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MEASURES TO VALUE THE SUSTAINABILITY OF THE METROPOLITAN AREAS: APPLIED TO CONCEPCION METROPOLITAN AREA

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According to the recent dynamic of growing of the cities and metropolitan areas, seems reasonable to argue about the urban sustainability in a territorial way. (Diamantini y Zanon, 2000; Folch, 2003; Font 2003). Nowadays, the city does not only consume external resources coming from an area with relatively close influence, but also its influences over rural and per urban areas which make them everyday more polymorphic and broad.

The actual rhythm of growing and dispersion of the urbanized areas seems to be transferring important environmental load to future generations, oppressing one of the basic principles of the sustainable development (Winchester, 2006). Also, it is not clear that the urban and territorial models that we are building, medium and long term, will be the most efficient ones from an economic perspective, it is not even clear that these models will help the social cohesion and inclusion.

* This work was developed for a doctoral thesis written by the main author of this paper. The doctoral thesis was named ¨sustainability analysis of the metropolitan territorial models: the case of Concepcion, Chile, Technologies applications of the geographic information. (2008) Sponsored by the graduate scholarship CONICYT Chilean government. The analyses were performed before the earthquake occurred on February 27th 2010. These kinds of proposals emphasize the importance of the spatial configuration and consider that is established the dynamic related to territorial sustainability.

These varieties of information are relevant to the new possible visions for the city, or changes in the future territorial planning of the metropolitan area.

In this context, the objective of this work is the application of a series of base territorial indicators with geographical information systems (SIG) in the metropolitan area of Concepcion, Chile. These have allowed monitoring the different patterns of the land use related to the territorial substantiality. As a result, it is assumed that a territorial metropolitan model is more sustainable if it tends to the socioeconomic integration between the urban growing settlings, and if it maintains an efficient use of the natural resources, keeping a balanced relation between the sustainable development dimensions.

The indicators are shown based in the criterions or guiding principles of a sustainable urban development.

Criterion N1: It is supposed that it is more sustainable a growing model less disperse and with a mixture of uses and functions with growing shapes from the CMA cities. It is important to have compact nucleus with manageable sizes that avoid the excessive fragmentation and that seeks high densities in centers, and in areas with accessible public transportation.

Criterion N2: It is believed that is more sustainable a urban growing model that is integrated with the natural and rural environment, and that minimizes the consumption of natural resources, a model that has a tendency of not using highly valuable ecological land, or land with agriculture productivity or affected by natural risks, also that keeps the connectivity between habitats and avoids fragmentations.

Criterion N3: It is supposed to be more sustainable a system of hierarchical settling, with a good connectivity that enforces the use of public transportation systems. This will allow a correct and equal accessibility to the territorial resources and an independence of the private transportation for people. This will be associated to the increment of the CO_2 levels in the atmosphere.

Criterion N4: It is supposed more sustainable a metropolitan model with an equal spatial distribution between social groups, without big differences of quality to access to housing between residential areas.

It is applied four synthetics indices (Table 1) that would represent the relation between the physic structure of the metropolitan area or occupational land model, and the functional structure or the use of land model.

To support the decision, it is found the assumption that the cause, (partially) of the levels of energy consumption is mainly the territorial structure. In other words, the different model of spatial distribution of the cover and use of land could be evaluated with different levels of sustainability.

The selected indicators are assumed as exemplified measures of the criterions mentioned above. Besides, they respond to concerns and current problems which are discussed in the study area (Rojas et al., 2006): in the last years, the fast growing has caused important natural and socio-economical impacts. In one side, alterations and lost in the ecosystem have been produced (Pauchard et al., 2006). On the other side, a debate about the effects of the housing development in the growing socio-spatial segregation of the cities has started.

Table 1
TERRITORIAL INDICATORS

Criterion	Synthetic indices	Description Indicators	Evolution desirable	Key Information
1	Urban growing dispersion (ID)	Level of dispersion of the urban growing stains. It is measured with four indices: Compactness (IC), Complexity (ICO), Centrality (ICc y ICbc) and Density (IDE). It is determined which one has a bigger impact in the urban dispersion.	A dense and compact urban space in the centres. Medium densities in the suburbs without having highly displacement costs.	Land use population.
2	Landscape connectivity(ICP)	Level of habitat fragmentation as a result of urbanization. The capacity of dispersion for the species is measured through the ecological. connectivity (ICE) which is complemented with a fragmentation indices (IF).	A model that maintains the functional connectivity, and preserves the ecological integrity of the natural systems.	Land use population Transportation networks.
3	Mobility (IM)	Level of integration with the centres related with the use of public transportation. It is measured in the transportation zones.	An accessible model that prefers the public transportation.	Population Public transportation networks.
4	Residencial segregation (IS)	Level of inequality in the distribution of the population between the different residential zones. It is measured in two poverty types: critic (PC) e inertial (PI).	A model less socio-spatially segregate, with an intrazonal diversity and a better interzonal equality.	Socio-economic condition of the population.

Source: own elaboration based in the revised literature review and available data.

The results (table 2) have shown a disperse growing model, complex and with low density (< a 65 inhabitants per ha) that is considered as a spatially unfavourable situation (Zhang y Guindon, 2006).

It is noticed that the density is the most important dimension of the urban sprawl and it is the antidote to dispersion (López y Hynes, 2003). Metropolitan areas such as Santiago, have proposed in their planning to raise the densities in urbanized areas from 100 to 150 inhabitants per hectare (Becerril-Padua, 2000).

Table 2
SUMMARY OF THE INDICATORS RESULTS

Índice	Indicators	Range	Results	interpretation>Sustained
ID	IC	0-1	0,58	Closer to 1
	ICO	1-2	1,46	Closer to 0
	ICc		17,24 Km*	
	ICbc		14,80 Km*	
	IDE		62,78 hab/ha	Closer to 100 hab/ha
ICP	ICE forest		122,55Km*	> cost of displacement
	ICE Renewals		111,64 Km*	(route distance)
	ICE bush		89,03 Km*	
	ICE grassland		94,02 Km*	
	IF forest		41,62 ha**	
	IFRenewals		48,46 ha**	< size surface
	IF bush		33,35 ha**	
	IF grassland		52,34 ha**	
IM		-1-1	0,56*	Closer to 1
IS		0-1	0,27	Closer to 0
	PC	0-1	0,33	Closer to 0
	PI	0-1	0,25	Closer to 0

*correspond to the arithmetic measurement of the displacement cost.
**average size of the surfaces according to the coverage.

This complex and disperse growing model has contributed to the lost of connectivity of the landscape due to, it has privileged for its extension (hills and areas with border forest plantation, bushes, mix vegetation and natural grassland). Considering the results of Pauchard et al. (2006) and Rojas et al. (2006), it is proved that the urban areas are spreading mainly because of the lost of grassland, plantations, wetlands and bushes. These surfaces are vulnerable to natural risks and valuable ecological damages affecting the connectivity of the landscape, species movements and habitat preservation.

According to the connectivity results, the natural forest covers and renowal are the ones that are most affected by the urbanization (highly displacement costs). However, the bushes and grasslands are more permeable to the urban use and have less displacement cost.

In relation to the size of the fragments, bushes' habitats have been the ones that have suffered the most, together with the native forests (minor size of fragments.) Ultimately, the data reveals that the woody areas are the most damaged by the urban model, especially native forests (41.6 ha).

With regard to the socio-economical effects, we will mention that the urban disperse configuration of the CMA seems much influenced by the location of the transport, showing a tentacle growing. This structure of networks allows the efficiency of the public transportation that, according to the results, has a slightly advantage over the private transportation. (0.56), especially in areas which are closer to the centers.

Only in new peripheral zones of San Pedro, Concepción and Chiguayante communes, where the quality of residential areas is high and the lack of public transportation is present, the use of private transportation is higher than the public one.

The changes in the mobility patterns, housing accessibility and the dispersion of growing allow a relatively new phenomenon in Concepción, the residential segregation. This is an observable fact, and for the sustainability point of view is negatively valued.

Despite of the poverty reduction, it can be proved that the socially disadvantaged urban areas have been concentrated in the most vulnerable ecological spaces. In this sense, the low income population is distributed in an unequal way and theoretically, they have to move a 27% of the population to reach an even distribution in the territory.

Finally, one of the values of this work is to generate the possibility to evaluate the sustainability of the territorial's models from the CMA, through a system of indicators with territorial base from which the principles and guiding criterions are explicit.

The tested indicators are easily reproduced in different contexts due to the relatively disposition of the used data: use of land maps and vegetables covers, also census data and mobility patterns. On the other hand, it is more accessible to add to the system of geographic information methods of calculation for the indicators. Today we can incorporate free programs which have been developed by different researches or universities departments to give a solution to concrete spatial problems.

In this way, the specific measures applied to the CMA allow us to recognize a new complex metropolitan area, which level of growing is conditioned by environmental factors such as the crust edge, hydrography and close mountain ranges, as well as socioeconomic factors such as the increase of population and the rising socio-spatial polarization.

We have proved how the urban growing has a direct impact in the socioeconomic and environmental aspects. The lower ecological connectivity of the native species coverage implies a lost in the landscape functionality. In contrast, the observable residential growing has increased the distances between new urban stains and the functional center of the metropolitan area. Also it seems that the residential growing has permitted the increment of the social groups' distances, against the urban mixture and the use of public transportation.

It is considered that the main outputs of this study are directed to expand the methodological possibilities of the metropolitan diagnostics from a sustained point of view. Clearly, the transversality of the analysis and the territorial planning can help us to synthesize and guide new sustainable aspects of the urban and metropolitan models. This work has as an objective to contribute with some tools and give some thoughts about this important and transcendental topic.