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Planning Support Tools: Policy Analysis, Implementation and Evaluation

Proceedings of the Seventh International Conference on Informatics and Urban and Regional Planning INPUT 2012

edited by Michele Campagna,
Andrea De Montis, Federica Isola,
Sabrina Lai, Cheti Pira, Corrado Zoppi

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Contents

Section one
Accessibility and planning

Application of the interaction potential model to studies of centrality, accessibility, and impedances of the territory: case study of Nova Lima, Minas Gerais, Brazil

by Sheyla Aguilar de Santana[1], Ana Clara Mourão Moura[1], Danilo Marques[1] and Fernanda Borges[1]

This article aims to assess the positioning of the city of Nova Lima in the context of the urban network. From a historical occupation of Minas Gerais, will be done through GIS techniques, the construction of urban network of the cycle of gold for Minas Gerais and the current network of the metropolitan area of Belo Horizonte with the aim of measuring the power and influence of each centrality with the goal to understand the importance of New Lima in this context. This technique can be used to assess the power of attraction and repulsion of a centrality, accessibility and the impedances of the territory that make it less or more accessible to its surroundings. This information can assist to understanding the growth of certain locations and, therefore, the issues related to urban planning. In addition it is possible to identify the service area of each urban centrality. We used Nova Lima, Minas Gerais, Brazil to prove the theory that this location has always been the edge of the urban network and that its development was closely related to the mining issue.

Introduction

The space is constantly changing as it is influenced by several physical or social factors. According to Correa (2002), if space is a social product, the actions that transform are given by various social agents, relating directly or indirectly, and these agents may change following internal and external trends, leading to new axes and thus locational drastic changes in land use.

The occupation of mining territory, population and mineral resources of

[1] School of Architecture and Urbanism, Federal University of Minas Gerais (Brazil).

the land enabled the formation of a unique history in this state. All the events on this earth were marked on the landscape in a cumulative way and some of these traces still remain in the cities, towns, old mines that were the scene of the formation of mining history.

This work will focus in Nova Lima, Minas Gerais, Brazil that has characteristics unique function in the context of its formation and history of ancient mining center and auriferous. According to Meneguele (2002) have these characteristics in addition to the terrain characteristics, which guaranteed the large reserve of land beyond a peripheral position in the current network, unlike other poles of expansion as Ribeirão das Neves and Ibirité, due to difficulties in the expansion in that region.

This work will make a comparison of the position, power and influence area of operation of Nova Lima context of the network of the gold cycle and the current network to see if the city represented or represents a centrality in the state, identify the position of accessibility and assess whether the impedances of the territory that may be the cause of its position in the past and today.

Methodological concepts

Urban networks

Networks are not a new phenomenon. Historically recognized in the path of socio-spatial man, part of the dynamics of the process of human-natural territory.

The primary form of networking is to organize by the presence of a number of reference points and joining these points, flows through. Take the example of the lines between business people as well as the complex ancient Roman trade throughout Europe, and earlier still, the shipping lines practiced by Chinese navigators, among others. By being part of the history of society, networks have become over time in form and function, acquiring new structures and objectives.

According to Dias (2005), the specific term of urban networks is first discussed by the geographer Walter Christaller in 1933, in his theory of central locations, in the case of a theoretical framework on the differentiation of the nuclei of settlement, with regard to the importance as places that present distribution of industrial products and services.

Today, the term network is used characterization of various social processes being discussed widely in different areas of knowledge and research in various ways, acquiring thus multiple connotations. In this work, we understand the network from the perspective of territorial occupation via the towns, or more precisely the dynamics of urban networks, which are an organization that articulated through a set of centers, establish interconnection dependent and hierarchical way. This fact is a structure in which there is the creation of areas of centrality, which express higher concentration and movement of people, more intense diversification of urban activities and/or those that concentrate greater symbolic significance, as a recognized benchmark of local identity.

Potential Interaction

The Potential Interaction program is used to determine the potential influence of certain points marked on maps in Raster format SAGA. These potentials are calculated as a function of relative distance and mass of points. Each point has an influence on the other, with the possibility to calculate the interaction potential due to roads (road networks) created by the user.

Xavier Silva (2001) states that the potential for interaction is a tool that helps identify hierarchical positions of events in order to understand their relationship to other events from a network.

The potential for interaction (PI) is calculated by means of a gravity model, the interaction between reference points of a given area. The calculation is made from an informed user mass and taking into account the distance between points, which is traversed by paths that connect them within that network and also considers the impedances or territorial frictions that facilitate or hinder the movement (Moura and Magellan, 2010).

To consider mass and friction the equation of the PI continues by calculating the distance of the routes radiating from the point and all others belonging to the matrix, weighted by mass and having their influence reduced by friction:

$$\left(FZ\right) = Gi\ MGI\ /\ \left[\left(Dx\ Gi\right)\ Gi\ Ax\right] \qquad (1)$$

where:

- (*FZ*) = *Gi* Force Zoning pole *Gi*;
- *MGI* Measure = mass of the pole *Gi*;

- *Gi Dx* = Euclidean distance between each point and the pole *Gi* examined; and
- *Ax* = *CkGi*,
  where in turn:
  - *n* = number of cells found in the trajectory of *XGI*,
  - *k* = estimated environmental value of friction for each cell of the same trajectory.

Voronoi polygons

Voronoi polygon is the identification of space as a complex reality, with many variables, which allow you to perform a cut timeline, where the distribution of occurrences is not homogeneous, but conditioned by the social composition and roughness territorial. This model generates polygons of influence a point of concern according to its position on the set. Does not divide the territory as a homogeneous space through Euclidean distances, but through spots tied to the power of attraction of points of interest, as well as repulsion of the roughness of the territory.

According to Moura *et al.* (2009), the principle of the Voronoi polygon or Thiessen is that of considering a territory, there are points that are closer to a generating source than from another source, and the result is a polygon whose distances between source and point as low as possible. The resulting polygons may go beyond the simple division of areas, and are deformed by environmental characteristics, which are the friction and the influence of mass points of their generators, which should have power to organize the space and define the area of influence of points. Voronoi complex, then, must be associated with spatial analysis techniques to get to a complex representation of reality.

Surface impedance

The map of friction is a surface that identifies the spatial impedances, that is, factors that prevent or hinder access to and urban sprawl. This map is generated from the crossing of several maps through the multi-criteria analysis methodology for the hierarchical analysis of weights.

Multicriteria Analysis

Multicriteria Analysis, in accordance with the hierarchical analysis of weights, is methodological procedure algebra of maps based in the mapping of variables, degree of relevance and notes for each of the layers to understand the dynamics of the studied phenomenon. It employs the simple average weighted to create a classificatory and ordinal. According to Bonham-Carter (1994), notes for the definition of the variables can made by "knowledge-driven evaluation", that is, for acquainted with the phenomena and the variables assessed the situation, or "data driven evaluation" referred to knowledge previous similar situations. To build a membership function indicates the application of the Delphi method (interviews with a multidisciplinary group of experts) or a direct consultation of experts (experts).

It is important to note that the evolution towards a consensus obtained in the process represents a consolidation the intuitive judgments of a group of experts on future events and trends. The technique is based on the structured use of knowledge, experience and creativity of a panel of experts, on the assumption that the collective judgment, when properly organized, it is better than the opinion of one individual or even a few individuals devoid of a wide range of expertise.

Methodology

Based on the methodology of potential interaction, we identify the economic centrality of power in order to measure the centrality of influence of each territory in order to understand the historical evolution of the position of Nova Lima within that network.

Gold cycle network

For the scenario of the networks of the gold cycle, we use the network generated from the vectorization of routes and paths from a collection of ancient maps. The reference points are towns and cities and some chapels and parishes that have emerged as important locations in relation to the supply of inputs to mining areas, presented by income or by the number of people at the site.

The mass of each point was the population that can be obtained from the 1872 Census.

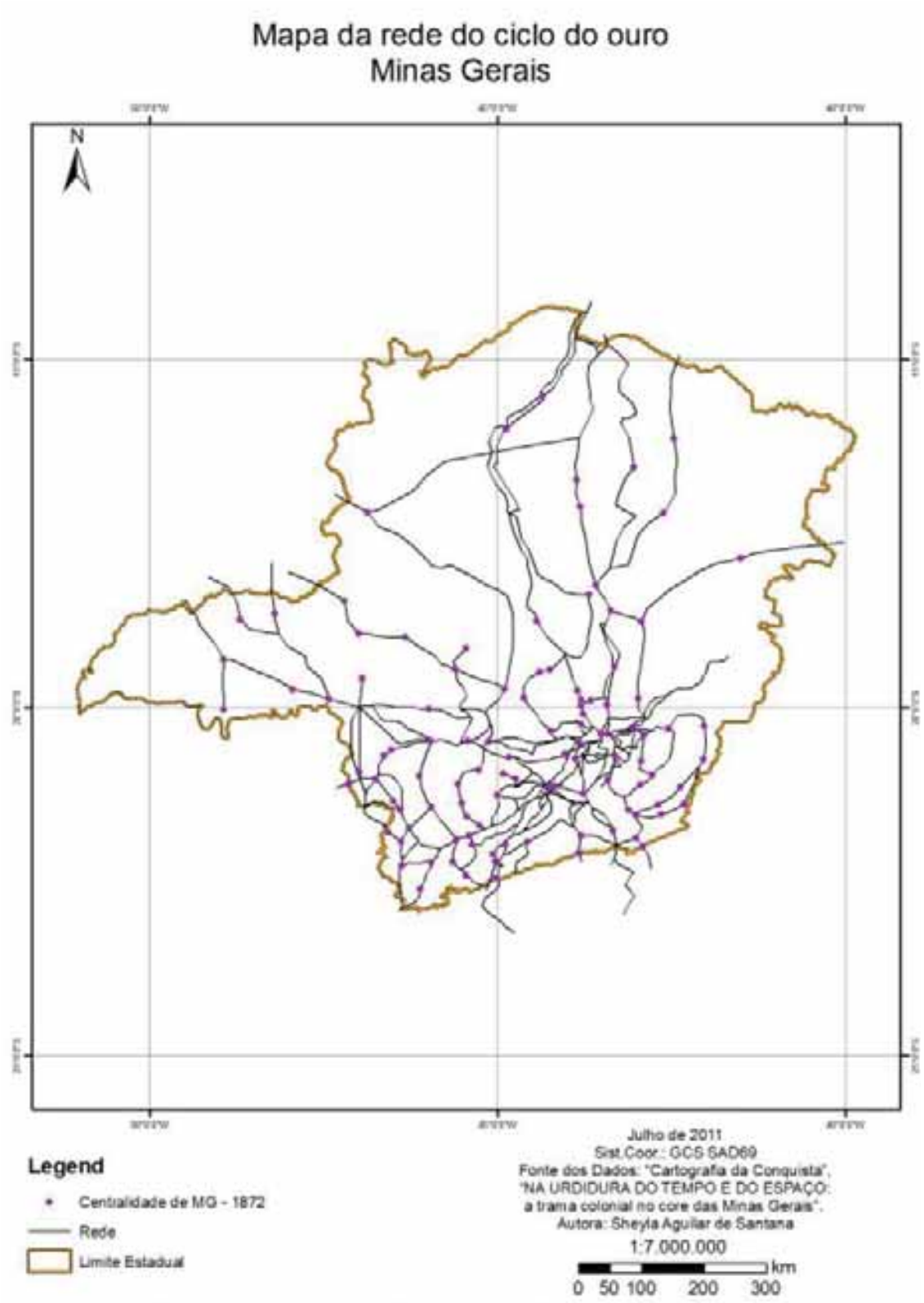

Fig. 1 – Map of the network and centrality of Minas Gerais, Brazil.

To identify the urban network of the period of the gold cycle were used descriptions of travelers who were touring the region, maps of the book

Mapping the territory conquest of Minas Gerais (Anthony Gilbert da Costa) and thesis "Warp in time and space: the plot in the core of colonial Minas Gerais" (Fernanda Borges de Moraes). Such data could infer that the formation of the network was initially through access roads to the mines, which were the major areas of centrality, and then a consolidation of the network occurred with the implementation of human occupation in the vicinity of the mine, as shown in Fig. 1.

With the network in place, the points defined and associated with the mass, the results indicated that the municipalities have a greater force of attraction within the network, as shown by a small piece of example in Tab. 1.

Tab. 1 – Example of the results of mass and potential interaction of the centralities of Minas Gerais, Brazil.

Name	***Mass***	***Potential Interaction***
Sabara	77754	21550.47
Ouro Preto	59249	19136.71
Mariana	56,404	18,809.05
Nova Lima	17,657	17,821.74
St. John Del Rey	48722	15583.34

It should be noted that the model of the IP (Interaction Potential) is a model that considered the gravitational force between points calculated by the performance of the relations of mass and distance of each point of origin in relation the whole set of points of the system. Thus, the higher the value of PI, the more interaction that point with other points of the set.

In the resulting table of PI initially considered only the mass and distance, there is the position of Sabara and Ouro Preto as routes and points needed centripetal and centrifugal connectivity of the network at that time. It highlights, above all, that New Lima points as the reference in the fourth set.

Once calculated the PI, it is the result of local specialization, using the model of Voronoi polygons, which are intended to identify the area of influence of a given factor from their point of origin. The value of PI can be spatialized by Voronoi simple, it takes into account only the value obtained as a factor of mass, but the interesting thing is spatialize from the Voronoi complex, which receives the IP as mass and also considers the influence of friction territorial. The friction means overcoming the difficulties of access to every portion of the region.

Thus, the map was drawn up territorial friction in Minas Gerais, taking into account the main variables that hinder the free movement as a whole.

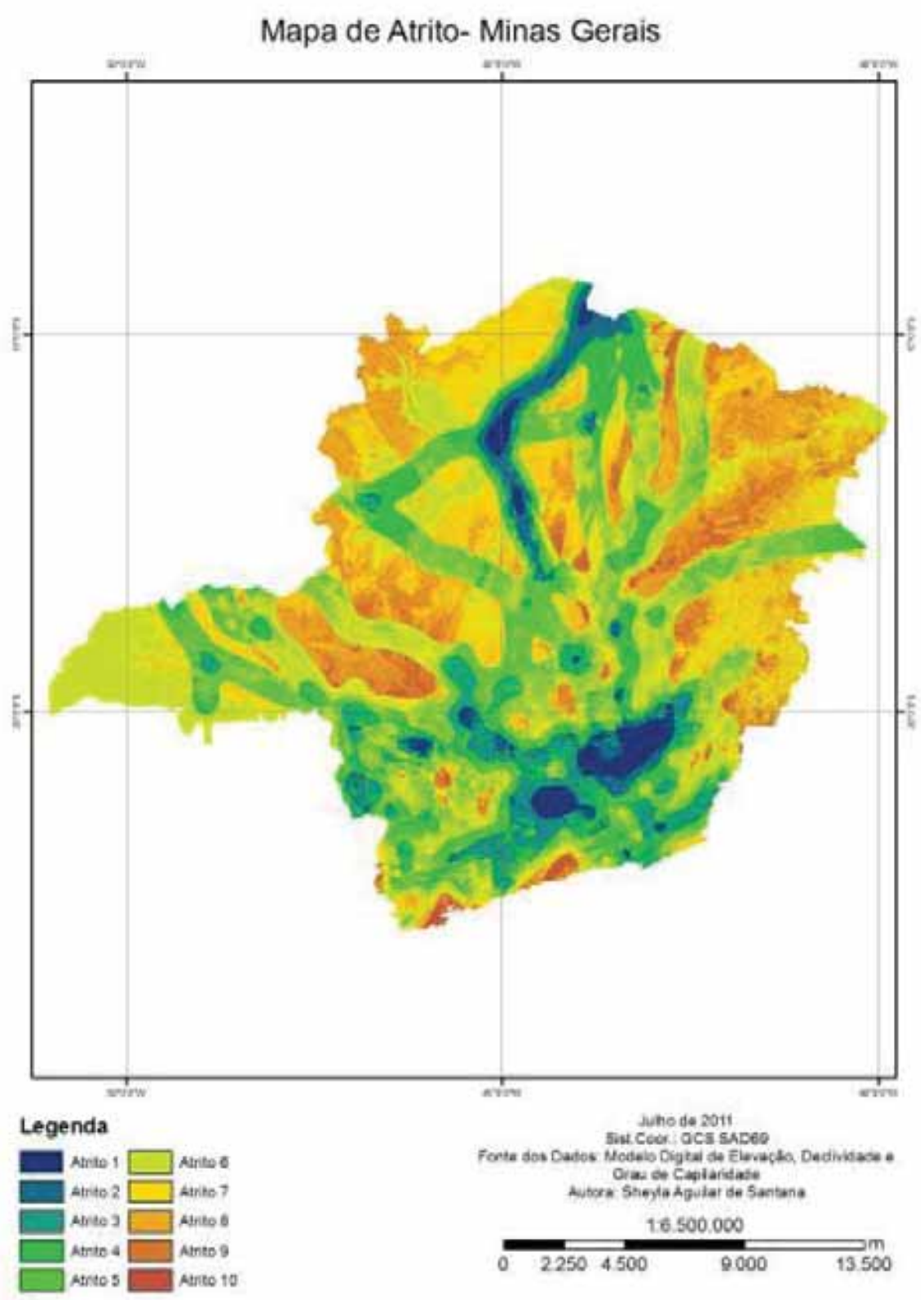

Fig. 2 – Map of friction of Minas Gerais.

The map was generated from friction variables:

- degree of capillarity: density and types of existing roads;

- topography: altimetry obstacles;
- slope: areas of easier access to.

The crossing of the maps generated the friction surface illustrated in Fig. 2.

Once obtained the values of PI and generated friction surface, it was possible to apply the model of complex Voronoi polygons.

Generating the areas of influence by the model Voronoi Complex from the map of friction and the mass of the points that correspond to the value of PI found from the existing network, we find that the network is well organized throughout the state, so that the most central areas of influence and has found, as shown in Fig. 3.

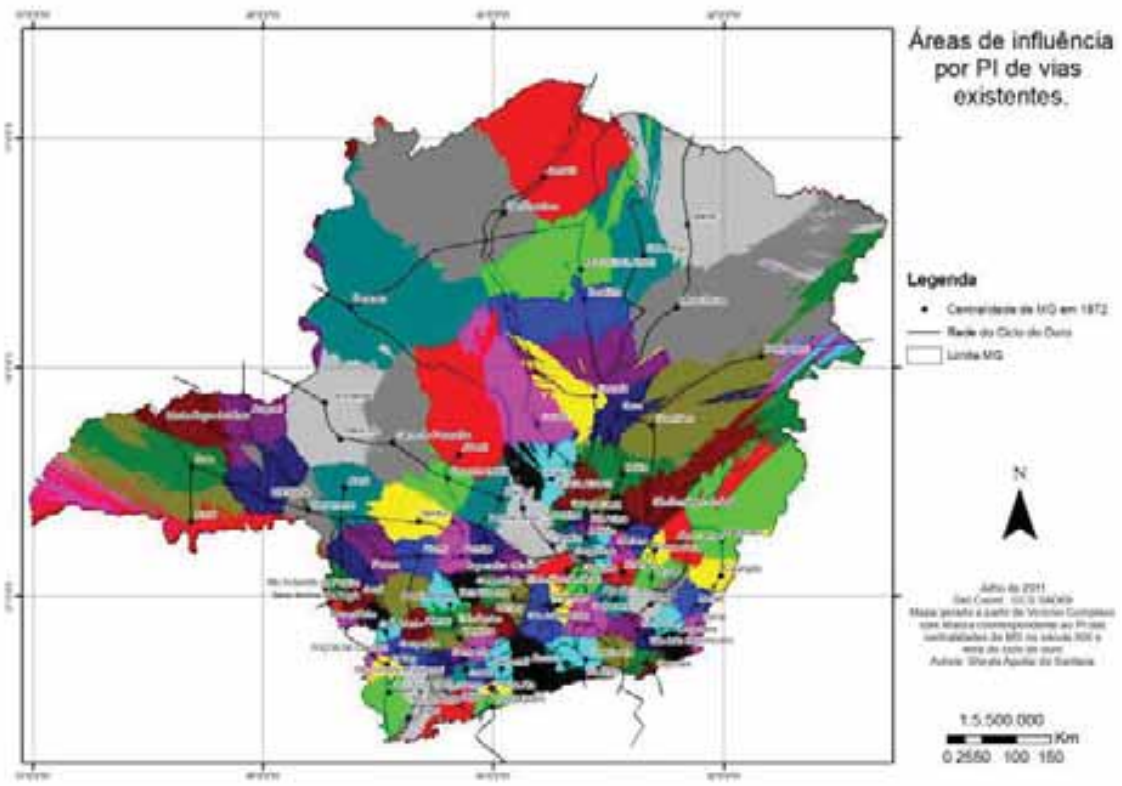

Fig. 3 – Map of hinterlands by interaction potential of existing routes in Gold Cycle.

Analysis of results

Results the map of potential interaction and area of influence of the centrality of the twentieth century which were generated in the work "The interaction potential model – studies of network centrality, accessibility and impedances within the RMBH" that was the product of 6 PDDI, developed by Professor Ana Clara Mourão Moura Marques and Danilo Marques developed in GIS Laboratory of School of Architecture of the UFMG at the

request of PDDI – Integrated Development Plan of the RMBH (Cedeplar) illustrated in Fig. 4. This map was important so we can then make a comparison to understand the area of influence and power of the central Nova Lima.

We realize that New Lima has a very important potential for interaction in the nineteenth century (Gold Cycle) and the fourth reference in terms of connectivity the existing network in the period. However, when we generate the map of the area of influence, we find that New Lima does not have a large area and the neighboring centralities end up meeting the demands of the region (Fig. 5).

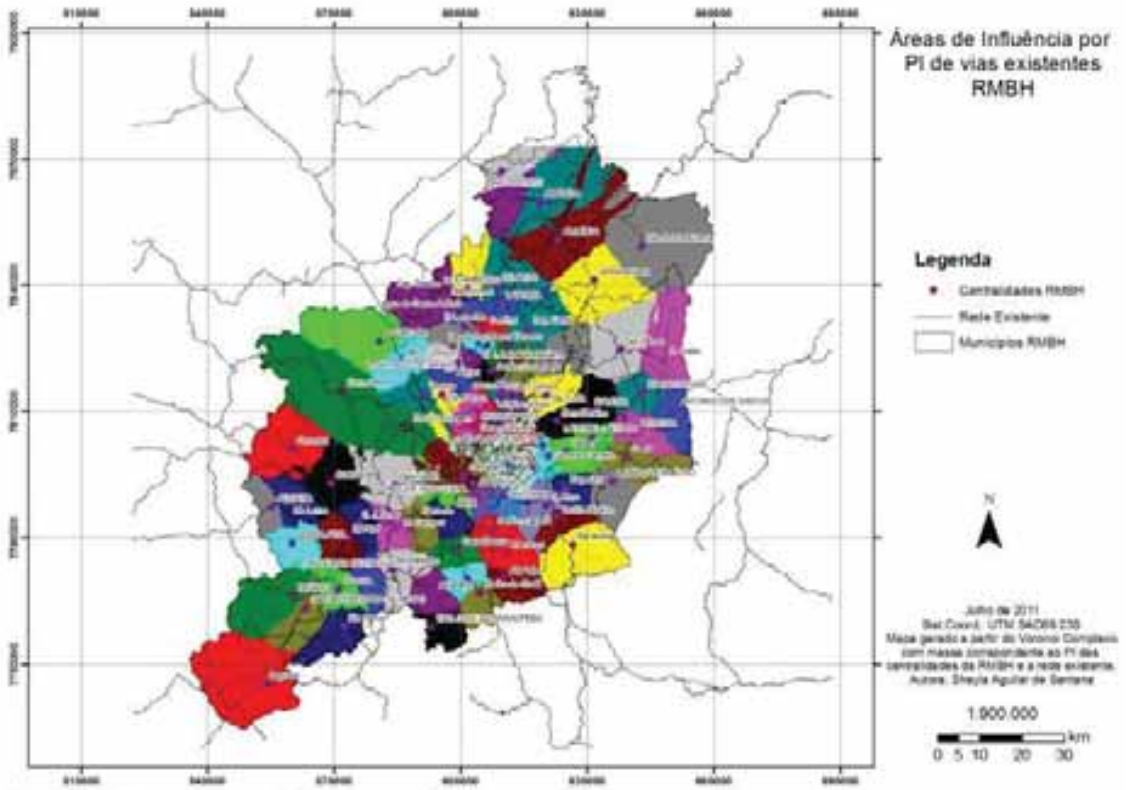

Fig. 4 – Map of areas for potential influence of interaction existing routes century.

It is clear that this is due to the constraints of urban form New Lima. Nova Lima is located in an area of great friction due to relief and steepness. New Lima is structured in two streams, the Crystals and Cardoso, bound by valleys and steep slopes. The stream of crystals, the principal, sectioned urban form for centuries and it developed at first in the directions north and west, in the narrow valley bounded by two watersheds. The terrain and land structure directing urban form that is implanted in a valley between land mine and the Morro Velho stream of crystals. The new jobs follow these directions to form and consolidate the city as typical of valleys and steep slopes, where the road connections are interconnected to a main axis to in-

duce the appearance of new areas that follow this same model city. Due to the roughness of the terrain, New Lima has a much localized area of influence serving only the needs posed by the central area of the city that was the place where he settled in the urban core process of implementing the company's Saint John in New Del Rey in Lima and areas around the mine mineral exploration.

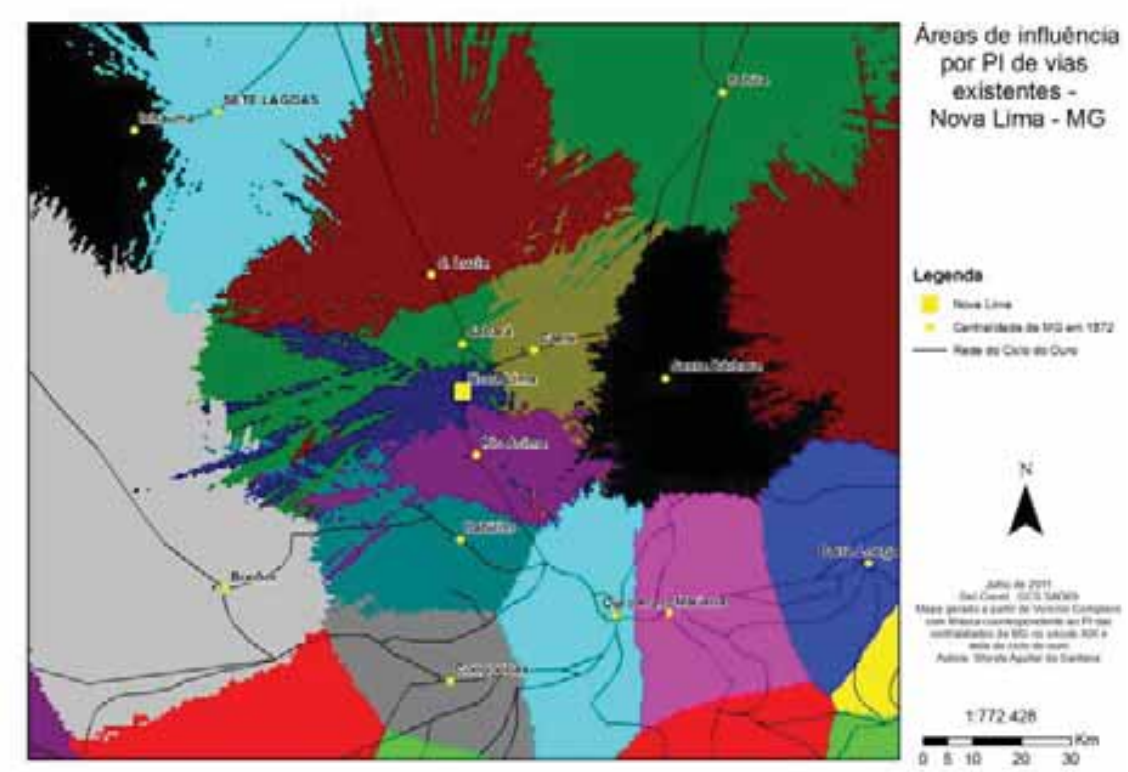

Fig. 5 – Map of Hinterlands by interaction potential of existing cycle routes gold, highlight New Lima.

In the current network, Nova Lima divides its influence within the city with two major locations: Six tracks and Garden Canada as shown in Fig. 6. To explain the shift from the influence of New Lima in the gold cycle to the present day, it is necessary to mention the three socioeconomic processes that established new local urban spatial structures. The first is between 1890 and 1939, characterized by the internationalization of the mining rights and underground mining of gold. The St. John del Rey Mining Company concentrates in the period, the ownership of numerous gold mines and much of the territory of the Upper Rio das Velhas. Neighborhoods and villages built by the company to its employees, following English standards of Victorian industrial companies, represents the product of the time. The second goes from 1939 to 1987, when economic development occurs in the region. In 1973 the first is bounded perimeter of the metropolitan region of

Belo Horizonte, with the inclusion of the municipality of Nova Lima in its area of influence. Since then, begins the conurbation areas bordering the city of Belo Horizonte and its expansion into the southern city of Nova Lima.

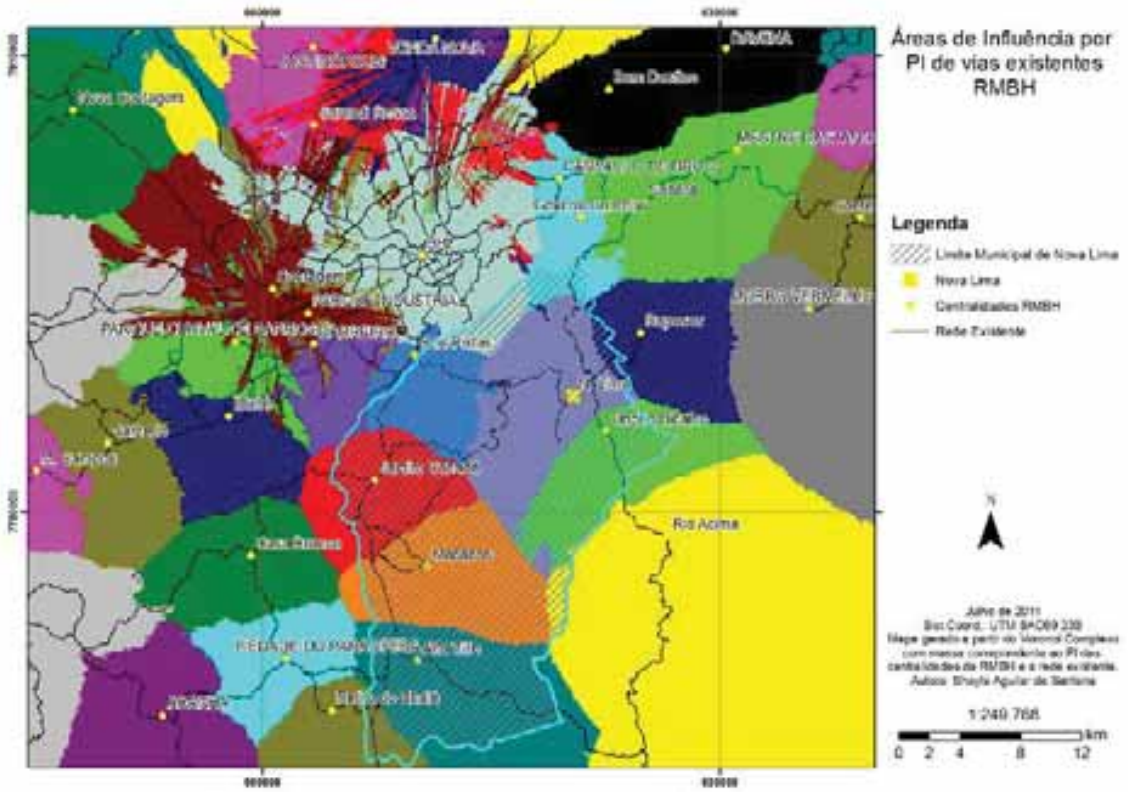

Fig. 6 – Map of hinterlands by interaction potential of existing routes in BHMA, highlighting places of Nova Lima

As a characteristic product of this period have been built neighborhoods for low-income population and gated communities and low-density neighborhoods, for layers of high and medium incomes, constructed in accordance with the standards contained in the countryside in the Federal Law 6766 to 1979. The last period is the time set between 1987 and 2011. This period is characterized by the decline of gold mining extraction, with the prevalence of iron ore exploration and expansion in the metropolitan area, with the occupation of the edges of cities. There is the inclusion of the environmental variable and this exerts significant influence on the land division. The typical product of this period is contained in or metropolitan edges, or along the many highways. It consists of condominiums and service areas and trade added to the urban area of Belo Horizonte, featuring typical fabric of the neighborhoods adjacent upright. The other products are found along the highways and are made up of large areas for specialized services and industry, as well as horizontal and gated residential neighborhoods from the

lower class. These products conformations and then explain the arrival of new localities who exercise power and influence within the territory of Nova Lima.

Conclusion

The theory of the emergence of urban centers from the routes of movement applies to the formation of urban spaces in question and this was used in defining the structure of urban corridors and vectors of urban settlement. These patterns, in turn, are a consequence of the application of certain ideological and artistic trends that influenced the architectural style, the use of coating material, which defined standards which make up a particular urban fabric (Tafuri, 1980).

Implementation of the model British industrialist in the city of Nova Lima and their standard of functionality resulting in the power of influence that New Lima has on the network of the nineteenth century. Despite presenting a great potential for interaction has always had activities and mineral extraction industry and thus have a large population and be a point of attraction for people of other places, the environmental constraints have made your stay more localized power due to difficulties of access. This power and influence area was changing over time, initially by increased capillary you should access and also with the inclusion of area of influence of the metropolitan region of Belo Horizonte. Then come the new central peripheral metropolitan area of Belo Horizonte that stands out for certain economic activities and features that establish the dynamic urban New Lima.

In the process of emergence of peripheral centrality in Greater Metropolitan Region of Belo Horizonte, you can check for new reactors and new settings in the production of urban space and permanence of socio-spatial control mechanisms in the occupation and use of urban space, allowing new locations to exercise power and influence within the existing network.

We decided to make the mass of the population points since the data was available more secure and standardized access we had. However, it is possible to feed the structured model with new data and perform new simulations, such as the weighting values of the mass movement of currencies and taxes. What we can say is that the model is structured enabling new inputs and outputs in terms of research interests through the use of GIS as a tool to support decision making.

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