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Evaluation of Urban Sprawl Speed and Intensity Based on International Urbanization. Example from a Mexican City

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ABSTRACT

Urban sprawl characteristics and forms have been investigated thoroughly, but studies are often at a country or a region level. The related observations fail to compare sprawl in cities from different continents or cultures. This paper tries to do this by quantifying sprawl in a mid-sized city in north-western Mexico (Ensenada) between 1980 and 2014 by means of Shannon Entropy and comparing it with 12 different cities from India, Iran, Portugal, Nepal, China, and Canada. The comparisons are conducted separately targeting sprawl intensity and speed. Shannon Entropy means are compared to represent differences in sprawl intensity, while Analysis of Covariance (ANCOVA) is applied to model and compare regression coefficients that represent sprawl speed. Homogeneity of regression slopes indicates differences in sprawl speed of Ensenada with the compared cities. The results reveal that Ensenada is more sprawled than 7 out of 12 of the observed cities, but continues to spread outward with the same speed as most of the compared cities. Such international comparisons on sprawl can on the one hand give an overview of the differences in sprawl characteristics in cities around the world. On the other hand, such investigations can provide local governments, such as Ensenada, insights to shortcomings and weak points of their land use policy. Concerning the latter case, the case-study city of this research, which represents about 20 mid-sized cities of Northern Mexico, has to take urban and suburban sprawl containment policies.

1. INTRODUCTION

Urban and suburban sprawl have been researched continuously during the past decades. Nevertheless, what makes it still relevant to study is that most of the comprehensive investigations come from the Western world, while less developed or developing countries have smaller part[1]. As a result, it is not really clear what relations there are between the extent and levels of what is called urban sprawl in different countries worldwide. In other words, it is not clear what relation is there between the speed and intensity of sprawl in different parts of the world. Thus, comparison between sprawl patterns in different regions and continents can still be significant and can contribute to the international understanding of the topic. It is possible that what is labelled as urban sprawl in one country is considered natural urban growth in other regions[2]. The lack of international comparative studies has led to our limited understanding of how different countries experience sprawl and what the similarities, common patterns, and differences are. In

1 This can be said from a rough comparison of the body of knowledge produced on the topic in North America, Western Europe, and Australia with that of less-developed or even developing countries. Of course, this comparison needs a stand-alone study collecting and analyzing numerous studies. This activity has not been within the scope of this paper. However, this conclusion is based on the judgment of authors based on previous experience of urban sprawl studies conducted on different regions, especially developing countries.

2 For differentiation between urban sprawl and natural urban growth in one county, refer to Pichler-Milanović's work [34].

other words, measurements targeting sprawl characteristics such as sprawl intensity and speed are not covered by the present literature. Very little is known about the nature of sprawl in many developing countries. Hence, this subject remains a hypothesis for future research.

Therefore, this study focuses on the above mentioned gap. A mid-sized city of Mexico is taken as a representative for similar cities that are confronted with urban problems caused by fast outward growth.

In section 2, the background of quantification of urban sprawl by Shannon Entropy is considered and the approach of the study towards computation of Entropy and comparing the calculations about Ensenada, Mexico are described. The method of comparing sprawl specifications in observed cities is also explained. Section 3 presents the outcomes of calculating the entropy of the observation city together with comparing them to the similar outputs coming from existing literature about 12 other cities. In addition, a brief discussion is given in the same section about the status of urban sprawl in the observed countries. The concluding remarks attempt to direct researchers to similar multi-country comparative studies about sprawl. The dissimilarity of the present study with the existing ones is that this research takes 12 cities from 7 countries located on 4 continents. Thus, we selected our case studies from a broader range than studies that compare two or three cases.

2. THEORY AND METHODOLOGY

Regardless of methods and approaches, urban sprawl measurements have scarcely had an international and holistic nature that can explain sprawl and fast urbanization with a global view. The works of Shlomo Angel and colleagues are some of the rare examples of this type [30], [31]. Among the nation-wide studies that focus on a group of cities the biggest share is related to the US studies [13], [14], [15], [16], [17]. Such studies can provide basis for comparing the sprawl rate/speed of different cities. Similar literature can be found about Germany [18]. Also some efforts have been done focusing on Indian cities, i.e. Taubenböck et al. (2008) have studied spatial parameters as absolute area growth, urbanization rates, built-up densities, landscape shape index, edge density, patch density, or largest patch index of three megacities of India, Delhi, Mumbai, and Kolkata in 1975, 1990, and 2000 [22].

However, all of the above are limited to national level. Studies able to provide international comparative frameworks are rare indeed. Such comparisons can be done by uniform methodologies taken for cities from international level. Some research has been conducted at the European level that can bring cities from several countries under one umbrella of sprawl assessment, i.e. the extent of sprawl in major European cities has been measured and mapped by Arribas-Bel et al. (2011) [19]. In addition, an older study, performed by the European Environment Agency, presents useful descriptive indicators in order to explain sprawl in different parts of the European Union [25]. Patacchini et al (2009) have studied sprawl in top 25 percent largest and smallest European cities, but their research is limited to only urban population densities [26]. GIS-based indicators have been often found a helpful method to measure sprawl in the European cities [27]. The work of Taubenböck et al. (2012) targets the urbanization status of megacities around the world using Remote Sensing (RS) applications [23]. Comparing cities from different parts of the world has become possible by such investigations, but urban sprawl is only a part of such them. In other words, their main topic is not quantification of urban sprawl in study cities. There are also studies that focus on urban structure in general but can provide inputs to sprawl differences between European cities [20]. Nevertheless, these studies on urban sprawl remain within the borders of the European Union/Europe. Outside this context, stand-alone and separate sprawl measurements have little connection with one another; therefore, the outcomes are hardly comparable. Consequently, this study attempts to connect studies previously done on cities in different regions of the world.

This study analyses the urban development pattern of a representative mid-sized city in the northern part of Mexico and compares it with comparable measurements in other parts of the world. To do that, the development pattern is first descriptively analyzed and then its growth speed is measured by Shannon Entropy. This method has been adopted in a number of previous studies. Therefore good ground exists for comparative observations. The outcome can be generalized to about 20 cities in the northern part of Mexico. It is meant to judge the sprawl speed of this region by comparing it with the international urban growth trends.

After reviewing similar studies about the measuring sprawl speed, particularly those about developing countries, the study continues with introducing Shannon Entropy and the city of Ensenada as the case-study city.

2.1. Shannon Entropy

The Entropy measurement method taken in this paper was suggested by Claude E. Shannon in 1948 [32] and is now being applied to urban development studies. The examples of the applications of Shannon Entropy for measuring urban sprawl are seen throughout this paper. Along with few other methods, Shannon Entropy provides a non-GIS monitoring observation method that can quantify urban growth

speed (though the numerical outcomes are easily transferred into GIS environment). The city growth rate is observed by using concentric circles or any other geometric or non-geometric form. It is meant to measure the areas of the regions that are built on in different time intervals by using equation (1):

$$Hn=-\sum Pi \ln(Pi) \quad (1)$$

Whereas Pi is the proportion of built up area in the zone (Xi) and Hn is the entropy value. Pi is calculated by (2):

$$P_i = \frac{x_i}{\sum_{i=1}^{n} x_i} \quad (2)$$

The Shannon entropy range varies from zero to Ln (n); when closer to the maximum level it means the city has an increased grade of urban sprawl. Low values of Hn represent compact urban developments, which opposes to high values that indicate dispersed development pattern. To standardize the results, equation (2) is applied:

$$H'n = \frac{Hn}{Log(n)} \quad (3)$$

As a result, the output is converted to relative entropy (zero to one).

2.2. Study area

The work takes a representative case study for a Mexican Northern mid-sized city. The city is located in the state of Baja California. Currently Mexico has 62 mid-sized cities (100 to 500 thousand inhabitants) and 14 are located in Northern Mexico. The case study is the city of Ensenada located in the state of Baja California (Fig. 1). The city presents a normal development for Mexican cities, contrary to some cities such as Cabo San Lucas with a tourism development.

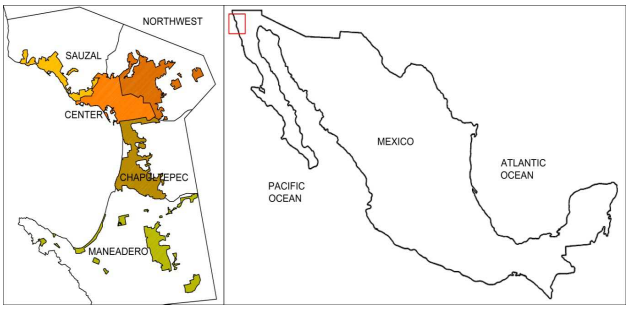

Fig. 1. The city of Ensenada in north-western Mexico *(source: based of the data originated from IMIP [24]).*

Located in North-West of Mexico, the city was founded in 1882 and grew from a small town of 2,800 inhabitants in 1910-1930 to the current mid-sized city of 420,000 residents. Ensenada's urban area covers 90 square kilometres in 2014.

Figure 1 also illustrates the city with its five main zones; Centre Zone (the oldest part), Northwest, Sauzal, Chapultepec, and Maneadero. The city's population density is of 3,600 inhabitants per sq. km, which is rather less than the figure of Mexican cities (5,700 inhabitants per sq. km. according to the Mexican National Institute of Statistics and Geography-INEGI [21]). For the Northern mid-sized cities (14 cities) the average density is around 3,400 per sq. km [29]. The dominant construction pattern of the city is based on low density developments, in the central zone the lots are around 250 sq. m., the social housing appeared in the latest decades with considerable smaller lots per household. The changes on the urban form of the city due to this progress in housing characteristics brought higher densities in the periphery [28]. The informal settlements have appeared in its majority in the periphery, where public services are limited [28].

Chapultepec and Maneadero are dominated by agricultural use, while Sauzal has the fishing area along with a secondary harbour. The city presents an urban centre (Centre zone), which is an area with better connectivity, while the second urban centre (Chapultepec) did fully develop due to lack of proper connectivity. The recent policies in Ensenada have the approach to limit the growth in the periphery and promote other urban centres, but still these centres have not been consolidated [28]. Between the informal settlement and social housing in the periphery combined with socioeconomic trends such as economic activities in the periphery seems to be the reasons behind this development pattern.

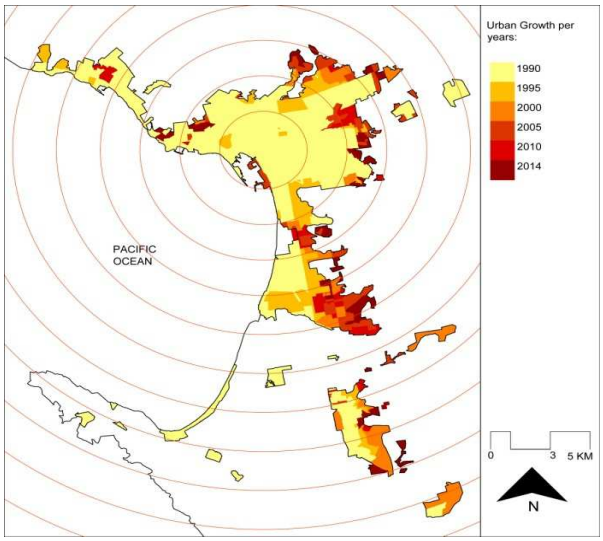

Fig. 2. Ensenada and its buffer zones between 1980 and 2014 *(source: based of the data originated from IMIP [24]).*

The case study is undertaken for the time duration of 1980-2014 for the city of Ensenada. Some 12 concentric circles are needed to cover the whole developments throughout these 34 years. The urban areas related to the years 1980, 1990, 1995, 2000, 2005, 2010, and 2014 were surrounded in Shannon buffers so that the Shannon Entropy is calculated based on the initial built-up areas of every year. The data of urban areas of different years were collected from INEGI [21] and IMIP [24]. Figure 2 to Figure 5 illustrate the city's growth during these years, and how it is embraced by the buffer zones.

2.3. International comparative study

The city-level output generated by the Shannon equations can mean little by themselves; they cannot clarify if growth is either fast or natural. One application of these outputs is in predicting the future trends and dynamics of urban land use. For this, Shannon Entropy is separately computed for different zones as well as uses. The numerical outputs are analyzed in Geographical Information Systems (GIS) environment to monitor the past dynamics and predict the future trends. The second method is to compute Shannon Entropies for different cities and compare them with one another.

In this case, the cities with regular entropy can be compared with each other and those with relative entropies are separately comparable. The reason is that Hn takes unlimited values more than 1 while H'n is standardized and is limited to 0 and 1. Not all of the studies carried out based on Shannon approach have taken relative entropy method. Since it was not possible to change the general Hn results to H'n, the authors of this paper compared cities with Hn with one another, and those having H'n with one another. Then it would be possible to find out more details about the sprawl speed of the target city. It would be possible to say in what status the sprawl of the case-study city is compared to other cities in the world. The latter method is taken by this study for Ensenada. 12 other cities are taken as international cases that have already been studied in literature. The cities are mainly located in transition countries while two of them are situated in Western Europe and North America. Selecting these cities was based on the accessibility to studies online, which can be translated into the international studies performed on the topic. The distribution of cities in different regions of the world and also their location in industrial and transition countries were important criteria for selection.

This study does not explain the causes and reasoning behind sprawl in different contexts, but the aim is to compare sprawl characteristics in different regions so that new questions arise for future research. In addition, the size of target cities was not a criterion for selection. As seen in Table 1, cities with different sizes were taken, so that dissimilarities should be indicated. The size of cities is less important because it is possible that smaller cities have faster or more intense sprawl rate than the large cities or metropolitan areas. The example is the mid-sized city of Yazd that dispersed from 710 hectares in 1956 to 11,000 hectares in 2001, while the population had a normal trend in the same period (63,502 to 388,107 inhabitants) [35]. This trend is much higher than in the case of many metropolitan areas around the globe.

The main idea behind this comparison is to analyze the speed and intensity of urban sprawl in Ensenada compared to the international trends.

The comparison cases are Jorhat, India [1]; Vadodara Taluka, India [2]; Calgary, Canada [3]; Hyderabad, India [4]; Mangalore, India [5]; Ajmer, India [6]; Sesimbra, Portugal [7]; Nanjing, China [8]; Sari, Iran [9]; Urmia, Iran [10]; Kolkata, India [11]; and Kirtipur, Nepal [12].

Both normal and relative Shannon Entropies have already been measured by other scholars in different studies, thus both Hn and H'n are computed for Ensenada to develop comparisons with the target cities. The comparison cities accommodate different sizes of populations as seen in Table 1.

Table 1. Population of comparison cities[3].

No.	City	Population	Date of Census
1	Jorhat, India	71,782	1 March 2011
2	Vadodara, India	1,822,221	1 March 2011
3	Calgary, Canada	1,095,404	1 May 2011
4	Hyderabad, India	3,943,323	1 March 2011
5	Mangalore, India	488,968	1 March 2011
6	Ajmer, India	542,321	1 March 2011
7	Sesimbra, Portugal	50,337	31 Dec. 2013
8	Nanjing, China	5,827,888	1 Nov. 2010
9	Sari, Iran	296,417	24 Oct. 2011
10	Urmia, Iran	667,499	24 Oct. 2011
11	Kolkata, India	4,496,694	1 May 2011
12	Kirtipur, Nepal	67,171	22 June 2011
13	Ensenada, Mexico	441,841	2014

For comparing the intensity of urban sprawl between the cities, the mean of entropies of each pair of cities are compared. The mean entropy is assumed to represent sprawl intensity throughout a period of time.

In order to compare sprawl speed, the linear regression coefficient (B) of Ensenada for the duration of 1980-2014 is compared to that of each target city. Steeper slopes indicate faster sprawls. It is possible that cities located in different regions of the world have started sprawling sooner or later than Ensenada and during the past one or two decades the speed of their sprawl has decreased, hence it is relevant to control for

3 The population of cities presented in Table 1 indicates the number of inhabitants living in the central cities. These figures are derived from web resources.

the time bias. For that, the Analysis of Covariance (ANCOVA) is applied to provide a ground for removing or minimizing time effects. To conduct ANCOVA, Shannon-Entropy (Hn or H'n) is taken as descriptive variable, and *"city"* is the independent variable. In all comparisons Ensenada is taken as reference category. For testing the homogeneity of regression slopes, the new variables of city*year are computed and put in the models. Two models are developed; one for Hn and one for H'n. Some 7 compared cities are included in the first model and 5 in the latter one. The null hypothesis is that the regression coefficients of Ensenada and the 12 cities (representing their urban sprawl speed) are equal.

3. RESULTS AND DISCUSSION

The entropies calculated for the city in the 1980-2014 are presented in Table 2.

Relative entropies fall between 0 and 1, while regular entropies can have any positive value. High entropies indicate high levels of outward urban growth or urban sprawl. During these 34 years, 10.165 percent is added to the entropy amount. It has increased from 0.76907 in 1980 to 0.85609 in 2014. As seen in the table, the sprawl has continued during the observation period steadily. The most intense sprawl occurred in between 1995 and 2000.

This amount of entropy accounts for more than 16 times higher than that of 2000-2005 and more than 7 times than 1990-1995. The reason behind this fast growth is the development of social and affordable housing projects around 1998-2000. This again shows that urban sprawl is not necessarily unplanned, but fast outward growth can be a planned and top-down process.

To have an understanding of the sprawl specifications of Ensenada in the international context, the mean and regression coefficient of its Hn and H'n are analyzed in two separate models.

The most important variable in these two models is City*Year. Tables 3 and 4 show the results of the ANCOVA models with the covariate of "Years". Table 3 indicates the results of Shannon Entropy analysis for Ensenada and 7 other cities, which have been subject of similar computations: Ajmer, Hyderabad, Jorhat, Kolkata, Mangalore, Vadodara Taluka in India, and Urmia in Iran.

The model shows that City*Year is a significant predictor of Shannon Entropy ($p<0.0001$).

The same procedure is taken for modelling relative Shannon Entropy H'n of Ensenada and 5 other cities: Calgary, Canada; Jiangning, China; Kirtipur, Nepal; Sari, Iran; and Sesimbra, Portugal (Table 4).

H'n has been calculated for the above cities in the existing literature, so they are put in a separate model. According to this model, City*Year is very marginally a predictor of H'n assuming that $p=0,1$ provides marginal significance.

Table 2. Shannon Entropy measures of Ensenada in 1980-2014 period.

Year	Shannon Entropy (Hn)	Relative Shannon Entropy (H'n)	Time Intervals	ΔH'n
1980	1.77086	0.76907	1980-1990	0.01071
1990	1.93769	0.77978	1990-1995	0.00769
1995	1.95679	0.78747	1995-2000	0.05578
2000	2.09539	0.84325	2000-2005	0.00359
2005	2.10431	0.84684	2005-2010	0.00347
2010	2.11294	0.85031	2010-2014	0.00578
2014	2.12731	0.85609		

Table 3. Tests of between-subjects effects for basic Shannon Entropies (Hn) of Ensenada and 7 other cities. *(Dependent Variable: Shannon_Entropy).*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.157	17	0.186	121.634	0.000
Intercept	0.033	1	0.033	21.294	0.001
City	0.200	8	0.025	16.370	0.000
Year	0.043	1	0.043	28.167	0.000
City * Year	0.203	8	0.025	16.615	0.000
Error	0.017	11	0.002		
Total	89.569	29			
Corrected Total	3.174	28			

Table 4. Tests of between-subjects effects for relative Shannon Entropies (H'n) of Ensenada and 5 other cities. *(Dependent Variable: Shannon Entropy).*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.103[a]	13	0.085	27.650	0.000
Intercept	0.048	1	0.048	15.698	0.001
City	0.039	6	0.007	2.120	0.111
Year	0.053	1	0.053	17.339	0.001
City * Year	0.039	6	0.006	2.093	0.115
Error	0.046	15	0.003		
Total	17.603	29			
Corrected Total	1.149	28			

Table 5 presents the parameter estimates of Ensenada and the first group of cities to compare their regression coefficients. It is meant to see if there is any homogeneity of Shannon Entropy-Year slopes between Ensenada and every one of the target cities. T-stat and p are computed to show the significant differences between the coefficients (B) of the reference city and the target cities.

The sprawl slope of Ensenada is significantly more than that of Mangalore and Urmia while it is less than Vadodara Taluka. Other Coefficients are considered to be statistically equal.

Table 5. Parameter estimates of Ensenada and 7 international cities *(Dependent Variable: Shannon Entropy)*.

Reference City	Compared City	No. of Years	B	Mean	Std. Error	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
[City=Ensenada, Mexico] * Year (No. of Years= 7; B=0.005; Mean=1,974)	[City=Ajmer, India] * Year	4	-0.003	1.602	0.003	-1.120	0.286	-0.008	0.003
	[City=Hyderabad, India] * Year	2	-0.006	1.594	0.009	-0.634	0.539	-0.027	0.015
	[City=Jorhat, India] * Year	2	0.007	2.313	0.004	1.562	0.147	-0.003	0.016
	[City=Kolkata, India] * Year	4	0.001	1.552	0.002	0.406	0.692	-0.004	0.006
	[City=Mangalore, India] * Year	2	-0.009	1.686	0.003	-3.545	0.005	-0.015	-0.004
	[City=Urmia, Iran] * Year	2	-0.009	1.356	0.003	-2.471	0.031	-0.016	-0.001
	[City=Vadodara Taluka, India] * Year	3	0.023	2.012	0.003	7.933	0.000	0.017	0.029

Table 6. Parameter estimates of Ensenada and 5 international cities *(Dependent Variable: Shannon_Entropy)*.

Reference City	Compared City	No. of Years	B	Mean	Std. Error	t	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
[City=Ensenada, Mexico] * Year (No. of Years= 7; B=-0.007; Mean=0,814)	[City=Calgary, Canada] * Year	6	-0.006	0.896	0.006	-1.042	0.314	-0.020	0.007
	[City=Jiangning, China] * Year	4	0.004	0.772	0.006	0.775	0.451	-0.008	0.017
	[City=Kirtipur, Nepal] * Year	3	0.002	0.173	0.007	0.333	0.744	-0.013	0.018
	[City=Sari, Iran] * Year	3	-0.008	0.789	0.009	-0.943	0.361	-0.027	0.011
	[City=Sesimbra, Portugal] * Year	3	0.000	0.803	0.007	0.034	0.974	-0.014	0.015

Table 7. The results of comparison between sprawl speed and intensification of Ensenada and selected cities.

Reference City	Compared City	Sprawl Speed (B) Analysis Result	Sprawl Intensity (Mean) Analysis Result
Ensenada, Mexico	Ajmer, India	Ensenada=Ajmer	Ensenada>Ajmer
	Hyderabad, India	Ensenada= Hyderabad	Ensenada>Hyderabad
	Jorhat, India	Ensenada=Jorhat	Ensenada<Jorhat
	Kolkata, India	Ensenada=Kolkata	Ensenada>Kolkata
	Mangalore, India	Ensenada>Mangalore	Ensenada>Mangalore
	Urmia, Iran	Ensenada>Urmia	Ensenada>Urmia
	Vadodara Taluka, India	Ensenada>Vadodara Taluka	Ensenada< Vadodara Taluka
	Calgary, Canada	Ensenada=Calgary	Ensenada<Calgary
	Jiangning, China	Ensenada=Jiangning	Ensenada>Jiangning
	Kirtipur, Nepal	Ensenada=Kirtipur	Ensenada>Kirtipur
	Sari, Iran	Ensenada=Sari	Ensenada>Sari

The same test is undertaken for H'n; the results are shown in Table 6. The regression slopes are homogeneous; and no significant differences are observed. That is while the mean H'n values of cities range from considerably less (0.173) to slightly more than Ensenada (0.896).

Table 7 summarizes the results derived from the above statistical analysis and modelling. Ensenada has equal sprawl speed like 4 out of 6 Indian cities examined, while its sprawl intensity is more than 4 of them. In other words, Ensenada is more sprawled than the observed Indian cities, but they are sprawling at the same speed.

The same conditions are true about the one of the Iranian cities, the Portuguese, the Nepali, and the Chinese cites. The exceptions are Calgary in Canada and Urmia in Iran. While Calgary is more sprawled than Ensenada, they are sprawling at the same speed. Both speed and intensity of sprawl in Ensenada is higher than that of Urmia, Iran.

The dominant pattern seen in the final results presented in the last table is that Ensenada is more sprawled but continues to grow as fast as 7 out of 12 studied cities. One reason behind this can be that most of the cities investigated are located in emerging countries whose mid-sized cities have started sprawling during the past two decades. It is possible that mid-sized Mexican cities have followed the general North American sprawl pattern to a less extent than the U.S. and Canadian cities.

This may be true particularly for those cities located near the Mexican-USA border. They have started sprawling even before 1980 and continued this growth pattern steadily. The urbanization rate of Mexico has become larger in the second half of the twentieth century [33].

4. CONCLUSION

Urban sprawl is not only a challenge to large metropolitan areas, but also mid-sized cities like Ensenada are experiencing its negative outcomes including high costs of infrastructure development and considerable car dependency rates. The observations of this paper show Ensenada as an example of mid-sized cities of Northern Mexico, being a more sprawled city compared to many cities of developing and emerging countries[4]. This is per se a challenge for the City; however, what makes it more complicated is that many cities of this type are unable or have problem to contain the sprawl by putting stronger control on urban development plans (such as Akure, Nigeria [40] Beijing, China and Taipei, Taiwan [41], and Urmia, Iran [10]) and providing compaction and local centres to attract short-range urban travels [43]. Academia has repeatedly recommended applying infill development plans and regeneration projects to combat leapfrog development [37], [38], [39], [42]. What is presented in this study can give scholars and practitioners an understanding of how they can evaluate their cities' sprawl characteristics and compare it to the specifications of sprawl in other countries. Monitoring urban land use dynamics are systematically done via computer-based studies, but such studies usually do not provide an international comparative basis, unless new research approaches can put them in internationally comparison frameworks.

The limitation of accessibility to studies that have already measured Shannon Entropy made this research compare fast urbanization of a Mexican city with similar trends in only 6 developing and developed countries. More in-depth studies are needed to broaden such observations to more countries from different continents and cultures to give an overview about international sprawl trends. Such studies are expected to pass the traditional limitation of urban sprawl studies to industrial countries. During the present study no trustable case of Africa and South America were found. As a recommendation for further research, it is suggested to focus similar efforts on less studied geographical contexts.

Studies like the present paper can show providing definitions applicable for different regions of the world, can bring international researchers and practitioners to a common point that they can easier understand one another. For that purpose, more comparative studies covering different continents are needed.

[4] Mexican cities have been experiencing fast urbanization rates during the second half of the last century [36]. Usually, fast urbanization and urban sprawl come together. There is a lack of sprawl evidence about Mexican cities, so the authors cannot address fast sprawl in Ensenada as a characteristic of this city or generalize it to other Mexican cities.

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