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ORIGINAL RESEARCH ARTICLE

Urban sustainability: Analysis on urban scale of Temuco Chile

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ABSTRACT

Cities develop in an excessive and disorderly way, losing their original characteristic identity and function. As a response to the deconstruction of the city, sustainable urban design came into being. This study evaluated the performance and sustainability level of Temuco community. The study was conducted in four sectors of the city, which are symbols and representatives of different stages of urban expansion. Through a set of urban design index standards including economic, social and environmental variables, the development of the community and the quality of life of its residents are evaluated. The results show that the Abraham Lincoln community has a better sustainability index, gathering a group that encourages sustenance and the availability of necessities nearby. The study found that new and old neighborhoods have deficiencies in neighborhood sustainability.

Keywords: sustainability; urban development; quality of life; spatial planning

1. Introduction

The emergence of cities is the direct result of a new way of wealth concentration. This development will break out once wealth can be separated from or anchored to the natural world[1]. Human intervention has changed the natural space from the development of natural space, transformed the land into the surface of buildings that meet human needs, such as housing, buildings, streets, lighting, equipment, etc., and produced a complex human occupation cycle over time[2].

The transformation of the city is driven by administrative, economic, technological, social, political or ideological variables[3]. Therefore, due to the changes brought about by globalization, big cities present complex characteristics and unsolved problems. “The sustainable development of cities in Latin America and the Caribbean continues to pose major challenges to space city policies at the regional, national, subnational and local levels”[4]. The path of integrated territorial development must be able to reconcile competitiveness, social welfare, environmental sustainability and the reduction of territorial imbalances[5,6].

Medium sized cities are no stranger to this transformation problem and the need for sustainable planning, as is the case in temuko, which has an excessive population density due to urban and rural displacement, environmental degradation and

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pollution, poor urban management, vehicle congestion, crime and poor quality of life. All these problems constitute urban pathology and must be prevented or addressed in order to achieve a healthier city[7].

In order to avoid this degradation of cities, land is formalized into specific urban and rural landscapes. Each city has its own diversity, which has increasingly become a framework element of urban planning[8].

For Lerner[9] sustainability:

If waste is zero, sustainability is unlimited. This is about saving and reuse. In general, I always say that at least three things have been very helpful: Use less cars, separate the garbage, and live near the work area.

In short, programmes aimed at improving mobilization and transport, encouraging recycling and increasing diversity of uses can lead to significant changes in the quality of life.

Each problem or group of problems has an optimal observation scale, which may or may not match the appropriate scope of solving the problem. This is a famous ecological principle: global thinking, local action[10(p64,65)], which is the basis of the idea of Local Agenda 21.

In order to analyze these sustainability components, it is necessary to determine a research scale and unit, among which one of the latest urban design units is the neighborhood unit.

2. Sustainability

In Chile, the general regulation on urban planning and construction defined the concept of community in its previous definition: “Residential, industrial, commercial or mixed areas that form part of a city, usually consisting of a group of blocks with similar characteristics”.

However, this definition seems flawed because it only involves physical aspects and its socio-cultural concepts are relevant. In this case, a community is different because of its unique cultural characteristics. In this sense, at the level of overall planning concept, neighborhood is traditionally the reference point of communities in the whole city[11]. They define their personalities and allow meaningful social relationships between their inhabitants and the territories they occupy[12].

This definition is supported by the new urban design, which “has been studying how to make the city as sustainable as possible by creating space to improve the quality of life of citizens. This is how these new urban communities have emerged in order to minimize their impact on the environment[13].”

Architecture aims to achieve sustainability goals through effective urban development or the transformation of existing cities in accordance with sustainability standards, plans and strategies[10].

An example is the “Agenda 21” plan implemented by the municipal government of Malaga, which proposes a series of measures to turn Malaga into a “sustainable city”. Based on urban sustainability, the plan aims to restore the balance of urban metabolism and improve people’s quality of life.

Agenda 21, adopted by the United Nations World Conference on environment and sustainable development, held in Brazil, in 1992, made a proposal to regularly assess urban sustainability through an urban indicator system[14]. This methodology, widely used in Europe, has been little developed in Latin America, where the work carried out in Cuenca in Ecuador by Cabrera-Jara et al.[15] stands out.

There is no doubt that Temuco is a developing medium-sized city, which “forces it to adapt to changes and face new challenges in planning and developing infrastructure to meet the new needs of modern residents”[16(p156,157)].

Therefore, Temuco is a city that urgently needs to evaluate its development process and determine its

growth sustainability. “Over the past 15 years, the development of urban structure, residential mode, professional services and urban image reflect the impact of globalization” [16(p156)].

This study aims to provide input into the sustainable planning of medium-sized cities such as Temuco, because it uses the concept of “community sustainability”, which shows the reality of Temuco community for the first time.

3. Materials and methods

3.1. Research field

The study was conducted in Temuco. The urban population is 268,437, and the urbanization area is 3,536.92 ha until 2003[17].

3.2. Neighborhood choice

To analyze the process, four residential areas in the city were selected **(Figure 1**).

According to the above definition, the neighborhood concept used in this study is based on typological characteristics, the role played in urban form, the stage era of expansion, the integration of neighborhood units and the understanding that the territory is “walkable”.

Among the selected sectors, three belong to the expansion area (North, South and West), and one is close to the basic center of the city.

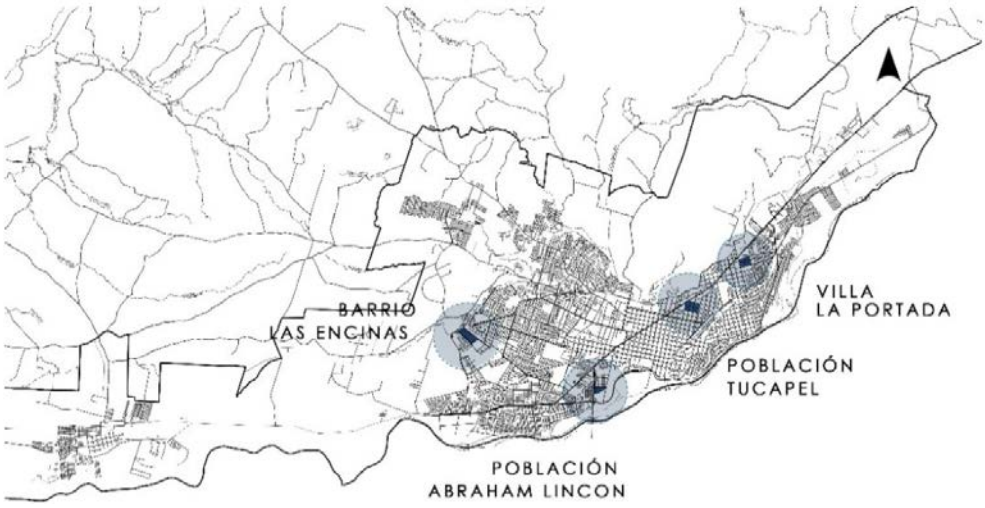

Figure 1. Geographical location analysis of Temuco city.

The community has the following characteristics:

Abraham Lincoln

It is part of the Amanecer macro-sector, a unit between Recabarren Avenue and the Cautín River, in the south-west sector of the city. Its use has certain heterogeneity, because over time, it has shifted from industry to housing and commerce. In the 1960s, it appeared on the edge of the city as a social housing.

The residential type is a continuous facade with one and two floors. It only provides the surrounding vehicle streets, because all the roads that make up the population are pedestrian.

Tucapel Neighborhood, Downtown Sector

Commonly known as tucapel stock. It is located in the infrastructure area of the city and adjacent to the main business centers, namely ferria Pinto and sector station. Due to its geographical location, the central position of infrastructure and services and the importance of history and heritage, it is the reference point and destination at the regional and community levels.

Tukapel population is a traditional residential area dating back to 1927. It emphasizes two stages of urban allocation. The first stage consists of a two-story continuous facade house and a large front

garden, while the second stage includes a lower height house and a smaller front garden. The surrounding streets and internal roads are vehicular in nature.

Las Encinas Neighborhood, Maipo or Poniente Sector

This is a new sector of the city, mainly residential, because it originated from the real estate project built in 2008. It belongs to a foundation of Frontier University and is currently part of a residential expansion area that is still under development. Its form is based on Garden City, with large houses, mainly gathering a part of the population with high socio-economic class.

La Portada Neighborhood, Pueblo Nuevo Sector

Located in the north of the city, it is famous for its shabby image, because although it is a residential villa, its environment is mainly consolidated as a service area. It has many workshops, wine cellars, etc., and emphasizes its close relationship with the railway department.

In 1964, it appeared as a social housing lottery. Its soil quality is poor because it is part of the floodplain. As far as housing is concerned, it has a wide range of housing, and there is heterogeneity in types, because over time, villas are facing the changing environment, from the periphery to the urban center, which is reflected in the differences in the quality and scale of existing housing.

3.3. Indicators to measure sustainability

Barrels and analytical methods

Visited these communities to learn about the application of indicators (**Figure 2**).

Figure 2. Photos of the study area. A. Abraham Lincoln, B. Tukapel, C. Las Encinas, D. La Portada.

The evaluation is based on the indicators identified in the sustainability axis of urban design in Malaga Agenda 21, involving the territory and form of the city.

The method proposed in this study is based on the theoretical basis of the agenda, but carries out the analysis of “unit to city”, that is, taking the “neighborhood” unit as the center and its connection access to different services. For this purpose, the influence radius or action radius is defined, and the extension range is from 1,000 m to 300 m (as the case may be).

In order to evaluate and compare the research department, and a proposal is made based on four

analysis components, which are related to the impact of quality of life and neighborhood structure (**Table 1**).

Table 1. Urban sustainability evaluation variables

Component	Indicator
Mobility and accessibility	Walking
	Public transportation
	Popularity
Diversity (uses, equipment and services)	Basic equipment (health, education, sports)
	Close to green space and leisure area
	Afforested area
Barrel structure	Residential density
	Occupied land
Environmental quality	Cleaning points and recycling areas

In the actual evaluation of the proposed indicators, reference was made to the criteria used in the methodological framework of the special plan on indicators of environmental sustainability of urban activities in Seville. The planning is a tool for urban planning through the description, evaluation and comparison of urban samples.

3.4. Essential information

The total population of each analysis area is obtained by estimating the population of each housing. In this regard, according to the density data proposed in the general regulations on urban design and construction, there are 4 people in each house as a reference.

According to the plane measurement of terrain and aerial image, the data of surface and street length are obtained. In order to obtain data on equipment, barrier free facilities, green space, etc., direct observation and repeated visits were made to the land in order to understand the current situation of the community on the spot (**Table 2**).

4. Results and discussion

Using the above method, the overall index results of the four communities studied are as follows (**Table 3**).

4.1. Mobility and accessibility

With regard to mobility and accessibility standards, the most critical indicator is walkability. In this regard, only a. Lincon district has a high sustainability indicator (43.9% related to sidewalks), while the walking rate in other study areas is 0%. This is mainly because only pedestrian areas or roads are not considered in community design. This is a trend in most parts of the city.

In this case, the A. Lincon district is an exception, and all internal passages are pedestrian passages, because the construction and design (1960s) did not consider the extensive use of vehicles in the planning area based on social housing.

The importance of walkability for sustainable design is that mobility is centered on the size of people, giving priority to pedestrians and cyclists to reduce car use and vehicle congestion[18].

At the same time, for the bicycle route indicator, three of the four communities provide access to the bicycle route network within a radius of 500 m, showing a medium degree of sustainability, while the fourth community La Portada shows a low level, close to 1,000 m.

About universal accessibility indicators, older communities (Tucapel and La Portada) do not have universal accessibility, i.e. Sidewalks do not have continuity, and there are horizontal differences mainly at the corners.

Table 2. Parameters by urban sustainability indicators

Component	Indicator	Methodology	Parameter calibrator		
			High	**Medium**	**Low**
Mobility and accessibility	Circular	Nearby radius: 300–500–1,000 m	Accessible within a radius of 300 m	Accessibility within 500 m	Radius 1,000 m
	Pedestrian	Percentage of pedestrian street length	50% pedestrian street (proportion to vehicle street)	Up to 15% of pedestrian streets (proportional to vehicle streets)	<15% of pedestrian streets
	Public transportation	Percentage of population near bus stops within 300 m	Approach within 300 m	Proximity within 500 m radius	Proximity within 1,000 m radius
	Universal accessibility	Percentage of the length of the reachable path continuity axis	Complete continuity	More than 30% continuity	Less than 30% continuity
Diversity (uses, equipment and services)	Basic equipment (health, education, sports)	Percentage of population close to equipment within 300, 500 and 1,000 m Preschool education: 300 m Primary school education: 300 m Secondary education: 500 m Sanitary facilities: 500 m Hospital: 1 km Sports center: 500 m	>50% of the population can access	Between 50% and 30% of the population can access	<30% of the population
	Close to green space and leisure area	Green space and small leisure space within 200 m (<1,000 m^2) (considering users with limited mobility)	Equipment or distance less than 200 m	Equipment with a radius between 200 and 750 m	Equipment with a radius of more than 750 m
		Green space and large leisure space, with an area of more than 1,000 m^2 and a radius of less than 750 m	Equipment with distance less than 750 m	Equipment within a radius of 750 m to 2 km	Equipment with a radius of more than 2 km.
	Afforested area	This ratio is obtained as the total area (m^2) of useful green areas per inhabitant	9 m^2 per capita	4–8 m^2 per capita	<4 m^2 per capita
Barrel structure	Residential density	Housing density = number of houses/ha	> 100 houses/ha	60–100 houses/ha	<60 houses/ha
	Land occupation ratio sup. total/built-up area	Percentage of land occupation = built-up area on land/total land area * 100	50% occupancy	<50% occupancy	>50% occupancy
Environmental quality	Cleaning points and recycling area	Percentage of population within the impact radius close to the recycling area	Equipment with radius less than 300 m	Equipment within a radius of 300–600 m	Equipment with a radius of more than 600 m

Table 3. Results neighborhood analysis

	Indicator	**Abraham Lincoln**	**Tukapel**	**Los Encinas**	**La Portada**
Mobility and accessibility	Circular				
	Pedestrian				
	Public transportation				
	Universal accessibility				
	Basic equipment				
Diversity (uses, equipment services)	Close to small green space				
	Close to main green space				
	Afforested area				
Structure Bucket	Residential density				
	Occupied land				
Quality Environmental	Cleaning points and recycling areas				

In the specific case of Las Encinas District, the sidewalk is not completely continuous, because most internal roads are passages with a length of less than 100 m. According to Chilean law, the roads in this case do not need sidewalks.

The only indicator that shows a high level within this standard is the public transport indicator, because three of the four communities have public transport stations and tracks less than 300 m away.

4.2. Diversity of uses and equipment

In terms of indicators of use and equipment diversity, all communities are close to green space on different scales. On the other hand, according to the green area method proposed by who (square meters of green area per capita), only the per capita green area of A. Lincon community reaches 9 m^2[19]. Under the same indicator, the average levels of cover and tukaper district are 1.2 m^2/ha and 1.11 m^2/ha respectively, which are far below the minimum range of Sustainability (4 m^2). The importance of this indicator not only affects the quality of life and health of residents, but also contributes to the social cohesion and integration between community residents and their cities. Public space can change a city's lifestyle and sense of the city[20].

In the case of access to basic facilities, the results are high and medium, and the best access rate to education and health facilities is between 33.3% and 66.6%.

4.3. Barrel structure

About community structure, the indicators show that the density of all communities is very low, less than 60 houses/ha, and the average land use rate is also very low, which is reflected in most cities like Temuco, where the land use rate is expanding.

The rapid and unlimited expansion of urban areas. The permanent filling of gap areas occupied by natural cover, or the extension of urban structure through main channels, heralded the end of the compact, unicentric and social homogeneity of cities in central Chile before 1980[21].

4.4. Environmental quality

Finally, with regard to the environmental quality variable, that is, near the cleaning point, three of the four communities have recycling points within 300 m, which is related to the community's social awareness of environmental sustainability.

This shows that over the past period, the global view of environmental awareness has changed, which has led to the frequent implementation of these actions in old and new communities.

Finally, in general, it can be said that an important aspect is the results of Las Encinas community, because although it is the latest community, it does not meet most sustainability standards and their respective indicators. Because it is located on the edge of the city, it mainly has no public transportation, pedestrian and equipment network, which may be because these housing projects are mainly designed for car users trying to leave the city center.

In contrast, the community with the highest sustainability index is Abraham Lincon community. Although it is a social housing community, it brings together aspects that encourage walking. In addition, it is equipped with the necessary equipment, close to the community (schools and health centers), away from "walking" or inaccessible through the public transport network connecting the community and the rest of the city, as the area is located in the center of Temuco community (less than 15 min from the historical center).

Although the parameters measured in this study are only part of all the standards required for urban sustainability, they mainly focus on the formal aspects of connectivity, equipment access and green space.

Overall, the study shows that the concept of sustainability lacks foundation, which is reflected in

the design and planning of housing portfolios in different sectors and periods of the community. Under similar circumstances, the reality of some Latin American cities, such as Cuenca, Ecuador, does not reach the optimal sustainability level proposed in Malaga Agenda 21, which is mainly flawed in terms of pedestrians, bicycle lanes, housing density and per capita green space.

As mentioned earlier, the analysis of specific points in the city may be the first method of more general or urban analysis, such as the method proposed by Cabrera-Jara et al.[15], using a similar approach in a larger urban center.

This study and that of Cabrera-Jara et al.[15] stressed the need to rethink the urban model in order to find more sustainable alternatives and comprehensively improve the quality of life.

5. Conclusions

The study concluded that neighborhood sustainability can be explored using rapid assessment indicators based on standards such as mobility and accessibility, diversity (uses, equipment and services), neighborhood structure and environmental quality. They provided evidence of their state.

In Temuco, the urban sustainability of new communities is low, mainly in terms of public transport, walkability and facility diversity indicators, because they are located in the periphery of the city, where there is no network to facilitate access to basic services, and they are often concentrated on a specific land use type (mainly residential land), which does not allow the diversity of facilities and services.

On the other hand, old communities have positive aspects of sustainability in terms of access to public transport networks, proximity to equipment and proximity to green areas, but there are deficiencies in housing density, universal accessibility, bicycle access and per capita green area, which are neither regarded as primary issues nor required by regulations at the time of construction.

The information generated by this study is an important input into sustainable urban design and the planning of new sectors, which will be able to improve sustainability based on community size analysis at a higher level, improve the situation of existing communities, and plan the sustainability of new communities generated by urban growth.

The sustainable development of the community means the improvement of the economy, society and environment. Therefore, when establishing a sustainable community model, it is very relevant to produce such research, which can provide themselves with basic infrastructure and urban connectivity, and enable users to engage in work, education and entertainment activities near their homes, so as to improve the growth planning of medium-sized cities.

Conflict of interest

The authors declare no conflict of interest.

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