

## THE RURAL-URBAN INTERFACE, A TERRITORIAL APPROACH TO THE SPATIAL FRAGMENTATION OF URBAN SPRAWL

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### Abstract

In the article influences of the urbanisation of outskirts of big cities in Mexico on natural environment as a whole and on individual elements thereof are analysed, in view of degradation as well as development factors. The so-called contact zone is hereby pointed out, including all its urbanisation changes. Conclusions are based on a qualitative evaluation and the so-called contact-spatial reclassification.

**Key words:** Mexico, urbanisation, peri-urban space, ecology, agglomeration, central region.

### INTRODUCTION

Regional urbanization trends at the peri-urban space of large metropolis –just like Mexico City- are the cause of some impacts on natural resources and on ecological value areas that, unlike those generated by great agglomerations, are barely known.

*Urban sprawl* –unlike concentrated urbanization of fordist period, reaches great number of small and rural cities in big extensions, whereas its effects appear equally fragmented and dispersed. Only when it is analyzed as a whole, their real magnitude appears; however, the interest is mostly centered on big agglomerations and on intermediate cities, leaving neglected what happens on these small rural towns.

At the present time, neither general theory nor accepted paradigms about societies behavior on changing biosphere exists (Kates, et al, 1990:5). In addition, we face a frequent theoretical and methodological separation between "environmental" and "social" focuses in the disciplines related to environment (Head, 2000:3). While in social disciplines country-town opposition model prevails, which leads to distinguish both words as separated fields –

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even for knowledge- (Veltz, 1999:13), in physical sciences, a difficulty to incorporate into the analysis of change on natural landscape the learning of "the social thing" prevails.

In this document we propose the notion of *environment-society* interface in order to articulate the explanations that we have separated until today. For that, we examine the theoretical background of three disciplines –two of physical order and one social-, to define a unified own methodology. Secondly, that methodology is applied to the Central Region. The preliminary outcomes allow to distinguish the areas where urban expansion on rural environment overlaps the most valued environmental areas with great accuracy and order.

We have had an unexpected outcome but which is very important for planning: when urban sprawl is analyzed separate, that is to say, from a socioeconomic point of view, the *hinterland* of the city-region grasps between 100 and 120 kilometers around Mexico City – the main central place- and the principal dynamics is found *inside* the regional belt. When the physical-environmental factors are introduced, the dynamics of physical-social interrelation goes beyond the belt and goes into the distant peri-urban space. The importance of this outcome relates mainly to the fact that, at the moment, no public policy, neither those related to the urban subject nor those focused on environment, recognizes the geographical extent of this field.

We name the identified areas as *contact spaces* and they constitute a first necessary step to perform more accurate local studies as well as a way to define specific environmental protection policies.

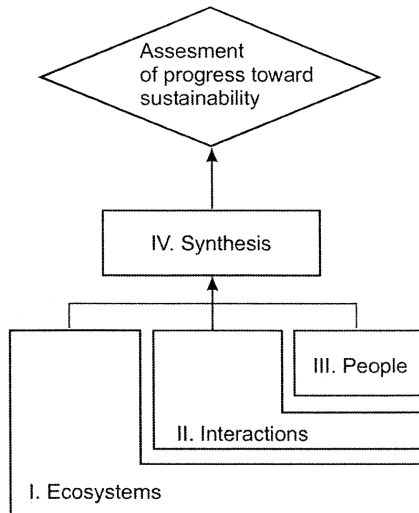
## THEORETICAL BACKGROUND OF THE *INTERFACE*

One of most valuable backgrounds to build the *interface* notion is the outline proposed by Hodge, since it identifies *interaction* processes or components among environment and society fields (see graphic 1). According to Hodge, interaction between people and ecosystems takes three shapes: reasons for interaction, the undesired effects of those reasons and possible policies to face those problems. In the author's terms, interactions contribute to:

1. to satisfy basic needs and to provide a quality of life, and consequently, they are valued,
2. to impose physical, chemical or biological perturbations on ecosystems,
3. to restore ecosystem and,
4. to reflect the success of advance in goals and targets of policies, regulations or legislations (Hodge, 1996:21).

Namely, *interface* is the ensemble of specific relationships between one society and the environment which surrounds it, besides a "territory" –though these interrelations are exposed, particularly, in an intermediate territory between both poles- generally fore mentioned as "peri-urban" space. According to Hodge, we can discern from his diagram, some of the components of each "section" the interaction case between *urban sprawl* (People) and the *environment* (Ecosystems). Among the first ones we can find notions such as urban expansion, economic specialization, rural industrialization and accessibility, while among the second ones we find such concepts as vegetal coverage, semi natural ecosystems (agricul-

tural areas), habitats and discharge areas, by only mentioning some of them. The first ones are studied by Regional Geography while the second ones are dispersed in at least two disciplines: Landscape Ecology and Hydrogeology (see table 1).



Source: Hodge, 1995

Table 1: General components of environment/society interface

Ecosystems	Environment/society interface	People
<ul style="list-style-type: none"> <li>• vegetal coverage</li> <li>• seminatural ecosystems (agricultural areas)</li> <li>• natural habitat</li> <li>• recharge or discharge groun water areas</li> <li>• hydric regime</li> <li>• biogeochemical cycles</li> </ul>	<ul style="list-style-type: none"> <li>• Water, food and raw materials' supply</li> <li>• waste management and used waters systems</li> <li>• conservation areas</li> <li>• perturbed ecosystems</li> <li>• rural-urban, urban-urban and rural-rural migrations</li> <li>• commuters' movements in a job basin</li> </ul>	<ul style="list-style-type: none"> <li>• demographic increase</li> <li>• urban expansion</li> <li>• economic specialization, PEA (Economically Active Population)</li> <li>• rural industrialization</li> <li>• urban accessibility and mobility</li> </ul>

Source: Authors' own elaboration.

Which seems clear is that concepts like that of sustainability cannot be undertaken only from interpretations of the state of natural system, because they need human judgments and values (Costanza, et al, 1992). Therefore, neither the purely environmental indicators, nor the

purely social ones are decisive to evaluate advances toward sustainability notion. The *interface* notion allows to locate ecosystemic processes which are able to temper urbanization's pressures and the urban dynamics they own.

In order to reach that, we count upon a series of notions that undertake different flanks of the interrelation, like water, food and raw materials' supply toward cities, the analysis of waste management and used waters, rural-urban migrations or commuters' movements in a job basin. We are going to follow the complete cycle in the next exercise, from social side (People) toward natural side (Ecosystems), enlightening the corresponding interrelations.

We are going to see each of them individually, and then we will try to "combine" them. The "relational" approach proposed is based on differentiating "non relational" and others "relational" processes. The formers are those concentrated on particular phenomena, without paying attention to their interrelations with components that have been studied by other disciplines but which allow to elaborate analysis that we will call "endogenous" to separate them from the second ones which, while considering interrelations, we will call "relation's".

In the first case, we can suppose that, larger the *endogeneity* of one element is, smaller is the knowledge of its interrelations. On the opposite side, if the *relationality* of components is larger, we will be in front of situations that we can name as *relational processes* or spaces that, independently of relationship characteristics and nature, either profitable or negative, they constitute *contact* spaces between the "social" and the "environmental".

## Processes in Landscape Ecology

In Landscape Ecology we can distinguish a series of relational components such as those related to natural resources management and those called environmental goods or services. The idea that landscape structure and sustainable conservation of its integrity depend upon a multiscale perspective, with limits or boundaries that cross each other and an "adaptive" type management, is proposed in this approach. This means that one dynamic conception results necessary in the face of the constant changes that it experiences due to natural transformations as much as anthropic ones (Bastian, 2001, Groot *et al*, 2002).

These positions give the rule for a new focus in which social aspects such as the geographical concept of region (this concept may coincide with Landscape Ecology principles taken to a regional scale (Odum, 2002:464). But even inside this approach, the treatment of the questions related to water performance is not explicit. That has to be solved with another discipline tools, the Hydrogeology.

## Processes in hydrogeology

Since ground water is a geologic agent of general character, the number and diversity of natural phenomena associated to the operation of underground flow systems is practically limitless (Tóth, 2000). For such a reason, the study of basic components (not relational) of hydrogeological context, can be useful to design management strategies which have as objective to maintain human and ecological resource benefits, like sustainable supply and the maintenance of recharge-discharge areas (Sophocleous, 1997, Neufeld, 2000).

However, it should be recognized that is not enough to design outlines of hydric resources supply, to solve the complex series of problems coming from society-environment interactions. It is necessary to consider other frames of analysis that pay attention to purely social processes. It is here where proposals made from Regional Geography, allow to reach -with emphasis in the social one- to specific interactions of environment-society interface.

## Processes in Regional Geography

Historically, the regional focus has been holistic, including territories and urban societies as much as rural ones. Although the prevailing processes are mostly of metropolitan character, its incidence on regional fields is difficult to frame in a cause-effect relationship, as one makes with physical indicators.

In the case of relationals components such as water supply for urban consumption, peri-urban agriculture and sewage of used waters, in the current time they reach a considerable magnitude. For example, in a global scale, annual water extraction from its natural medium, is now about 3,600 Km<sup>3</sup>, when in 1680 was smaller than 100 Km<sup>3</sup> (Kates, *et al*, 1990). Equally, urbanization of sites that have environmental value, also arises as a trouble in big European metropolis by the same time.

Only urban sprawl is the most recent process and its pertinence as an analysis category is still studied in less developed countries, like Mexico. Wherever it appears, the intense population and activities relationship between country and town have taken to stump the urban frontier in such a way that is impossible to trace a clear border line, since new relationships between the traditionally established urban components and peri-urban relocation.

Now we propose to resume the three reviewed approaches. The first methodological step consists on identifying such environmental units in the Central Region of Mexico, from a physical point of view in order to integrate it later to the social perspective.

## ENVIRONMENTAL UNITS DEFINITION AT CENTRAL REGION

Although most of the territory of the region presents a humid or semi-humid climate, ground water represents the main source of supply for population, since the majority of surface glides and channels are employed for moving used waters out (CTMMA, 2003). It is for this reason that identification and evaluation of environmental importance areas can be fulfilled from the examination of performance conditions of this geological agent in the region.

Inside the hydrological continuum from recharge areas to discharge areas, an interaction dynamics between ground water and surface water is produced, which conditions a great variety of ecosystemic processes (Töth, 1999, Sophocleous, 2002, Winter, 2001) as soon as they determinate the environmental change magnitude (Edmunds, 1996).

There exists a wide discussion regarding which type of spatially defined units are the proper ones for hydric resource management (Winter, 2001). For Mexico's case the concept of hydrographic basin has dominated regulation and implementation of public policies schemes, although there is a strong dependence on ground resource and in the most of the cases, per-

formance boundaries of aquiferous systems do not correspond to the superficial border, since the territory is characterized by a complex geological and geomorphologic frame.

Particularly, it has been suggested that the handling outlines based on the hydrographic basin concept and the little knowledge one has about the real performance limits are some of the causes of policies inefficiency facing the environmental complex problematic of the region (Tortajada, 2001; Angeles-Serrano, *et al.*, 2003). For this reason, the delimitation of recharge and discharge areas starting from its likely functional limits in the territory, as much spatially like temporally, is decisive to make a diagnosis of the environment-society interaction processes that serves as a basis for the formulation or modification of plans and programs for resource management.

It exists, however, a strong lack of information to carry out a quantitative evaluation of the recharge process and its interaction with natural discharge environments as humid soils, bodies of water, *riparias* areas, etc. In this paper, an identification and systematic ponderation was carried out of those components that control the flow of ground water: 1) climate, 2) relief and 3) geological frame (Töth, 1963, Freeze and Witherspoon, 1967, Winter, 2001, Sophocleous, 2002), as well as of those that are surface manifestations of the ground flow: i) soil type and ii) vegetation (Töth, 1999).

When assigning different categories to each one of the components a pondered classification is obtained from each one of them, in accordance with a qualitative evaluation about how are manifested in recharge areas, opposite to what happens in discharge or recharge areas of local flows of little regional interest (see table 3).

On the other hand, urbanization processes, irregular settlements presence, agricultural frontier expansion through natural areas and modification of traditional rural economic activities, can transform ground water recharge and discharge conditions. For this reason, identified *environmental units* refer basically to those areas that keep a high degree of conservation agreeing with their characteristics of vegetable coverage (Palacio, *et al.*, 2000). What is assumed here, is to concentrate on spaces where regional dynamics of settlement coincides with areas of greater environmental value.

The previous methodological criteria were useful to carry out a first exercise of regional classification of those areas with potential for recharge or discharge of ground water starting from the reclassified sum of the pondered and normalized values of gradients, topography and vegetable coverage byr community, in scale 1:250,000. In the map I the location and relative value of identified environmental units are presented, which were valued by their biggest relative altitude (except glaciers) and smaller slope.

Due to the fact that only areas with a bigger degree of natural vegetation conservation were considered, it is possible to assume that they keep their natural potential for recharge. Therefore, *biophysical factors* (precipitation, evapotranspiration and infiltration ability of soil and undersoil), are those which control quality and quantity of infiltrated water. On the contrary, in the wide agricultural areas and in those of induced pasture-ground, as well as in urban areas, it is necessary to use a greater number of factors and evaluation criteria to determinate change in quality and amount of recharge water (Custodio, 1997, Carmon and Shamir, 1997).

The vegetation criteria has also been used to delimit discharge areas, as well as the presence of lakes and lagoons or areas without apparent vegetation, which are characteristic of

areas of regional flows discharge due to its high salinity, as Texcoco Lake (Huizar, *et al.*, 2003). Ground waters flows discharge areas are considered of high environmental value because of the biodiversity they show and its capacity to temper the effect of contamination processes, such as waste infiltration. This is the case of humid soils of Xochimilco and Texcoco located in Mexico City periphery.

Table 2: Identification, Classification and Hierarchization of areas with environmental value

1 Discharge areas LOW	2 Rechargeareas	
	MEDIUM	HIGH
it does not apply	Arid and semi-arid	Humid and semi-humid
< 1500 mosl (meters over sea level) for regional flows, a range between 1500 to 2000 mosl was used in the plateau (Altiplano), with gradients larger than 30°.	2000-3000, moderate gradients: 15 -30°	>3000, low gradients smaller than 15°.
Lacustrine, alluvial silts of more relative age.	Alluvial, volcanic silts, of tertiary era	Recent volcanic.
Contacts of the flaws of highly contrasting permeability Great thickness of the units and bigger heterogeneity of the materials. Older fissures can present salts precipitation that diminish porosity	Bigger heterogeneity or thickness of material Fissures and recent fractures of medium magnitude	Highly fractured material Recent fissures of bigger relative magnitude
Humid soil vegetation Halophilous or Gypsophila Palmar Popal-Tular	Mixed Forests, Low forest, perennial and subperennial vegetation Categories of high recharge with secondary vegetation typical of perturbed environments	Xerophila vegetation (heath, chaparral, huisachal), temperate forest (oyamel fir, pine, tascate), high and medium forest sub-perennial, perishable and sub-perishable
Basics	acid, neutral	

**Note:** The classification, although it is general, was made according to biophysical characteristics for Central Region of Mexico, for what they could vary in other regions. A wider discussion about this sort of qualitative valuation can be found in Delgado-Campos and Angeles-Serrano, 2003.

**Fuente:** Authors' own elaboration based on Tóth, 2002.

Finally, to make easy comparison between these areas (that keep their ecosystemic functions) with the complex dynamics of urban sprawl that characterizes the region, a relative value was assigned by municipality, according to the coverage percentage presented by each environmental valued unit. The outcome allows to reclassify municipalities with a relative value of agreement with the percentage of natural recharge areas and discharges of ground water that they own. (see table 3).

Table 3: Reclassification of Areas with environmental value by municipality

	Extent of recharging environmental units coverage by municipality (%)						
	Low		Medium		High		
<b>Discharge</b>	0	<50%	>50%	< 50%	> 50%	< 50% + M	> 50% + M
It has not	0	1	2	2	3	3	4
It does have	1	2	3	3	4	4	5

Source: Authors' own elaboration.

This reclassification by municipality allows, now, to incorporate the social type variables, particularly those related to urban sprawl<sup>2</sup>.

## URBAN SPRAWL DYNAMICS

The study of urban sprawl is quite recent, as much to world level as in our country. In general terms, it is accepted that it results from three types of sociospatial processes: 1) novel trends related to *economic changes* with strong impact on territory's conformation (intra-regional decentralization and sprawling of typically urban activities, industry, trade and services), 2) *social* processes among which sub-urbanization, counterurbanization and polarization reversal are outstanding and, finally, iii) as a result of the above-mentioned, integrated *urban* processes because of the construction of the necessary material supports to carry out the first two groups.

- a) Nevertheless, there is no proved methodology to measure urban sprawl<sup>3</sup>. In this paper we propose, besides, to be concentrated only on rural spaces that more express wanted sprawling. The analysis has been carried out in two times:
- b) Municipalities were distributed in three groups according to the **rural-urban category change** observed between 1970 and 1995: i) those that changed from *rural to transition*, ii) those that changed from *transition to urban* and iii) those that changed from *rural to urban*<sup>4</sup>.

Former distribution was contrasted with *medium index value* of four indicators that express socioeconomic changes related to sprawling: a) Migration, as a percentage of population related to immigration or emigration of inhabitants, b) Urbanization Level, as the proportion of urban population with regard to total population, c) Non Agricultural Labor Force as the percentage of employment in industrial and services activities and d) Rural Industrialization as rural areas that present a quotient of industrial location (Delgado, 2003).

<sup>2</sup> A frequent trouble when comparing both types of variables, environmental and social ones, is that societies are often expressed in geostatistical units, such as municipalities, while environmental variables are always geofoms.

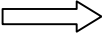
<sup>3</sup> A tentative proposal can be seen in Delgado *et al.*, 1999.

<sup>4</sup> We consider as rural those municipalities with a population smaller than 10,000 inhabitants, municipalities in transition, those between 10,000 and 15,000 inhabitants and urban municipalities, those whose population overcomes 15,000 inhabitants.



In this way, the greatest value (5) was assigned to municipalities that have had the most drastic change of category *rural-urban* and that, at the same time, have had the greatest *medium index value*. At the inferior extreme, the minor value (0) was assigned to those municipalities that have changed from *rural to transition* (minor group dynamics) and which have had low values for the index. Intermediate values (2 to 4) were distributed among intermediate ranks in both sides of the matrix. Obtained values allow to identify those municipalities where there is a high dynamics of rural-urban change (see table 4).

Table 4: Identification of the RURAL-URBAN DYNAMICS

<b>RURAL-URBAN CHANGE (1970-1995)</b>	<b>URBAN SPRAWL</b> a) Migration b) Urbanization Level c) Non Agricultural Labor Force d) Rural Industrialization		
			
	<b>Medium index value</b>		
	<b>Low</b> (0-2)	<b>Medium</b> (3 to 4)	<b>High</b> (5 to 6)
0 Rural to Transition	<b>0</b>	<b>2</b>	<b>3</b>
1 Transition to Urban	<b>1</b>	<b>3</b>	<b>4</b>
3 Rural to Urban	<b>2</b>	<b>4</b>	<b>5</b>

Source: Authors' own elaboration.

In spatial terms, the obtained outcome throws the following results:

- a) Unlike geographical diversity of the particular indicators considered individually (migration, non agricultural labor force and urbanization level), the obtained classification presents most of municipalities with the biggest value of rural-urban change dynamics at the *external boundaries of the regional ring*, and
- b) A *spatial overflow* of this type of municipalities in the distant peri-urban. The above mentioned seems to confirm, on one hand, the heterogeneity of the regional ring as well as the extent of urban sprawl.

The following methodological step consists on combining the outcomes of both components, from the natural context and from the social one, which constitutes properly, the interface society-environment. Society-environment interaction.

It has been argued that pressure on natural resources and their management make necessary to undertake environmental and social problems from an interdisciplinary and in great scale perspective, because it is in this way that any sustainable management plan can be successfully implemented.

According to Odum"(...) *One way of moving toward regional approach is to describe raw data in a spatially explicit way, or over small spatial scales, in order to have data rapidly*

aggregated in different ways and to create different regions depending on the question of interest (Odum, 2002:464)".

The proposal for final integration is to ponderable hierarchically these contact spaces where there is, in a potential way, an interaction between urban sprawl dynamics and the defined environmental units. The above-mentioned can be achieved overlapping those municipalities that have a larger rural-urban change dynamics with different units that have greater environmental value (see table 5).

Table 5: Identification of Contact Spaces (Rural-Urban Dynamics in municipalities with High Environmental Value)

	Environmental value					
	Discharge Areas*		Potential Recharge Areas		Both Areas	
Change of the Rural-Urban Dynamics	Non (0)	Yes (1)	Medium (2)	High (3)	Medium Recharge + Discharge (4)	High Recharge + Discharge (5)
0	1	1	1	2	2	3
1	1	2	2	2	3	3
2	1	2	3	3	3	4
3	2	2	3	4	4	4
4	2	3	3	4	5	5
5	3	3	4	4	5	6

\* Municipalities with presence of discharge areas Source: Authors' own elaboration.

The outcome expresses hierarchically the territories where urban sprawl processes pressure threats the integrity of defined environmental units. 36 municipalities have been identified with *high* or *very high potential* of interaction between rural-urban change dynamics and the greatest environmental value areas as ground water recharge and discharge areas. Most of them are located inside the regional ring, nevertheless, they can also be found in distant peri-urban limits, beyond the ring (see Table 6).

If municipalities with medium value are also considered (129 or 23% of municipalities), their location allow to identify at least five big clusters if *contact spaces*, where changes on land use can have negative effects over natural contiguous areas, which are characteristic of urban basins: decrease of recharge because of the expansion of urban border, contamination due to industrial and domestic waste, instability of hillsides due to enlargement of highway net, soil salinity, eutrophication of water bodies and land sinkings, among others.

Nevertheless, these *contact spaces* can constitute a positive interaction with the natural environment if resource management and protection schemes are orchestrated or if the traditionally "rural" activities combine themselves with new eco-tourism and environmental education activities that depend on the maintenance of the resource for their realization.

Table 6: Contact Spaces Reclassification.

Rural-Urban Dynamic	Environmental Units Value						Total	
	0	1	2	3	4	5	Population	Localities
Population		13.745	184.551	10.009	122.395			
<b>0 Localities</b>		26	595	8	269		<b>330.700</b>	<b>898</b>
average Migration		99,0	66,3	10,7	91,5			
Population		16.331	211.185		227.659	16.557		
<b>1 Localidades</b>		106	581		666	140	<b>471.732</b>	<b>1.493</b>
average Migration		-13,8	65,5		109,7	12,5		
Population	14.483	41.094	249.924	15.086	182.033	15.184		
<b>2 Localidades</b>	6	136	528	23	327	67	<b>517.804</b>	<b>1.087</b>
average Migration	130,1	94,1	100,6	337,4	111,1	218,3		
Population	47.398	59.282	430.621		201.623			
<b>3 Localidades</b>	61	231	861		642		<b>738.924</b>	<b>1.795</b>
average Migration	71,8	74,7	103,9		83,4			
Population	175.130	307.507	367.549		338.555			
<b>4 Localidades</b>	76	234	462		177		<b>1.188.741</b>	<b>949</b>
average Migration	190,1	275,3	171,1		160,2			
Population	863.363	70.013	504.696		21.571			
<b>5 Localidades</b>	57	57	421		26		<b>1.459.643</b>	<b>561</b>
average Migration	148,0	284,8	193,7		327,6			
<b>Total Poblacion</b>	<b>1.100.374</b>	<b>507.972</b>	<b>1.948.526</b>	<b>25.095</b>	<b>1.093.836</b>	<b>31.741</b>	<b>4.707.544</b>	<b>6.783</b>
<b>Localidades</b>	<b>200</b>	<b>790</b>	<b>3.448</b>	<b>31</b>	<b>2.107</b>	<b>207</b>		

## CONCLUSIONS

Exercise's outcomes allow to identify a wide group of *contact* spaces which combine an important rural-urban change dynamics (which is part of the most general processes of *urban sprawl*) to the presence of high environmental value areas in vast periurban spaces of the region. This particular case is one of the environment-society interface examples.

Environmental importance of these *contact* spaces resides on the fact that they work as ground water recharge and discharge areas that keep relatively well conserved their vegetal coverage and, consequently, their capacity to assimilate waste, habitat provision and attenuation of pollutants. For this reason one can affirm that *contact* spaces, more than impact areas, may be considered as areas of environmental reduction since they still keep their natu-

ral performance ability, contrary to what happens in population concentration areas, where impacts are often irreversible.

An unsettled task is to evaluate the historical behavior of ground water resource. There is a consensus with regard to the negative effects of current model of urban supply from distant sources, as well as of used water sewage system that impacts on rural areas at great distances. If the capacity of certain territories to keep ecological and human benefits from ground water diminishes, one must wait the appearance of local problems such as shortage of the resource and pauperization of material conditions of life and conflicts due to competition for having the resource, conditions that, generally, use to generate strong migratory flows rural-urban, urban-urban and rural-rural looking for better life conditions. The above mentioned could impact in a greater extension and complexity of the identified *contact* spaces.

The above-mentioned puts on relief the need to have a regional planning system that faces urban trends toward concentration, even regional. The development of protection strategies in recharge and discharge areas of ground water should have a high-priority character.

A feasible goal to be reached in the medium and short term is to evaluate *contact spaces* of the region where basic conditions of regional performance of the aquiferous system are condensed with the perspective of replacing the current system of distant water supply due to its negative effects on the ecosystem.

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