Measuring Urban Diversities in Cities in Transformation: Case of Temuco, Chile

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Abstract. Contemporary studies have shown that the core challenges of future cities will be the crossfires between urban form, liveability and sustainability due to transformations. One key area of concern is how the current transformations contribute to more sustainable urban environments by encouraging a diversity of users, not only to meet and get to know each other but also encourage people to gain a strong sense of belonging to space and to collaborate in its transformation and the restructuring. In this study, therefore, the morphological and transformational processes in the neighbourhoods of Temuco were explored to understand how it encourages inclusive pluralism of social and spatial dimensions of the urban space, and how the process is essential for achieving a sustainable urban form. The study revealed that the morphological transformations in the study neighbourhoods between 1990 and 2018 have encouraged inclusive pluralism of social and spatial dimensions, which is vital for a sustainable urban form. The study recommends amongst other things the sustaining of the existing diversity through a modification to the Communal Regulatory Plan of Temuco to regulate developments at the neighbourhood level.

1. Introduction
Since the majority of the world's population became urban in 2008, emphasis has been placed on working assiduously in improving living conditions in cities and social justice, in this case, where there is equitable distribution of resources, services and access to opportunities [4]. Intrinsically linked to the above attestation is how the contextualized diagnoses and approaches are to be followed in contemporary times is how cities exhibit urban complexities and unusually large set of interrelated variables [14], [3]. Ideally, on how the current transformation processes that take place in the urban space contributes to a more sustainable urban environment by ensuring the co-existence of urban activities, encouraging diversity of users, and to encourage people to gain a strong sense of belonging to space and to collaborate in the transformation and restructuring of urban spaces.

In the Latin American context, a flurry of literature exists on the urban transformations of the biggest cities, examining both morphological patterns and internal configuration [9]. These studies revealed that the biggest cities show a new model that had evolved from a compact form to a fragmented and expanded form, undergoing a complex-mixed of changes [15]. The ramifications have rather shown "unsustainable" developments of the urban space, generating new forms of urban footprints, whose main
features are fragmentation and privatization, increasing social polarization and segregation on a reduced scale [1], [12]. Consequently, units such as the neighbourhoods have gradually lost their discernible structure, identity and emptying content. Literature points to the fact that intermediate cities in Chile will face similar fate due to the activities of real estate investments, interested in creating standardized urban forms and homogeneous identity [9]. Temuco, for instance, has received such accelerated transformations in the last decades. However, it is unclear how the morphological and transformational processes in Temuco encourage inclusive pluralism of social and spatial dimensions. Little is known on how these changing land use spaces invariably create multiplicity and heterogeneity in terms of the combination and co-existence of mixtures of activities, not separate uses, and maintaining human enclaves that are sustainable. This study bridges the gap by assessing how the current transformation in the city of Temuco, encourages inclusive pluralism of social and spatial dimensions, by measuring and understanding the transformational changes between 1990 and 2018 using the Simpsons and Shannon Diversity Indexes.

2. Urban Heterogeneity and Multiplicity- A review.

The urban diversity agenda is one of the oldest urban planning and design characteristics that have been elusive. The extremization of the diversity concept was championed by Jane Jacobs in 1961 in her book The Death and Life of Great American Cities [7], which criticized the dominant planning paradigm of the latter half of the twentieth century, which primarily consisted of large-scale redevelopment and highway construction. The main characteristics were solving urban problems by segregating them—segregating people from cars, segregating places for living from places for working, and segregating the ‘haves’ from the ‘have-nots’. Since the 1970’s urban diversity, which is opposite to ancient planning, has been seen as part of the solution [4], [16], [20] to restructure the urban form towards sustainability. It has been seen as possessing essential components necessary for sustainable places and sustainable urban form [4], [18] and has influenced the planning policies and guidelines in many parts of the world including the UK’s compact city development guidelines, the Urban Design Compendium [8].

2.1. Diversity as a Dimension of a Sustainable Urban Form

Diversity as a dimension of sustainable urban form addresses two important aspects. First, the diversity of land use – which has been understood as balances in the development of residential and non-residential land. Tarbat [18], deposited the benefits that can be derived from this aspect. These include cultural pluralism, economic vitality, environmental sustainability—facilitating people to shop locally without cars) and liveability. Secondly, socially diverse neighbourhoods continue to be seen as essential for the well-being of a community and the goals of social equity [13]), where the relationship to sustainability is drawn from the: combination of income, races and ethnic groups; which is believed to form the basis of an "authentic" sustainable community [16], [5].

The urban diversity agenda inherits many contrasting political positions which are counter-productive (see [20], [16]). The study therefore adopts a less ambiguous definition, where urban diversity is seen as a dimension of the urban form and possesses both spatial diversity- A balanced development of housing and non-housing land (land use), and social diversity- the mixing of socio-economic characteristics and social groups [16], [2]. The study, therefore, defined the variables for analyses as:

**Spatial Diversity**- land uses, housing types, urban form- block type, building size and shape, urban grain-plot size and shape.

**Social Diversity**- race/ethnicity, age, family income, family type, housing tenure, unit size, housing value and built year.

The study focuses on these static tissues of the urban form and the socio-economic characteristics of residents to understand how the changing multiplicity and heterogeneity in these variables can improve urban spaces in terms of vitality and social control [17], promote the degree to which local environments offer points of connection and contact to people and resources at a variety of scales, and how it can lead to higher levels of interaction between residents and the environment [16], [13].
3. Study Area
The scope of the study is the southern Chilean city, Temuco, whose urban spaces have been influenced by the historical polarization between the colonists (later government) and indigenous communities. The by-products of these processes led to the polarization between foreigners/Chileans (1) and locals/Indigenous people (Mapuches), leading to complexities in the growth dynamics of Temuco. Founded in what is known as the “Pacification of the Araucania” (as colonizers referred to the conquering of Mapuches)- a slow process that spanned until 1850, Temuco and the whole Araucania region constituted what was called the La Frontera (limit/boundary) of Chile and the Mapuche nation, who subsisted independently until the end of the Pacific War.

Beginning of 1850, foreigners were invited to help settle the south of the Biobio River\(^1\). By 1900, colonization was in full swing by Chileans and foreigners, incorporating indigenous territories into the country’s political economy. The city of Temuco was founded 1881 to advance the colonization and occupation. Few years after its foundation, Temuco witnessed early indications of urban planning with the arrival of the Teodoro Schmidt Topographical Committee. The Committee created and rationalized the first public institutions. The Cautín Provincial Administration was created in (1887) and attained a Municipality status in (1888). Fast forward, the urban area has grown considerable towards two main fabrics. A lower dense indigenous community in the nucleus of the urban limits, which are continuously resisting undergoing urban transformations, and a rapid changing municipal territory fuelled by explosive population growth and real estate speculation on the other hand. Two neighbourhoods (Villa Llaima and Banco Estado 1- Carabineros) were however, selected for in-depth analysis of how the current trends of accelerated transformations have affected their fabric and identity.

4. Methodology
The study adopted a mixed method (both qualitative and quantitative) to holistically understand the complexities and interrelationships of the urban diversity variables in the study neighbourhoods. Primary and secondary data were collected, processed and analysed to understand the spatial, demographic and socio-economic characteristics of the study neighbourhoods. Both the Spatial Variables and the Social Variables were analysed and measured based on Simpson Diversity Index\(^2\) and Shannon Diversity Index\(^3\). The combination of both Simpson’s and Shannon diversity indexes are

\[ D = 1 - \frac{\sum (n-1)}{N(N-1)} \]

\[ s = \text{ranges from 0-1 where higher scores close to 1 indicate higher diversity} \]

\[ \text{Shannon diversity index is given by} \]

\(^1\) Translated and modified base on the History of Temuco-INE Araucania [6].

\(^2\) Simpson's diversity index is given by \[ D = 1 - \frac{\sum (n-1)}{N(N-1)} \] ranges from 0-1 where higher scores close to 1 indicate higher diversity

\(^3\) Shannon diversity index is given by s ranges from 0-1 where higher scores close to 1 indicate higher diversity
important to understand the level of diversities and to provide enough bases to compare both communities.

For each diversity aspect in the two study communities, an index is generated for 1990 and 2018 on both Simpson and Shannon Indexes. These indexes generated are then compared under the same category against the two communities and the transformation years of 1990 and 2018. For example, “housing typology” index generated with Simpson Index in 1990 on Villa Llaima is compared with the same “housing typology” index generated with Simpson Index in 1990 on Banco Estado1-Carabineros, and the highest index value is highlighted in bold. Scores have been given based on the individual diversity variable ranking of the index value. For example, when considering, “housing typology” index generated with Simpson Index in 1990, Villa Llaima ranked first (0.510) scoring the highest index value, whereas Banco Estado1-Carabineros ranked lower (0.490). Hence, Villa Llaima is given a score of “two” and Banco Estado1-Carabineros is given a score of “one” for this particular diversity variable. The total score is the sum of all individual ranking scores. The same is done for the Shannon Diversity index as well. Only the 2018 indexes were generated for Social Diversity Variables used in the study due to the unavailability of data in 1990.

5. Analysis of Results

Table 1. Diversity Indexes for Villa Llaima and Banco Estado-Carabineros

| Neighbourhoods | Simpson Diversity Index | Shannon Diversity Index |
|----------------|-------------------------|-------------------------|
| Diversity      |                         |                         |
|                | Villa Llaima            | Banco Estado1+ Carabineros |
|                | 1990 2018               | 1990 2018               |
| Physical/ Spatial Diversity | | | |
| Land Uses     | 0.10 (2) | 0.241 (3) | 0.033 | 0.272 |
| Intensity      | 0.46 (3) | 0.679 (2) | 0.578 | 0.777 |
| Housing        | 0.51 (0) | 0.494 (6) | 0.490 | 0.564 |
| Spatial        | 5   (3) | 4 (6) | 6 |
| Social Diversity | Income groups | - 0.728 | - | 0.725 | - 1.35 (7) | - 1.356 |
| Family type    | - 0.753 | - | 0.821 | - 1.39 (2) | - 1.561 |
| Employment status | - 0.721 | - | 0.711 | - 1.24 (9) | - 1.206 |
| Years of tenure in the communities | - 0.732 | - | 0.616 | - 1.34 (4) | - 1.013 |
| Educational Levels | - 0.284 | - | 0.358 | - 0.58 (8) | - 0.639 |
| Marriage status | - 0.652 | - | 1.246 | - 0.73 (1) | - 1.348 |
| Age Groups     | - 0.771 | - | 0.803 | - 1.43 (5) | - 1.544 |
| Social Diversity score base on Ranking | - 9 | - 12 | - 11 | - 11 |

\[ H = \sum_{i=1}^{S} (P_i \cdot \ln P_i) \]

S represents the number of categories which shows diversity index (how many categories exist) as well as the distribution dynamics in the neighborhood.
The results show that Villa Llaima and Banco Estado1-Carabineros are both spatially and socially diverse communities on Simpson and Shannon indexes. This is because the indexes of the variables measured recorded diversity ranges. Homogeneity in any of the measured variables would have scored zero (0) on Shannon index. The results are explained using the Richness and the Evenness factors of urban diversity variable. The “Richness” factors of the diversity variables look at the number of classes of variables present whereas the “Evenness” factor explains the relative abundance or how the abundance of the classes are distributed among the community or neighbourhood. The results show Villa Llaima as spatially diverse neighbourhood (in terms of combination and mixtures of land uses and intensities, and the mix of different types of housing) on both Simpson and Shannon indexes in 1990 than Banco Estado1-Carabineros.

It recorded a Spatial Diversity score of (5) on Simpson index and Six (6) on Shannon index whereas Banco Estado1-Carabineros recorded Four (4) on both Simpson index and Shannon index. This is due to the fact that Villa Llaima was “richer” and well distributed in terms of different classes of land uses and housing types than Banco Estado1-Carabineros in 1990. Banco Estado1-Carabineros however, was more diverse in 2018 than Villa Llaima due to increased richness and evenness of the variables. For instance, juxtaposing the indexes obtained for “housing typology” for both communities in 1990 and 2018 on the “Richness” and “Evenness” factors explain the disparity in the indexes. Villa Llaima, which was more diverse in 1990, had all the classes of housing typology present within the Chilean context (urban block, semi-detached houses, detached houses and terrace houses), given it 100 per cent richness. This is fairly distributed as well (in terms of the parcel of usage- see table 1 and figures 2, 3 & 4) as shown by the Shannon Index. Banco Estado1-Carabineros, on the other hand, had 75 per cent richness, as there were no urban blocks in 1990 (see Table 1). However, 5 per cent land parcels, which translate

\footnote{A neighbourhood with only one species /uses would have an H value of 0 because \( P_i \) would equal 1 and be multiplied by \( \ln P_i \) which would equal zero.}
into 22 urban blocks with an average of eight (8) stories per block, were recorded in 2018. Not only did Banco Estado Carabineros achieve 100 per cent Richness level of housing typologies in 2018, the distribution dynamics was also the highest as compare to Villa Llaima, which had three (3) additional urban blocks within the period.

6. Discussion

6.1. Effects on Physical/Spatial Diversities

The mix of housing types and different tenures (see Figures 3 and 4), for example, homeowners (60 per cent in Villa Llaima, 55 per cent in Banco Estado Carabineros), renters (40 per cent in Villa Llaima and 45 per cent in Banco Estado Carabineros), provides multiple housing opportunities to the neighbourhoods. The mix between old and new housing properties creates an inclusive environment for various income groups as older units become more affordable through the downward housing and land use filtering process. This is where higher-end properties eventually become cheaper and available for moderate-income households. This was observed in Villa Llaima where many of the urban blocks and semi-detached housing used to be occupied by the working class and the upper echelon, are now occupied by students and low-income groups. This kind of mix observed in the study neighbourhoods is important to ensure that social mobility does not require geographical mobility. In other words, providing opportunities for residents to change their housing without moving out of the neighbourhood. This was observed in Villa Llaima where many homeowners reported to have lived in the urban blocks prior to buying their current residents. This process neutralizes the idea that some areas are for steppingstones for a better future and that one moves up in the social ladder by moving out to a different and better neighbourhood [16].

Another observation was that the housing and land use filtering process did not only manifest in the ‘downward’ trend as demonstrated above, but also evidence of ‘upward’ filtering process (where cheaper houses/ lots/ land parcels are replaced through gentrification) were observed. Though the process had some old properties replaced by higher income groups, a loftier part of the “upward”
filtering process went into increasing the “Richness” and “Evenness” of urban diversity variables in the neighbourhoods.

This manifested in the land uses changes observed in the neighbourhoods. These variations were evident in the indexes, as Villa Llaima between 1990 and 2018 had a 57.7 per cent change in land use diversity index (0.102-0.241 on Simpson’s Index) whilst Banco Estado-Carabineros registered 87.9 per cent (0.033-0.272) on the same index. Both neighbourhoods recorded an average change of 65.5 per cent on the Shannon Index. Commercial land uses in Villa Llaima and Banco Estado-Carabineros increased by 7.60 per cent and 5.38 per cent whilst educational land use increased by 5.7 per cent and 6.14 per cent respectively. These two neighbourhoods currently host four (4) universities and dynasties 35 per cent and 40 per cent student population correspondingly.

6.2. Effects on Social/Cultural Diversities
The effects of urban transformation on the social dimensions of the study neighbourhoods were overwhelming as observed by the study. This was evident in the espousal of a full range of human complexity (such as the co-existence of students and elderly, married couples and singles, large and single families, professionals, varying income and cultural backgrounds) found within the urban environment of the study neighbourhoods. Retirees who normally live alone (one-person household) or husband and wife type of family in the study neighbourhoods now have students living together with them on the arrendar pieza/pension concept. Aside from the additional income (about 185, 000 pesos (US$ 300) per student per month) it provides, it also keeps the house active and diminishes loneliness, which has become a contemporary problem.

The study also revealed that the mix of housing types and different tenures, and the mix of different forms and sizes, from single family housing to multi-family housing were important in the space economy of the neighbourhoods. This was evident from the refuge provided by the study neighbourhoods for migrants (especially students- who come from all over Chile to study in Temuco)

\footnote{A concept where a room in a house is rented out to a complete stranger mostly students who become part of the house but are not relatives.}

\footnote{Pesos-Dollar conversion base on May 2018 rates.}
and the spaces provided for the co-existence of neighbourhood shops and residential facilities, which are essential for retaining the lower-income people in the neighbourhoods. The blend and co-existence of mixtures of activities and structures have increased the degree to which local environments offer points of connection and contact by providing walkable distances to shops and facilities. This was corroborated by the accessibility-based mix survey done on the purchase of basic food items and groceries in the study neighbourhoods. This mix is essential for a sustainable urban form, which counters the socially insular and physically disconnected car-dependent land uses.

7. Policy Reflections and Conclusions
The study revealed that the transformation has encouraged inclusive pluralism of social and spatial dimensions. It was clear that the diversity generated have to be preserved in order to improve connectedness and social cohesion in the two neighbourhoods. In light of these findings, the study recommends the sustaining of the existing diversity through a modification to the Communal Regulatory Plan of Temuco to regulate developments at the neighbourhood level. Diverse places invariably attract more people and constantly face development pressures. Without neighbourhood planning and design, small neighbourhood shops and businesses may be pushed out by chain stores, old residents may be displaced by young professionals, lower income houses are likely to be replaced by high-class houses, whilst the communal and neighbourhood support spirit, which characterised them in the formation stages, dwindles. The study found out that the control of development at the local or neighbourhood level is virtually not in existence in Chile. It is important that modifications are made to the Communal Regulatory Plan of Temuco to regulate developments at the neighbourhood level. These modifications should include neighbourhood involvement or neighbourhood review of projects to foster collective input. The neighbourhood plan may also recognize which kinds of neighbourhood developments or improvements are essential for the neighbourhoods’ long-time resilience and without them the neighbourhood may decline. The plan may also include controls on how new developments sustain and ensure compatibility of diverse types of developments that are essential in promoting urban diversity. While every city, town and neighbourhoods have a unique character, in terms of their identity and diversity dynamics, it is expected that this research will have some implications for Medium size cities and neighbourhoods in Chile.

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