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REFLEXIONS IN THE CONSTRUCTION OF AN URBAN ENVIRONMENTAL MODEL: ENVIRONMENTAL PROBLEMS, YOUR INTERPRETATIONS BY LOCAL ACTORS AND THE IMPACTS VISUALIZATION.

Cristian G. Terreno

Architect Mg. Sc. in Environmental Urban Development Cristian Gabriel Terreno
Instituto del Ambiente Humano- Facultad de Architectura- Universidad Nacional de Córdoba- Argentina
Sol de Mayo 1212-5010-Córdoba- Argentina
0054-351-4872494- cterreno@hotmail.com

The accelerate process of urban growth of little cities that integrate metropolitan areas in Latin America produced important levels of environmental degradation and social segregation. Further, local government lack technical instrument to generate a sustainable development.
This paper explore, in the first part, the development of an integrated urban-ecological simulation modelling to assist municipal institutions and leaders in deciding the future planning policy for this cities category.
The method comprises the integration of disperse information in a Geographical Information Systems, to analyze the site carrying capacity und the impact assessment of urban growth with temporal trend analysis and specifically the changes of residential pattern. This will build on previous technical studies where environmental problems are defined and interlinked with a series of interviews with local actors involved in the process (policymaker, economical und social actors). From this integration is clear a general recognition of the most environmental problems, but not as part of their own systems of shares and not specialised in its own territory.
For this reason the structure of the proposed simulation is organized around the 3-Dimension visualization of these complex environmental process und the generation of different futures scenarios and the related impacts on the territory.
The second part of the paper presents an application of the model in Rio Ceballos (18.000 inhab. and urban growth rate around 5%.) in de meadows of the metropolitan area of Córdoba (1.200.000 ha), Argentina.

A ENVIRONMENTAL URBAN GROWTH MODEL

The need of a model

The ability to model and simulate diverse urban growth scenarios constitutes an important advance for land use change research. Large quantities of models emerged in the last decades (agents based models, micro simulation models and cellular automata) which show great potential and capability to represent the complexity of urban process (Pinto, 2007). Urban modelling still suffers from a lack of knowledge and understanding of physical and socio-economic drivers that contribute to the pattern and dynamics of urban areas.
The way to precisely evaluate environmental and social consequences of landscape tranformation is with an analytical hibryd framework of urban-ecological models that integrated:

- An interpretation model of quantitative and qualitative information to represent broad spectrum of values and opinions regarding the future of the process of driving forces and residents
- An environmental carrying capacity model,
- A model that spatially represents historical land occupation patterns and their tendency

The environmental analyses need to comprise the conflict of the social appropriation of the natural resources (Fernandez, 1999). The value and opinions regarding the future of urban growth of representatives groups and individuals of the local, state, and federal governments, the private sector, and non-governmental organizations, help to determine the types and extent of environmental problems Therefore, this model ensures that the study reflects local values about the process.

The environmental complexity will be discussed from pioneering planning concepts of land aptitude and compatibility recent like the one of potential of sustainability (Antequera,2005). A multi-criteria methodology allows the integration of these concepts, facilitated by the ongoing development of Geographical Information Systems.
Also, the new approach "sustainable development" will depend, upon improvements in our knowledge of the cause, chronology and impacts of the process of urbanization and driving force (Bozzano, 2009), as well as future possibilities. Dynamic spatial urban models provide an improved ability to assess future growth and to create planning scenarios, allowing us to explore the impacts of decisions that follow different urban planning and management policies. (Henriquez, 2007).
From this conceptual structure has been analyzed existing models with the same work scale and similar objectives. The direct use of this models was considered not viable by the high degree of uncertainty of the inputs as land developments policies oder regional and local economic forescasts. For this reason criteria and feasible methodology instruments of this models were taken up to a spefic model for the local context.

The proposed model

The proposed model has a target the urban sustainability. It will be built on a mesh of actors, environmental problems, history, land potentialities and possible futures and named Environmental Territorial Urban Model, organized in two following phases:
The **first phase** starts with the organization of the information about environmental problems, in order to define the problems with precision and to systematize information for the model database. Here the task is collecting information of different sources, in many instances is necessary the digitalization and finally the information is homologated. Moreover, it is necessary the social validation of environmental problems: a series of depth interviews with key local actors, allows confirming or not this problems and delving deeply into their understanding. With these elements it is possible to develop the description and explanation of the urban growth process to define the Current Situation.
Through the analysis of territory's carrying capacity using multicriteaia methodology is defined the potential of sustainability and the restrictions for further growth. Beside is analized the historical development of the occupation to explain the forms of occupation and appropriation and to define patterns.
The selected analysis scale is that of urban sector, because exist previous studies to local level and microregional, but not in this scale. Also this scale is seen as more conducive to recognize environmental problems and possible solutions.
The triangulation of social validated environmental problems, historical occupation process and territory carryng capacity, allows to define synergies, potentialities and restrictions for a sustainable urban development. Thus is shape the initial state for the next phase: future scenarios.
In **the second phase** the model examine through a built-out model three futures development scenarios. In orders to generate these futures scenarios urban land patterns dynamics can be "simulated" taking into in account the initial state of the system, the participating factors for land dynamics, and the rule that produce the dynamics of the evolution of actual cities.(Gallopin, 2004)

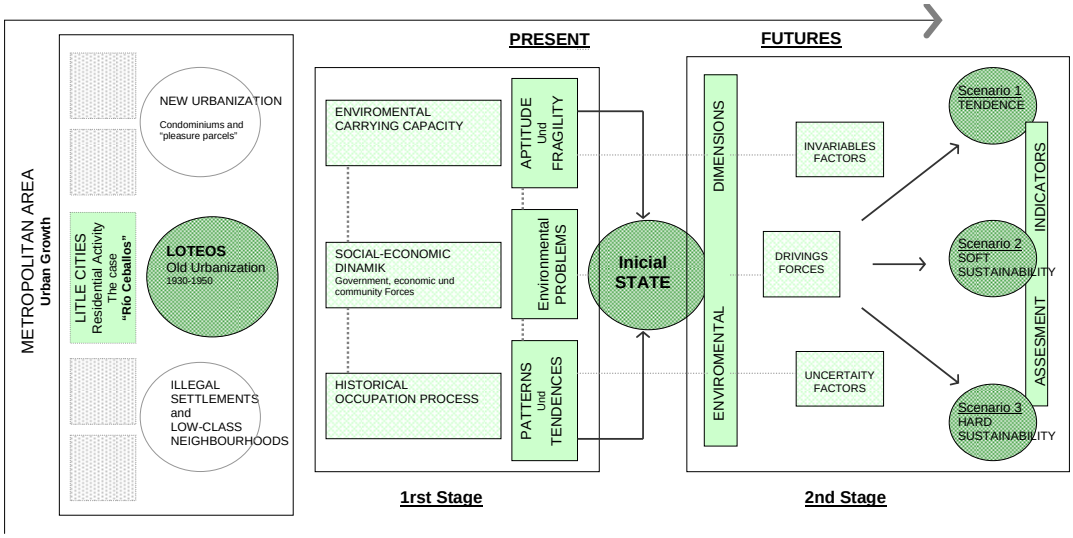

Fig.1 Methodology: Model Synthesis

Three scenarios were selected, that describe the likely range of possible changes. Scenarios A and C represent the extremes. Scenario **A** assumes the continuity **"status quo**" of the actual tendency in the metropolitan areas (social and economic fragmentation, spatial dispersions, economic speculative forces as single driving force, low investment, and

low policy regulation). This scenario is expected to result in the most change in land use and the greatest impacts, although with higher potential economic benefits in the short time. Scenario **C**, the "conservative scenario" follow the concept of **hard sustainability** (Fernandez, 1999) (social community organization, long term local economic development, high investment, high policy regulation). This scenario is expected to produce the lowest environmental impact and least landscape change. Scenario **B** forms a mid-point, with a realistic mix of possible changes between the tendency and the total change. In the concept of **soft sustainability** (Fernandez, 1999) the key word is development. These three scenarios provide a range of incremental policy changes, serving as basis for comparative policy analysis. The projected configuration for each scenario is unique, varying in the extent, direction, and pattern of growth. Finally, the model asses the different impact of the future scenarios on a suite of environmental indicators in relation with the local environmental problems. (Venturini, 2002)

Model in action

The study areas

The city of Córdoba, capital of the Province which the same name, is located in middle Argentine between the rich Pampa plain and the first foothills to the Andes and experienced a rapid growth since the 1950s thus becomes the second largest metropolitan area in this country with more than 1.5 million people. The growth characteristics have changed over the last two decades: From a large central city growth has come to an explosive growth of small towns in the metropolitan area. In this area there are more than 20 localities between 50,000 and 2,000 inhabitants. These were linked to agricultural production, mining or tourist activity, and today became dormitory towns, with consequent problems of mobility, lack of infrastructure, weak local governments and the arised environmental impacts.
For the application of the model were selected three representative cases:

- Río Ceballos in the North West metropolitan area an the food hills Sierras Chicas
- Punilla Sur Villages (San Antonio de Arredondo- Majuc Sumá- Tala Huasi- Icho Cruz) located along the San Antonio river an the West metropolitan area (Avila, 2006)
- Toledo a litle town in the south metropolitan area on the Pampa plain.

In this paper was presented the Río Ceballos (31º 10' 16.3" South and 64º 31' 08,8" West), a little city located 30 km from Córdoba city connected by highway with it. The current urban populations of Rio Ceballos is 18.000 inh. with a growth rate over 5 %.(INDEC, 2004) The city and its surrounding areas are blessed with great natural beauty: hills, forests, river, streams and an artificial lake in the proximity. The even limited extent of development has left the Río Ceballos region with much open space, offering a wide range of recreational opportunities for residents and visitors. A strong connection with nature remains vital aspect of life in Río Ceballos, attracting day tourists, in search of an alternative to the faster-paced and more congested capital city, Córdoba.
Río Ceballos have transited four stages of social-economic development:

a- founded in 1900 as summer tourist place for high-income groups
b- Since 1945 change to popular social tourist place for the new industrial worker groups
c- Since 1970 decline of tourist activity as consequence of impoverishment of middle- and low income groups
d- Since 1980 metropolitan residential place with a height rate of urban growth (between 3.2 and 5.2%) and emergent environmental and social problems. The new direct highway connection to Córdoba Capital since1996 hat intensified this process. In the last years, the general economic growth affects the cities: Land sales and new buildings have been high increasing.

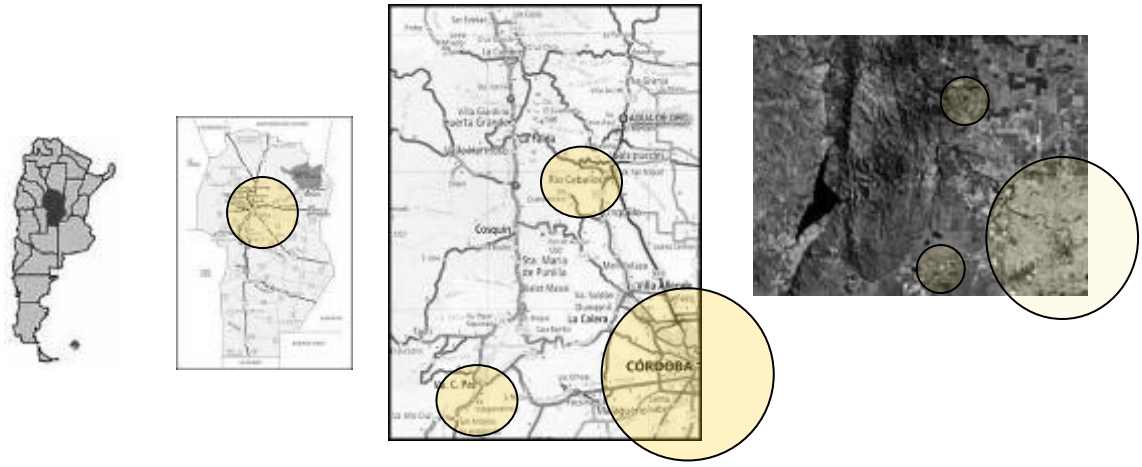

Fig.2 Localization of the study area

The 95 % of urban land was legal created between 1920 and 1950 and is only in the central areas occupied. Today about 80% of urban land is low occupied or vacant and without an adequate layout, whitout infrastructure and whitout public open place. The actually occupation is spatial very disperse and social fragmented. Moreover, in a previous study (Foglia, 2000) a modelling approach had been developed and applied for the entire city of Río Ceballos to estimate environmental problems and indicators, but ist general and with low effectively.
This study examined 10 "**loteos**" (legal urbanization unit) in three differents areas. The selection was done with criteria of representativeness: environmental (critical areas- steep slopes, water recarge areas, natural forest, etc.), social (permanent residents and new arrivals, high income groups- population under poverty line) and historical occupation process (never occupied, occupied and abandoned, recovered and for sale).

The aplication in the case study Río Ceballos

Social and economic information about Rio Ceballos dynamic was explained in previous study (Foglia, 2000). This information was crossed with a series of interviews and discussions with local and regional government-, mark- and community- members, with direct connection to the urban residential growth and the environmental consequences. The qualitative interpretation of this information result in a table of environmental problems, that ensures that the study reflects local values.

PARAMETER	ENVIROMENTAL PROBLEMS
Productivity	Acceleration of economy around residential activity
	High demand of urban land for buildings
	High increase urban land price
	High potential increase of urban infrastructure
Natural Environment	Drink water scarcity
	Ground and surface Water contamination because not waster water treatment
	Destruction of natural habitat trough new building and garden arrangement. Visual obstruction. Loss of sense of place
Economical Fragmentation Habitability	Dormitory city
	Inequitable infrastructure distribution
	Increase social and spatial fragmentation and segregation
	Scarcity of public space and community equipment
Gobernability	Powerless legal frame
	Low local and regional political management
	Absence environmental policies

Fig.3- Environmental Problems Classification

To define the **carrying capacity** was used: Existing data layers as topographical maps (1:50,000) were attained from the Military Geographic Institute and details maps (1:5.000) of the local Water Company.The vector-based soils data was compiled from a variety of sources including geologic maps, field data of the local water Company and academics studies. Other physical environmental parameters are modeled based on the contour data o digitalized from aerial photographs and satellite information (vegetation).

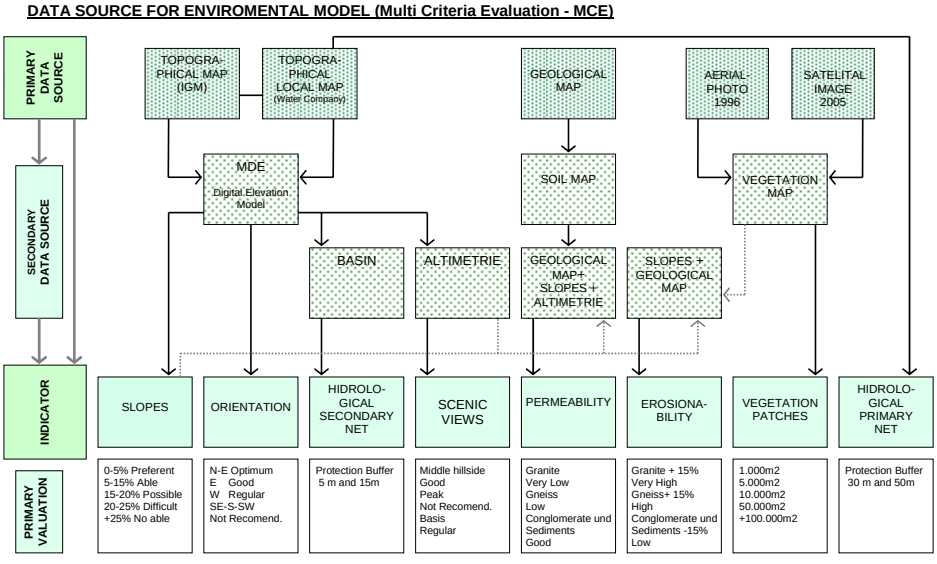

Fig.4- Data structure for environmental aptitude model

A raster data structure was selected for digital elevation and environmental modeling because of the ease and simplicity of algorithm implementation (Felicisimo,1996) and the availability of spatial modelling tools for the subsequent analysis of raster-based. In the choice of an appropriate scale was considered that a 1 m grid cell resolution is adequate for the urbanization lots aptitude evaluation. The lots areas are between 300m2 and 1000m2.
The Digital Elevation Model was built slightly larger than the study areas to prevent erroneous estimates in physical environmental parameters. Hydrological, slopes, orientation models was obtained trough module within ArcGis9 (ESRI). With this information in raster format, previously standardised with a value of 1 to 10 (minimum-maximum) and weight through Saaty hierarchical method and using the command ArcGis 9 Mac Calculator, will produced environmental aptitude maps, first for the studies areas und then pro lot of each urbanization.
The historical occupation changes in the specific study areas are determined through the digital interpretation of aerial photographs from 1970 (scale1:5.000), 1996 (1:5.000), 2005 (1:5.000). These photographs were scanned and geo-referenced in a common Universal Transverse Mercator (UTM) coordinate system.Occupation polygons were interpreted and digitalized with GIS ArcGis 9 and interpretations were verified with field visits. A shape data structure was selected for and the minimum mapping area was derived from the spatial resolution of the aerial photographs and reference maps.

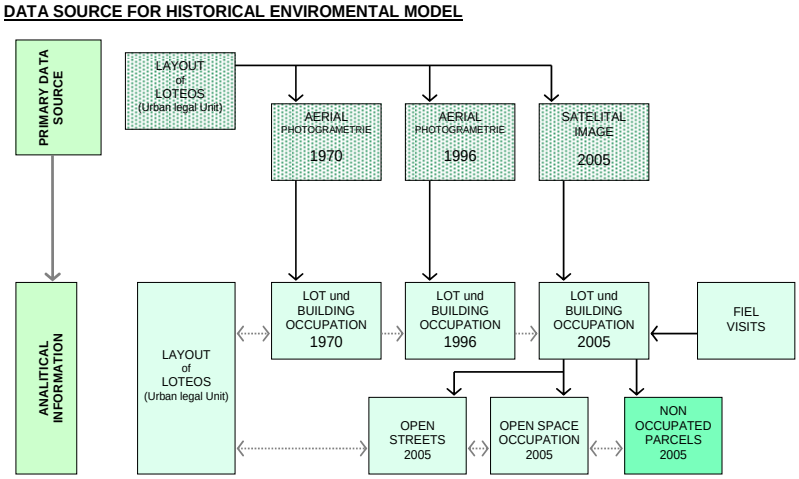

Fig.5- Data structure for historical occupation model

The scenarios are defined by seven strategically important variables:

- Economic dynamic reflect in type of activities
- Spatial distribution of activities and materialization of buildings
- Mobility
- Public policies that guide future land use.
- Open Space and Natural areas conservation
- The amount of money the government has available for spending on public projects and investments.

Among the many factors that will shape the future of the city, these variables represent the most important sources of uncertainty. For example, the level of future economic growth in the city will depend heavily in the performance of the argentine economy and global markets and development of the metropolitan city. Spatial distribution is the over coming another variables, and work as landscape result of the process.
Particularly, conservation of open space and natural areas is very important, because in this old urbanization types “loteos” are scarce and is very important to maintain the the environmental quality of the city and surroundings.
The choice of public policies is more directly within the control of the city. Yet the political process could produce any one of numerous possible public policy choices.
The amount of money available for public investments and policy implementation depends highly upon choices made at the federal and state levels. The population growth projections assumes a continuation of last decades growth rates (averages 4.2% per year).(INDEC, 2004) This level of growth assumes a demand for home in the average 3.5 persons pro dwelling.
The projection adopts a recommended time lapse of 30 years for environmental scenarios study (Gallopín, 2004)
The analysis of different scenarios allows to test and study the consequences of different possible futures for the city.
The demographic projections, and the seven variable and his alternatives has been combined to create the three in model proposed possible scenarios (Tendency, Soft and Hard Sustainability) for the analysis. The allocations are based in spatial patterns and the previous variable set.
The consequences of each alternative future are assessed using a series of interlinked Indicator come out of the selected of the most important problem parameters, and very easy to quantify and evaluate. (Venturini, 2002)

Par example: Assessing the hydrological impacts of the urbanization requires two indicators: one for the drink water demands and a second indicator for groundwater recharge (Waster water treatment). The impacts on terrestrial ecology are estimated through the use of indicators that valuates changes to different vegetation and habitat categories, and this observation. In relation with then, the Changes in the visual landscape are estimated using a indicator of visual quality of the landscape as loss on visual point-lines. The social economic parameters are valuate trough the different price of parcel pro m2 in the studies areas and social integration trough open space areas y number of publics institutions (education, sanitary, security, etc.) At last, the mobility will evaluate trough investment in roads, pedestrian and public transport.

PARAMETER	INDICATOR	VALUE
Infrastructure	Drink Water	m3
	Wastewater Treatment	Type
Natural Environment	Soil Absorption	Area %
	Vegetation clear	Area %
	Visual obstruction	ml
Economical Fragmentation	Urban parcel price	$/m2
Social Integration	Open Space	m2 pro resid.
	Public institutions	m2 pro resid.
Mobility	Public investment in roads	ml o $
	Public investment in pedestrian roads	ml o $
	Existents of public transportation	Line-resident

Fig.6- Asses Indicator of future scenarios

Adjustments during the implementation

With the results of the first phase of the mode in hand was taked up contact with local stakeholders to build the plot of the future scenarios. There was detected the difficulty to understand the mapping language and the need to adjust this variable for greater effectiveness of the model in its second phase. Therefore it is decided to incorporate the visualization as cross-cutting concept for the model. Landscape visualization techniques enable the qualitative interpretation of landscapes and can be powerful decision support tools in landscape planning.Landscape visualization is often used for communicating complex information about the state of a landscape and how it might change, and can be particularly effective when communicating to community groups and policymakers (Steinitz, 2005).Visualization techniques are fairly new and have recently seen an increase in use in testing scenarios, such as “What will the landscape look like another this planning policy” or “How will this development impact upon the character of the landscape?. Landscape visualization models try to mimic the features of real landscapes and may be three-dimensional and/or dynamic, showing change over time. Significant attention in landscape visualization has focussed on realism and effective human–computer interaction in a landscape planning context. Several studies have demonstrated the value of landscape visualization in a range of areas including forestry, landscape ecology (Velasco, 2000) and urban planning (Nogués Bravo, 2000).
Starting from this conceptualization, the three future scenarios, the growth and their distributions in space and the associated impacts evaluation were represented in the model on a digital elevation model and displayed in three dimensions.

The results

The results of each scenario show:
Scenario A Tendency: new growth patterns in the form of disperse expansion, ever more distant from the city centre (leap-frog), and in which the gravitational effect of access routes is noteworthy. The physical fragmentation of the urban landscape is closely connected with the social fragmentation of the corresponding areas, since higher income groups tend to be located at increasing distances from the city centre in urban patches with the high environmental quality and low income in the areas without infrastructure and environmental conflict areas. The projected tendency of this spatial patterns of urban proof the hypothetic sustainability critical future.
Scenario B Soft Sustainability: more compact growth patterns, nearer urban city centre improved vehicle circulation, but does not solve social fragmentation. Mitigation measures can reduce the impact of some environmental factors (p.e. Wasterwater, vegetation) but in others ist very low (p.e.Water consum, open space, road investment). The diferent environmental carrying capacity of the analized area show a greater or lesser impact of this scenario. Therefore it is proposed a carrying capacity zoning, where some environmental problems can be solved from the guidelines from this scenario in the short and medium term.
Scenario C Hard Sustainability: compact growth patterns, spatial urban continuity, open space und community infrastructure, privilege of pedestrian mobility, change household consumption patterns generate urban continuity, a sense of community and low environmental impact. The economic costs and the process of behavior change required to

think this proposal in the medium and long term, although some aspects will be addressed in the short term to prevent a environmental crisis, especially in low-carrying capacity araes and in some factors as water consum.
Therefore, it is recommended a participatory management process, where be work with areas, environmental problems, time and actors related by priorities for a sustainable future.

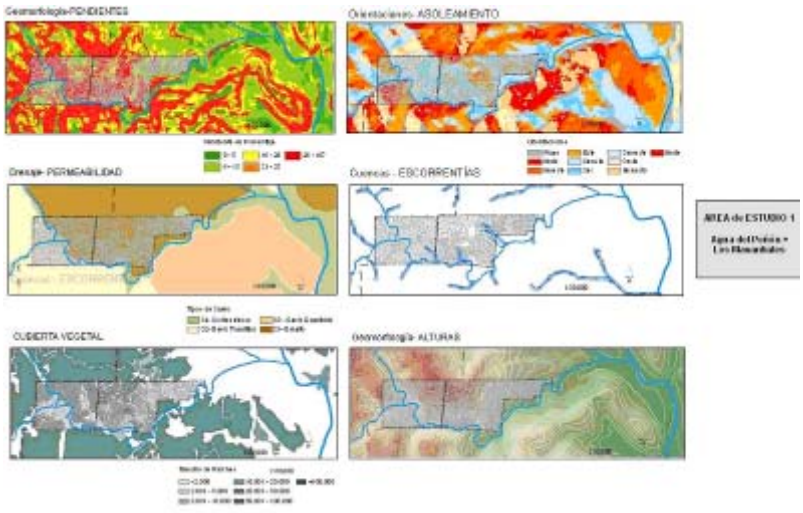

Fig.7- Environmental aptitude model: information for muti criteria evaluation

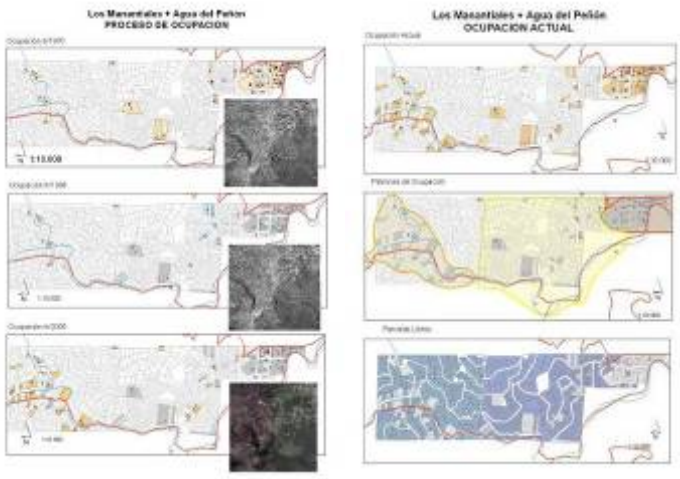

Fig.8- Historical Ocupation model und pattern

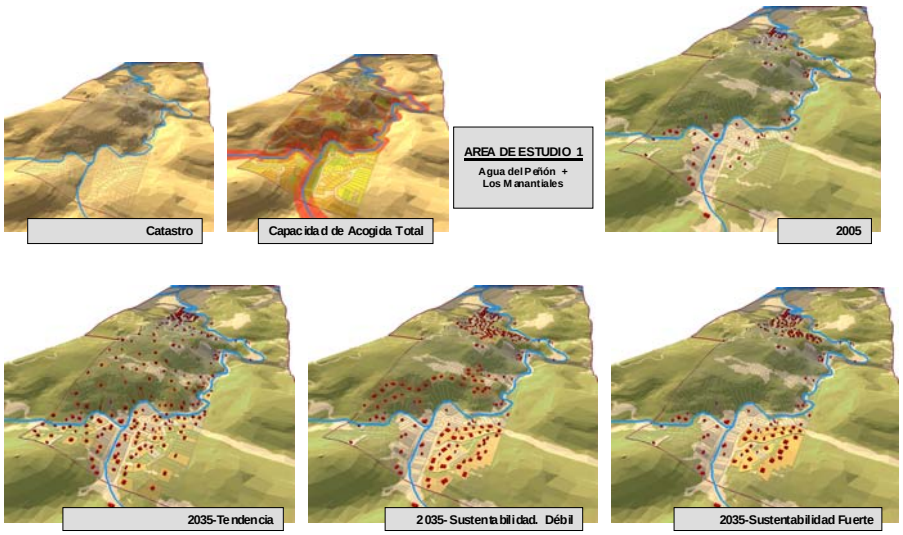

Fig.9- Futures und alternatives scenarios: Ocupation

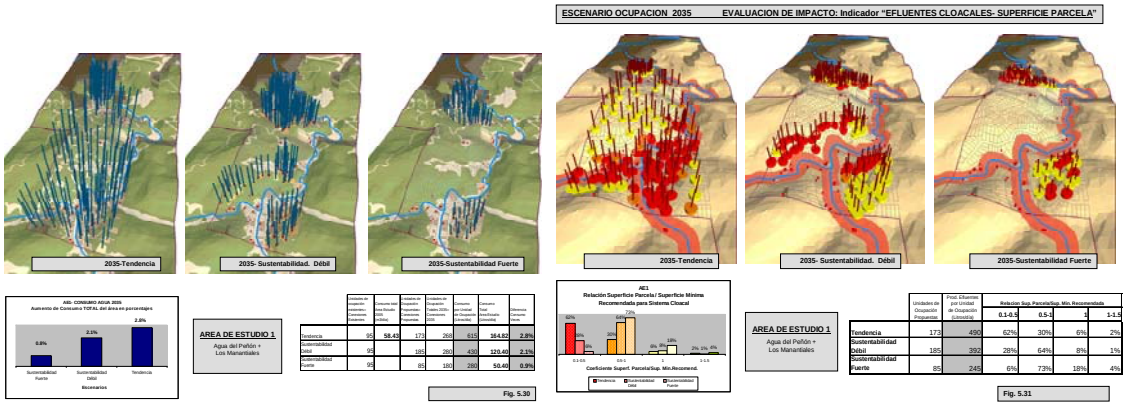

Fig.10- Futures und alternatives scenarios: Impact evaluation

REFLEXIONS ABOUT THE PROPOSED MODEL

Modelling and information

The application and performance of the model is still limited by the quality and scope of the data need for their parameterization. In the last years exist in Latin America few information sources about social and physical aspect, but it's not systematic. Also, critical in the description, analysis, and modelling of urban form and his change was spatial metrics. It is necessary for more effectively forther studies, a necessary homologation of information data source und networks for information exchange.

Modelling and environmental problems valuation

An important request for the validation of the model is the integration of the environmental problems, identified in previous research, with a series of depth interview and opinion polls developed to local actors involved in the problems. From this integration is detected a clear reconignition by the stakeholders and general public of the most environmental problems at a level of generality, both procedural and spatial, but not in their own environment and not as a result of their daily practice.
These results lead to checking the concept of sustainability and the models as representation of the environmental complexity. H.Hahn proposed that the basis for sustainable concepts for the external environment is a better understarding of the inner world, the internal environment of humans – the inherent laws of human's inner environment (Hahn, 2005). This requires interaction with disciplines as human ethology, behavoir sciencies and environmental psicology can give relevant insight for a better understanding of the deeper subjetctive (emotional, social, spritual) conditions of man-nature relationship. This interaction will be able to check the model without quitting his strong theoretical foundations, objective information and judgment, to built a better relation between local actors-model. The incorporation of the Value Sensitive Design methodology in the model Urbansim is an example of the potentialities of this interaction. Value Sensitive Design is a theoretically grounded approach to the design of technology that seeks to account for human values in a principled and comprehensive manner throughout the design process. That help shape the design of UrbanSim to better support the democratic process, as well as to be responsive to the values held by different stakeholders and the conflicts among them. (Friedman, 2008).
In this way, the interaction between the model structure and the subjects field, closer to the theorical ground concept of territory and environment as dialectic hybrids of natural and social basis, (Santos, 1996) will allow developing, for this research, first the improvement of the interphase model-actors, as much in the operation with them (for example at the construction of futures) as in the interpretation of results (indicators of environmental impact); second the deepening of the spatialization and the visualization as axis to understand the relations between the external manifestations of the environmental problems (phenosystem) and their generative processes (cryptosystem) (Gonzalez Bernaldez, 1981); finally the model transformation in a didactic instrument for the citizenship construction implicated in sustainability horizons.

Modelling and the planning process

In Argentina, as in the great part of the Latin American countries, planning has a low impact in the public policies and the decision makers. (Karol, 2003). And so that is a split between theory, planning and policy. This raises the question in the academic field about the relationships between theoretical constructs and their impact on reality, as well as on ways to make policies, and the policy makers assessment about the knowledge developed by academics. These latter issues are beyond the scope of this work, but the first are key to evaluating the model rom there continue their adjustment and implementation.
One of the critical issues lie in the differences between the times of planning and policy: the local political logic, thinks in periods of four years, which is the duration of most of the political mandates. During that time should be solve the problems that arise everyday, in theway to give positive responses to citizens to ensure their future candidacy and thus remain within the political system. Planning for the environmental sustainability requires long-term thinking; so most of the models when dealing with future 30 years periodos, as was the case of the proposed model.This time frame is necessary for the planner and is regarded as useless or simply far away and with some semblance of utopia by the politicymakers. This political logic is manifested similarly in actors linked to economy, where local and regional economic instability, leads to think in the short term and in the solution of local or global market current problems.
The strategies to bridge the gap from theory and planning to policy, may arise from:

- think faster operational models
- That the models allow the visualization of solution paths for the short, medium and long term. in this way may appear nearby points of interest to political timing (short term) and prospects for the medium as a political strategy for continuity.
- To assess specific policies to implement or already implemented
- Deepening the educational dimension of models as tools for review established social values that pug up the construction of a sustainable future, not only the policiesmakers but also in different social groups. Therefore should be distinguished between those actors who can promote processes of change, those who are most prone to the status quo and the indifferent positions, to propose different strategies for each.

The future of the model

From these reflections is proposed to adjust the model:

- The internal structure review to allow operation with different levels of complexity: so the model can address immediate problems with a little data amount and deliver results in short term, and in parallel, the problems mesh is processed in the model with the necessary data and more time for results, adjustments and validation.In addition it appears as necessary the time degree in the future scenarios, in order to present images of future in short, medium and long term (5, 15 and 30), as shown in similar models. (Pinto, 2007)
- Build an interface between models and social actors to enable them to operate on the model, for example variables elections in the construction of scenarios, such as land use location, infrastructure extension, roads opening, green areas- community facilities incorporation, lot internal surface usage. Thus can enhance the results of three-dimensional images produced by the model. References are the experiences that are developed with models such as INDEX or Urbansim. (Pinto, 2007)

In this way , the three major roles for land use model proposed by Couclelis, in order to increase their mission to support plannig: scenario writing (what may be), visoning (What should be) and storytelling (what could be) (Couclelis,2005), may enhance because

- will consolidate the model internal logic structure through different complexity levels, gradation of time, interface improvement.
- will increase the integration of community interests and values in the operation of the model in order to try major engagement an to reach broad concensus on strategic matters (scenario visoning)
- Storytelling can hepl to compare future desired and feared evolutions, in realistic terms that could effectively assist the planning process.

In this way is the future model development. To achieve these objectives will seek integration into a multidisciplinary research structure.

CONCLUSIONS

This paper aimed to briefly present the construction and implementation of an urban environmental model in the Latin American context. The goal was to reflect upon this experience, open the way to linking with similar cases and provide inputs for deepening developments.
The fast growth Latinamericas's metropolitan cities and the serious environmental problems generated justifies the need for models that contribute to the urban management of these processes. Moreover, the particular spatial and social

structure, the the paradoxical social valuation of environmental problems and the special relationship between planning and policy, led to construct a specific model from different investigated sources.
It is necessary for more effectively forther model applications a necessary information data source homologation and networks for information exchange, a more complex internal model structure and a better interface between model and actors for a more effective communication and that facilitates the participation.
Finally, the experience developed with the model and the prospects for deepening displayed here, projects the model as an effective tool for urban environmental planning and to learn to think posible sustainable futures.

ACKNOWLEDGEMENTS

This article is part of the main author magister thesis in Environmental Management Urban Development – Maestría G.A.D.U.- Facultad de Arquitectura, Urbanismo y Diseño Universidad Nacional de Córdoba-Argentina and with a Postgraduate Award scholarship of Secretaría de Ciencia y Técnica- Universidad Nacional de Córdoba- Argentina.

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