Sustainable Supply Chain Management in Smart City Design: A Case Study of Al Khobar City Centre

Hany Hossam Eldien[1], Karim Gazzeh[2], Emad Hammad[3]

[1]*Department of Building Engineering, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, 31451 Dammam, Kingdom of Saudi Arabia*

[2]*Department of Urban and Regional Planning, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, 31451 Dammam, Kingdom of Saudi Arabia*

[3]*Department of Interior Architecture, College of Architecture and Planning, Imam Abdulrahman Bin Faisal University, 31451 Dammam, Kingdom of Saudi Arabia*

[1]hehassam@iau.edu.sa

[2]kaalgazzeh@iau.edu.sa

[3]Ehammad@iau.edu.sa

***Abstract*—The purpose of this study is to analyze the impact of supply chain management (SCM) on smart city development. More specifically, we investigate the connections between smart cities, and supply network characteristics (supply network structure and governance mechanisms). Urban spaces, which have high acoustic quality, are a rare resource that must be protected to achieve the sustainable urban development as well as health and comfort of the urban space users. Urban morphology and urban environment are major topics for various urban studies using multiple approaches. Many of these approaches focus firstly on the visual analysis of urban area, while a shortage of urban sound quality studies can be highlighted. In this study, we propose the sound-walk procedure to evaluate the urban supply chain managements in Khobar city center. This work aims to understand how the use of supply chain management concept can help in environmental issues in urban areas. The relationships between smart cities, big data and supply networks cannot be described simply by using a linear, cause-and-effect framework. Accordingly, we have proposed an integrative framework that can be used in future empirical studies to analyze smart cities and big data implications on SCM. This will allow city-users and planners to determine and identify the urban supply chain management, and suggest that a decrease of noise level is not the only way to improve the urban environment.**

***Keywords*—** *Urban Logistics, Sustainable Supply Chain Management, Khobar City, Environments, smart city.*

1. Introduction

The main motivation for this exploratory study is to analyze the impact of smart city initiatives on supply chain management (SCM). In particular, the adoption of smart city concepts poses both opportunities and constraints to supply chain management. eminence of the acoustic environments of contemporary cities is pretty growing apprehension at an international gauge. When such excellence is pitiable because of (amongst other concerns) elevated exposures to undesirable echoes, there will likely be noise effluence, which has been recognised as a part "distressing excellence of life and well-being and as an vital community health concern" [1-9]. At dissimilar levels, noise problems are the entity of consideration of numerous groups with possible contending interests towards the acoustic environment, comprising residents, establishments, policy-makers, local experts, and development and design specialists. The policy outline for this topic in the Member States of the European Union is stipulated by the ostensible "Environmental Noise Directive (END)" [10-17], which conveys direction on the "valuation and organization of environmental noise". It is now usually accepted that the administration of the urban acoustic environments can no longer trust on a meager noise controller or acoustic retrofitting method [3–6] and it should encompass to a wider concept of "urban sound planning" [18–21]. A numeral local experts around Europe incorporated this source and tried to contrivance numerous actions into their guidelines, expecting at improving the environmental sound value in a "proactive", rather than a "reactive", way.

IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

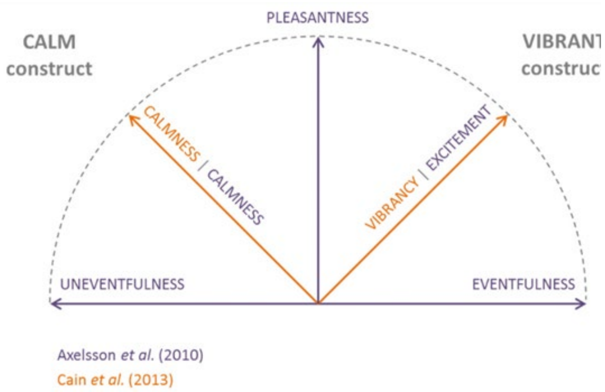


Figure 1. Schematic representation of the models for supply chain management characterization [22]

This shift towards an excellence pattern calls for further devotion on how acoustic environments are observed. Within this agenda, the supply chain management viewpoint shows a crucial character. Supply chain management is the perceptual hypothesis arising from the human indulgent and considerate of any acoustic environment, in context. Perpetually since its advent as a research field, supply chain management quickly become a relevant topic for planners and designers enquiring the "sonic identity" of metropolises and how this would contest their "visible" authenticity.

Community noise ordinances have been propagated by local and national authorities in many countries; establishing noise zones and noise limits and defining the responsible bodies and obligations to noise reduction [23–29]. Prior to commissioning new or expanded current activities, planning permission is required. This requires a study to predict and analyze future noise levels due to new or changed sources. Prior to commissioning, levels are controlled to ensure compliance, once in operation, rating levels can be controlled to ensure continued compliance. Where problems are identified, noise reduction measures must be taken into consideration to minimize pollution and protect the environment. As Saudi Arabia continues to develop and as it strives to maximize the efficiency of its existing facilities, airports, highways and industrial areas, there will be ever increasing noise impact on the quality of life for residents. Therefore, the authorities should adopt a realistic, comprehensive policy that recognizes the noise impacts of traffic growth and urban activities. However, just as the nation strives to make incremental improvements in the safety and efficiency of its public facilities, airports, highway network, industrial zones, etc., emanating noise must be managed through a similar incremental, comprehensive approach, to reduce its pervasive impacts on the residents and the environment.

In current years, supply chain management investigation has been going through speedy growth, with global specialists and exploration factions directing at standardizing definitions, procedures and analysis measures [30–36]. This is perhaps due to the scientific communal will to offer policy-makers and experts with effective tools (i.e., predictive models). There is an existing lack of supply chain management descriptors and indicators, which has been beforehand acknowledged as a gap to fill, in order to familiarize with the supply chain management method into the urban dominion's management.

2. Background of the study

The main aim of this research is to show how these parameters (urban fabric, urban morphology, landscape, building facades, etc.) can determine and identify the supply chain management in urban areas. The selected study area to achieve this objective will be located in Khobar city center, Eastern Province. The supply chain management in two of the main commercial areas in the district of north Khobar: King Fahd street and Prince Bandar street, will be characterized and identified using the binaural microphone system

Figure 2. Case Study areas - Khobar in the Eastern Province next to the Arabian Gulf

2.1 Sustainable Development Method

Supply chains consisting of suppliers, manufacturers, transportation service providers, storage facilities and distributors, as well as retailers, and consumers, serve as the backbones Design of sustainable supply chains for sustainable cities 41for the provision of goods as well as services on our modern global economy. Supply chains have revolutionized the way in which products are sourced, produced, distributed, and consumed around the globe. We passively hear sounds that we are not trying to listen to or understand. By Attending, we can select what interests us in a way that involves responding to fundamental properties of the sound. Comprehending involves semantics. "The sound is treated like a sign or code, as a representation of content or meaning".

Table 1. Diagram of listening modes [11]

4 UNDERSTANDING – inside level : signs – outside level : meaning The emergence of *meaning* of sound, and notion of *references* of sound	1 LISTENING – inside level : indications – outside level : events *Emission* of sound	1 & 4 : objective
3 ATTENDING – inside level : perceptual qualification – outside level : sound quality *Selection* of certain aspects of sound	2 HEARING – inside level : inarticulate about features and contexts of sound – outside level : inarticulate about information of sound *Reception* of sound	2 & 3 : subjective
3 & 4 : abstract	1 & 2 : concrete	

"SonoScout" Soundwalk binaurally tool will be used to record the sound ambient in the selected urban public places, King Fahd and Prince Bandar streets, during the weekdays and weekends (morning, afternoon and evening) for a period of 15 to30 minutes. Four soundwalks in King Fahd and Prince Bandar streets, one on each street side, will be achieved at the same time.

Sustainable supply chains are critical for the examination of operations and the environment. Moreover, according to [37], firms are being held accountable not only for their own environmental performance, but also for that of their suppliers, distributors, and even, ultimately, for the environmental consequences of the disposal of their products. Poor environmental performance at any link of the supply chain network may, thus, damage what is considered a firm's premier asset—its reputation. The recordings will be stored in wave format. The sound walk tool will be calibrated by means of b&k calibrator. The sound recorded, wav files, will be analyzed in the College of Architecture newly acoustical laboratory, where the acoustical parameters will be calculated.

The recorded data will be analyzed either in 3D spectrum form or in 2D form or the equivalent Sound level. 2D equivalent Sound level will help to evaluate different frequencies, during the soundwalk period, in order to show the sound effect of the urban fabric, the built-area and the landscape elements and obtain a visual translation of the auditory impression.

2.2 Methodology to characterize urban – landscape features effect on supply chain management

In this section I present the model for sustainable supply chain networks with a focus on the frequency of the various supply chain activities. As noted in the introduction, logistics in cities are often characterized by more frequent shipments, especially using primarily freight vehicles such as trucks. However, the scope of this model is broader and I also capture the optimal frequencies of the other activities: that is, those of manufacturing, storage, etc. As well, the existing landscape elements condition - either natural or artificial -, have direct impact on the supply chain management of urban areas. The presence and distribution of these elements could affect the noise either by reinforcement or reduction which urges studying the effect of the current landscape situation of the selected area and finding means of development.

Figure 3. SonoScout Soundwalk system.

As the study area covers two streets, as components of the urban fabric with specific morphology and functions, this research intends to focus on a relevant selected set, from the above mentioned urban features, which we assume having the most significant effect to identify the supply chain management in this particular urban area; including the study of landscape elements (softscape, hardscape, street furniture, materials,…etc.) and their relation and effect on sound propagation and distribution in the selected area, pointing out desirable and/or undesirable features in order to find alternatives.

Determining to what extent these parameters affect the supply chain management, how much do they influence the sound diffusion and sound propagation in this area, and what is the significance of correlation do they have with the recorded sound ambient, are believed to be the major output of our study.

Through the analysis of the recorded sound ambient in connection with different combinations of the selected urban and landscape parameters, this study aims to help the users, urban-planners, and decision makers to realize the relation between supply chain management and urban spaces characteristics, and suggest guidelines to improve the quality of the supply chain management and the comfort of the users by proactive design solutions in similar urban areas

3. Urban features inventory and analysis

According to researchers, urban spaces are usually designed according to a visual reference. Urban planners and designers use, in addition, functional aspects that respond to the users' needs according to the paradigm of the planning/design process ranging from goals and objectives formulation to the alternatives/scenarios evaluation through a systematic methodology of data collection and analysis. Furthermore, the end users of the urban space, being a major stakeholder, evaluate spatial qualities as a combination of senses [38]. We assume that urbanity is, also, the result of a combination of sound features and processes that are not necessarily visible. "We are always at the edge of visual space looking into it with the eye. But we are always in the centre of auditory space listening out with the ear"

Supply chain management enrich the visual aspects by providing additional information that helps to highlight other components, activities and characteristics of urban public spaces giving to each place its unique sense. Hence, the urban planning/design process needs to incorporate acoustic qualities in the built environment to balance the lack of sense that affects the quality of public spaces due to the prevailing reference to the visual and functional approach.

Different urban environments have various configurations in terms of buildings' spatial arrangement, traffic roads structure and operation, pedestrians' pathways, landscape features (parks, fountains, trees, etc.), land use and activities.

This research intends to characterize the study area of the research. Two shopping streets with relatively heavy traffic, 93 percent of mixed land use (commercial use in the ground floor and residential or offices uses in the upper floors), and 92 percent of medium building height (two and three floors).

3.1 The study area profile: Location and general information

The study area is located in the central area of Khobar city, a district locally known as "Khobar Shamaliya" which is an Arabic translation for "Northern Khobar". Northern Khobar is one of the oldest and first batch districts of the city, surrounded by important arterial roads and streets including the main roads entrances to the city ending with the central area. The district covers 0.52% of the total area (299.9 hectares out of 57100 hectares) and accommodates 7.1% of the total population of the city (around 42000 people out of 600000 in 2010).

The one-way grid system with clear geometric shape is the roads planning pattern adopted for this area, which gives a high mobility. Five Minor collector streets (according to the roads hierarchy classification standards) acting as commercial hubs collect traffic from many local streets, two of them have been selected for this research:

King Khaled Street,

King Fahad Street,

Prince Bandar Street, locally known as “Al Suwaiket”,

The 10th Street,

And the 16th Street

These one-way hubs, with two lanes and large sidewalks, are characterized by a wider geometry compared to the majority of the other streets within the area. The concentration of specific commercial activities is the first distinctive attribute of these major commercial poles, which continue their success in maintaining a high level of attractiveness despite the competition of Malls, Hypermarkets and Supermarkets.

Al-Suwaiket Street is a main commercial artery since four decades ago, and a major popular destination for Khobar residents to access basic needs, as it embraces many commercial activities such as gold shops, fabrics, perfume, on both sides. Al-Suwaiket Street has seen its catchment extended beyond Khobar city and has become a “landmark” for residents of the Eastern Region, with a continuous movement during the opening hours, seven days a week, all over the year.

King Fahad Street has raised to the level of Prince Bandar Street featuring different commercial specialization and has become as much important for providing a wide range of goods mainly in the field of telecommunication.

3.2 The Urban characteristics of Prince Bandar Street and King Fahad Street

Spatially informed decisions in urban development, renewal and conservation, landscape architecture, transportation planning, renewable energy, disaster management etc., can help identify the best location for alternative sustainable transportation systems, decide effective solutions to implement redevelopment programs, and more. Ranges of options are available for planners and urban designers to shape the space, revitalize buildings, and create mixed-use projects. In this research, we explore the use of spatial analysis along with sound records to understand the supply chain management of the study area in order to suggest solutions about how to design more effectively urban open spaces from a supply chain management point of view.

The link between the built environment and the supply chain management has recently been of major interest to the field of urban planning and urban design where the work aims to enhance the quality of life, improve systems’ efficiency, or reduce environmental impacts.

Towards achieving the research objectives of characterizing the supply chain management of these two streets with relation to their spatial features, a typical methodology of primary data collection and analysis of the study area has been adopted. The objective is to highlight the urban features and the spatial distribution of the physical components as well as the activities that shape these two important commercial hubs.

Usually, for the purpose of a typical site analysis, the following elements are considered (non-exhaustive list)

- Location: mainly major streets or landmarks. Depending on the objectives and the level of analysis (Neighborhood or district), by driving or walking, distances and time from and to major places are to be documented.
- Neighborhood context: Zoning of the neighborhood including immediate surroundings of the site, architectural patterns, street lighting, land use, heights and condition of existing buildings, analysis of existing paths (pedestrian, cyclist, and vehicle), nodes (key public gathering places that encourage people to linger and socialize) and landmarks.
- Site and zoning: Site boundaries, zoning classifications, set-backs, height restrictions, allowable site coverage, uses, and parking requirements.
- Legal aspects such as properties’ description, ownership, local governmental jurisdiction.
- Climate and Natural physical features such as topography, contour map, drainage, existing natural features of trees, ground cover, ground texture, and soil conditions.
- Man made features such as buildings, walls, fences, patios, plazas, bus stop shelters.
- Circulation: uses of streets, roads, alleys, sidewalks, and plazas.
- Location of utilities.
- Sensory: sketching, photographs, aerial photograph, in addition of direct observation for noise, odors, pollution sources and types of pollutants.
- Human and cultural information.

Due to the large number of items considered, and rather than a comprehensive site analysis methodology, we made the choice to limit the analyzed elements to those expected to influence the sound profile of the streets and that are relevant to the scope of this research without altering the process of the site analysis.

We hypothesize that land use, heights and condition of the buildings, types and spatial distribution of commercial activities (scarcity, concentration, or dispersal) are key factors influencing quality and physical evaluation as well as comfort of the urban spaces' users. The physical analysis of the study area is intended to emphasize on the specific dimensions of the above-mentioned features that influence supply chain management-related profile and quality. We are also interested in the extent to which they relate to each other.

3.3 Physical survey: Data collection and analysis

The physical survey is initially based on the GIS database of Dammam Metropolitan Area, granted by the Eastern Region municipality (Amana), from which we have extracted the attribute tables related to the Land Use and the Heights of buildings along Prince Bandar Street and King Fahad Street.

As a first phase of the field survey, and in order to update and complete the initial maps, the research team used a "GoPro" camera with a wide-angle lens, taking a photograph every two seconds using an automatic time-lapse setting. The camera was attached to a car in move at a speed of 20 km/hour along the streets and surveying both sides, which led to four trips (two trips for each street). The primary objective of the data collected is to survey and update the streets' land use and heights of buildings extracted from the GIS database and complete the set by the data related to the buildings' condition.

A preliminary set of 346 photos of the area was collected , viewed and analyzed, helping the research team to end up looking to the study area's urban environment more holistically than from an individual perspective.

A second set of 404 photos, with adjustments of the angle of view, the position of the camera and the speed of the car, was collected and distributed, as shown in table 2.

Table 2. Set of photos from the field survey along Prince Bandar Street and King Fahad Street.

Prince Bandar Street (from 4th St. to 16th St.)		King Fahad Street (from 16th St. to 4th St.)		Total
Right side	**Left side**	**Right side**	**Left side**	
100	112	89	103	**404**

Source: H. HOSSAMELDIN, K. GAZZEH, Y. FARGHALY - Field survey 2014-2015.

As a second phase, the photos for both sides of each street were systematically aligned and analyzed. The result of the analysis is then adequately reported, tabulated, processed and presented.

The third phase of the field survey , focused on a "walk-observation" and manual record of the commercial activities along the streets based on a spatial sequential division into 12 blocks/zones in each street delimited by 13 perpendicular streets (from South side to North side: from 4th street to 16th street).

The spatial division outcome is a series of 24 blocks/zones, not necessarily of equal sizes or equal number of plots, each block consists of two sub-blocks. A sub-block consists of all contiguous plots on the left side or the right side of the street. An average of 14 plots by block/zone has characterized the spatial division are shown.

Table 3. Blocks/zones and number of plots resulting from the spatial division of Prince Bandar Street and King Fahad Street in SCM.

	Blocks/zones			King Fahad Street		Prince Bandar Street		Total
	#	Street start	Street end	Right Side	Left Side	Right Side	Left Side	
South to North	1	4th	5th	3	3	4	4	**14**
	2	5th	6th	4	4	3	3	**14**
	3	6th	7th	3	4	1	2	**10**
	4	7th	8th	3	4	4	4	**15**
	5	8th	9th	2	4	4	4	**14**
	6	9th	10th	3	4	4	3	**14**
	7	10th	11th	4	4	3	4	**15**
	8	11th	12th	4	4	4	5	**17**
	9	12th	13th	5	5	4	4	**18**
	10	13th	14th	4	3	3	1	**11**
	11	14th	15th	4	4	3	1	**12**
	12	15th	16th	4	4	4	3	**15**
			Total	**43**	**47**	**41**	**38**	**169**

3.4 Land-Use inventory and analysis

The "Mixed-use" variable performs above all other variables surveyed along both streets. This highlights the strong ability of the area to draw residents and maintain a high density of people that feed and animate the commercial activities with continuous movement of local population coupled with the through and visiting flow of people and cars, giving the place its unique dynamism and consequently its unique supply chain management. Despite this general picture, apparently uniform, differences exist when we analyze the details of the distribution.

Along Prince Bandar Street, the "Mixed-use" category posted the strongest share of all categories with 70 buildings out of 79 (89%). Far away, the "Vacant" category ranked second with 5 plots out of 79, which counts for 7%. The third place goes equally to the "Residential", "Commercial", "Services" and "Religious" uses with only one plot for each category and that counts for 1% of the total uses in the street.

Table 4. Spatial distribution of the Heights of buildings along Prince Bandar Street

South to North

Blocs		Number of Plots					
Street start	Street end	1 Floor	2 Floors	3 Floors	4 Floors and more	Vacant	Total
4th	5th	0	4	4	0	0	**8**
5th	6th	0	4	2	0	0	**6**
6th	7th	0	2	0	1	0	**3**
7th	8th	0	4	4	0	0	**8**
8th	9th	0	2	5	0	1	**8**
9th	10th	1	2	4	0	0	**7**
10th	11th	0	3	3	0	1	**7**
11th	12th	1	4	4	0	0	**9**
12th	13th	0	3	5	0	0	**8**
13th	14th	1	1	1	0	1	**4**
14th	15th	1	1	0	0	2	**4**
15th	16th	0	3	4	0	0	**7**
	Total	**4**	**33**	**36**	**1**	**5**	**79**

3.5

3.5 Sustainable development

The model introduces the novel feature of the frequency of operation of the various links into sustainable supply chain networks, which was inspired by [39], who proposed a transportation model with the frequency of operation for buses (and planes), assuming capacities. In addition, I do not limit the decision maker to assess only the emissions generated, but, rather, also allow for the inclusion of any relevant environmental impacts, as well as waste costs. Waste costs were described earlier in [40] in the context of a distinct supply chain network model and application, in which perishability was the primary feature of the product of concern. Moreover, unlike the model of [41], here, for the purpose of flexibility in decision making, I allow for the option of direct shipments from the manufacturing plants to the demand points.

3.6 Buildings' condition inventory and analysis

The "Good" condition of the buildings within the study area takes the first place position, followed by the "Fair" condition, which gives a positive overall evaluation regarding this variable for both streets, yet with some disparities. Prince Bandar Street ranked second due to its low performance given by 52% of the buildings in "Good" condition category. The "Fair" condition element holds a moderate share, but relatively high, with 33% of the buildings.

3.7 Commercial activities inventory and analysis

The comprehensive survey (walk-observation) of the commercial activities conducted along Prince Bandar and King Fahad streets (between the 4th Street and the 16th Street), demonstrates a very animated activity specialization that is continuously scattered along both sides of the streets. The area has sustained the same commercial dynamism since many decades. These commercial destinations have attained the rank of principal place of supply for a significant part of the surrounding population, and have become popular as they offer specific services for users coming from beyond their immediate surrounding area.

Although the visible specialization that raises from the survey, the study area still has a fairly diversified and permanent commercial configuration that is clearly low and middle-income people-oriented. In Prince Bandar Street, as Table 6 shows, between the 4th Street and the 16th Street, 72 out of 79 of the plots (91%) are commercially dynamic (the rest, 9%, is either vacant or non-commercial activity)

4. Results and discussion

4.1 Car Measurements

Firstly, we will present the results obtained at 1 pm where all commercial spaces are closed. The sound measurements, using a car, started on 4th street veered towards the 16th street. All car windows were opened. The main objective is to analyze the perception of sound at the car driver position in order to define sound sources in the study area.

4.1.1 SCM Prince Bandar Street

Figure 6 presents the binaural impulse responses measured in Prince Bandar Street. The red curve shows the impulse response received by the driver's right ear, while the blue curve presents the impulse response received by the driver's left ear. Higher sound energy was clearly identified on the left side, ranging from 60 to 92. This is due to the different building facades heights. The sounds are reflected on the surface causing a quasi-diffuse field in some parts of the left side. The acoustic images highlight the spectral signatures of the recorded sound sources. This masking effect can be verified for a lot of human, mechanical or natural activities. As shown in Figure 29, on the afternoon sound walk "1,13, 15 and 20" marks correspond to a wind effect in the street where the SPL is higher than the other points (ranging from 80 to 92. Traffic noise, which ranges from 60 to 80, can be considered as the main sound source. The road junctions have a high SPL while the area between the 10th street and the 13th street is the quieter area.

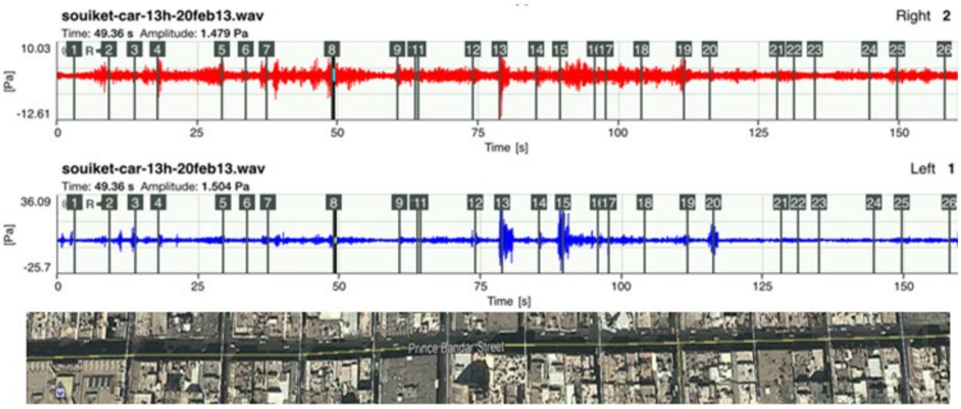
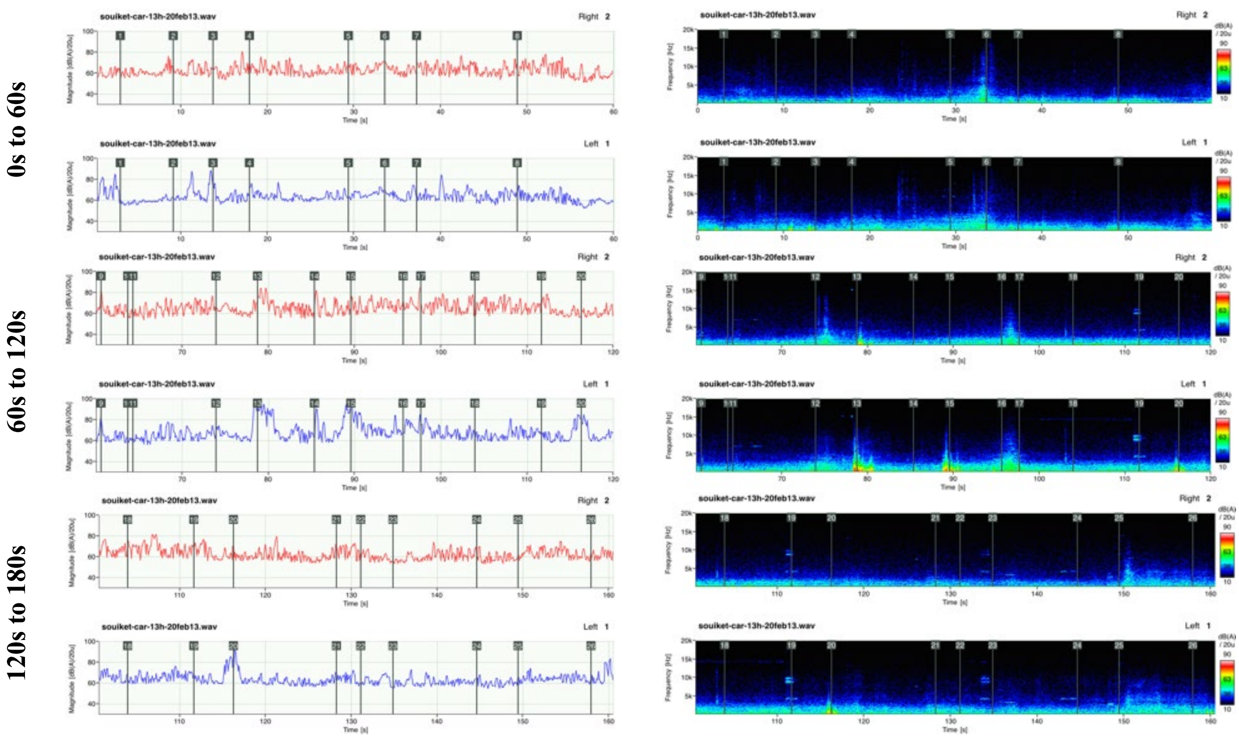


Figure 4. Impulse response, Prince Bandar Street.



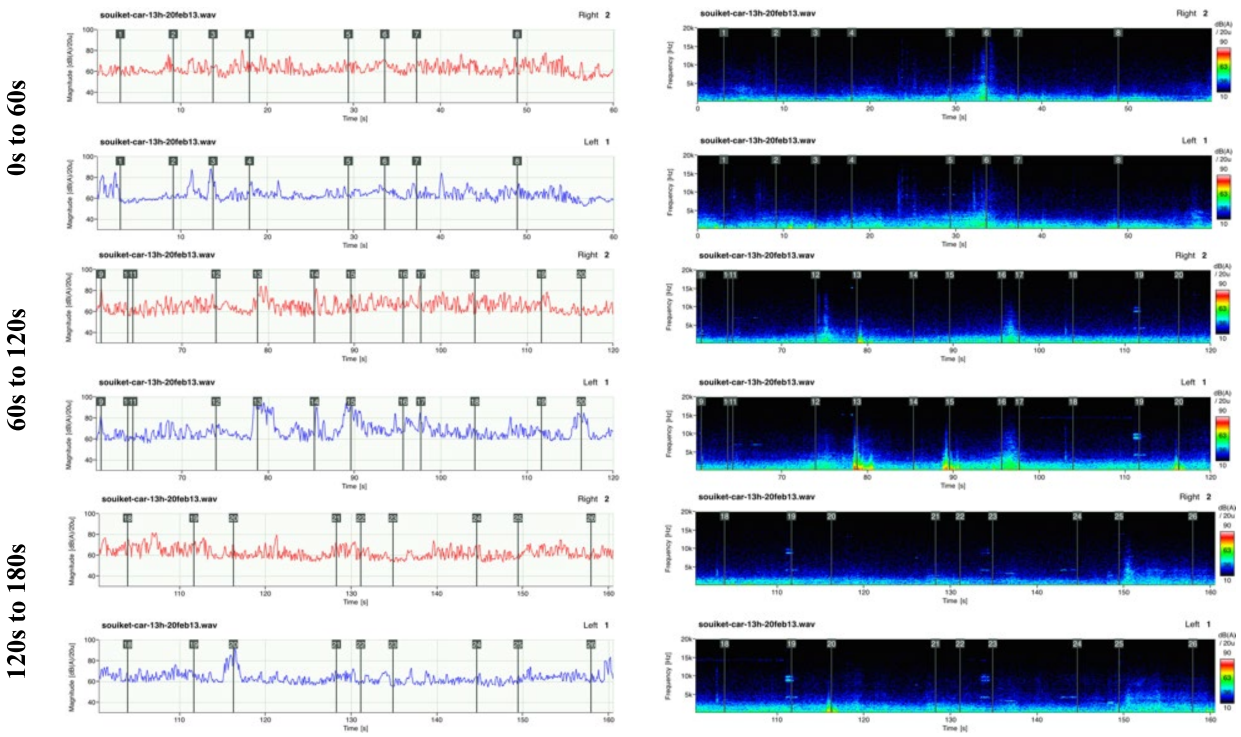


Figure 5. SCM, Prince Bandar Street.

4.1.2 King Fahad Street

Figure 7 shows the binaural impulse responses measured in King Fahad Street. The main motivation for this exploratory study is to analyze the impact of smart city initiatives on supply chain management (SCM). In particular, the adoption of smart city concepts poses both opportunities and constraints to supply chain management. eminence of the acoustic environments of contemporary cities is pretty growing apprehension at an international gauge. The red curve shows the impulse response received by the driver's right ear while the blue curve presents the impulse response received by the driver's left ear. Like the case of Prince Bandar Street, higher sound energy is found on the left side, ranging from 60 to 98.

These results show that King Fahad Street is louder than Prince Bandar Street. This is due to the car workshop, banks, parking, and restaurants located in this street.

On the acoustic images, we can observe that the wind effect appears clearly at locations 1,6,7,8,11, and 12 because of the different heights of buildings. The wind effect causes high SPL, ranging from 70 to 98. Traffic noise increases notably at road junctions, locations 4,9,12,14, and17, where the SPL values range from 60 to 80. Human voice appears near to car workshops, parking, and banks (locations 3,17,18,19, and 20). SPL of the Human activities ranges from 65 to 75.

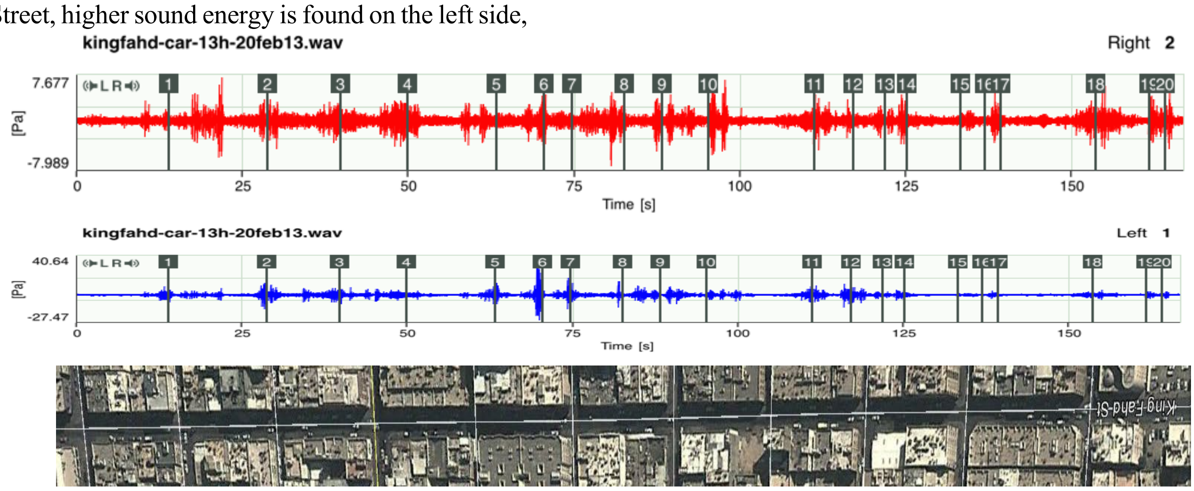


Figure 8. Impulse response, King Fahad Street

.

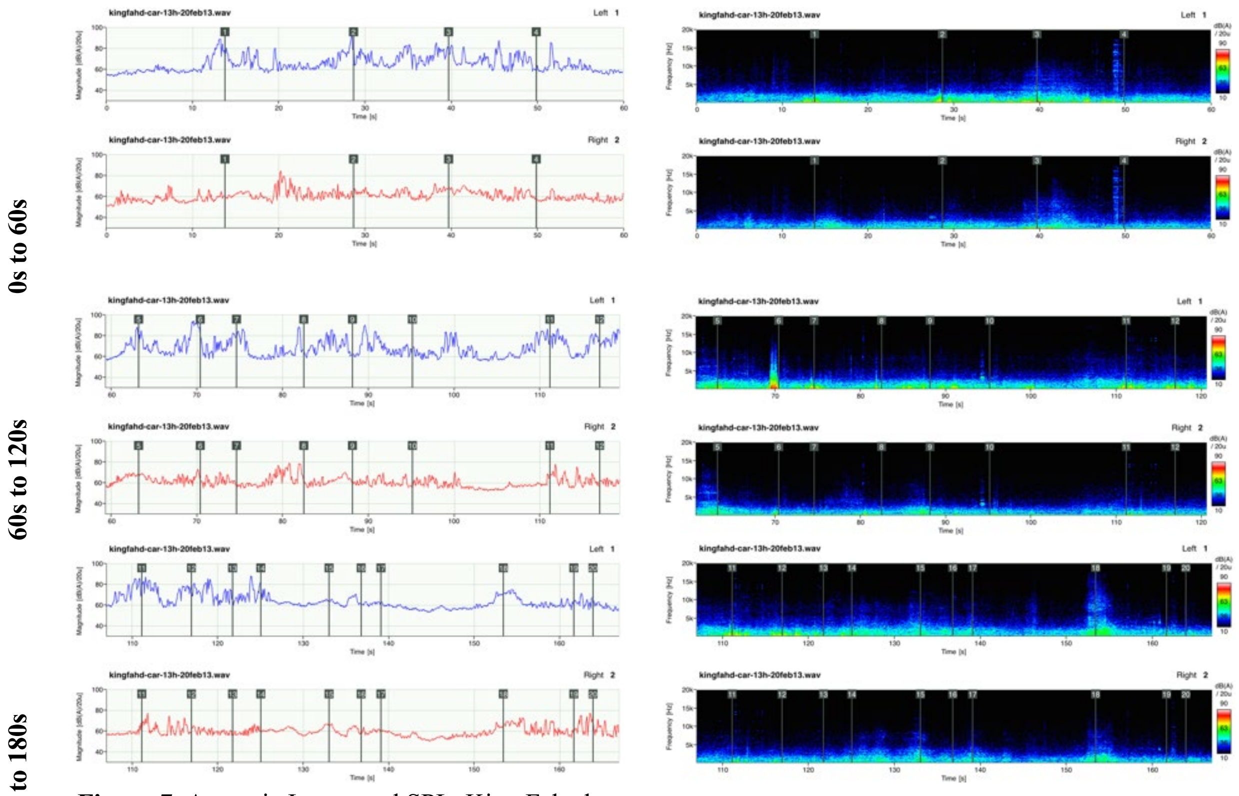


Figure 7. Acoustic Image and SPL, King Fahad Street.

4.2 Sound Walk Measurements

Firstly, we will present the results average obtained at 10h, 14h, and 20h For prince Bander street and King Fahed street, started on 2nd street veered towards the 13th street. The main objective is to analyze the perception of sound at the pedestrian ear level in order to define sound sources and its impact in the urban space.

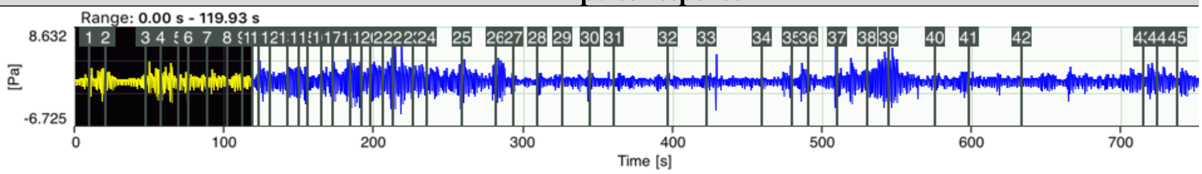
4.2.1 Prince Bandar Street

In Figure 8, we present the binaural the average of impulse responses measured in Prince Bandar Street. We found that more sound energy on the left side and at the end of the street segment. According to WHO, the acceptable SPL for the residential area ranges from 50 to 65 dB A. We observed 45 points along the street segment exceed the acceptable SPL.

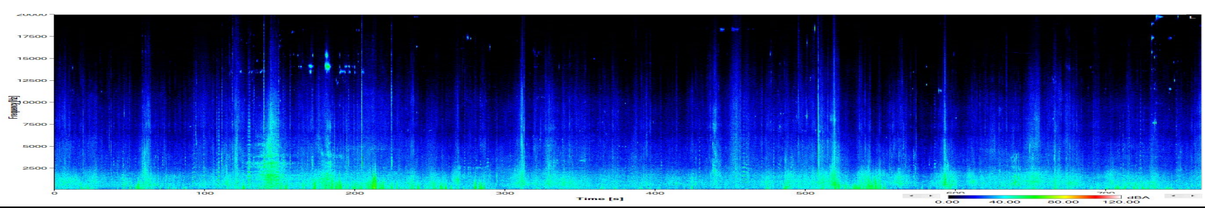
As a result of sound walk measurement, we defined the noise sources in this urban area. As shown in table 12, four noise sources were found. Traffic noise and human activities can be considered the main noise source. Wind noise is located at the crossroads where SPL ranges from 75 dB A to 100 dB A. Noise pollution created by commercial activities appears clearly in the left side of the street. This is due to women clothes shopping area. For that reason, we observed women and kids voices in this part of the street. Generally, the SPL obtained because of commercial activities is between 75 dB A and 90 dB A. Noise generated by a fish shop outdoor decorated fountain is found in the end of the street segment. SPL due to this fountain is 80 dB A.

As presented, we can note that the left part of the street can be considered as more noisy part of the street.

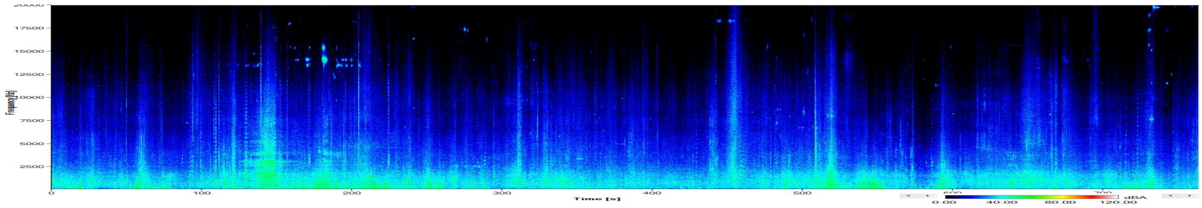
Impulse response



Noise Spectrum (Left side)

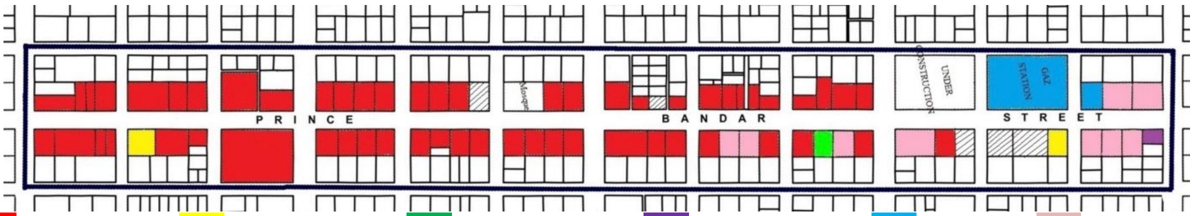


Noise Spectrum (Right side)



Land Use

Commercial Activities



Fashion *Parfumes* *Electronic* *Resturant* *Real state* *Other*

Figure 8. Impulse response, Noise Spectrum, Land Use, and Activities in Prince Bandar Street.

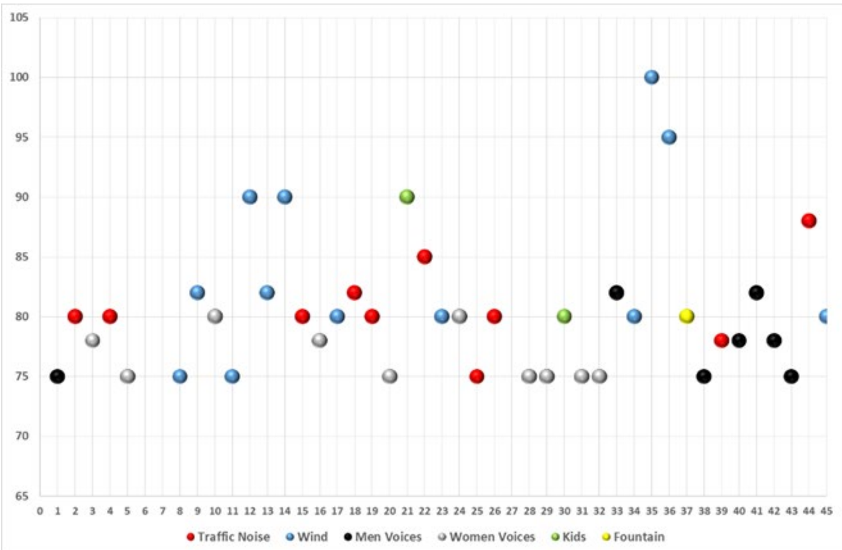


Figure 9. Noise source in Prince Bandar Street

Table 7. Types of noise sources and SPL values in Prince Bandar Street (Al Suwaiket).

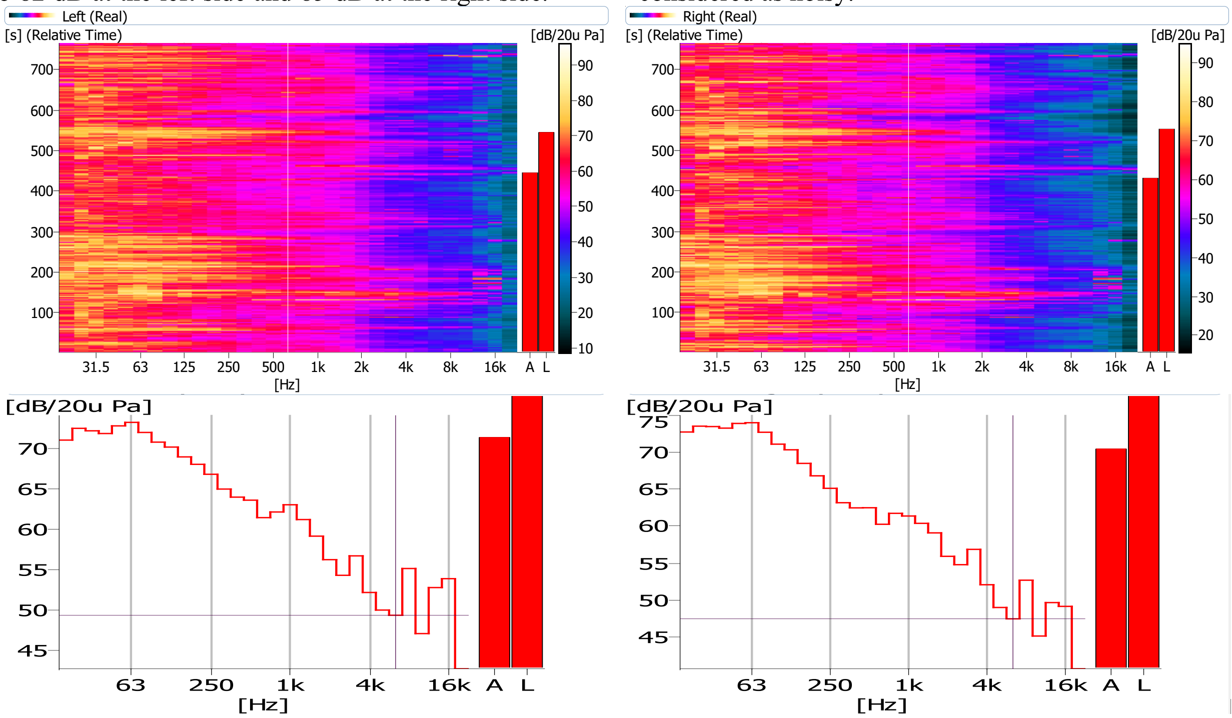
Type of Noise Source	**Points of smart / SPL (dB A)**																**SPL Min. (dB)**	**SPL Max. (dB)**
Traffic Noise																		
Points SPL (dB A)	8 75	9 82	11 75	12 90	13 82	14 90	17 80	21 90	23 80	28 75	29 75	30 80	34 80	35 100	36 95	45 80	**75**	**100**
Wind																		
Points SPL (dB A)	2 80	4 80	15 80	18 85	19 80	22 85	25 75	26 80	39 78	44 88							**75**	**88**
Men Voices																		
Points	1	5	10	16	20	24	28	29	31	32	33	38	40	41	42	43	**75**	**82**

SPL (dB A)	75	75	80	78	75	80	75	75	75	75	82	75	78	82	78	75		
Women Voices																		
Points SPL (dB A)	3 78	16 78	20 75	24 80	28 75	29 75	31 75	32 75	33 82								**75**	**82**
Kids Playing																		
Points SPL (dB A)	21 90	30 80															**80**	**90**
Fountain																		
Points SPL (dB A)	37 80																**80**	**80**

Figure 8. Human activities and types of SCM in Prince Bandar Street

Figure 11 demonstrates the overall sound pressure level over the street sides. This analysis correspond to 23% of the centre frequency. We can observe the increasing of sound level values at the first third of the street segment, where increasing of commercial activities. The two sides of the street approximately have the same sound level. The left side of the street has an average A-weighted sound level equal to 72 dB(A), while the right side has 70 dB(A) average A-weighted sound level.

Furthermore, the linear sound pressure level is equal to 82 dB at the left side and 85 dB at the right side. This confirm that the sound environment in the street is considered as noisy.



CPB (3rd octave):Left CPB (3rd octave):Right

Figure 9. Constant percentage bandwidth (CPB 1/3-octave) –Left and Right sides of Prince Bandar Street. By SCM trends

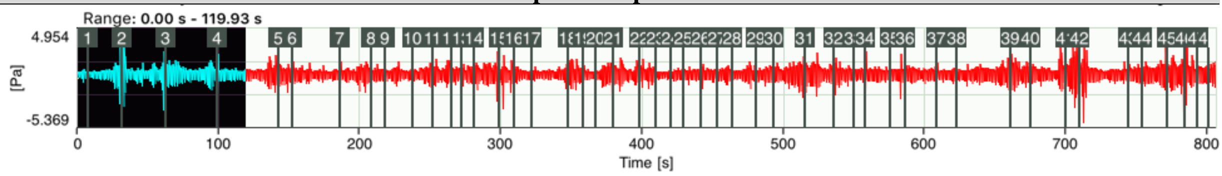
4.2.2 King Fahed Street

In Figure 13 shows the binaural the average of impulse responses measured in King Fahed Street. It is found that the street sides have approximately the same sound energy. As the Bander street and according to WHO, the acceptable SPL for the residential area ranges from 50 to 65 dB A. As a result of the measurements, unacceptable SPL where found at 48 points along the street segment which can define the noise sources in this urban space. Four noise sources were found, see table 13. Because of the commercial activities along the street, traffic noise and human activities cause the main noise source. Traffic causes SPL which is between 70 dB A and 85 dB A. Wind noise effect appears clearly in the end of the street (the same zone as Bander Street). The noise generated by wind ranges from 65 dB A to 82 dB A. Commercial activities and restaurants produce sound pressure level between 65 dB A to 80 dB A. In general, these activities appear clearly on the first half of the street. Because of the type of commercial activities (mobile shops) and restaurants (restaurants for singles), most of voices we can hear is male voices.

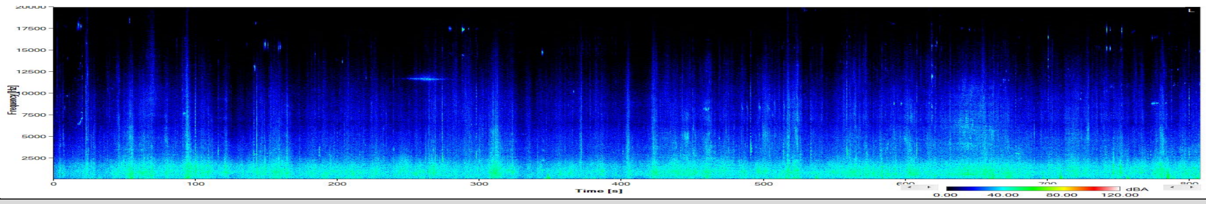
New type of noise generated by the air condition mechanical system can be observed. This is because of the air conditioner/compressor replaced outside the restaurants and at the street level. Noise pollution generated by air conditioner /compressor ranges from 70 to 80 dB A.

Generally and as presented in figure 14, we can consider King Fahed Street quieter than Prince Bander Street.

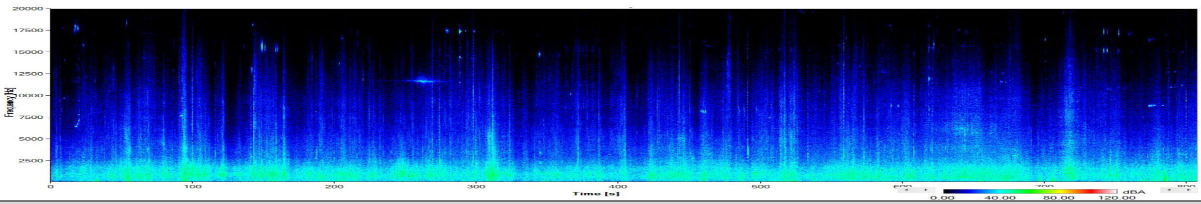
Impulse response



Noise Spectrum (Left side)



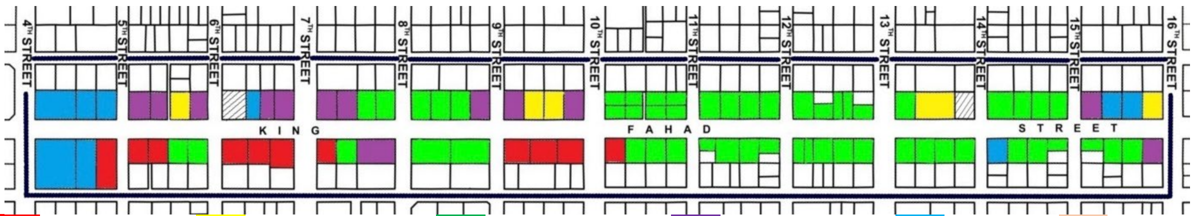
Noise Spectrum (Right side)



Land Use

Mixed Use *Residential* *Vacant*

Commercial Activities



Fashion *Parfumes* *Electronic* *Resturant* *Real state* *Other*

Figure 10. Impulse response, Land Use, Noise Spectrum and Activities in King Fahed Street.

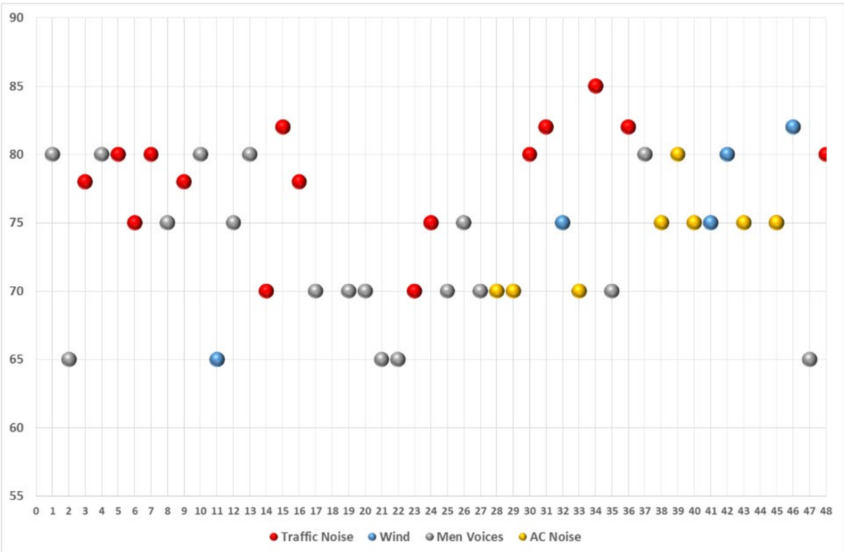


Figure 11. Noise source in King Fahed Street.

Table 8. Types of noise sources and SPL values in King Fahed Street

Type of Noise Source	Points of Noise Source / SPL (dB A)																		SPL Min. (dB)	SPL Max. (dB)
Traffic Noise																				
Points SPL (dB A)	3 78	5 80	6 75	7 80	9 78	14 70	15 82	16 78	23 70	24 75	30 80	31 82	34 85	36 82	45 75	48 80			**70**	**85**
Wind																				
Points SPL (dB A)	11 65	32 75	41 75	42 80	46 82														**65**	**82**
Men Voices																				
Points SPL (dB A)	1 80	2 65	4 80	8 75	10 80	12 75	13 80	17 70	19 70	20 70	21 65	22 65	25 70	26 75	27 70	35 70	37 80	47 65	**65**	**80**
AC Noise																				
Points SPL (dB A)	28 70	29 70	33 70	38 75	39 80	40 75	43 75	44 75											**70**	**80**

Figure 12. Human activities and types of noise sources in Prince Bandar Street.

Figure 16 presents the 3rd octave Constant Percentage Bandwidth (CPB) and Constant Percentage Bandwidth (CPB) mapped as a function of time. The overall sound pressure level over the street sides is presented in figure 17. The overall sound pressure level measurement can approximately describe most environmental noises. Environmental noises can be derived from overall sound pressure levels by analyzing the variation of measured levels with time and frequency.

The maximum overall sound pressure levels values are found at the first third and the end of the street segment resulting an overall level of 80 dB A at the listeners' ears. The two sides of the street approximately have the same overall sound level. The left side of the street has an average A-weighted sound level equal to 65 dB(A), while the right side has 68 dB(A) average A-weighted sound level. Furthermore, the linear sound pressure level is equal to 78 dB at the both sides of the street.

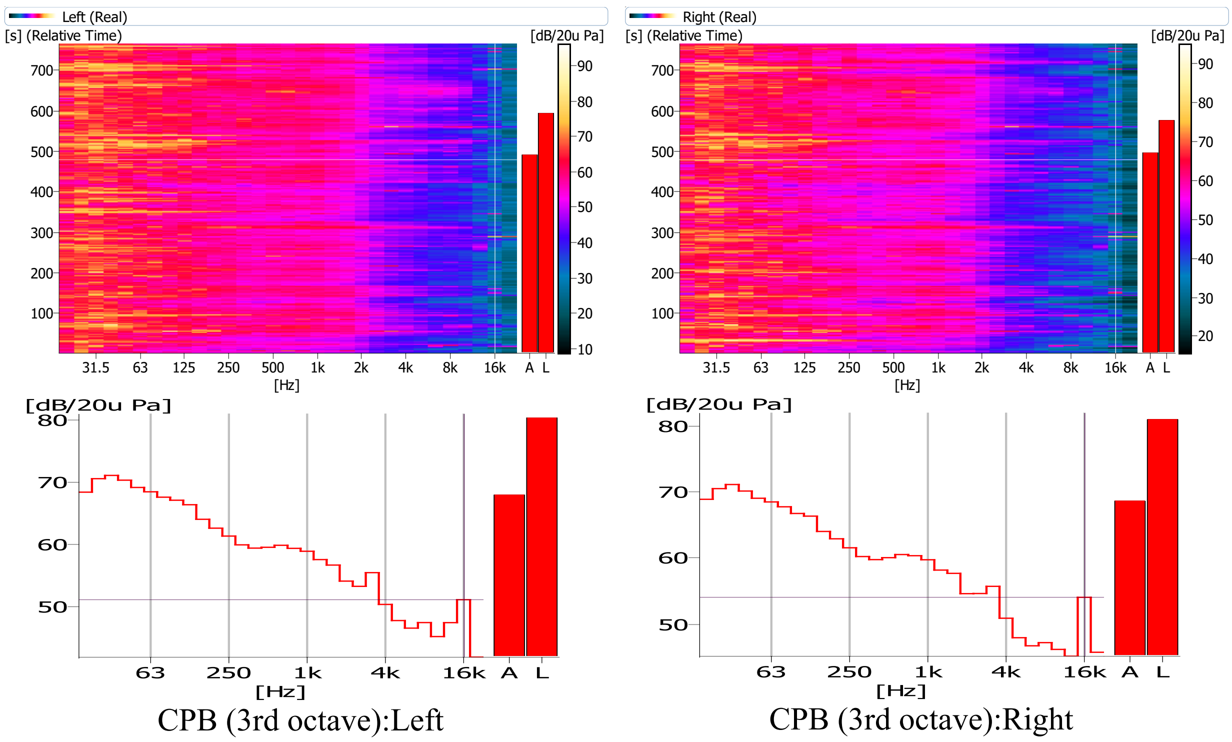


Figure 13. Constant percentage bandwidth (CPB 1/3-octave) –Left and Right sides of King Fahed Street.

5.0 Conclusion

In this paper, we developed a rigorous mathematical modelling and computational framework for sustainable supply chains with a focus on sustainable cities. Cities, as centres of population, represent not only demand points for numerous products for their residents as well as workers and even tourists, but also as supply points or sources of environmental emissions as well as wastes. Hence, a holistic, system-wide approach to capturing the complexity of supply chains with the associated activities of manufacturing, transportation/shipment, as well as storage, coupled with the reality of the frequency of such supply chain activities and the associated environmental impacts, in order to satisfy the demands has been needed. Measuring the sound perceived from a driver position and from a pedestrian position was intended to define the sound sources in this commercial area according to the users of the streets. Pedestrians and drivers are, indeed, the only users, as no other means of movement exist in this area (tramway, metro, etc.). As the different levels of SPL measured correspond to a typology of activities that seems to match the physical survey, especially the distribution showed on Figure 27, we can conclude that the typology of activities which has a spatial "footprint" and can be recognized by the urban form and pattern, the architectural style, the landscape arrangement, and the visual elegance, is also defined by its sound profile. We demonstrated that the sound walk methodology output can define the nature of an open space according to the sources of sound and their SPL levels that can be compared to the comfort standards for each type of space, activity and users. The results of a sound walk measurements and interpretation can, hence, be used to transform the open spaces, or some of their features, in order to achieve better sound comfort as a core part of the urban user's comfort.

References

[1] F. Aletta, J. Kang, and Ö. Axelsson, "Supply chain management descriptors and a conceptual framework for developing predictive supply chain management models," Landscape and Urban Planning. 2016.

[2] J. Y. Hong and J. Y. Jeon, "Influence of urban contexts on supply chain management perceptions: A structural equation modeling approach," Landsc. Urban Plan., 2015.

[3] A. L. Brown and A. Muhar, "An approach to the acoustic design of outdoor space," J. Environ. Plan. Manag., 2004.

[4] W. J. Davies et al., "Perception of supply chain managements: An interdisciplinary approach," Appl. Acoust., 2013.

[5] J. Y. Hong and J. Y. Jeon, "Exploring spatial relationships among supply chain management variables in urban areas: A spatial statistical

modelling approach," Landsc. Urban Plan., 2017.
[6] W. Yang and J. Kang, "Supply chain management and sound preferences in urban squares: A case study in Sheffield," J. Urban Des., 2005.
[7] M. Zhang and J. Kang, "Towards the evaluation, description, and creation of supply chain managements in urban open spaces," Environ. Plan. B Plan. Des., 2007.
[8] D. Botteldooren, B. De Coensel, and T. De Muer, "The temporal structure of urban supply chain managements," J. Sound Vib., 2006.
[9] P. Jennings and R. Cain, "A framework for improving urban supply chain managements," Appl. Acoust., 2013.
[10] P. De Vos and A. Van Beek, "Environmental Noise," in Encyclopedia of Environmental Health, 2011.
[11] E. Murphy and E. A. King, "Strategic environmental noise mapping: Methodological issues concerning the implementation of the EU Environmental Noise Directive and their policy implications," Environment International. 2010.
[12] S. Kephalopoulos, M. Paviotti, F. Anfosso-Lédée, D. Van Maercke, S. Shilton, and N. Jones, "Advances in the development of common noise assessment methods in Europe: The CNOSSOS-EU framework for strategic environmental noise mapping," Sci. Total Environ., 2014.
[13] European Parliament and Council of the European Union, "Assessment and management of environmental noise (EU Directive)," Off. J. Eur. Communities, 2002.
[14] E. Murphy and E. A. King, Environmental Noise Pollution: Noise Mapping, Public Health, and Policy. 2014.
[15] EEA(Europeon Environment Agency) et al., Common Noise Assessment Methods in Europe (CNOSSOS-EU). 2014.
[16] European Parliament and Council of the European Union, "DIRECTIVE 2002/49/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 June 2002 relating to the assessment and management of environmental noise," Off. J. Eur. Communities, 2002.
[17] E. A. King and E. Murphy, "Environmental noise - 'Forgotten' or 'Ignored' pollutant?," Appl. Acoust., 2016.
[18] J. L. Carles, I. L. Barrio, and J. V. De Lucio, "Sound influence on landscape values," Landsc. Urban Plan., 1999.
[19] English Partnerships, "Urban Design Compendium," Design, 2000.
[20] S. Saura and L. Pascual-Hortal, "A new habitat availability index to integrate connectivity in landscape conservation planning: Comparison with existing indices and application to a case study," Landsc. Urban Plan., 2007.
[21] Kasmir, Bank dan Lembaga Kuangan Lainnya. 2014.
[22] Ö. Axelsson, M. E. Nilsson, and B. Berglund, "A principal components model of supply chain management perception," J. Acoust. Soc. Am., 2010.
[23] R. P. King and J. R. Davis, "Community noise: Health effects and management," International Journal of Hygiene and Environmental Health. 2003.
[24] A. V. Moudon, "Real Noise from the Urban Environment. How Ambient Community Noise Affects Health and What Can Be Done About It," Am. J. Prev. Med., 2009.
[25] B. and N. Bolt, "Noise and Vibration During Construction," Transit Noise Vib. Impact Assess., 1971.
[26] L. H. Royster and J. D. Royster, "Chapter 9a: Noise and Vibration Control," in Noise Vibration Problem-Solution Workbook, 2009.
[27] H. Hossam Eldien, "Noise mapping in urban environments: Application at Suez city center," in 2009 International Conference on Computers and Industrial Engineering, CIE 2009, 2009.
[28] J. L. B. Coelho, Chapter 130 Community Noise Ordinances. 2007.
[29] T. L. Gebhardt, K. Kaphingst, and W. DeJong, "A campus-community coalition to control alcohol-related problems off campus: An environmental management case study," J. Am. Coll. Health Assoc., 2000.
[30] A. Farina, N. Pieretti, and L. Piccioli, "The supply chain management methodology for long-term bird monitoring: A Mediterranean Europe case-study," Ecol. Inform., 2011.
[31] S. Fuller, A. C. Axel, D. Tucker, and S. H. Gage, "Connecting supply chain management to landscape: Which acoustic index best describes landscape configuration?," Ecol. Indic., 2015.
[32] H. Slabbekoorn and N. Bouton, "Supply chain management orientation: a new field in need of sound investigation," Anim. Behav., 2008.
[33] N. S. Bruce and W. J. Davies, "The effects of expectation on the perception of supply chain

managements," Appl. Acoust., 2014.
[34] O. Medvedev, D. Shepherd, and M. J. Hautus, "The restorative potential of supply chain managements: A physiological investigation," Appl. Acoust., 2015.
[35] J. Sueur, A. Farina, A. Gasc, N. Pieretti, and S. Pavoine, "Acoustic indices for biodiversity assessment and landscape investigation," Acta Acust. united with Acust., 2014.
[36] D. Smalley, "Space-form and the acousmatic image," Organised Sound, 2007.
[37] C. Semidor, "Listening to a city with the soundwalk method," Acta Acust. united with Acust., 2006.
[38] K. H. Evensen, R. K. Raanaas, and A. Fyhri, "Supply chain management and perceived suitability for recreation in an urban designated quiet zone," Urban For. Urban Green., 2016.
[39] M. Sikora, M. Russo, J. Derek, and A. Jurčević, "Supply chain management of an archaeological site recreated with audio augmented reality," ACM Trans. Multimed. Comput. Commun. Appl., 2018.
[40] M. Barakat, "An Architectural Approach to the Soundwalk Method," Sonic Environ., 2016.
[41] J. Liu, J. Kang, H. Behm, and T. Luo, "Effects of landscape on supply chain management perception: Soundwalks in city parks," Landsc. Urban Plan., 2014.