent the size of the window side $\epsilon = (2i + 1)$. The Y-axis represents the average number of points counted per window and the main parameter is the size of the window side ϵ . The analysis of urban morphology and its relations with the distribution process of spatial structures performed by fractal analysis can be used to help studying intra-urban occupancies, as seen in the work of Franchiser (2004). Here, the comparison of the shapes of the Town of Itá will be used in the three phases listed here:

The dimension of a fractal indicates the space occupied by it that is related to roughness, irregularity (similar to different scales) or fragmentation degrees. This is the reason why fractals have fractional dimension and not integer, because they are not perfect Euclidean figures.

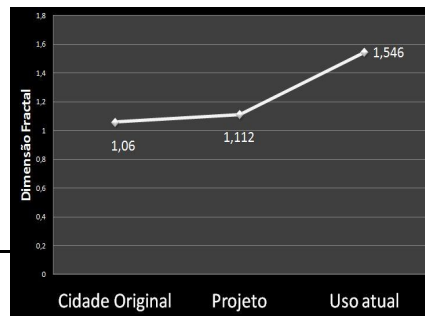


External Edge of the Original Town (a), of the Initial Project, and (c) currently - 2013

The values of Fractal Dimension seen in Itá/SC can be connected to the historical context of the organization of the town based on the Original Project. The analyzes are made on the scale of the town as a whole by comparing the planned structures and the less controlled urban emerging patterns that happened after the deployment plan and the allocation of the population. The expansion of the town’s Fractal Dimension value from the deployment plan up to present days demonstrates an emerging behavior where expansions occur, mostly in the form of new "islands" with large internal voids.

We can observe that the current urban form of Itá, measured by the correlation process, had a bigger number of irregularities of its Fractal Dimension. It shows the dispersion of the urban fabric, as seen in the analyzes above, form "occupation islands" or clusters on the topography.

Fractal Dimension	Original Town	Implemented Project	Current Town
	1,06	1,112	1,546



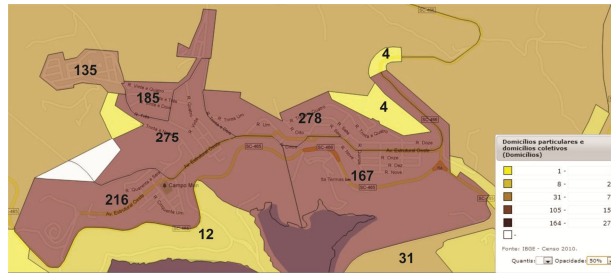
Fractal Dimension of Itá

In this evaluation of the urban evolution of Itá we can see that the original project already presented the tendency to scattering order to better adapt to the topography of the new urbanite. Considering that, the evolution of its urban form happens reinforcing these characteristics, bringing a more complex form and with more "roughness", that has its reflection in the significant increase in the value of Fractal Dimension found nowadays.

Population Density

The study of the population of a city can provide important information about an urban system. In the case of Itá, its structural properties such as spatial dependency, densities and group formation will be studied, in order to discuss the population density distribution. According to that, the population’s location now is a complement to socio economic, configurationally and shapes studies, products of continuous evolution of the town after the deployment of the original plan.

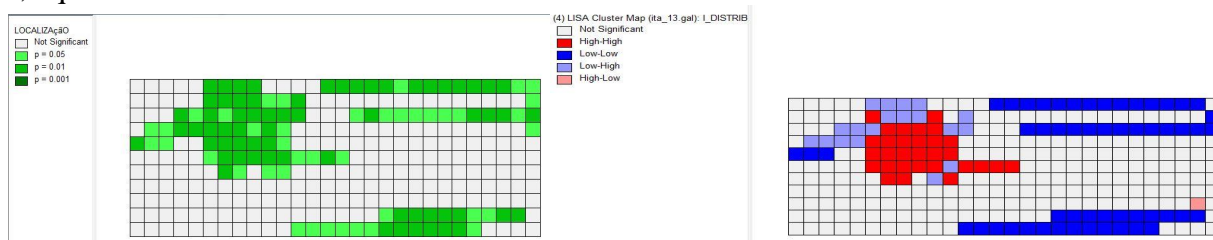
The first aspect to be pointed out is that the town’s census areas correspond mostly to clusters defined in Detecting Centers and Neighborhood Degree graphs. In addition, the main structural path, which appears with high Between’s Centrality, defines the division of the sectors that represent the properties of the grid plan of the town, studied previously.



Number of households per census areas in Itá (IBGE census 2010)

The main objective of spatial statistics is to describe spatial patterns among the analyzed data. Spatial variables make it difficult the use of simple statistical methods due to the existence of phenomena such as spatial dependence and heterogeneity. Generally speaking, Moran's I serves to a test whose null hypothesis is spatially independent; in this case, its value would be zero. Positive values (between 0 and +1) indicate direct correlation and negative values (between 0 and -1), an inverse correlation.

From this point of view, we analyzed the property of spatial dependence and cluster analysis using the Statistics software Open Geo Da 0.9.8.14 (2009) having as variable the number of households in each census area that have been translated into raster language to allow software processing. It has been carried out the random permutation test of I 's significance level under the null hypothesis of no spatial auto-correlation between the locations of industries and the result was 0.1056, almost reaching null value, equal to zero.



LISA Test and Population Cluster Formation. OpenGeoDa 0.9.8.14 (2009) Spatial Statistics Software Results to the year 2013 at Itá.

The emergence of allotted areas with higher densities indicates growth in new places as we can see in the most significant groups revealed by LISA (Local Indicator of Spatial Analysis), that shows the existence of spatial clusters of similar values around each observation or, in the case presented here, a cell representing a portion of urbanized land in Itá. The most significant groups include both the densest areas (the larger group, in red), and almost uninhabited ones (of linear character, in blue).

As stated previously, new activities gave young people the opportunity to get a job in activities that invigorate daily life in Itá today, such as Industry and Tourism. This information complements the analysis of the formation of Detecting New Centers, the differentiation of the configurationally characteristics of the current town in relation to the initial project, reinforcing clusters and new directions of growth, as we see in the most significant groups of the population.

Final Comments

A dynamic urban process can be described as the growth of the number of companies and households located in a city. At any period, companies located in a city are "followed" by new houses in response to the increasing demand for workers.

In this case, the territory has an effect on the different networks where urban activities participate and are also affected by this process. This concept is suitable for this research in order to enable to build a new representation of the spatial transformation process and urban land usage considering spatial, structural, demographic and socioeconomic relations. The profile of a town, especially considering Itá, where this transformation was so dramatic, can hardly be evaluated with only one study method. In this case, the evaluation is carried out by a set of analyses tools; each of them has different approaches concerning the object to be measured and tested. This process leads to a more complete understanding of the variables that are being evaluated, as it seeks to explain urban properties by means of different contents.

The organization of an urban system evolves according to society's needs. These changes are identified in their physical characteristics, such as intensity of urban occupation and the development of its fabric. Each decision of activity allocations taken by considering the existing urban structure, which limits the ability of other activities to decide about the use of space or the established relationships, behaving systemically. In an Urban System, there is a functional relationship between agents, generating complex collective properties. Thus, different evaluation techniques that could bring out elements considered essential for the identification of urban properties such as its organization and structure formation were applied.

Using analysis techniques, characteristics such as community formation, generation of centralities related to Closeness and between's, as well as detecting centers were collected. We identified the fragmentation of the forms analyzed in the three phases; as a result, Fractal Geometry values ended up being higher as the systems matured and the internal and external interactions (economic growth) have become more effective. On the other hand, due to the need to adapt to the site, growth resulted in reduced spatial dependence, that is also present in the low Moran I 's, when spatial statistics to the primary data of 2010IBGE Census was applied.

The analyzes used here were complementary, bringing out varied characteristics such as internal organization, spatial dependence system behavior, spatial structure, grouping and shape, opening speculation about future usage in different studies, especially those that consider the urban structure as part of an evolutionary process with characteristics that emerge over time.

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