Architecture and Planning Journal (APJ)

Volume 25 | Issue 1
ISSN: 2789-8547

Article 2

January 2020

THE IMPACT OF CHANGES IN BEIRUT URBAN PATTERNS ON THE MICROCLIMATE: A REVIEW OF URBAN POLICY AND BUILDING REGULATIONS

Hiba Mohsen
Assistant Professor, Faculty of Architecture- Design and Built Environment, Beirut Arab University, Lebanon, h.mohsen@bau.edu.lb

Rokia Raslan
Associate Professor, The Bartlett School of Architecture, University College London, UK, r.raslan@ucl.ac.uk

Ibtihal Y. El-Bastawissi
, *Professor, Faculty of Architecture - Design and Built Environment, Beirut Arab Universit, Lebanon*, ibtihal@bau.edu.lb

Recommended Citation

Mohsen, Hiba; Raslan, Rokia; and El-Bastawissi, Ibtihal Y. (2020) "THE IMPACT OF CHANGES IN BEIRUT URBAN PATTERNS ON THE MICROCLIMATE: A REVIEW OF URBAN POLICY AND BUILDING REGULATIONS," *Architecture and Planning Journal (APJ)*: Vol. 25: Iss. 1, Article 2.
DOI: https://doi.org/10.54729/2789-8547.1001

THE IMPACT OF CHANGES IN BEIRUT URBAN PATTERNS ON THE MICROCLIMATE: A REVIEW OF URBAN POLICY AND BUILDING REGULATIONS

Abstract

Previous studies conducted on Beirut have historically overlooked research in the field of urban microclimate. A better understanding of how Beirut urban development, including zoning and building regulations, has affected the current urban thermal climate is crucial in order to analyse how different factors have led to the structure of the city, including the quality of urban space and the degradation of its natural environment. Within the context of limited government capability to set out strategies for sustainable urban development, this paper examines the historical evolution of the Lebanese building regulations specifically in Beirut and investigates the impact of changes in building regulations on the city's urban microclimate. The review highlights the historical urban growth of the city and identifies the dynamics that have contributed to the uncontrolled expansion of the built up areas. Analyses linked to the direct effects of the urban morphological features forming a different local microclimate in Beirut. Initial findings highlight the correlations between building regulations and the different urban design factors and how they affect Beirut local climate, resulting in the formulation and adaption of the necessary strategies to alleviate unhealthy urban conditions.

Keywords

Urbanization, Beirut, Building Regulations, Microclimate, Urban Development.

THE IMPACT OF CHANGES IN BEIRUT URBAN PATTERNS ON THE MICROCLIMATE: A REVIEW OF URBAN POLICY AND BUILDING REGULATIONS

H. MOHSEN[1]
R. RASLAN[2]
I. EL- BASTAWISSI[3]

ABSTRACT
Previous studies conducted on Beirut have historically overlooked research in the field of urban microclimate. A better understanding of how Beirut urban development, including zoning and building regulations, has affected the current urban thermal climate is crucial in order to analyse how different factors have led to the structure of the city, including the quality of urban space and the degradation of its natural environment.
Within the context of limited government capability to set out strategies for sustainable urban development, this paper examines the historical evolution of the Lebanese building regulations specifically in Beirut and investigates the impact of changes in building regulations on the city's urban microclimate.
The review highlights the historical urban growth of the city and identifies the dynamics that have contributed to the uncontrolled expansion of the built up areas. Analyses linked to the direct effects of the urban morphological features forming a different local microclimate in Beirut. Initial findings highlight the correlations between building regulations and the different urban design factors and how they affect Beirut local climate, resulting in the formulation and adaption of the necessary strategies to alleviate unhealthy urban conditions.

KEYWORDS
Urbanization, Beirut, Building Regulations, Microclimate, Urban Development.

1. INTRODUCTION

Over the past years, several studies have shown evidence of climate change in most Mediterranean cities that have been observed and mapped. This evidence includes the decrease in precipitation, the rise of the temperature and the increase in the summer heat waves (Gao and Giorgi, 2008; Giannakopoulos et al., 2011). Despite the growing importance of such research, there is still a lack of studies that examine the relationship between urban morphology and microclimate in this region.

1 Hiba Mohsen, Assistant Professor, Faculty of Architecture- Design and Built Environment, Beirut Arab University, Lebanon h.mohsen@bau.edu.lb
2 Rokia Raslan, Associate Professor, The Bartlett School of Architecture, University College London, UK r.raslan@ucl.ac.uk
3 Ibtihal El-Bastawissi, Professor, Faculty of Architecture - Design and Built Environment, Beirut Arab Universit, Lebanon ibtihal@bau.edu.lb

Urbanization has transformed Beirut from a tiny city to an urban agglomeration. Nowadays, Beirut urban sprawl has extended to the extent that it has damaged natural resources in the surrounding mountains. The capital city is nearly saturated with concrete and this densification has immensely taken toll on the local climate. Hence, it is essential to understand the historical urban development and how changes in the built environment have led to degradation in the natural environmental. This includes, but is not limited to, the identification of the local characteristics of the studied urban area including physical structures, topography, and ventilation, which directly affect the microclimate. The constant process of environmental deterioration including loss of green areas, pollution, and energy consumption, challenges the set-up of urban design sustainable and comprehensive strategies, which in turn needs to incorporate climatic information on several spatial and temporal scales. The microclimate within the current outdoor urban space can be mitigated using bioclimatic design principles to improve outdoor thermal comfort.

2. BEIRUT AS A CASE STUDY

The city of Beirut (33°53′ N, 35°29′ E), Lebanon's capital, is a coastal city set on a peninsula on the east shore of the Mediterranean Sea and extends over 9 km into the sea. The north and west sides are open to the sea while the east side is surrounded by Mount Lebanon. The city has a Mediterranean semi-arid climate characterized by four distinct seasons; a pleasant fall and spring, a cool rainy winter and a hot humid summer. August is the hottest month of the year with a monthly average high temperature of 30°C and January and February are the coldest months with a monthly average low temperature of 10°C. The city is cooled during the hot season by the sea breeze carried from the littoral to the inner land to cool the city, which enables the prevailing southwest wind to infiltrate its urban form (Saliba et al., 2010).

2.1 Understanding the Urban Context

Greater Beirut's strategic location and importance as a primary centre of governmental activities are all factors that have attracted the majority of Lebanon's population, 87% of which resides in urban areas (UN-Habitat, 2011), mainly in the coastal cities. This demographic distribution led urbanized areas to multiply by a factor of 3 from 1994 till 2005 (Faour, 2015). In 2010, half of the urbanized population inhabited Lebanon's capital, which became known as Greater Beirut Area.

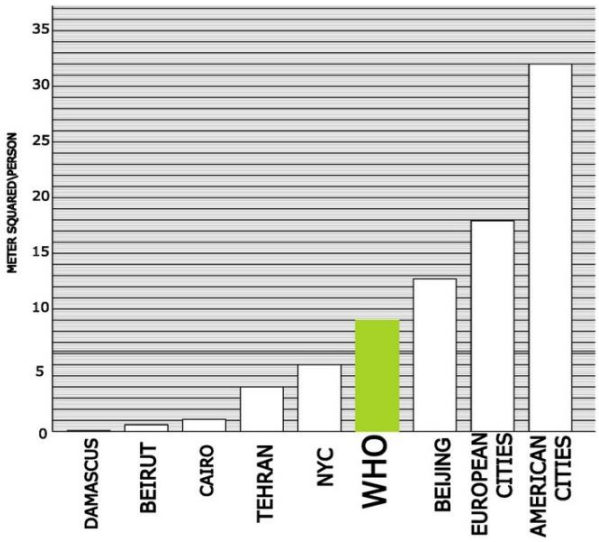


Fig. 1: Percentage of Green Area per capita
Source: Rishani, 2014

It includes municipal Beirut and surrounding suburbs with a surface area of 233 km2. The city has not only been expanding to the south and north of the littoral but also eastward towards natural setting over Mount Lebanon. The high concentration on the coastline can be mainly attributed to the topographic characteristics and limited national territory. Here, the steep terrains require costly construction and infrastructure network, have hindered the spread of population over the mountains and valleys regions.

Therefore, up to 70 % of the population inhabits the lower altitudes of the country that range between 0-200m, while the country elevation rises up till more than 3000m. Faour et al. (2005) analysed Beirut's topographic maps and satellite images and looked into the evolution of urbanization in the Greater Beirut Area.

According to his studies, the urbanized area was around 68 km2 in 1963 and expanded to double the area in 2005, reaching a total of around 143km2. In addition to the demographic changes, other push factors caused urbanization including internal migration from rural areas and successive emigration from surrounding countries of people escaping earlier and on-going conflicts and war, like Armenians,

Palestinians and Syrians. The continuous pressure exerted by population growth on Greater Beirut, which area is 2.2% of the Lebanese territory (UN-Habitat, 2011), has caused many changes in the physical characteristics of the city. According to the National Physical Master Plan for the Lebanese territory, an annual 10 km2 of natural areas is expected to be destroyed due to the expansion process (NPMPLT, 2005).

At the city scale, green spaces count for only 0.8 m2 per capita of the city, while the World Health Organization recommends a minimum of 9 m2 per capita (Stanley D. et al., 2016) . The city has been recently becoming denser and deprived of green spaces. Figure 1 illustrates the remaining green patches in Beirut per person compared to the high abundance in vegetation in European and American cities.

2.2 Microclimate changes in Beirut

An increase in temperature has been identified in the city of Beirut where, based on an analysis of temperature extremes in Beirut over 131 years, the maximum and minimum yearly temperature (T max. and T min.) were found to have increased by 0.13°C and 2.9°C respectively while daily temperature range has decreased by 2.6°C (Mhanna, 2007). A report by the Lebanese Second National Communication to the United Nations Framework Convention on Climate Change recorded the diurnal temperature (DTR) of Beirut over long term dates between 1980 and 2000, and showed a strong decrease in its value. Furthermore, based on the Lebanese ministry of Environment report 2011, Figure 2 illustrates the projected climatic change estimated using the PRECIS model calculates Tmax for the coming century (Ministry of Environment - MOE, 2011) and indicates that Tmax will increase by 4°C.

In terms of the impacts, research by El-Zein et al. (2004) has correlated the high temperature and mortality resulted from heat waves - especially when temperature exceeds 27.5°C in Beirut - and found it to be significant. It is also worth noting that the deterioration of air quality is intensified by the increase of human activities (Farah et al., 2014), which is clearly seen in the high traffic rate recorded on the streets of the city. Moreover, anthropogenic heat accentuates during the summer in Beirut due to the excessive use of air conditioning as the electricity consumption increases by more than fourfold. All these conditions demonstrate the discomfort in the outdoor thermal environment in the hot season, which affects the pedestrian behaviour at the street level of the city.

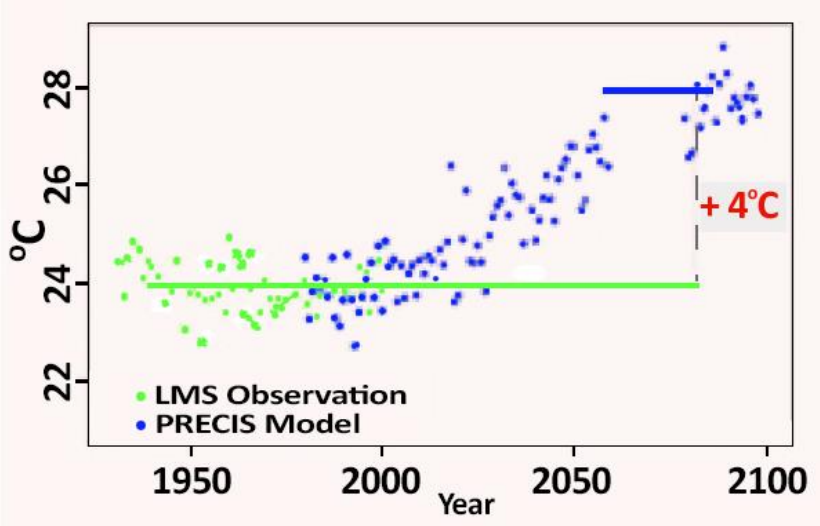


Fig. 2: Long-term time-series of annual Tmax over Beirut as observed by LMS and projected by PRECIS Source: adjusted from MOE, 2011

2.3 Previous Studies of the Local Climate

Despite the focus on urban climatology in many cities over the decades, there is still a lack of numerical studies on urban design and planning strategies on Beirut, which could have an implication on modifying the city's energy balance. Relatively, only very few studies have recently assessed the evolution of urbanization in Beirut and its effect on urban climate, and these studies were limited to the meso-scale of the city (Faour, 2015; Kaloustian and Diab, 2015). Other academics have qualitatively proposed urban design guidelines to enhance the visual and functional quality of Beirut streets (Balaa, 2014; Mohamad, 2014; Samaha, 2011). It is crucial to analyse and identify the urban morphological features in Beirut that directly pertain to creating a different local microclimate. This will help in understanding how the increase in building density due to modifications in the regulations reduces air flow, affects thermal comfort, and augments building energy demands, and comprehending how urban air ventilation is structured within the built environment of the city. Recently, the National Council for Scientific Research derived land use and cover changes in Beirut from high-resolution multispectral images (Figure 3). The remote sensing image maps quantify different patterns including the intense concentration of population in the major urban pole of the country, the fragmented natural habitat due to urban activities, and infrastructure and agricultural activities.

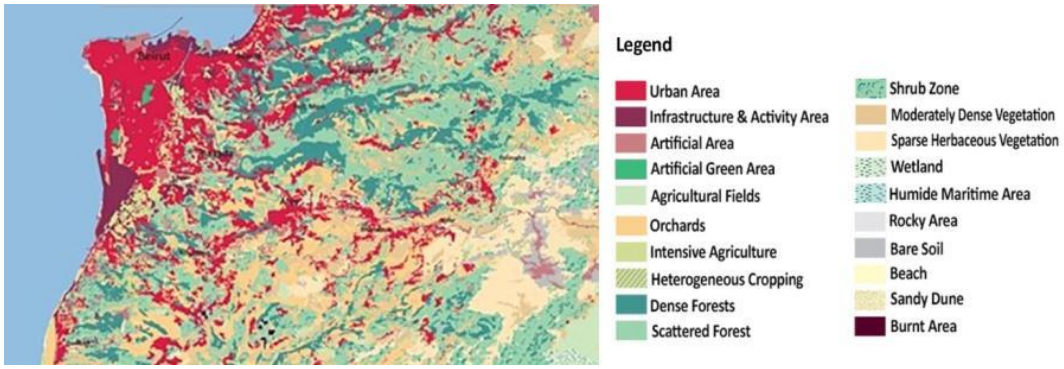


Fig. 3: Multispectral image indicating landuse and cover change of Beirut
Source: Hamze, M. and Faour , G., 2014

Salhab, T. (2013) undertook another study that conducted field measurements covering Beirut City, in which he measured the highest and lowest temperatures zones. As shown in figure 4, this study identifies the urban hot spots and correlates them to the city's physical structure and activities. For example, the work found that the area close to the Beirut port records one of the highest temperatures in the city, unlike Horsh Al Sanabar (Beirut's largest urban park), which registers the lowest temperature.

Previous studies focused on the thermal aspects of the city, which shows a lack studies that aim to quantify the aerodynamic properties of Beirut, which heavily affect the city's urban microclimate. By understanding how wind blows all over the city and the different urban patterns, other questions related to heat, moisture and pollutant patterns in the city could be answered. It is also crucial to focus on the

neighbourhood scale to assess the effect of urban design on the microclimate. Incorporating all the detailed design features and urban climatic parameters can evaluate the thermal and mechanical turbulences occurring within the different layers of the local atmosphere and quantify Beirut's outdoor thermal conditions at the street level.

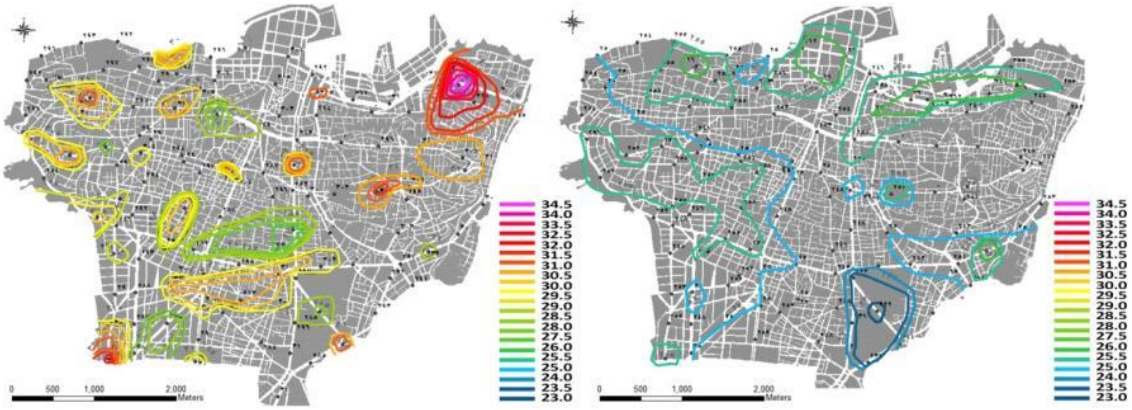


Fig. 4: Distribution of Temperature in Beirut/ Summer Season/ day/night time dates
Source: Adapted from Salhab, 2013

3. MATERIALS AND METHODS

This paper evaluates through an in-depth review the historical changes in the Lebanese Building regulation and discusses the previous attempts to urban policies. It provides an in-depth analysis of the various parameters that influenced Beirut urban development. Quantitative and qualitative data were collected and analyzed identifying the changes of the built environment over the past years. A timeline of the Lebanese Building regulations is used to show the effects of Beirut urban regulations on the urban morphology and therefore it is effects on the microclimate.

3.1 Overview of Lebanese Building Regulation

The understanding of the present urban environment at the micro-scale and the assessment of its changes due to high-density developments and loss of green areas, are valuable in revaluating decades-old building and planning regulations. Lebanon's original building law dated back to 1940 authorized the municipality to regulate or control different aspects of construction such as specifying setbacks, building heights, elevation materials in certain zones, plots and areas where construction is banned, space between urban blocks and the area of the building with respect to the total plot area. The existing building law is based on the French model and was written during the Mandate period (Ghandour, 2001). As a result, decree 6285 was issued in 1954 to divide Beirut city into areas and determine its building systems and easements. In addition, Article 38 issued in 1962, helped in putting the bases of General Urban Design. Based on the different analysis of Beirut urban patterns and microclimate environment, the Evolution of the Lebanese building Regulations has been related to the loss of green Areas. Figure 5 summarises the relationship among the Lebanese building laws amendments, the decrease in the Green/Built-up area ratio and the absolute extreme temperature during the last 45 years. (Mohsen, H., 2016)

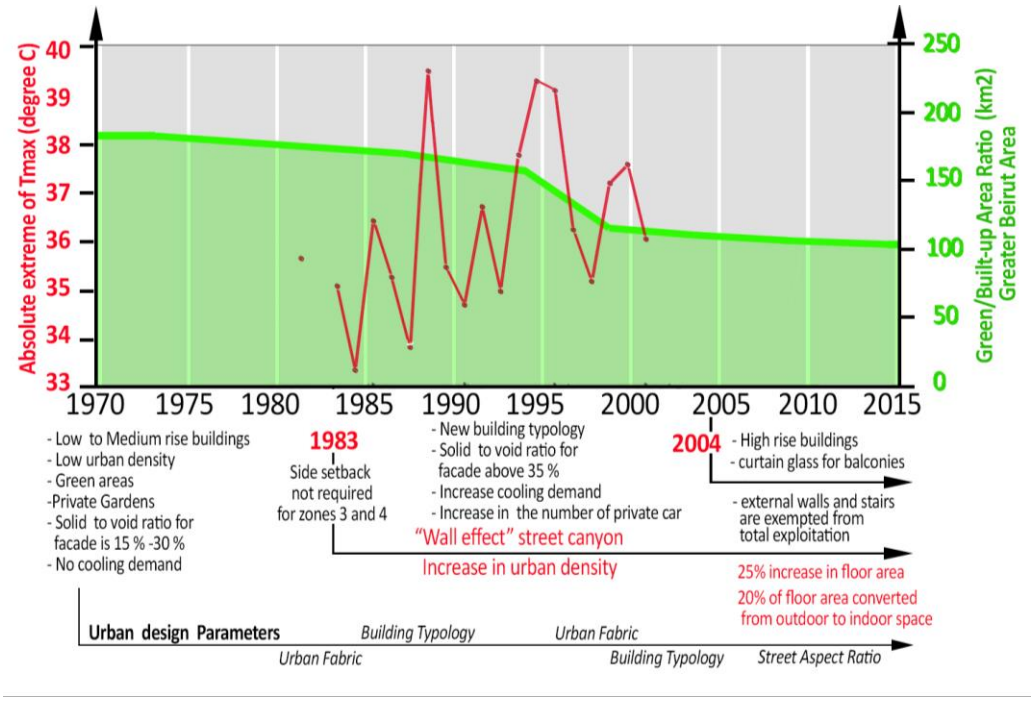


Fig. 5: Temporal comparison between the Evolution of Lebanese building regulations And Loss of Green Spaces (The author, 2016)

The urban density indicates the population concentration in the city and is usually related to land use and vertical density. In the case of Beirut, the dimensions of urban blocks are limited by zoning regulations, which subdivide the city into several concentric zones that specify the allowed construction on a parcel. As shown in figure 6, each zone is subject to floor area ratio and building coverage ratio according to Beirut cadastral maps and zoning regulations. The central zone of BCD has the highest exploitation ratio; the ratio decreases as the zones get further away from the centre. The zoning regulations allow low exploitation ratio along seashore, in addition to setbacks from all lots' sides, which increase the permeability of the wind from the littoral. In other central zones, buildings in adjacent lots can be attached with no setbacks, which creates a wall effect building, reducing airflow.

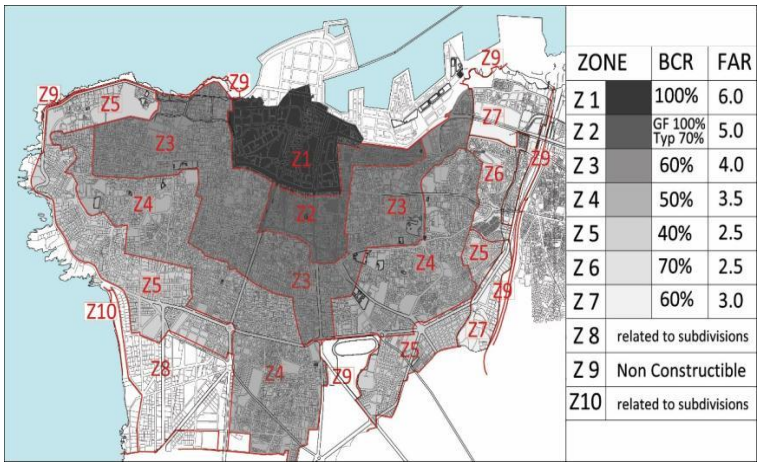


Fig. 6: Beirut Zoning Regulation Source: Adapted from Beirut Cadastral Maps and Regulations

An investigation of the evolution of Lebanese building laws over the last years illustrates how the amendments to these regulations aimed to increase building density without taking into consideration the changes in the urban environment. Although urban densification promotes compactness and sustainability, in a city like Beirut, which has one of the lowest public green space ratios (0.8m2/person) and lacks urban infrastructure, dense urbanization is equivalent to deterioration of the urban space.

Figures 7 and 8 show the total area of building permits since 2000 in Beirut and Lebanon respectively. The data were collected from the digital archives of the Order of Engineers and Architects - Beirut (http://www.oea.org.lb, 2018). The graph on the left illustrates that the areas of building permits per year almost doubled between 2004 and 2008. This significant increase in the construction sector is mainly due to the reconstruction after the July war in 2006, but also to the incentives amended in 2004 Construction law which offered to increase the land development.

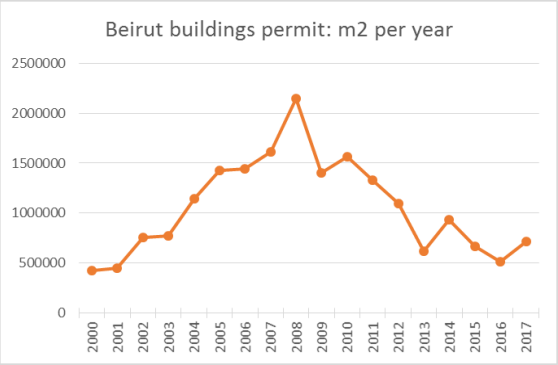


Fig. 7: Total Building permits (m2) in Beirut since 2000 (the author, 2018)

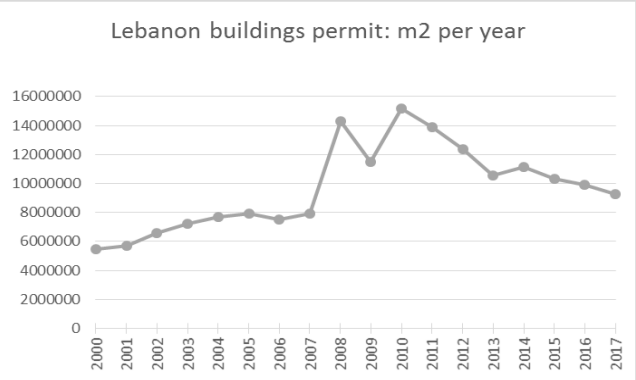


Fig. 8: Increase in building permit area in Lebanon due to the change in regulations (the author, 2018)

Nevertheless, in the buildings regulations, 2002 decree (Lot 2002/444) states that half of the leftover spaces in the built lots should remain as green areas; however, this particular decree has never been appropriately implemented.

While regulations are implemented to maintain community rights by developing and maintaining the quality of the built environment while responding to the city's social evolution and demands, this has not been the case in Lebanon. Regulations here have potentially played a negative role by increasing built up areas, both vertically and horizontally. For example, the high 'allowable exploitation factor' of lots that lie in the central zone of the city allows maximization of profit from densification at the expense of the urban quality. This not only causes the loss of traditional urban character, but also alters the spatial and physical characteristics of the urban fabric, leading to dynamic perturbations affecting the urban microclimate

3.2 Previous Attempts to Urban Policies

Within the limited governance structures of the country, Beirut metropolis lacks a strategic urban development vision that regulates its vertical and horizontal expansion. Analysing the preceding spatial conceptions of the city shows that specialized authorities have ignored formulating a strategy that would tackle the emerging urban issues of the overwhelming city, except for limited land regulation, infrastructural investments and building codes. The previous urban planning strategies of the city reflect non-comprehensive, unmonitored and short-term approaches. The political dimension of urban planning projects was key in driving towards the development of a modern state (Verdeil, 2010). Early attempts in Beirut's urban planning started in the forties with Ecochard's plans to delimitate of the territory of Beirut and suburbs, ignoring its natural topography. Then, during what is known as "Chehabist reform" period and the prosperity of the country, IRFED studies highlighted unprecedentedly on the gap in socio-economic status between the capital city and the periphery of the country. In the end of eighties, the SDRMB focused on the infrastructural transportation and means to reconnect the capital city with new centralities (SDATL, 2005). Following this, the 'Plan Horizon 2000' proposed by the Council for Development and Reconstruction (CDR) (Khoury, 1995) and the physical master plan of Lebanese

territory proposed ten years ago were also not enacted as a regional framework. As observed in these different attempts, urban planning policies in Beirut have long neglected to take into account protection and promotion of green spaces. Today, with the continuous spatial transformations over the coastal areas, Beirut urban footprint that extends to reach northerly Jounieh city and southerly towards Saida, renders previous unimplemented regional framework out-dated. The governmental still lacks the means to control and curb the pressure of hyper-centralization of the capital city and suburbanization of the surrounding that are posing accelerated pressures on the natural environment and microclimate conditions.

4. DISCUSSIONS

4.1 Building Regulations and Its Impact on the Urban Form

Densification defined as the construction of new residential units within existing urban areas (Broitman and Koomen, 2015) alters ventilation conditions within the urban fabric at the street scale as well as buildings natural ventilation demands. The environmental deterioration is the result of the failure of the current laws to limit the fast urbanization and protect remaining green spaces. Although the laws give the right to expropriate private lands to protect natural areas, they have been only used in the case of roads infrastructure.

4.1.1 Changes in the side setback: Wall Effect

Before 1983, the regulations forbade side attachments in zones 3 and 4, thus forcing architects to keep a distance from adjacent buildings and promoting proper urban ventilation. Later changes in the building laws allowed sides attachments, which lead to the creation of continuous barriers along the streets. This "wall effect" takes place at both sides of Beirut's street canyons, preventing good ventilation and reducing airflow. The allowance of side attachments of buildings in many zones in Beirut often generates two continuous tunnels within the street canyon. The channelization effect is reinforced by the geometry of buildings. Moreover, tall high-rise buildings and large podium structures are new common urban typologies that have led to lower permeability for urban area ventilation at the pedestrian level (Figure 9). For instance, the Verdun Gardens, a residential and commercial complex project constructed on a lot area of 7,000 m2 and having a total built-up area of 66,000 m2, provides a clear example. This large-scale building is different from the surrounding urban typologies; and creates a "wall" that blocks win-flow and suffocates the rear buildings.

Fig. 9: Newly attached buildings in front of old buildings with setbacks

4.1.2 Building Regulations Exemptions

Sea Shore Construction the blocking of ventilation also occurs on the seashore level, as seen in a new project named Eden Rock Resort located in Ramlet El Bayda in Zone 10, which, according to zoning regulations, is a non-constructible area. The resort, which has been criticized for its encroachment on the public domain, disturbs the continuity of the flow of sea breeze towards the city, disrupting the

surrounding urban ventilation. Giving approval to such projects legally categorized as “exceptions” does not only endanger the right of citizens to access public spaces, but also affects the urban climate.

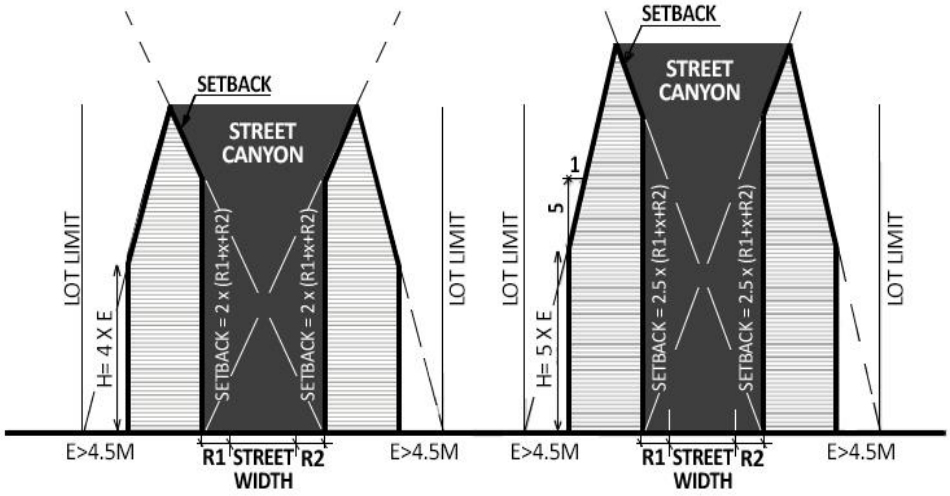
4.1.3 Increase in FAR and Ground Coverage

Furthermore, in 2004, the drastic transformations in the Lebanese building laws accentuated the decline of the built environment whereby, for example, the area of external walls, stairs and lifts were exempted from the total exploitation area. The given justification for these amendments was that double walls can work as thermal insulation walls and that, by increasing the allowable built areas, the market supply will better meet the demand for housing in the city. Consequently, the law led to an approximate 25% surge in floor area due to the increase in exploitation ratios distributed across all floors. As a result, an increase in ground floor density and thus, in the rise of building coverage at the expense of green and open space, has been noticed.

4.1.4 Increase in Building Heights

In addition, within areas where there is no limit to maximum building height, which is the case of Beirut, the building envelope known as Gabary has increased since 2004 from a height equals to two times the width of front setbacks and road to a factor of two and half.

As mentioned in section 3.1, building regulations in 2004 increased the building density and modified the street aspect ratio. They allowed the building envelope to be two and half times the street width plus the setbacks (Figure 10). This stops wind flow from infiltrating within the urban fabric to reduce the amount of solar radiation.



Building Regulation before 2004 in Beirut Setback and Building Envelope (GABARIT H=2x(R1+X+R2)

Actual Building Regulation in Beirut Setback and Building Envelope (GABARIT H=2.5 x (R1+X+R2)

Fig. 10: Building regulation changes on street Canyon geometry

4.1.5 Turning Balconies into Indoor Spaces

Moreover, the law permits balconies, which should be a transitional space from inside to outside, to be totally closed by adding curtain wall glass, which was previously prohibited, discouraging the use of protruded balconies and the play of solid and void in the facades, and turning them nowadays to a flush-glazed wall. As a result, the allowable area of balconies, which is 20% of the floor area, becomes an indoor area (Ashkar, 2014).

4.1.6 Land Pooling

Building regulations do not prohibit combining various lots in one large lot to construct a large-scale project. Investors use this technique (known as land pooling- Figure 11) whereby they buy small lots and combine them into one in order to take advantage of a high exploitation area. As a result, new skyscrapers and high-rise buildings are now increasing haphazardly in Beirut's urban fabric, causing drastic changes to the urban morphology of the city. The large size of these urban blocks degrades ventilation as well as dilution and transportation of pollutants and heat exhaust away from the city congestion, causing a stagnation of wind.

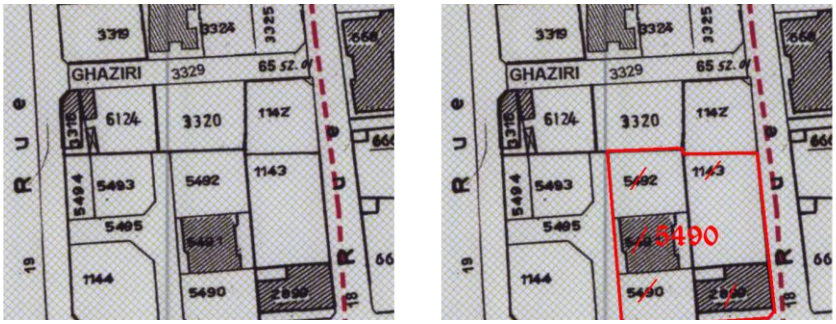


Fig. 11: Land Pooling

4.1.7 Additional Factors Affecting the Deterioration of the Microclimate

The irregular streets network in Beirut is characterized by different orientations and varied widths. The majority of the streets are considered street canyons, considering their narrow and deep dimensions, resulting in trapping traffic pollutants and hurdling pollutant disperse in the atmosphere, especially in the poorly-ventilated roads that are not in the direction of south west prevailing wind. The weak public transportation infrastructure that has made the city car-dependent curbs the street activities of pedestrians even when travelling the shortest distances. Moreover, the value of albedo materials used in building roofs, facades, roads, pavements and cars affects the surface temperatures on the horizontal and vertical planes. Dark colours like asphalt's and the excessive use of reflective surfaces such as glazing contribute to an increase in the amount of sensible heat produced. Based on the previous section, figure 12 correlates between the changes to the Lebanese Building Laws, urban geometry and urban surfaces and their effects on the microclimate. It shows that the 2004 latest modifications in the Building Law significantly altered the urban morphology and thus increased horizontally and vertically the building geometry which increased the anthropogenic heat, decreased wind speed as weel as green areas.

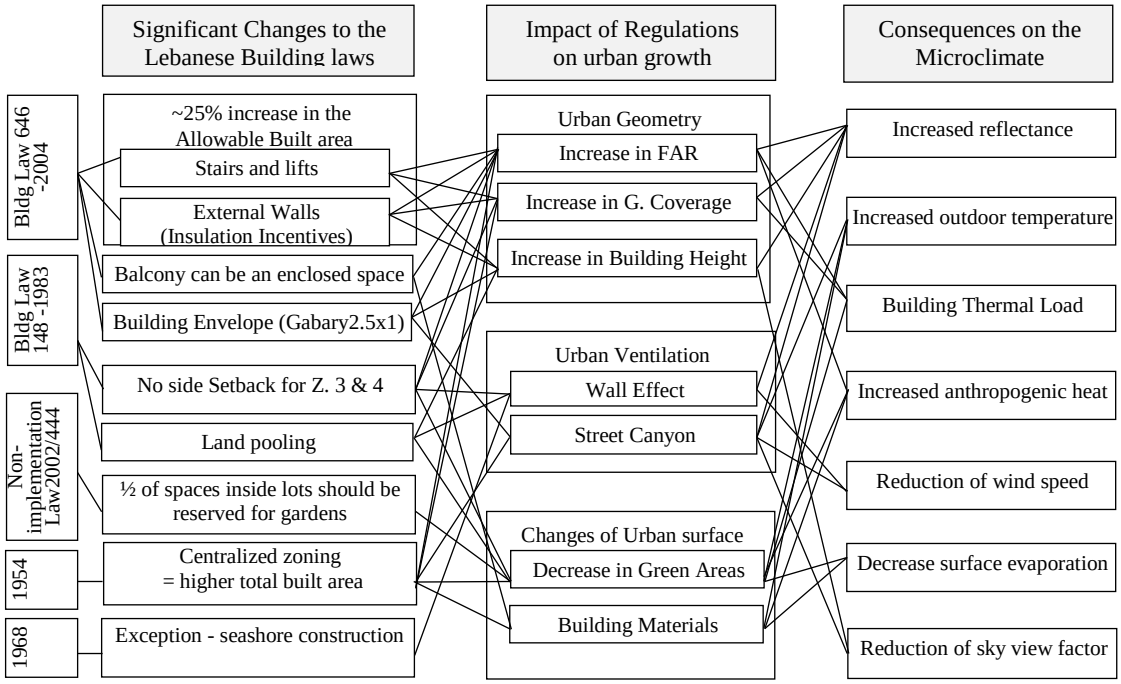


Fig. 12: The correlations between the Changes to the Lebanese Building Laws, Its impact on the urban growth and its consequences on the Microclimate (the author, 2019)

5. CHALLENGES AND OPPORTUNITIES

Zoning and building regulations should be designed to improve the quality of life instead of luring in more real estate agents and their project that increase congestion, pollution and unhealthy environment. Private actors in Beirut are controlling the planning of the city and therefore increasing high end development (Krijnen and Fawaz, 2010) and development profit (Bou Akar, 2012). On the other hand, and walking the first steps towards setting regulations for green buildings, the Lebanese Standards Institution (LIBNOR), which is a public institution, is currently working on the first draft of a regulation on the subject matter that includes a category related to urban heat island effect. The projected date for activating this Lebanese standard NL 800:2016 "Building Environmental Performance-Principles, Requirements and Guidelines" is in 2020, making Lebanon very retarded compared with other countries in implementing such policies. Moreover, several initiatives have been taken to protect the environment (Law 444) which assess the potential impacts of any large scale planned development project on the Lebanese environment. Another step is the Lebanese Green Building Council established the first Lebanese green building initiative to promote sustainable building practice. Furthermore, the Decree No. 15874/2005 Article 13 is clearly stating in the existing Law 2002/444 that half of the residual spaces inside lots should be reserved for gardens, however this decree lacks implementation from the governmental institutions. Hence, there is potential to overcome the environmental challenges and protect the existing built environment.

6. CONCLUSION

With rapid urbanization, Beirut has experienced a significant loss of natural areas and a major hike in constructions, which is leading to an environmental degradation. It is not only urbanization that is threatening the landscape vulnerability and causing its natural environment to shrink but the lack of implementation of rules that can protect the existing Lebanese physical environment.

As discussed before, many changes demonstrate that regulations in Beirut are to increase the digits on the pay checks of developers who manipulate nuanced principles in construction laws to maximize their income at the expense of boosting or even creating liveability in the communities. For instance, the changes in the building envelope as well as the increase in the total exploitation areas affected the physical and spatial characteristics of the city especially in its central zone.
In order to propose effective urban strategies, it is important to evaluate previous and current urban and planning policies in order to highlight on the failure to enforce them to protect the natural environment.

- Offer incentive mechanisms such as tax incentives by the local government to promote green building design principles.
- Amend specific sections in Lebanese building codes and planning regulations in order to adapt to measures for environmental sustainability including microclimate regulations, biodiversity, and performance standards.
- Motivate the Lebanese Standards Institution (LIBNOR) to work and coordinate systematically with all stakeholders to ensure the implementation of the "Building Environmental Performance-Principles, Requirements and Guidelines" Lebanese standard NL 800:2016.
- Ban real estate developers from using plots on the seashore for investments, such as beach resorts, which modify the zoning legislation from zone 10 (non-constructible) to zone 5, highly blocking the sea breeze effect.
- Make the municipality list all empty and vacant small parcels (non-constructible) in the city in order to explore the potentials of implementing green strategies by reconnecting them through corridors, instead of keeping them vulnerable for risks of maximum exploitation by real estate developers that combine them into larger lots.
- Investigate urban climate modelling tools to integrate the micro- and mesoscale scales.

REFERENCES

- Ashkar, H., 2014. Lebanon 2004 Construction Law: Inside the Parliamentary Debates. Civ. Soc. Knowl. Cent.
- Balaa, D.Z., 2014. Enhancing walkability through urban connectivity: the case of Hamra, Beirut.
- Bou Akar, H., 2012. Contesting Beirut's Frontiers. City Soc. 24, 150–172. https://doi.org/10.1111/j.1548-744X.2012.01073.x
- Broitman, D., Koomen, E., 2015. Residential density change: Densification and urban expansion. Comput. Environ. Urban Syst. 54, 32–46.
- El-Zein, A., Tewtel-Salem, M., Nehme, G., 2004. A time-series analysis of mortality and air temperature in Greater Beirut. Sci. Total Environ. 330, 71–80. https://doi.org/10.1016/j.scitotenv.2004.02.027
- Faour, G., 2015. EVALUATING URBAN EXPANSION USING REMOTELY-SENSED DATA IN LEBANON. Leban. Sci. J. 16, 23.
- Faour, G., Haddad, T., Velut, S., Verdeil, É., 2005. Beyrouth: quarante ans de croissance urbaine. M Ppemonde 3, 12.
- Farah, W., Nakhlé, M.M., Abboud, M., Annesi-Maesano, I., Zaarour, R., Saliba, N., Germanos, G., Gerard, J., 2014. Time series analysis of air pollutants in Beirut, Lebanon. Environ. Monit. Assess. 186, 8203–8213.
- Gao, X., Giorgi, F., 2008. Increased aridity in the Mediterranean region under greenhouse gas forcing estimated from high resolution simulations with a regional climate model. Glob. Planet. Change 62, 195–209. https://doi.org/10.1016/j.gloplacha.2008.02.002
- Ghandour, M., 2001. Building Law: a critical reading of the Lebanese case.
- Giannakopoulos, C., Kostopoulou, E., Varotsos, K.V., Tziotziou, K., Plitharas, A., 2011. An integrated assessment of climate change impacts for Greece in the near future. Reg. Environ. Change 11, 829–843. https://doi.org/10.1007/s10113-011-0219-8
- Kaloustian, N., Diab, Y., 2015. Effects of urbanization on the urban heat island in Beirut. Urban Clim., Cooling Heat Islands 14, Part 2, 154–165. https://doi.org/10.1016/j.uclim.2015.06.004
- Khoury, P., 1995. Reconstruction: Implementing Horizon 2000. Leban. Rep. 6, 8.
- Krijnen, M., Fawaz, M., 2010. Exception as the Rule: High-End Developments in Neoliberal Beirut. Built Environ. 36, 245–259. https://doi.org/10.2148/benv.36.2.245
- Mhanna, M.H., 2007. Modeling Temperature Trends and Extremes: Beirut Region as a Case Study. American University of Beirut, Department of Land and Water Resources.
- Ministry of Environment - MOE, 2011. Lebanon's Second National Communication to the United Nations Framework Convention on Climate Change.
- Mohamad, M., 2014. The shifting divide: towards an urban design strategy for a Green Line in motion-the case of Beirut.
- Mohsen, H., 2016. Optimizing Beirut Urban Neighbourhood through green Infrastructure- A 3 D Urban Modelling Approach (Unpublished doctoral dissertation). Beirut Arab University, Beirut, Lebanon.
- NPMPLT, 2005. National Physical Master Plan of Lebanese Territory.
- Salhab, Tarek, 2013. Heat Islands in Beirut City – A Study in Urban Climatology. PHD in Geography, Beirut Arab University.

- Saliba, N.A., El Jam, F., El Tayar, G., Obeid, W., Roumie, M., 2010. Origin and variability of particulate matter (PM10 and PM2. 5) mass concentrations over an Eastern Mediterranean city. Atmospheric Res. 97, 106–114.
- Samaha, S.N., 2011. Legalizing nature: sustainable urban greening strategies for Corniche Al-Mazraa-by Sandrine Nabil Samaha.
- SDATL, 2005. Schematic design director of Lebanese territory.
- Stanley D. Brunn, Maureen Hays-Mitchell, Donald J. Zeigler, Jessica K. Graybill, 2016. Cities of the World: Regional Patterns and Urban Environments, 6th Edition. ed. Rowman & Littlefield.
- UN-Habitat, 2011. Lebanon Urban Profile: A Desk Review Report.
- Verdeil, É., 2010. Beyrouth et ses urbanistes: une ville en plans (1946-1975). Institut français du Proche-Orient.