Measuring Sounds with a Grid Method for Supporting the Design of Public Spaces

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Abstract: Sound is a "forgotten" element and is seldom considered a built environment feature by urban planners, architects, landscape architects, civil engineering and many other disciplines. Currently, there are a few studies related to sound approaches in the United States. Accordingly, this research provides a scope of the relationship between sound and public space by performing mobile devices in Dallas Fort-Worth metropolitan area. The main question of this study is whether characteristics, program elements and use of public open spaces have a relationship to sound levels. To answer the aforementioned research question, this study adopts technological instruments for sound environment in public open spaces by using the grid method for sound measurements. This research suggests that time intervals associate with sound levels. Additionally, this study provides comparison of micro programmable spaces within a public space regarding sound.

Keywords: Sound environment, landscape architecture, urbanized areas, micro programmed elements

1 Introduction

Urban open spaces are essential parts of human life since they provide natural, social and cultural connections between users, users and space, and between users and nature. Natural environments also provide an experience for users of open spaces through the senses, such as smelling, touching, and hearing (HARRISON et al. 1987). People experience public spaces with all their senses and when an open space is created, it is important to create a harmony between all elements and micro programmable spaces. These program elements include recreation areas, social platforms, vegetation, and animal areas (CHIESURA 2004). However, open spaces should not only connect structures and places, but also they need to create integration of people and their surrounding elements. Such spaces should communicate with users through all senses. This research aims to see how those allocated program elements or micro spaces in open spaces are taken into account for sound environments. Are they projected with sound implications on open spaces?

The origin of environmental sound goes back to R. Murray Schafer (SCHAFFER 1977). His main goal was to highlight the loss of sound environments and he emphasized the importance of sound (TRUAX 1999). To do this, he assessed the interaction between sound and people. He conducted a field study as World Soundscape Project including sound recordings and descriptions. Since then, many other sound measurement methods have been developed and these developments currently play major roles for simulating sound environments (MORILLAS et al. 2011). Generally, there are two basics for sound measurement methods, measuring sound and evaluating sound. Measuring sounds is performed by sound level meter to check the energy and intensity of the sound while evaluating sound is about audio production, microphone effects, mixing sounds, and enhancing sound quality (Brown and Lam, 1987). There are many sound measuring methods that have been used to obtain sound samples for the last decades. For instance, BROWN & LAM (1987) suggest three methods for measuring sound. One of them is random samplings which measures sound in a systematically described

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grid locations. Second is to stratify sound areas by dividing them into land-uses. The third is receptor based measurements rather than physical locations which measure sources of sound. In addition, methods and measurement procedures, especially in design and planning fields, have changed over time, even in sound studies.

Currently, mobile and digital state-of-the-art technologies assist in more reliable and inclusive options for these purposes (MORILLAS et al. 2011). In regard to the design and planning disciplines, sound measuring, sampling, and analysing procedures are developed for sound application. However, few studies have applied these improvements for sound and public open spaces. For the purpose of this study, the grid method is used to measure sound levels in public spaces in the cities of Dallas and Fort Worth.

The grid method applies a virtual grid on a map. Selected points of the grid are used for the sound measurement purposes. The size, distance, and shape of the grids might be modified for related purposes (ESCOBAR et al. 2012). This method has both advantages and disadvantages for sound sampling. While it is useful to evaluate sound environment comprehensively to identify sounds and provides data for current and future sound modelling, it does not provide any qualitative evaluation for sounds. Besides, it cannot assess the sound or noise exposure in urban areas (BROWN & LAM 1987). Although, the nature of this method has its own limitations and deficiencies, it offers a convenient sound assessment (BARRIGON et al. 2005) and there are some practices in literature that suggest the prominence of using grid method (ZANNIN et al. 2002 and MARTIN et al. 2006).

For example, grid method was used to collect 645 sound measurements in the city of Caceres, Spain with nearly 70 feet grids (MORILLAS et al. 2011). In the same location, Gomez Escobar and his team conducted another research to apply the grid method. This time the aim was to evaluate noise by applying 70 feet grids (ESCOBAR et al. 2012). They found that the percentage of sound samples are above the reference noise level (ESCOBAR et al. 2012). In another study, the sound levels were measured to evaluate noise pollution in the city of Curitiba, Brazil for almost 1000 locations (ZANNIN et al. 2002). The study found that almost 90 percent of the study locations are exposed to over 65 dB(A) sound levels. Even though this study used a similar method, the scope of this study goes far beyond the evaluation of noise of previous studies. This study assessed sound measurements from positive or neutral point of view rather than negative noise context.

In addition to concentrating on measuring sound level in program elements within public spaces by applying the grid method, another aim of this study is to create a strong connection between landscape architecture and sound environment studies. Landscape architecture as a planning and design discipline aims to create high quality environments for humans and other species. Landscape architecture, urban design and planning disciplines focus on visual features and pay little attention to the other senses, particularly aural. People apply all senses in order to experience the environment (YU & KANG 2008). Moreover, these senses have different implications on perception and they may be changed by different factors. Hence, sound and its perception could be operated in the same direction with many urban areas (YU & KANG 2008).

The first aim of this study is to evaluate sound environments in urbanized metropolitan area by using grid methods. The study analysed statistically the programmable areas of the open spaces as its second goal.

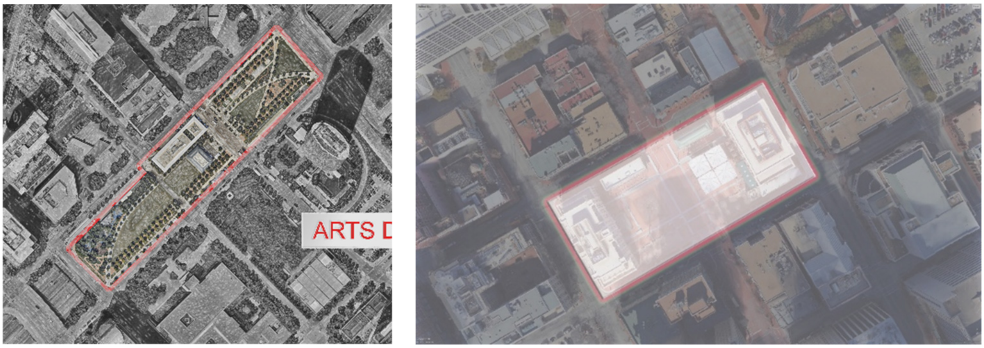

Fig. 1: Aerial view from both study areas (NEARMAP 2016)

2 Methodology

Data collection methods of this research are including primary and secondary data on sound level measurements and site observations. Since the data collection does not involve human or other species, Institutional Review Board permitted this research. This research examines sound characteristics in two public spaces in two largest downtowns in Dallas Fort Worth metropolitan area.

The selected study areas for this research are Klyde Warren Park in the city of Dallas downtown area and Sundance Square in downtown Fort Worth. The first one, Klyde Warren Park, is on a roughly 5 acre area just over an eight-lane freeway in Dallas (KWP FOUNDATION 2016). The park was aimed to have various open spaces between Dallas Arts District, downtown Dallas, Dallas Museum of Art, Nasher Sculpture Center and many other types of buildings. The park was officially opened in 2012 (KWP FOUNDATION 2016). There are many elements, such as a main lawn, children's playground, restaurant space, and dog parks. The second study area, Sundance Square, was designed with the idea of transforming almost 2 acre parking lots into a public space as a downtown square. The square was opened in 2013 and it exists on a two block area as pedestrian place just adjacent to the historic courthouse (LAF 2015). There are many program elements in the square. One edge of the square has seating and dining areas. The other corner has a sculptural umbrellas for providing an ideal size of shading. In addition, there are two water elements that brings dynamic and attractive movements to the users. Last but not least, the square has many light and sound sources as attractions.

For the purpose of this study, both sites are divided into micro areas based on program elements. Figure 3 shows these micro areas. Also, the sites were evenly divided into nodes on a virtual grid overlaid on their master plan (figure 2). Literature suggested that 200 m (roughly 75 feet) is far enough distance to apply this method (GARCIA et al. 1991). Therefore, the grid size was selected 75 feet square for both public open spaces. Nodes of these shapes were used for measuring sound pressure levels. By applying 75 square feet grid size, there are 51 measurement points emerging 32 square for Klyde Warren Park and 18 measurement points and 10 square for Sundance Square Plaza. The grids are placed in allocated micro programmable spaces shown in Figure 3 and are categorized as sound samples.

Sound pressure level measurements were performed in summer 2015 for Klyde Warren and summer in 2016 for Sundance Square Plaza. The sound levels were collected weekdays and weekends at 10 am, 1 pm, and 4 pm. Each grid point was measured 8 times. Hence, 408 sound measurements were gathered for Klyde Warren Park and 144 measurements were collected for Sundance Square Plaza. Measurements have been done for both researcher's and open space authorities' preferences on the sites. For the measurement, Landtek Instruments Professional Digital Sound Level meter 30 to 130 dB with Bluetooth was used. The sound level meter is IEC651 Type 2, ANSI S1.4. It has 4 measurement parameters; Lp (sound level), Leq (equivalent continuous A sound level), Lmax (maximum sound level), LN (percent of all readings over alarm value set). Leq 5 minute was performed for this research since its significance as a reference sign of the sound assessment and its implications on individuals in standards (ISO 1996-1). The measurements were performed by the researcher with the same equipment in the aforementioned period of times and there were not any extreme weather conditions in both sites.

After measuring sound levels in all these micro programmable spaces within each study area, T-test and ANOVA were applied to the collected data to distinguish whether there is statistically difference between these spaces in each location. Table 1. Shows the result of T-test and Table 2. Illustrates the result of ANOVA test.

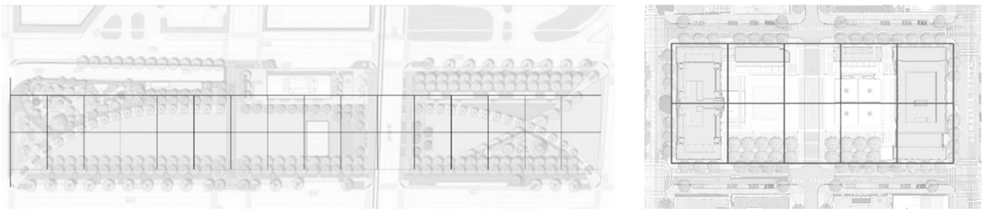

Fig. 2: Applied grid methods for both study areas (LAF 2015)

3 Results

For the research findings, while overall sound measurements are between 62.1 – 96.5 dB for KWP, they are between 63.8 – 91.4 dB for Sundance Square Plaza. For both study areas, weekend measurements are higher than the weekday samplings. The reason might be caused by both areas are providing events and organizations, particularly weekends. While Klyde Warren Park has 71.2 dB sound pressure level on weekends, Sundance Square has 81.6 dB. So, sound levels in Sundance Square is higher than Kylde Warren Park. In a similar pattern, Sundance Square is also louder (75.4 dB) than Klyde Warren Park (70.2 dB) in weekdays.

Another aspect of measuring sound levels in both public space is that examining different time intervals. As it was mentioned above, sound measurements have been conducted in three time intervals; 10am, 1pm, and 4pm. For the Klyde Warren Park, while noon measurements had the highest sound pressure levels (average 74.6 dB), morning measurements had the lowest sound values (average 66.0 dB) and afternoon measurements were at the moderate level (average 69.4 dB). Sundance Square has the similar pattern for time intervals with higher sound levels. So, the average of noon (1 pm) measurements is 80.5 dB whereas afternoon (4pm) measurements is 77.3 dB and morning sound measurement is 71.2 dB.

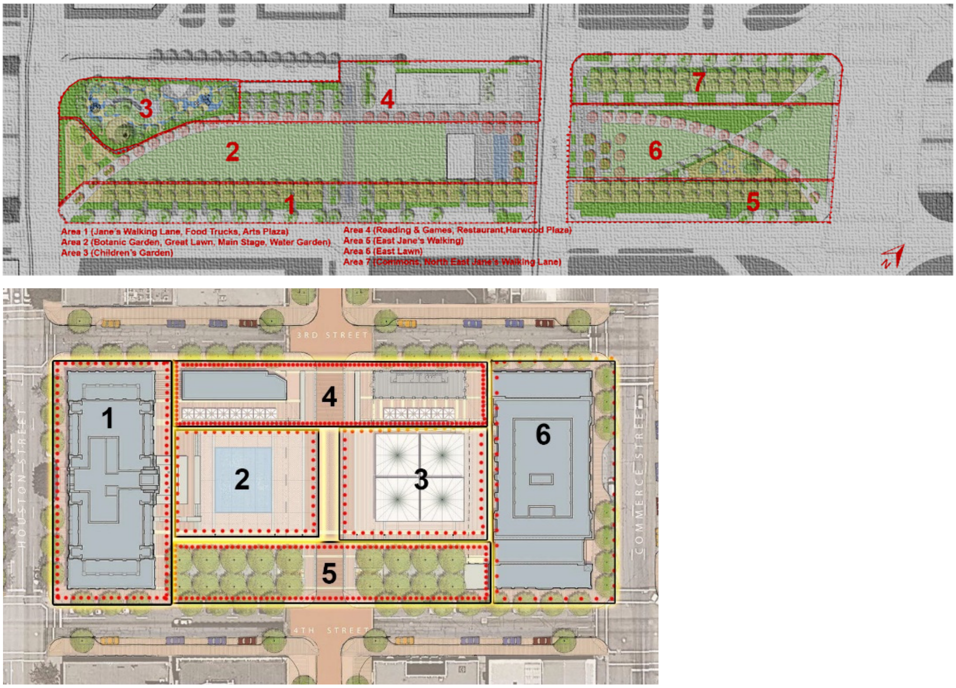

Fig. 3: Programmable areas for both study areas (LAF 2013, LAF 2014)

Table 1: T-test results for both study areas

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
dB	Equal variances assumed	0.673	0.413	1.778	398	0.076	1.271	0.7148	–0.1343	2.6764
	Equal variances not assumed			1.806	185.539	0.073	1.271	0.7039	–0.1176	2.6597

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
dB	Equal variances assumed	15.681	0.000	–6.319	141	0	–6.2388	0.9874	–8.1908	–4.2868
	Equal variances not assumed			–8.543	118.537	0	–6.2388	0.7303	–7.6849	–4.7928

In addition to providing general profile of sound patterns in time, public spaces were divided into micro programmable areas and sound levels were examined in these areas and according to the grids. The results show that, elements and nodes locating near roads have more anthropogenic activities and these areas have higher sound levels compare to other locations in the sites.

Also, the result of T-test and ANOVA methods which where used to distinguish the statistical differences between these micro spaces within each study area shows different results for Klyde Warren Park and Sundance Square. After running ANOVA test for micro programmable elements, no statistically significant difference was found for difference spaces within Klyde Warren Park while there is a significant difference for spaces in Sundance Square (Table 2). One reason can be the fact that Klyde Waren Park is almost fully surrounded by roads and highways while external sound sources in Sundance Sqaure are not as penetrative as Klyde Warren Park. Regarding time intervals, ANOVA test shows a significant difference between different times of the day in both sites.

To analyse the sound pressure levels in weekdays and weekends, T-test was applied to the collected data. The pattern is not similar as oppose to other findings. While this parameter is not at significant level for Klyde Warren Park, it is at significant level for Sundance Square (Table 1).

Table 2: ANOVA results for Sundance Square

Descriptives
sound_level

	N	Mean	Std. Deviation	Std. Error	Confidence Bound	Bound	Minimum	Maximum
1	3	80.6333	.32146	.18559	79.8348	81.4319	80.40	81.00
2	2	74.3000	.28284	.20000	71.7588	76.8412	74.10	74.50
3	2	73.7000	.70711	.50000	67.3469	80.0531	73.20	74.20
4	4	75.9250	1.43382	.71691	73.6435	78.2065	74.10	77.30
5	4	77.1000	1.20277	.60139	75.1861	79.0139	75.50	78.40
6	3	78.6333	1.05040	.60645	76.0240	81.2427	77.60	79.70
Total	18	76.9944	2.45104	.57772	75.7756	78.2133	73.20	81.00

ANOVA
sound_level

	Sum on Squares	df	Mean Square	F	Sig.
Between Groups	88.629	5	17.726	15.755	.000
Within Groups	13.501	12	1.125		
Total	102.129	17			

4 Discussion and Conclusion

This study attempted to address the relationship between sound and programmable micro areas in public spaces. To answer this research question, the grid method was applied to measure sounds. In addition, this research provided statistical sound descriptions for different time intervals, and weekdays/weekends. Based on the findings, some of these sound samples have a significant relationship and some others do not.

This research examined the sound levels in the heart of two fast growing cities of Dallas and Fort Worth, by applying sound measurement techniques and technologies in regard to the sound environment. However, this study did not aim to compare the public spaces or research locations. Rather, this study used grid method to evaluate and to collect more data from the study areas based on sound levels in different micro spaces within them.

The important note here is that no matter what type of open spaces are labelled as public space, the most essential characteristic is direct or indirect contact through senses, visual, aural and etc. While creating an open space for the people, sound environment is an important feature as well as visual, functional, and ecological designations. Since open spaces provide many activities and many sound sources with its micro programmable areas, each element should be evaluated with their unique sound environments. Thus, this is a crucial point for landscape architects, urban planners and designers to consider when introducing sound sources in public spaces or surrounding areas.

Correspondingly, open spaces have significant characteristics in terms of sound generation. In order to study sound components for designing public spaces, digital technologies would support sound evaluation and analysis, and assist to enhance quality of space. This research attempts to contribute the advancement of digital technologies which allow landscape architects to study other dimensions of human senses or experiences, specifically sounds, as part of comprehensive landscape architecture field. It can be claimed that the availability, affordability, and practicality of the mobile tools and technologies within recent years provide researchers and professionals new opportunities to study and assess multifaceted landscape issues on the field.

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