Digital tools for urban development project.  
GIS application to PTAL assess and land valuation and traffic simulation for piazza renewal

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Abstract
Nowadays, the increasing density and expansion of urban areas make cities as complexes with massive activities. The new input of the upgrating urban functions brings uncertainty to the transformation of downtown. Previous to the urban design, to visualize and assess the land value, and evaluate the possible density of the urban development supported by the public transport, a GIS platform is required.

During the project of urban renewal design for the 13 km\textsuperscript{2} area of downtown Baotou (China), our GIS work as advanced territorial analysis tools, helps to provide the technological support for the decision of the urban spatial plan. The overall project site has been divided into a 20x20m grid, and in each cell a specific value for each factor deems relevant for this design stage was assigned. The factors include topographical morphology (sun exposure, elevation, slope or flat terrain), the positive ones are the accessibility, proximity to public transport stops, to waterfront or park, to attractive places (cultural and commercial facilities), and so on. While the traffic congestion, pollution and noise are considered as Negative factors. For some important urban facilities like shopping mall, theater or symbolic buildings the calculation of “visibility” is also a crucial factor. This process allows us to derive new information from the existing data and to analyze complex spatial relationships.

The public transport service provides great support for the future construction. Based on the capacity of public transport modals and the estimated frequency, the PTAL (Public Transport Accessibility Level) map, produced by GIS as well, reflects the acceptable passengers and hence shows the support to the density of the future development, the PTAL level is direct related to modal share and quantify the usage of private car. In this sense the 3D PTAL map can be regarded as the visualization of the city’s skyline. Vice versa, if the density estimated by

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PTAL could not meet the requirement of official plan the increase of certain capacity and frequency of public transport vehicles can be accordingly suggested.

In a word, the maps of land value and development density could help the urban plan to utilize the land portion or find suitable locations for main urban attractors in a more reasonable way.

In addition, in some cases the renewal design of some important urban areas requires the modification of traffic flows. Does the new project meet the necessary of urban livability in term of traffic generation? Or would it improve the organization of traffic flows? The traffic simulation could assess and visualize the effect. Our project for Piazza Santa Croce (Parma) demonstrates this solution.

Introduction

While in 1900 only 10% of the world's population lived in cities, nowadays the percentage has risen to 53 (although earth's surface occupied by the city remains at 2%) and by 2050 it will be about 75%.

Cities are growing fast and their overpopulation implies many different problems that need of rapid interventions in order to offer less traffic congestion, increasing of urban quality and more public livable spaces.

For a good strategic plan and urban planning project, digital tools like GIS and simulation software could be a great assistant instrument to analysis the existing problem, and to check the result of planning intervention, in order to find the better solution to plan future cities.

The following two study cases show GIS and simulation model as tools to support the redevelopment project inside the urban area in two different scales, respectively 13.3 km² and 1.2 hecter.

1. **Baotou case: GIS application to PTAL assess and land valuation**

   During the project of urban renewal design for Baotou (China), our GIS work helps to provide the technological support for the decision of the urban spatial plan.

   **Public transport project**

   Baotou is located in Inner Mongolia region and it is a famous industrial base of north China, which possess the greatest source of rare earth metals and it accounts for nearly half of the total production on earth.

   Baotou is composed by three parts, the historic city, the 1950s industrial city, and the XXI century new city (Fig.1). In the near future a large number of functions and facilities of municipal
management, culture, services will be moved from the 1950s industrial city to the XXI century new one.

Therefore, the redevelopment and revitalization of '50s industrial city became an urgent task that the municipal government is trying to resolve, and for this reason it has held the urban design competition.

The project area is located long two main streets which formed a “T-shape”: the horizontal street is 7.1 km long and the vertical one is 5.3 km. The total project area is 13.3 km².

Fig.1 - The project area in Baotou city master plan

The project forecasted the transformation of the area by higher constructive volumes. The challenge faced in this project was to define the most appropriate strategy for limit the impact of new building density in an already consolidated urban context.

In particular, our target is to find an appropriate mobility strategy to limit the increasing of vehicular generation related to the new functions.

Defining a sustainable mobility scenario is one of the most important issues of the project, which plays a vital role in the future development of the city.
Nowadays China is undergoing the rapid development of urbanization. Baotou urban population increased from 1.7 million in 2005 to 2.1 million in 2011, according to the forecast, it will reach 2.7 million by 2020. With this velocity, which kind of development should be appropriate for Baotou? the mode of Los Angeles: “car + low density + urban expansion” (which represents the common American cities) or like Tokyo and many European cities: “public transport + high density + compact city”?

Undoubtedly, the latter model is more suitable for the future Chinese cities that are densely populated and usually with insufficient energy and resources. Thanks to a stronger support of public transportation, the compact, organic and decentralized urban layout can help the future city development with less land occupation and less energy consumption.

Therefore, we proposed a pragmatic traffic strategy, with step-by-step program to support and to be adapted to urban development (Fig.2).

First step:
- from 3 to 5 years to construct BRT and DBL (Dedicated Bus Lanes) network.
- set BRT along the two main streets, with the distance between stops around 600-800 meters, and headway of about 8 minutes.

Second step:
- from 5 to 8 years to build metro lines along these two streets, with the distance between stops around 900-1200 meters and headway of 5 minutes.
**PTAL assess**

By using GIS application, we made the calculation of time-distance from the center (intersection of the two streets) of the 1950s industrial city to the XXI century new city and historic city. The digital result shows clearly the progress of the public transport service and the enlargement of the catchment area.
For example, today travel by car from the same origin – the center of ‘50s industrial city - to the center of XXI century new city takes 30 minutes and to historic city takes 45 minutes (Fig.3), while with BRT it would take only 20 minutes to arrive to the center of XXI century new city, serving 200,000 passengers (Fig.4). Eventually, the trip to the center of XXI century new city can be reduced in 10 minutes and to the historic city in 20 minutes by metro, serving 520,000 passenger (Fig.5).
Fig. 4 – Planning. BRT scenario.
The public transport service provides great support for the future construction. Based on the capacity of public transport modals and the estimated frequency, the PTAL (Public Transport Accessibility Level) map, produced by GIS as well, reflects the acceptable passengers and hence it shows the support to the density of the future development. The PTAL level is directly related to modal share and quantifies the usage of private car. That is, more public transport service and better quality means less car usage. Vice versa, if the density estimated by PTAL could not meet the requirement of official plan the increase of certain capacity and frequency of public transport vehicles can be accordingly suggested.

From the PTAL analysis, we can also clearly notice the upgrade of the public transport service. Along the two streets, the PTAL increased from average 2 to 4/5, that demonstrates that area
has strong public transport support for the public facilities, for instance, cinema, museum, shopping centers, office tower etc. Besides the support to public functions, the bigger PTAL means more possible construction density. In this sense the 3D PTAL map can be also regarded as the visualization of the city’s skyline (Fig.6-7).
Fig 6.7. – PTAL map: Existing situation and proposed scenario

**Land valuation**

We can provide a general map showing the land value by using a comprehensive estimation. The overall project site can be divided into a 20x20m grid, and in each cell a specific value for each factor deems relevant for this design stage was assigned. The factors include topographical morphology (sun exposure, elevation, slope or flat terrain), the positive ones like the accessibility, proximity to public transport stops, to waterfront or park, to attractive places (cultural and commercial facilities), and so on, and the negative ones like the traffic congestion, pollution and noise. Also the calculation of “visibility” is a crucial factor for some important urban facilities like shopping mall, theater or symbolic buildings (Fig. 8).

This process allows us to obtain new information from the existing data and to analyze complex spatial relationships.

The natural factor can be attributed with more value in the factor/weight system When it needs to observed in a smaller scale, depending on some specific locations and requirements, for instance, when a new residential district need to connect with the nearby green space or a famous lake.

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In a word, the maps of development density and land value could help the urban plan to utilize the land portion or to find suitable locations for main urban attractors in a more reasonable way.

Fig.8 Factors of land valuation
2. **Parma Case: Traffic simulation for piazza renewal**

Another kind of digital tools can be applied in smaller scale. In some projects the renewal design of some important urban areas requires the modification of traffic flows. Does the new project meet the necessary of urban livability in term of traffic generation? Or would it improve the organization of traffic flows? The traffic simulation could assess and visualize the effect. Our project for Santa Croce Piazza (Parma) demonstrates this solution.

In April 2009 through the Agency for Quality Architectural and Urban, the City of Parma held an ideas competition entitled "Public Rooms outdoors" for redevelopment of Santa Croce piazza, Pablo piazza and Mattarella piazza. The goal pursued by the municipal administration was to
promote the enhancement of public spaces as places of architectural and urban quality and to stimulate social meeting, aggregation and recreation.

The piazza redevelopment project
Coming from the north-west along the Via Emilia, this piazza represents the main gateway to the city of Parma and it is in perfect opposite position to the Vittorio Emanuele II piazza with Garibaldi piazza at center. With the demolition of the walls and the creation of the current system of bypass roads, the old gates of the city have seen gradually diminishing their identity to just become roundabouts and junctions for vehicular traffic. This phenomenon is particularly evident in the case of the Santa Croce piazza: it is just an island completely surrounded by a tree-lined driveway (Fig.10).
Despite having a size of about 1.2 hectare, the piazza is not able to assume the role of public space because its physical conformation.

Fig.10 – Existing situation of Santa Croce piazza, Parma
Interventions on the road network
The first intervention provides the complete pedestrianization of the central space through a reset of the total road network node moving all the vehicular maneuvers in the left part of the project area. The proposed solution aims to optimize and thinning the existing routes, preserving present relationships and the capacity of the roads (Fig.11-12).

Fig.11 Project plan
Micro-simulation model

The solution of road reconfiguration has been verified through a dynamic micro-simulation model because of the importance of the node in the system of urban mobility. The analysis took into consideration both the functional aspects about the best definition and regulation of traffic flows, that the quality of urban spaces by fostering a safer pedestrian accessibility.

The analysis of the status quo has been structured according to the following main activities:
- A general overview of the study area;
- A special study consisting of traffic surveys in order to acquire a complete knowledge about the distribution of current traffic flow during peak hours on an average weekday;
- Modeling with micro-dynamics simulation code of the current scenario (status quo) in conjunction with the calibration of the model.

The development of the proposed intervention has considered the following studies:
- The proposal of further needed improvements to ensure adequate solution to the mobility
issues of the new traffic junction;

After these steps and in the light of the results of simulation, we finally came to a reasoned
synthesis for the best guidelines to be proposed to manage the problem of vehicular traffic in
the project area.
The analysis about the functionality of the scenarios involves the implementation of a model of
dynamic behavioral micro-simulation through simulative code S-Paramics ® (manufactured by
SIAS Ltd and distributed in Italy by Systematica Srl), which has the purpose of simulating the
conditions of circulating current and the effectiveness of the different schemes of future project
by evaluating the functionality of the system (Fig.13).
The traffic study has a duple purpose: on the one hand it explains the results about the study
area traffic flows; on the other hand, it provides an orientation and a design solution about the
pattern of accessibility and circulation of the intersection.
Fig.13 - Micro-simulation model

The implementation process of the traffic pattern of the status quo has been structured according to the following activities:

- A detailed description of the current infrastructure, to include the existing public transport lines (by specifying the hierarchy of the different existing axes, their physical and functional characteristics, the presence of reduced lane section, the frequency of lateral interference and friction edge of the road, the presence of stop on the road, intersections and type of adjustment of the intersections thereof);
• Outlining the current demand for mobility in the area and then estimate the matrices Origin / Destination, to understand the demand for mobility for the study area;
• Assigning obtained traffic demand to the road network to allow the dynamic reconstruction of the most important phenomena of traffic related to the project area and the consequent identification of critical issues related to strong wasters and intense queuing phenomena;
• The process of calibration and validation of models of the status quo to ensure the reliability of the simulation tool that can be used for the analysis of design scenarios;
• The definition and implementation of design scenarios to reflect the accessibility layout chosen and to include the full range of needed improvements, for minimizing the impact of the added vehicular traffic generated by the project;
• The collection and study of the simulation results (performance indicators) to allow quantitative analysis of the level of efficiency and functionality of the proposed scenarios selected in a direct comparison between the current scenario and future scenarios.

In particular, the simulation code S-PARAMICS® offers the possibility of:

• Simulate the components of the traffic and congestion that may result and manage the results of the calculations carried out by means of a two-dimensional or three-dimensional representation in "real time";
• Have the choice of the optimal path functions for dynamic learning to integrate intelligent transport systems;
• Directly interface to instruments of automatic adjustment of the traffic, such as systems for the management of installations of traffic lights coordinated;
• Introduce the public transport systems and evaluate their influence on other components of traffic during the march and at bus stops, and simulations of traffic lights for the passage of public transport;
• Obtain statistical and graphics reports from the level of "comprehensive network" up to the level of the "individual driving the vehicle for a single moment", to provide very effective tools for evaluating the functionality and efficiency of a given scenario.

**Result of micro-simulation**

The analysis of the road traffic conditions has considered the evaluation of the results of the simulation traffic model, which are the network performance parameters that show quantitatively the functionality of the whole of the road network.
The modeling of the proposed solution has resulted an improvement over the existing situation, in particular, for Gramsci road that is an axis which currently exhibits strong congestion. Improvements can be quantified by a reduction in journey time of 41% of the node (morning peak hour), thereby reducing vehicular emissions of pollutants. It involves the installation of a system of coordinated traffic lights to allow the safe pedestrian crossings and to make the new public spaces easily accessible.