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Walid Al-Shaar, Olivier Bonin

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# Factors behind the dynamics of land use evolution: case of Lebanon

Walid Al-Shaar<sup>1</sup>  · Olivier Bonin<sup>2</sup> 

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## Abstracts

Monitoring and understanding the evolution of land use and land cover is a key factor for many environmental studies as well as for policymakers. Moreover, policymakers are interested in understanding the factors that have a significant impact on land use change. This paper analyses the dynamics of land use change in Lebanon between the years 1984 and 2019 and identifies the main factors behind this process. The use of Landsat satellite images enables the creation of land use maps at several periods and the monitoring of the evolution of built up areas as well as of green areas. Five periods emerge from this analysis, for which it is possible to propose explanatory factors, after an in-depth qualitative analysis. Within the framework of Structural Equation Models, a Confirmatory Factor Analysis is carried out to determine the impacts of several factors related to governance and financial data. Moreover, the urban sprawl is further investigated and explained by cultural, environmental, and infrastructural factors. The main results reveal that the development of built up areas is highly dependent on good funding conditions, whereas banking conditions and weak governance are correlated. The case of Lebanon presents specificities probably linked to historical and cultural considerations that deserve to be studied in future works. In the form of recommendations, new land use policies should be enacted to ensure sustainability in the form of an equilibrium between the urban development, from one side, and the preservation of natural resources and good environmental conditions on the other side. This could comprise the preservation of natural zones; the subsidization of the cultivation profession; and the encouragement of urban densification instead of horizontal sprawl.

**Keywords** Urban development · Land use · Remote sensing · Lebanon

## 1 Introduction

Understanding the dynamics of land use, land cover, and the factors behind, these dynamics is a classical issue. It can help the scientists, environmentalists, planners, and policymakers in monitoring and anticipating the land use changes and in designing urban plans and land use policies. For that purpose, great efforts were made to design and prepare land cover and land use databases. For instance, the land cover databases, such as Corine Land

Cover for Europe, are designed and created by human photo-interpretation of satellite images. However, the factors explaining land cover dynamics are often intricate. Furthermore, several studies were conducted to identify the driving factors behind the dynamics of land use change.

In most studies, the identified factors include the land use policies, the socio-demographic conditions, the economic situations, the topography, the provision of infrastructure, and biophysical factors. It is noted that only the country's inner factors are taken into consideration

✉ Walid Al-Shaar, [walid-al-shaar@hotmail.com](mailto:walid-al-shaar@hotmail.com); Olivier Bonin, [olivier.bonin@univ-eiffel.fr](mailto:olivier.bonin@univ-eiffel.fr) | <sup>1</sup>Civil Engineering Department, Doctoral School for Science and Technology, Lebanese University, P.O. Box 6573/14, Badaro, Museum, Beirut, Lebanon. <sup>2</sup>LVMT (Laboratoire Ville-Mobilité-Transport), Unité Commune Université Gustave Eiffel and École Des Ponts, 6-8 Avenue Blaise Pascal, 77420 Champs-sur-Marne, Paris, France.



in almost all relevant studies. Moreover, the political and security conditions have not been discussed in details.

For instance, the rapid growth of economic and commercial development was found to be the main factor behind the rapid urban development in the study of Hamad [1] in Soran district, in the Erbil governorate of Iraq, over the period extended between years 1998 and 2018 and in the study of Arulbalaji [2] in Salem district, South India, over the period 1992–2015. Additionally, national economic conditions could also represent one of the major factors that direct the land use changes and evolution. For example, a study conducted by Salvati et al. in the year 2015 [3] revealed that the national economic situation could significantly affect the urban sprawl by altering the pace of urban development and by changing the actual spatial housing patterns. The authors examined the growth of built up land use in many countries in southern Europe and compared the corresponding development trend before and after the global economic crisis that happened in year 2008. The findings showed that stagnant national economies were observed over the period between years 2008 and 2014 within the studied countries.

This economic stagnation has deteriorated the socio-economic situation, slowed down the pace of urban growth and recessed the population spreading and the dispersed urban expansion by converting the new/changing forms of urban agglomerations to the compact, dense, and centralized shape. From other perspective, low governance and weak law enforcement were identified as the main causes of a significant forest degradation in 38 Sub-Saharan African countries between years 1996 and 2011 [4].

Similarly, low effectiveness of land use policies would lead to decrease the natural green areas in favour of increased urban development [5].

The population growth and the induced increase in the demands for construction materials and infrastructure were reported as the main driving factors of land use change in Ethiopia and in Tanzania [5, 6]. For instance, these factors were behind the growth in the areas of urban development and cultivated lands and the decrease in the areas of natural green zones as the wetlands, grass lands, shrub lands, and forests in Gumara watershed in the Northwestern area of Ethiopia over the period from year 1957 to year 2005 [5]. Similarly, the population growth, the provision of infrastructure, the high profits from forests and cultivation's products, and the growth in demand market are identified as the driving forces of land use change, observed as an increase in farmlands and a decrease in wetlands, from year 1990 to year 2016 in the Kilombero Valley in Southeastern zone of Tanzania [6].

This paper contributes to this growing literature by investigating and discussing the factors behind the

evolution of land use dynamics in Lebanon. In this study, the identified driving factors are divided into two categories: the country's inner factors and external factors.

The case study selected is Lebanon since the country is facing major land use changes. For instance, the extensive urban development, the degradation of natural and cultivated zones in addition to the lack of appropriate urban planning and Land use policies represent the main land use problems that Lebanon is facing [7, 8].

This paper investigates further the interactions between the green areas and other land uses, and the risks menacing the cultivated and forest areas.

It is hypothesized that the total area of natural green zones and agriculture areas is not decreasing, but rather these areas are expanding spatially and in some cases, they are taking place in new other locations to reconstitute their consumed and abandoned areas. It is hypothesized also that urban development is not the main factor menacing the green areas; and that the abandonment of the agriculture profession, the non-attachment to land in addition to the pollution represent the principal factors responsible for the degradation of green areas.

This paper is structured as follows. Section 2 presents the case study. Section 3 highlights the methodology of the research and the techniques of data collection. Section 4 presents the analysis, and Sect. 5 summarizes the paper and presents future areas of research.

## 2 Study area: Lebanon

Lebanon is an interesting case study since this country has previously witnessed and is currently experiencing major land cover and land use changes. Lebanon is located on the eastern side of the Mediterranean Sea. The 10,452 km<sup>2</sup> total area of Lebanon extends in a 200 km long coastline and a 60 km average width [9].

A study conducted by Masri et al. [10] showed a decrease in the total area of forests by 32% and cultivated lands by 54% from the year 1963 to the year 1998. The author indicated that this decrease was associated with a significant increase in bare soil lands and built-up areas. Similarly, Fawaz [11] reported a decrease in the total area of cultivated lands and degradation of natural zones. The Food and Agriculture Organization of the United Nations (FAO) [8] indicated that Lebanon faced many land use problems such as the degradation of natural lands as forests and cultivated areas, water bodies, and natural sites. Within the same context, the Lebanese ministry of environment [12] reported a decrease in the areas of agricultural lands from 3324 to 2944 km<sup>2</sup> during the period from the year 2002 to the year 2011 in Lebanon and an increase

in the areas of forests from 2588 to 3043 square kilometre over the same period.

The United Nations Development Programme (UNDP) [7] indicated that the increased population and the limited land area of Lebanon have caused the increase in urban development. Moreover, high lifestyles and high income levels have increased the demand for second homes as summer houses, villas, and chalets and represent additional factors that increase the urban development.

High profits from real-estate development projects and the inadequate adherence to land use policies and planning guidelines represent a second factor leading to increase the chaotic urban sprawl [7]. These developments are taking place in old built-up lots, in vacant lands, and in natural areas as forests and agriculture zones. The UNDP and FAO [7, 8] pointed out that the evolution of land use in Lebanon lacks appropriate urban planning policies and laws. In addition, the land use dynamics are not monitored due to the absence of an effective central administrative entity for land use management and a suitable national urban master plan. For instance, 84% of the total country's area are unplanned areas in terms of land use plans [7]. The lack of land use strategies will continuously result in land degradation [8].

In a similar way, the Lebanese ministry of environment [12, 13] stated in the years 2012 and 2015 that the lack of land use administration, caused by inappropriate land use policies, has resulted in an increase of the chaotic urban expansion.

This urban development occurred by the overconsumption and degradation of natural landscapes and cultivated lands. The data provided by the World Bank Group [14] show that the total areas of agricultural lands in Lebanon increased from 5,980 square kilometres in the year 1984 to 6,580 square kilometres in the year 2016. Also, the World Bank Group [15] reported an increase of forest areas in Lebanon from 1,310 square kilometres in the year 1990 to 1373.8 square kilometres in the year 2016. These previous studies and reports contain contradictory data concerning the area's changes of built up land use, agricultural, and forest lands in Lebanon. Moreover, Lebanon was selected as a study area since this country has witnessed different complicated security and geopolitical events in addition to several economic and financial activities. These events, from the year 1984 to the year 2019, are depicted in Table 1.

### 3 Methodology and data

This section is divided into two parts. The first part discusses the implemented research methodology. The second part presents the available sources of data, the

collection techniques, the data collected in addition to the accuracy, and the limitation of the used data.

#### 3.1 Methodology

The adopted research method consists of two parts. The first part examines the evolution of urban development and the factors affecting it. It is worth also emphasizing that the spatial expansion of urban development and its interactions with other land covers must be explored. Therefore, the second part, that is an extension of the first part, investigates whether this urban expansion takes place at the expense of green areas or not. This part discusses also the general interaction context between different land use types. A collection of satellite images was conducted to generate land use maps within ArcMap software and to monitor the evolution of built up areas over years (1984–2019). Additionally, data on political, security, and economic events are collected. The data on these events will be employed to conduct qualitative and quantitative analyses. The qualitative analysis is depicted as linking the political and socio-economic factors with the evolution trends of built up land use in order to define the factors responsible for these dynamics and the priority of their effects. On the other side, the quantitative analysis will be conducted on the basis of structural equation models (SEM) to check the validity of the relations between the political, security, and economic events, and the built up expansion. The qualitative analysis is complemented further by a study investigating the spatial interactions between the land cover classes (Built up, Green Areas and Bare Soil). In order to perform this investigation, the land use maps of Lebanon were further divided into the main five administrative zones of Lebanon: Beirut, Mount Lebanon, Bekaa, North and South Lebanon.

The Structural Equation Model (SEM) framework, and especially the Confirmatory Factor Analysis (CFA) formulation, was selected because of its adequacy to check hypotheses about relationships between variables. Xiong et al. and Fan et al. [16, 17] pointed out that SEMs are particularly helpful to develop and test structural hypotheses of direct and indirect causal dependencies among variables. Xiong et al., Fan et al. and Bag [16–18] indicated that the SEM represents a new type of statistical models that intend to interpret the assumed relations between different science variables. Moreover, in an SEM, it is possible to define unobservable variables (latent variables) representing concepts of interest and link them through dependency relationships with observed variables [16–18]. Bag [18] pointed out that the researchers employ the SEM to examine the existence and the type of the assumed relationships and interrelationships (causal effects: “regressions”, covariances, and correlations) between these latent

**Table 1** Political, financial, external and internal security events after year 1984

Event and a Brief description	Time period	Source
Civil War (1975–1990)	1984–1990	[22]
Israeli conflicts with Lebanon: land occupation in South Lebanon	1984–2000	[23]
Start of Syrian Tutelage	1990	[24]
Start of the post war reconstruction		
Lebanese—Israeli conflict	1993	[25]
Reconstruction of City Center	1994	[26]
Founding of Solidere company to manage the rent real estate in Beirut's downtown		
Lebanese—Israeli conflict	1996	[27]
Pegging the Lebanese's national currency (Lira) to the United States Dollar (USD) at 1500 for 1 USD	1997	[28]
Israeli withdrawal from the South of Lebanon	2000	[23]
11 September attacks in the united states	2001	[26]
The 11 September attacks in the united states have boosted the influx of Saudi shareholders in Lebanese companies. The attacks also diverted the Saudi funds in the United States to Lebanon and Arab countries		
Paris I conference: external loans to reinforce the Lebanese national economy		[29]
Paris II conference: external loans to reinforce the Lebanese national economy	2002	[30]
Injection of money deposits from the Iraq after the Iraqi-US war (because of instability and violence activities) to the Lebanese banks	2003–2014	[28]
Enacting a new construction law:	2004	[24]
Significant increase in the total land exploitation, and the authorization of higher constructions		
Assassination of Prime Minister Rafic Hariri	2005	[26]
End of Syrian Tutelage	2005	[24]
Lebanon Israel War	2006	[26]
Post Lebanon-Israel War reconstruction	2006	[7]
Stockholm conference: external loans to reinforce the Lebanese national economy	2006	[29]
War on militant terrorist organization in Nahr El Bared camp in North Lebanon	2007	[31]
Paris III conference: external loans to reinforce the Lebanese national economy		[30]
Presidential vacuum		[32]
World economic crisis	2008	[7]
Influx of money deposits and short term investments from the Arabic Gulf Countries	2008–2014	
Civil strife	2008	[24]
Internal security conflicts and protests		
Presidential election		[32]
Real estate bubble: Accelerated growth in the real estate market	2008–2014	[26]
Arab Spring: Series of anti-government protests in Tunisia, Libya, Egypt, Yemen, Syria and Bahrain	2010–2012	[28]
Injection of money deposits from the Arab Spring countries (because of instability) to the Lebanese banks		
Start and spillover of the Syrian Civil War	2011	[33]
Lebanese Protests against the government		[34]
Arrival of Syrian Refugees	2011–2013	[33]
Significant subsidization of housing loans by the Lebanese Central Bank through commercial banks	2012–2018	[28]
Oil crash	2014	[26]
Presidential vacuum	2014–2015	[35]
Terrorist activities—security conflicts caused by the terrorist group: "Islamic State in Iraq and the Levant (ISIS)"	2014–2017	[36]
Lebanese Protests against the waste crisis	2015–2016	[37]
Presidential election	2016	[35]
Collapse of the National Economy: Start of Financial Engineering Mechanisms by the Lebanese Central Bank	2016–2020	[28]
Lebanese war on the Terrorist militant group: ISIS	2017	[38]
General Parliamentary Election	2018	[39]

**Table 1** (continued)

Event and a Brief description	Time period	Source
Start of Economy's Deterioration: Lebanese Protests against government	2019	[28]
Drop in the value of the Lebanese Pound to US Dollar (from 1507 to 2250 in December 2019)		[40]

variables and the measured causal parameters. Xiong et al. and Fan et al. [16, 17] stated that the CFA and the path analysis are the main ways to use the principle of SEM. The CFA was first used to estimate the psychometric attributes that are unobservable and thus modeled by latent variables. On the other side, the path analysis was first introduced to explain and quantify the causal relationships among biometrics variables through a path diagram [17]. The examination of the assumed relationships is conducted through the process of estimating the values of latent variables within the context of CFA and the process of assessing the validity of the estimated model. The SEM employs a sequence of equations for the CFA in order to estimate the values of latent variables. Hereafter, a comparison between the estimated model and the empirical data should be conducted. This comparison is known as the fit statistics assessment. In other words, a model is considered fit if the dependency assumptions are validated by matching the observed data [17, 18].

## 3.2 Data collection

### 3.2.1 Available data sources

Several sources of data provide different and incomplete info about the land use situation of Lebanon, however, the satellite images represent the only complete source of data for land use mapping in Lebanon for the period extended between the years 1984 and 2019. Moreover, data about economic, political, and security conditions were collected.

These data include the governance indicators (as the effectiveness of the government, the rule of law, and the political stability and absence of terrorism/violence), the shares of economic sectors in the Gross Domestic Product (GDP), the values and volumes of real estate transactions, the share of foreigners in the real estate sector, the net foreign assets, the construction, and housing loans in addition to the construction permits.

### 3.2.2 Landsat Images and land cover/use classification

The website EarthExplorer [19] provides 30 m' resolution Landsat satellite images of Lebanon. The satellites Landsat 4, 5, 7, and 8 are the sources of these images. The collected

images correspond to all years from the year 1984 to the year 2019 except the years 2010 and 2012 (the images of years 2010 and 2012 are damaged and could not be used in the land use classification process). The images were utilized for the process of supervised land use classification in ArcMap 10.6.1 software. The defined land use classes adopted in the classification process are: the built-up areas, bare soil lands, green areas, and water bodies. The built-up class includes the roads, buildings, and any form of urban development. The green areas include forests, cultivated lands, and any land with significant vegetation. The bare soil lands comprise areas with no significant vegetation. The validation of the land use classification processes was performed using the accuracy assessment test of ArcMap software. This test provides for the land use maps of each year the accuracy percentage and the kappa test value. The results showed good classification indexes since all percentages and kappa test values have exceeded, respectively, the values of 85% and 0.8 [20, 21]. The classes obtained by this process are mostly land cover classes, as commonly obtained from satellite imagery.

### 3.2.3 Political, financial and security events

The Political and Financial events in addition to the external and internal Security events over the 1984–2019 period were collected from different sources. The relationships and effects of these events are analyzed and discussed in details via the SEM in the analysis section.

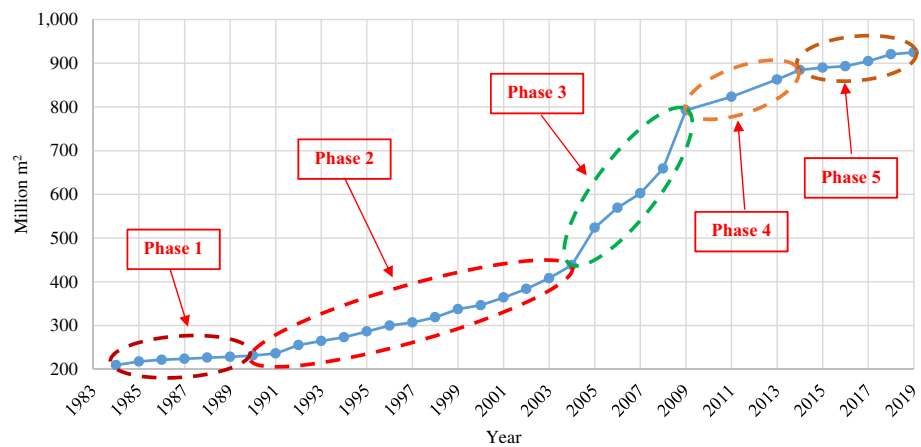
## 4 Results, analysis and discussion

### 4.1 Land use classification maps

The built-up land use change in Lebanon between the years 1984 and 2019 is illustrated in Fig. 1. This graph shows five trends of built-up land use evolution corresponding to the periods: 1984–1990, 1990–2004, 2004–2009, 2009–2014, and 2014–2019.

The dynamics of these 5 phases are characterized by their linear trends. The urban development of phase 1 corresponds to a stagnation phase. Similarly, phase 5 shows a significant decelerated pace of urban development which could present the potential start of a stagnation phase.

**Fig. 1** Linear phases of the Built-up land use Evolution in Lebanon (1984–2019)



Between these aforementioned phases, the elevated paces of urban development corresponding to phases 2 and 4 are considered, to some extent, the same. Furthermore, a particular accelerated urban development corresponding to phase 3 is remarked.

Qualitative and quantitative types of analysis were conducted next to link and identify the factors affecting the trends in these phases.

## 4.2 Analysis: factors affecting the built up land use change

A list of the main political, economic, and security stability factors that could affect the dynamics of urban development in Lebanon is illustrated in Table 1. (N.B: the factors with the highest impacts are indicated in bold).

### 4.2.1 Qualitative analysis

The factors corresponding to each of the five urban development phases are discussed in this subsection to identify their importance and impacts.

**Phase I: 1984–1990:** This phase reflects a very slow increase in built up land use as shown in Fig. 1. The political and security instabilities depicted by the civil war that started in the year 1975 and ended in the year 1990 [22] in addition to the Lebanese-Israeli conflicts, and the existence of the Israeli army in south Lebanon [23] represent the main reasons explaining this trend.

**Phase II: 1990–2004:** This phase witnessed an increase in the pace of built up development. Many factors have contributed to this increasing trend. One of the main factors is the stability of political and internal security conditions presented by the end of the civil war in the year 1990. The end of the war was paralleled by the Start of Syrian Tutelage to ensure internal security stability and followed by the start of the post-war reconstruction phase [24]. A great part of the reconstruction is presented by establishing a

renting business company “Solidere” to manage the reconstruction and real estate rents in the downtown of Beirut [26]. Ashkar [24] pointed out that the construction and real estate industry was promoted by different incentives, and by the state’s policies since the year 1990. The author argued this by the fact that the construction sector represents the dynamo of the economic growth since it represents a way to make profit and to circulate money, and that the majority of Lebanese politicians have direct investments in this sector.

This period witnessed also significant economic events starting by pegging the Lebanese’s national currency (Lira) to the United States Dollar (USD) at 1500 for 1 USD in the year 1997 after several fluctuations [28]. Additionally and within the same context of economic growth, Berthier [26] indicated that the “11 September” attacks in the United States in the year 2001 have boosted the influx of Saudi shareholders in Lebanese companies.

The attacks also diverted the Saudi funds and direct investments from the United States to Lebanon and Arab countries. Furthermore, the conferences: “Paris I” held in the year 2001 and “Paris II” held in the year 2002 have reinforced the Lebanese national economy and subsidized the reconstruction by, respectively, granting actual loans of 500 Million Euros [29] and 3.9 Billion USD [30]. Moreover, Holtmeier [28] reported that the instability and violent activities in Iraq after the start of the Iraqi-American war in 2003, led to the injection of Iraqi money deposits in Lebanese commercial banks, and steered the investments toward Lebanon in addition to other countries. It should be noted that during this period two Lebanese-Israeli conflicts have occurred in 1993 [25] and in 1996 [27]. Nonetheless, these conflicts did not affect the growth of urban development. Besides, the withdrawal of the Israeli army from the South of Lebanon in the year 2000 as reported by Wikipedia [23] has allowed the urban development to take place in the southern part of Lebanon. In conclusion, the stability of national security conditions and the economic

growth (driven by international grants and influx of foreign money deposits due to international conflicts) are perceived as the main factors that significantly contributed to the increase of urban development.

**Phase III: 2004–2009:** The trend of urban development in this phase is characterized by an acceleration of built up evolution. The political and security stability achieved in phase II, in addition to the corresponding good economic growth, has provided a good investment environment and increased for investors the trust in the banking, construction, and real estate sectors. Moreover, the influx of investments in addition to the injection of money deposits from Iraq after the Iraqi-American war has subsidized the real estate and construction sectors in Lebanon. Nonetheless, additional factors improved the overall national stability and accelerated the urban development. Ashkar [24] reported that the Enactment of a new construction law in the year 2004 allowed a significant increase in the rate of land exploitation in addition to the authorization of higher constructions; and this has encouraged real estate investors to trade in this sector and boosted the built up development. The author listed other factors that boosted the real estate market as the investment and speculation of wealthy Lebanese expatriates in this trade, the belief that the properties keep their money values during political and security instabilities, and the money laundering with non-defined impacts. It is worth noting that Lebanon witnessed a boom in the construction sector [24, 26] concurred with the occurrence of several political and security instability conditions. These instabilities started by the assassination of prime minister Rafic Hariri in 2005 [26] and continued by the ending of relative stability under the Syrian tutelage from 1990 to 2005 [24]; the Lebanese-Israeli war in 2006 [26]; the Lebanese war on a militant terrorist organization in Nahr El Bared camp in 2007 in

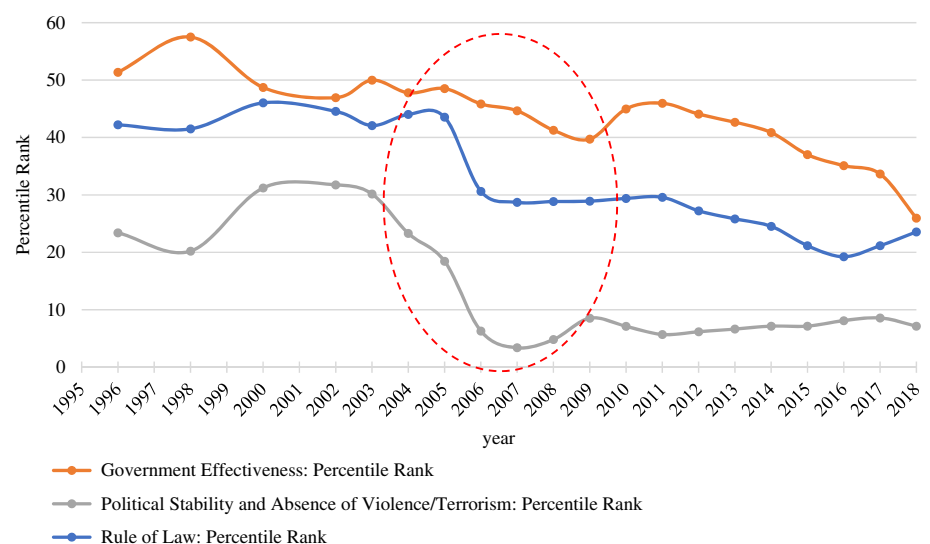
North Lebanon [31]; Presidential Vacuum in 2007 [32]; the civil strife in 2008 [24] and the World Economic Crisis in 2008 [7]. Moreover, the governance indicators comprising the government effectiveness, the political stability, and the absence of violence/terrorism in addition to the rule of law, have been decreased in Lebanon over this period (2004–2009) as indicated in Fig. 2.

It should be pointed out that the instability of security conditions and the decrease in the governance indicators did not actually affect negatively the evolution of urban development. By contrast, and despite these instabilities, an accelerated expansion of urban development is perceived. This could be best justified by the fact that the impacts of other supporting factors are much significant in comparison with the force of these retarding factors.

The list of supporting factors is presented by the reconstruction phase after the Lebanese-Israeli war in 2006 [7]; the loans granting conferences: Stockholm conference in 2006 [29] and Paris III Conference in 2007 [30], the influx of money deposits and short term investments to Lebanon from the Arabic Gulf Countries due to the international economic crisis in 2008 [7] and the Lebanese presidential election in 2008 [32]. Additionally, Ashkar [24] indicated that money laundering could represent one of these reasons, where this laundering could benefit from the decreasing governance indicators during the period of phase II.

**Phase IV: 2009–2014:** For instance, the UNDP [7] indicated that the global financial crisis in 2008 forced and encouraged many Arab investors and Lebanese expatriates to transfer some of their funds towards the real estate sector in Lebanon. By contrast, Ashkar [24] reported that the Lebanese real estate sector started to show some stagnation signs by the start of the year 2010. The author indicated that the estate industry was exhausted by the

**Fig. 2** Governance Indicators in Lebanon (Source: World Bank Group [41])



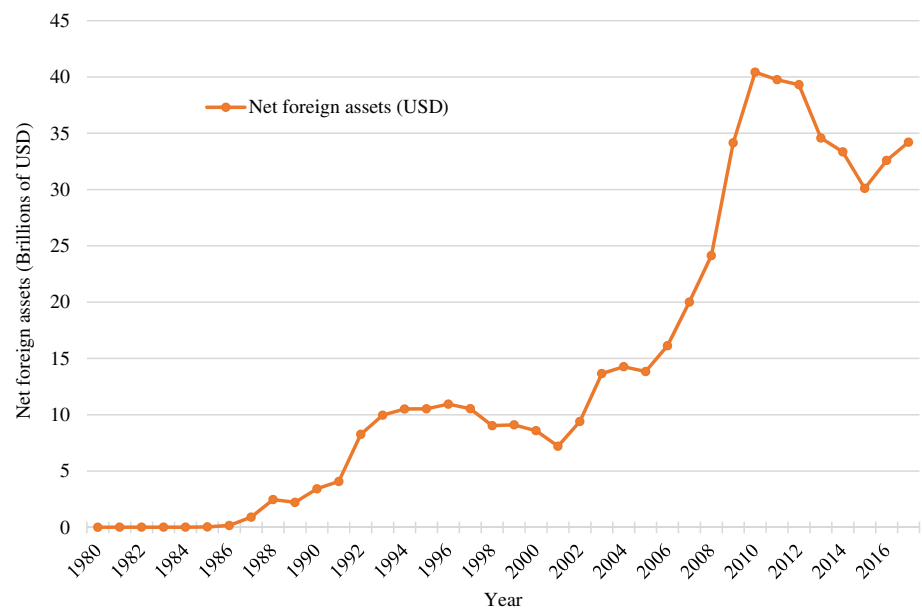


supply–demand imbalance where the excessive construction is considerably surpassing the local demand. But, this stagnation was delayed because of several emerging circumstances. Holtmeier [28] mentioned that a series of anti-government protests that occurred between years 2010 to 2012 in Tunisia, Libya, Egypt, Yemen, Syria, and Bahrain and called the “Arab Spring” encouraged many residents of these countries to transfer financial deposits to Lebanese banks and to invest in real estate in Lebanon. This steering of Arabic funds towards the short terms investment in Lebanese real estate was better explained by the Lebanese Central Administration for Statistics [42, 43] which indicated that the real estate and the construction sectors have contributed between years 2004 and 2018 by 18–21% to the Gross Domestic Product (GDP). These data indicate that the construction and real estate

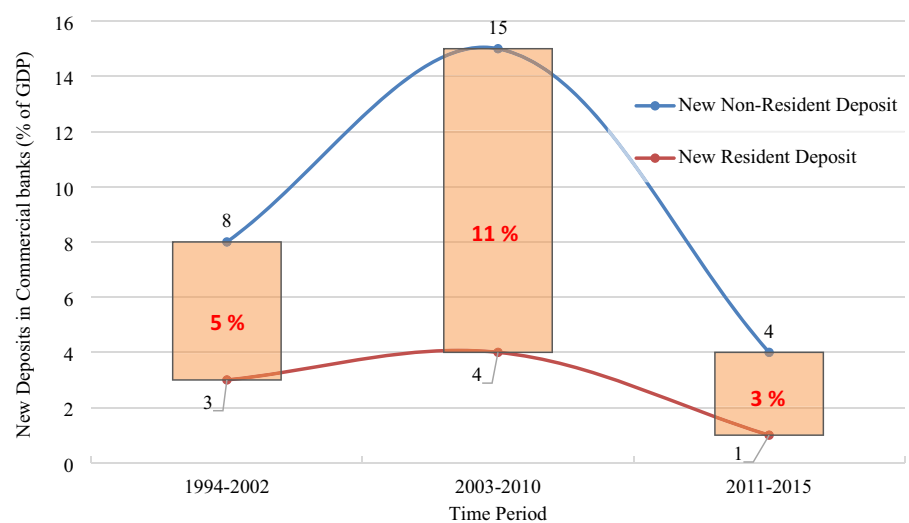
sectors are intensely attractive since they are generating high rates of profits and revenues. This also led to change the business’s mentality of the Lebanese population towards investments in these sectors regardless of the decreased governance indicators; and this explains why the Lebanese Protests against the government in 2011 [34] did not show any significant effects on the urban evolution. Figures 3 and 4 illustrate, respectively, the Net Foreign Assets in Lebanon and the New Deposits in the Lebanese Commercial banks. These figures show the increasing foreign assets and new non-resident deposits between the years 2005 and 2010.

Moreover, The Start and spillover of the Syrian war in 2011 and the arrival of Syrian refugees between years 2011 and 2013 [32] represent the key event that delayed the stagnation of the Lebanese estate sector. Ashkar [24]

**Fig. 3** Net Foreign Assets of Lebanon ( Source: World Bank Group [44])



**Fig. 4** New Deposits in Commercial banks ( Source: World Bank Group [45])



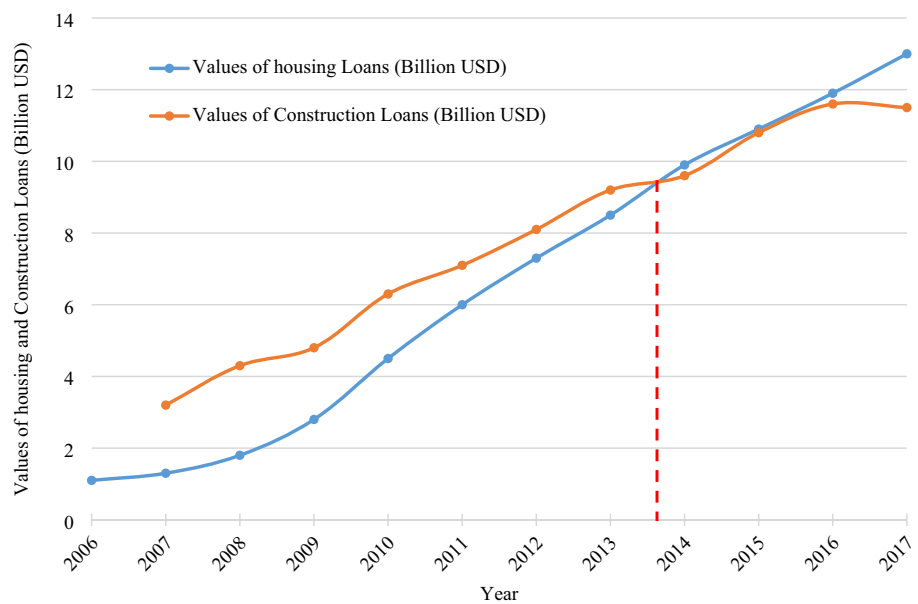
stated that the estate sector benefited from the Syrian war, and particularly from the arrival of wealthy Syrian refugees which represent the vast majority of refugees. The arrival of refugees compensated the reduced local demand, sustained high housing demands, and raised the renting prices by 40% in the year 2012 [24]; and enhanced the rent economy [28]. Also, Holtmeier [28] reported a significant subsidization of housing loans by the Lebanese Central Bank through commercial banks observed in the year 2012 and continued until it is halted in the year 2018. The author indicated that in this year the real estate transactions have decreased by 17%.

All these factors assert clearly the increased growth of urban development over the period between 2008 and 2014 as indicated by [26, 28].

Figures 5 and 6 show, respectively, the values of construction and housing Loans and the volume and values of real estate transactions. The available data on volumes and values of Real Estate Transactions were collected from different sources over the period extended from the year 2000 to the year 2019. Each of the data sources provides part of these info over different time periods [46–51].

It is noteworthy that the values of construction loans show an inflection point in their trend in the year 2013 indicating a reduction in construction trades. Likewise,

**Fig. 5** Values of housing and Construction Loans ( Source: BankMed [46, 47, 52]; Credit Libanais [49], GPG [53])



**Fig. 6** Values and volumes of real estate transactions in Lebanon ( Source: BankMed [46, 47]; Credit Libanais [48–50])

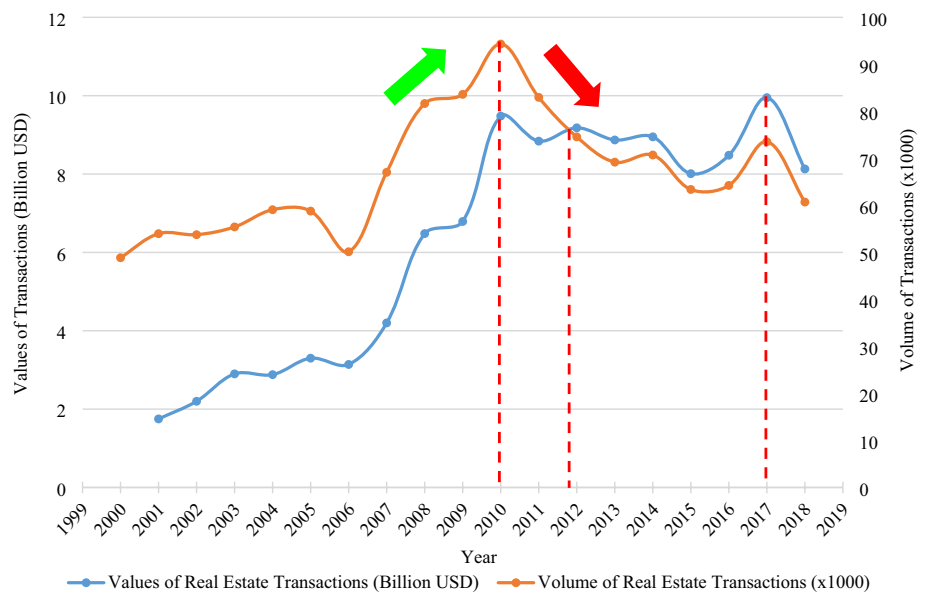


Fig. 6 shows an increase in the values and volumes of real estate transactions starting by the year 2000 until the year 2010. By the year 2009, the property prices started to increase significantly in comparison with the increase of transactions' volume since a decrease in the distance between the 2 curves is observed. Starting by the year 2010, a decrease in both volume and values of transactions is observed, however, the distance between the corresponding curves continued decreasing to reach an intersection point observed at the end of the year 2011. Hereafter, the distance between the curves starts to increase again to reach its maximum value at the end of the year 2016. Afterward, the curve of transactions' values is observed at the top over the curve of transactions' volumes. The trend between the years 2011 and 2017 indicates that the values and volume of real estate have not decreased synchronically, and this indicates clearly that the property prices continued with an increasing trend in coincidence with a significant decrease in the total number of transactions.

The graph shows that during the year 2017, the volume and values were dropped dramatically, and the distance between their curves decreases significantly.

It could be concluded from these 2 graphs that a hidden stagnation (due to the influx of foreign money and investments in addition to the arrival of Syrian refugees) of the estate sector has started between years 2010 and 2011. This deduction is in conformity with the argument of Ashkar [24] reporting the exhaustion of the real estate sector by the year 2011.

Phase V: 2014–2019: The period shows a stagnation phase in the construction and real estate industry as shown in Fig. 1. A stagnation of this industry emerges by the year 2010 due to the supply-demand imbalance witnessed as the excessive construction with no respect to the local demand as indicated by Ashkar [24]. The volumes and values of the estate transactions illustrated in Fig. 6 confirm this argument. However, this stagnation was delayed by several factors such as the influx of estate investments and money deposits due to the global economic crisis [7], the Arab Spring, and the arrival of Syrian refugees [28]. The delay lasted for 4 years where its end started actually by the year 2014. Berthier [26] stated that the oil crash that occurred in 2014, has dramatically reduced the remittances and profits of the Arabic Gulf countries, and this has prevented the influx of money and investments to Lebanon. It is worth noting also that other factors contributed to the preparation of the end of this delay through the reduction of the investments and money influx to Lebanon. For instance, the end of the Arab Spring in the year 2012 [28], and the stop of any significant arrival of Syrian refugees after the year 2013 [33] could be considered as the main factors. These factors have affected not only the

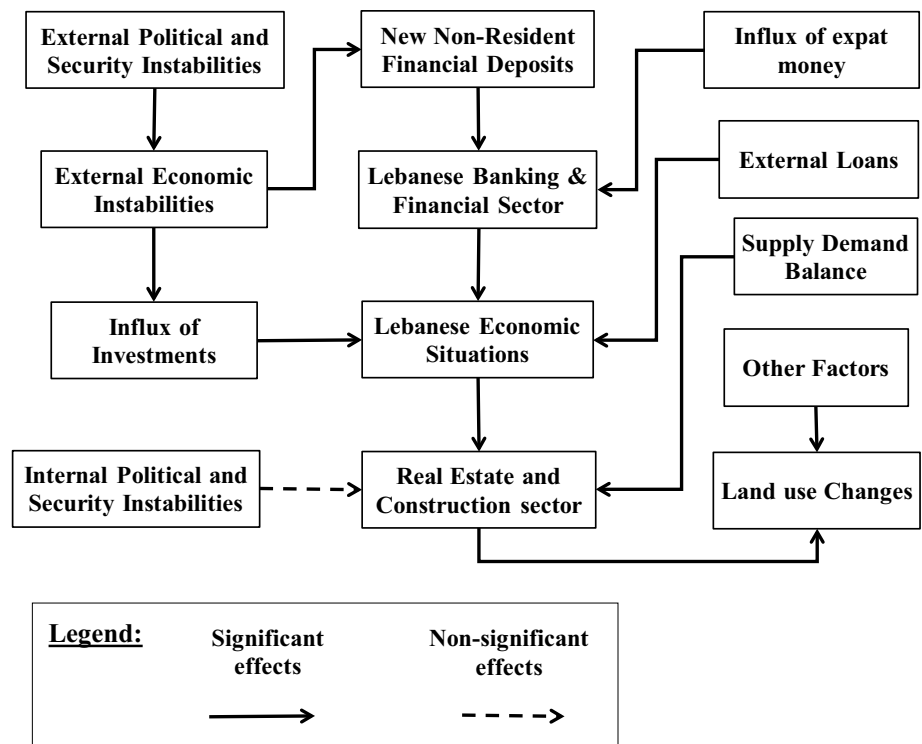
estate sector but rather the whole national economy. The burst of the estate industry bubble perceived as the existence of more than 200,000 vacant housing units in 2014 [24], the start of the collapse of the national economy in 2016, followed by the adoption of financial engineering mechanisms by the Lebanese Central Bank, the halt of offering housing loans in the year 2017, the start of economy's deterioration [28], in addition to the drop in the value of the Lebanese Pound to US Dollar (from 1507 to 2250 in December 2019) as indicated by the World Food Programme [40] are considered as the consequences. Other events as the Presidential Vacuum between 2014 and 2015 [35], the internal security conflicts due to terrorist activities caused by the Islamic State in Iraq and the Levant (ISIS) between 2014 and 2017 [36], Presidential Election in the year 2016 [35], the Lebanese war on ISIS in the year 2017 [38], the general Parliamentary Election in the year 2018 [39], have no significant impacts on the estate industry. The Lebanese Protests against the waste crisis between 2015 and 2016 [37] are considered as results of the deteriorating economic conditions rather than a causing factor. As a result, it could be concluded from this qualitative analysis that the urban development and the industry of real estate and construction are not depending on the political and security stability conditions at the regional or local level. However, they are strongly dependent on capitalistic dynamics. Figure 7 illustrates the general factors affecting real estate and urban development.

It is noteworthy to take into consideration the effects of other factors such as the future evolution of Population in addition to the political situation after the end of the Syrian war and the post-war Reconstruction.

#### 4.2.2 Quantitative analysis

The qualitative analysis allows the verification of assumptions about factors that seem to have a strong impact on the evolution of land use. As these factors might be strongly correlated, special attention must be paid to analyse potential correlations and causations that might also be indirect. A quantitative analysis is proposed here with a Structural Equation Model (SEM) that enables the identification of the regressions (corresponding to causal effects, unidirectional relationships) and the covariances (bidirectional relationships) between the observed variables, the defined latent variables, and between both types of variables. The observed variables have been collected for years ranging from 1996 to 2018, and three latent variables are constructed corresponding to the main global factors that might have an impact on land use evolution (Table 2). The final SEM model was designed and estimated by using the Lavaan package of the R statistical software. Some of the observed factors

**Fig. 7** Potential factors affecting the real estate and urban development



**Table 2** Latent and observed variables

Latent variables	Initial data (before trials) Observed variables	Final data (after developing model) Observed variables
Urban development (urb)	Volume of real estate transactions: (B1) Values of real estate transactions: (B2) Total areas construction permits per year: (B3) Economic contribution of real estate and construction: (B4)	Volume of real estate transactions: (B1) Total areas construction permits per year: (B3)
Banking sector (bnk)	New non resident deposits: (C1) New resident deposits: (C2) Housing loans: (C3) Construction loans: (C4) Net foreign assets: (C5)	Net Foreign Assets: (C5)
State Governance (gov)	Rule of law: (A1) Government effectiveness: (A2) Political stability and absence of violence: (A3)	Rule of Law: (A1) Government effectiveness: (A2)

could not be introduced in the model since they lead to non-convergent maximum likelihood iterations.

Table 2 shows the final observed variables used in the model. As with all statistical models, it is important to assess the quality of fit. The Comparative Fit Index (CFI) was first introduced by Bentler in the year 1990 [54] to evaluate the fit of a structural model. The value of the Comparative Fit Index (CFI) of the model is: 0.946 > 0.90, and as indicated by Hooper et al. [55] this shows that the model is acceptable. The estimation result shows significant causal effects (regressions) between the latent variables and their final corresponding observed variables

since the p-values of the hypothesis tests are all less than 0.05 [56].

The coefficient of the regression between the urban development and banking sector is: 0.86. The p-value of the hypothesis tests is less than 0.05, and this indicates that the urban development and banking sector are in perfect regression [56]; and as a result, the urban development is depending strongly on the banking sector. In other words, this means that good banking conditions cause a growth in the built up development.

Besides, a significant negative covariance (coefficient: -46.04 and p value: 0.015 < 0.05) between the banking

sector and the state's governance is reported. This is clearly explained by the increasing net foreign assets accompanied by a decrease in the governance indicators between the years 2003 and 2019. This analysis is in line with the findings of the study conducted by Assa [4].

Furthermore, a positive covariance among urban development and State governance is remarked, however, the significance is low (coefficient: 6.98 and  $p$  value:  $0.159 > 0.05$ ). Figure 8 shows the diagram of the developed SEM.

### 4.3 Interactions of land uses: land use change within the zones of Lebanon between the years 1984 and 2019

To better study the land use dynamics of Lebanon, its area was divided into five zones: Beirut, Mount Lebanon, North Lebanon, Bekaa, and South Lebanon. The studied north

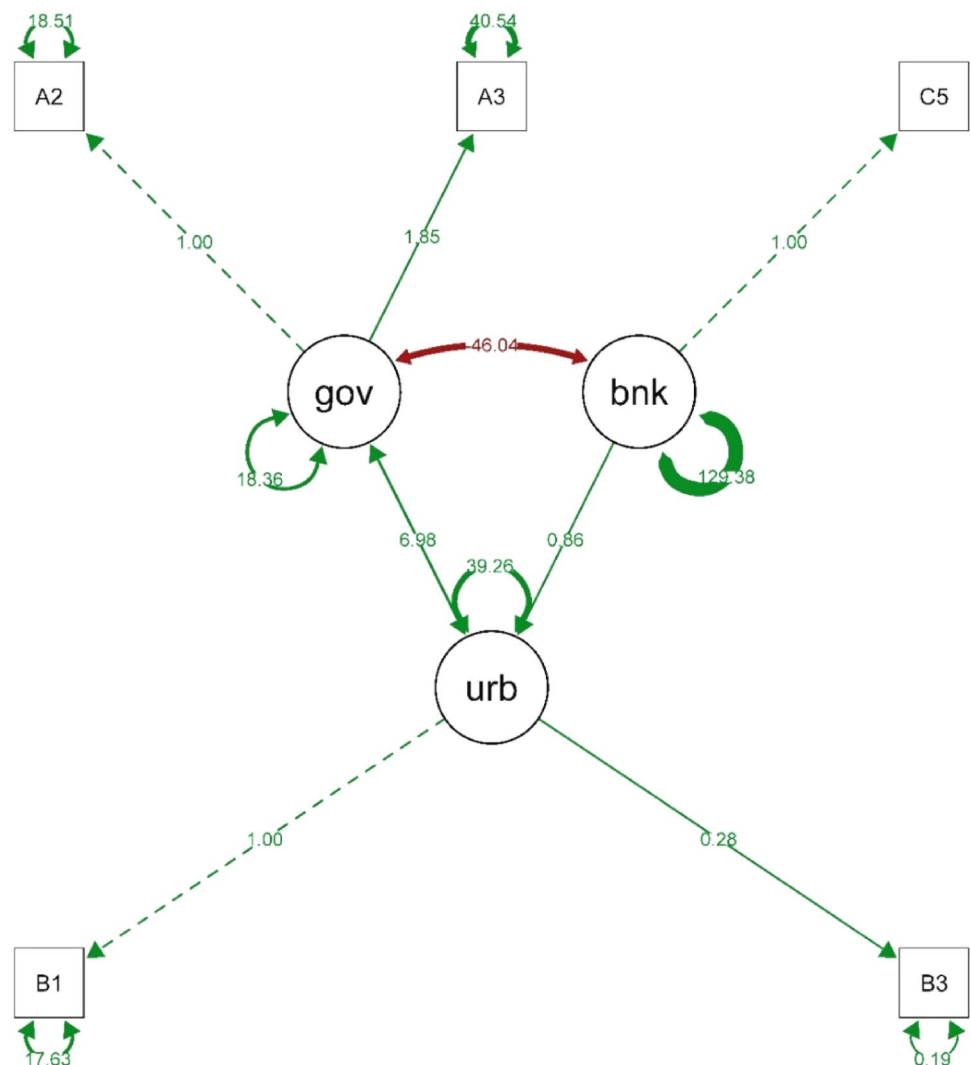
Lebanon zone includes two administrative zones: Akkar and North. Similarly, South Lebanon includes the administrative zones: El-Nabatieh and South. The Bekaa zones include the administrative zones: Baalbek El-Hermel and Bekaa.

Figure 9 shows the current administrative zones in Lebanon and the study zones.

The land use maps of Lebanon were divided to these five zones in order to detect the detailed land use dynamics. Figures 10, 11, 12, 13 and 14 show the trend of the land use dynamics in the study areas. It worth noting that in Beirut and for the period from the year 1984 to the year 2000 the total area of green zones has increased; however, the area of bare soil lands decreased during the same period.

Similarly, in the four other zones, but with a slight difference in the time period, the total area of green zones increased from the year 1984 to the year 2004 and the area of bare soil lands witnessed a decrease. In

Fig. 8 Diagram of the developed structural equation model



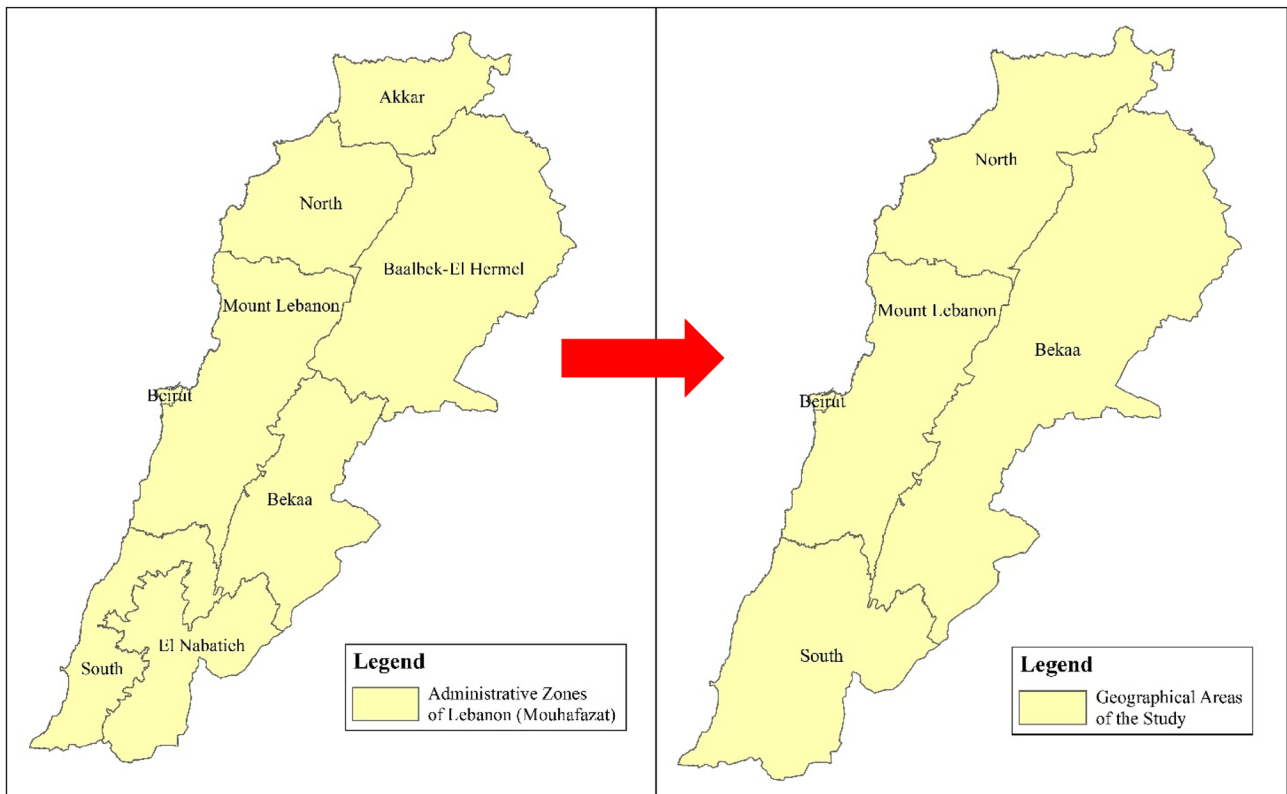
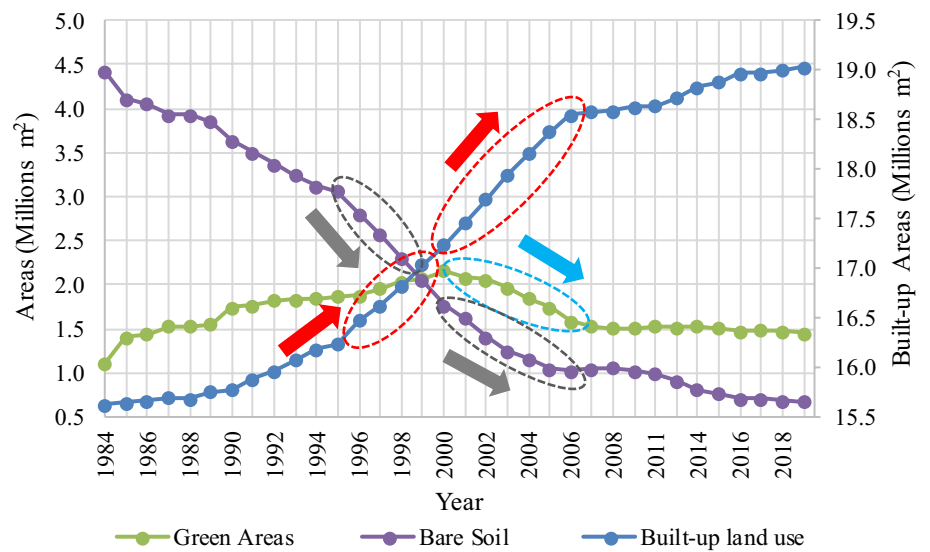
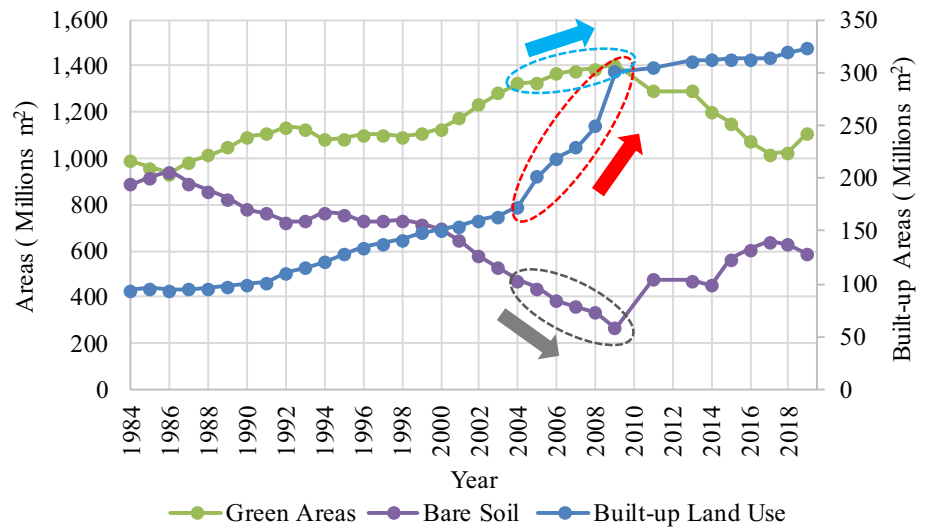


Fig. 9 Administrative zones and selected study areas

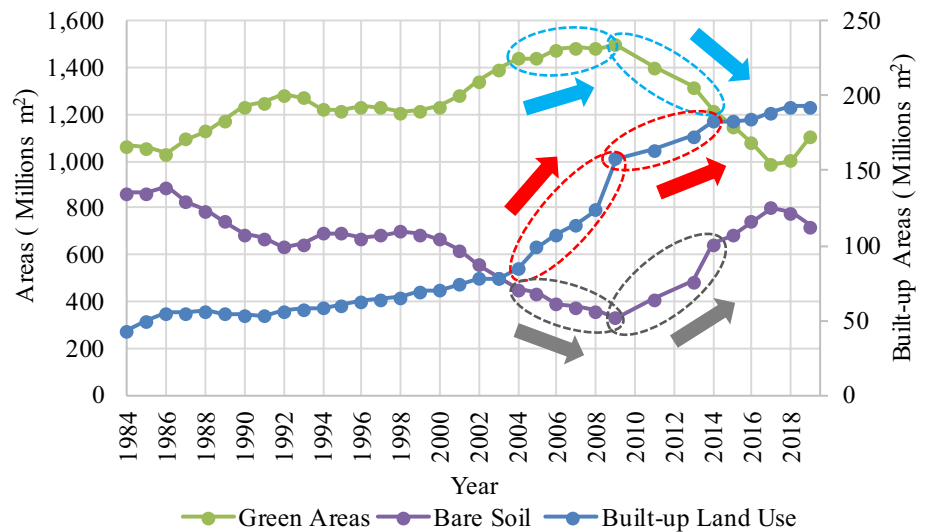
Fig. 10 Land use dynamics in Beirut (1984–2019)



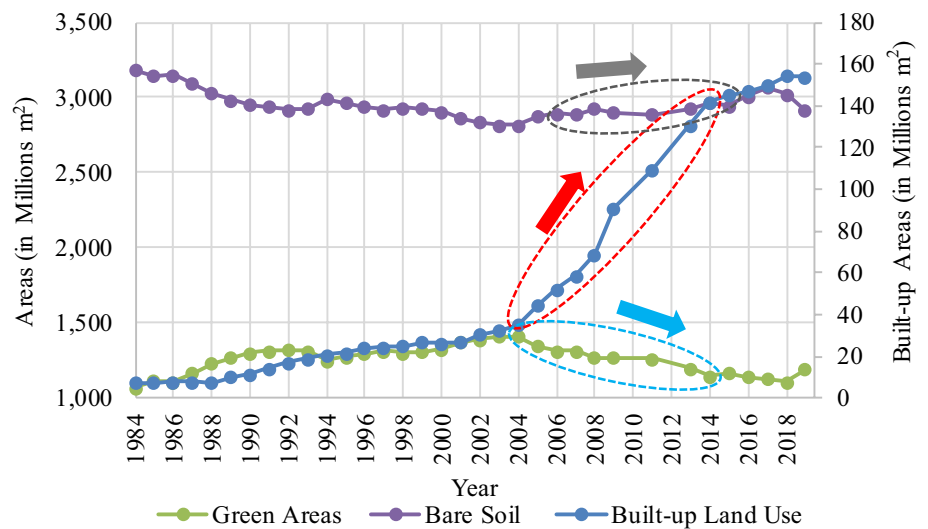
**Fig. 11** Land use dynamics in Mount Lebanon (1984–2019)



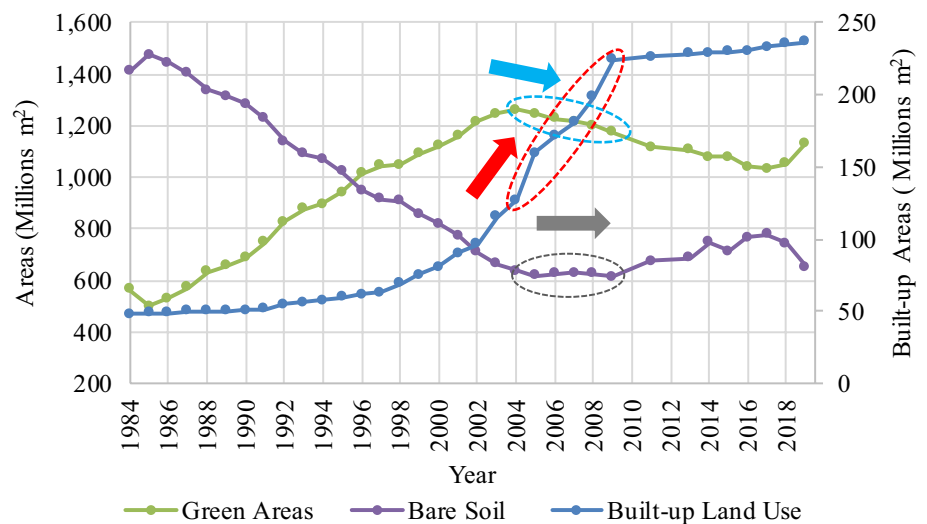
**Fig. 12** Land use dynamics in North Lebanon (1984–2019)



**Fig. 13** Land use dynamics in Bekaa (1984–2019)



**Fig. 14** Land use dynamics in South Lebanon (1984–2019)



all the studied zones, the total areas of built-up land use continued to increase from the year 1984 until the year 2019 with different increase rates over different periods.

#### 4.3.1 The normal increase of built-up areas

Figure 10 shows that the built-up land use in Beirut witnessed an acceleration in the rate of increase starting by the year 1996 until the year 2006. It worth noting that the significant deceleration of urban development in Beirut after the year 2006 could be referred to the built-up saturation (89.5% of Beirut's total area) and to the existence of non-constructible green areas as the Beirut park and the hippodrome and non-constructible bare soil lands as the public beaches. Figures 11 and 14 show, respectively, that the built-up land use in Mount Lebanon and South Lebanon has witnessed an acceleration in the rate of increase starting by the year 2004 until the year 2009. After the year 2009, the decelerated evolution of built-up areas could be referred to the effects of the international economic crisis that occurred in the year 2008. Figures 12 and 13 show, respectively, that the built-up land use in North Lebanon and Bekaa has witnessed an acceleration in the rate of increase starting by the year 2004 until the year 2014.

The land use effects of the international economic crisis that occurred in the year 2008 did not take place immediately in Bekaa and North Lebanon since the arrival of Syrian refugees in the year 2011, and their main distribution in these zones has increased the urban development particularly between years 2011 and 2014.

#### 4.3.2 The accelerated increase of built-up areas

The period corresponding to the accelerated increase in built-up areas in Beirut was divided to two sub-periods

the first is from the year 1995 to the year 1999, and the second is from the year 1999 to the year 2006. The first period shows an increase of built-up areas accompanied by an increase in the areas of green zones and a decrease in the area of bare soil lands. However, the second period differs from the first one by a change in the evolution trend of green areas, from increasing to decreasing. The first period indicates that the urban development is not occurring at the expense of green areas. Contrariwise, the second period shows that some of the green lands and bare soil areas are converting to urban development.

The period corresponding to the accelerated increase in built-up areas in Mount Lebanon from the year 2004 to the year 2009 (Fig. 11) shows that the total area of green zones has increased, however, the total area of bare soil lands decreased. This leads to a conclusion that the bare soil areas are converting to green and built-up areas.

The periods corresponding to the accelerated increase of built-up areas in Bekaa and South Lebanon, respectively, from the year 2004 to the year 2014 (Fig. 13) and from the year 2004 to the year 2009 (Fig. 14), show that parts of green zones and bare soil lands are converting to built-up areas.

The period corresponding to the accelerated increase in built-up areas in North Lebanon was divided to two sub-periods: 2004–2009 and 2009–2014. The first period shows an increase of built-up areas accompanied by an increase in the areas of green zones and a decrease in the area of bare soil lands. Contrariwise, the second period differs from the first one since the areas of green zones started to decrease and the areas of bare soil lands increased. The first period indicates that the urban development is not occurring at the expense of green areas.



However, the second period shows that the increase of built-up development and bare soil lands is occurring at the expense of green areas.

### 4.3.3 The decelerated increase of built-up areas

Between the years 2006 and 2019, the increase of built-up land use in Beirut witnessed a very slow pace. The total area of greens zones remained the same during the whole period. This area is equal to 1,500,000 m<sup>2</sup> and is equal to the total area of Beirut Park, the hippodrome, and some cultivated lands in the vicinity of Beirut River.

The period of decelerated increase in built-up areas in Mount Lebanon and south Lebanon from year 2009 to year 2019 was characterized also by a decrease in the areas green zones.

Similarly, the period of decelerated increase in built-up areas in North Lebanon and Bekaa Lebanon from year 2014 to year 2019 was characterized also by a decrease in the areas green zones.

This could mean that the conversion of the green zones into bare soils could be referred to either rural fire or the abandonment of cultivated lands and the agriculture profession.

Figure 15 presents the difference in areas of built-up, bare soil, and green areas for year 1984 and year 2019 over the whole area of Lebanon. The figure shows that the area of built-up land use increased from 290,484,900 m<sup>2</sup> in 1984 to 924,920,400 m<sup>2</sup> in 2019. Similarly, the area of forest and cultivated lands (green areas) increased from 3,687,924,292 m<sup>2</sup> in 1984 to 4,550,184,400 m<sup>2</sup> in 2019. However, the area of bare soil lands has decreased from 6,351,540,608 m<sup>2</sup> in 1984 to 4,869,972,500 m<sup>2</sup> in 2019.

Over all the area of Lebanon, the total areas of built-up land use and of the green zones are increasing at the expense of the decreasing area of bare soil lands.

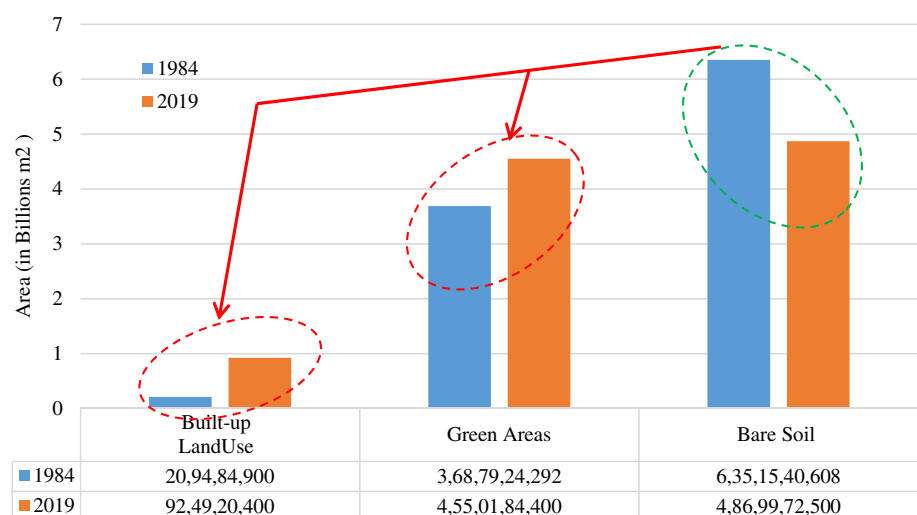
These results are in conformity with the data provided by the World Bank Group about the changes in the total green areas in Lebanon and over the globe. The data provided by the World Bank Group [14, 15] showed an increase in the total areas of agricultural and forest lands in Lebanon during the period 1990 to 2016. The World Bank Group [57, 58] indicated that the total areas of green zones over the globe (Agricultural lands and Forests) increased from 80.3 (39 for agricultural lands and 41.3 for forests) million square kilometre in the year 1984 to 87.9 (48 for agricultural lands and 39.9 for forests) million square kilometre in the year 2016. It worth noting that during this period the increase in the total area of the world's green lands is only due to the increase of agricultural areas since the total area of forests has slightly decreased by 3.4%.

The findings do not oppose and do not totally agree with the general belief that the areas of built-up land use are extended at the expense of forest and agricultural zones [7, 8]. As discussed previously, the increase in the area of built-up land use was occurring simultaneously with an increase in the area green zones in Beirut from year 1984 to 1996 and in the other four zones from year 1984 to year 2004.

In addition, in some cases, the total area of green zones was increasing at the same moments of the accelerated built-up areas increase, as for instance in Beirut for the period from year 1996 to year 2000, in Mount Lebanon and North Lebanon from year 2004 to year 2009.

It is deduced that the areas of built-up land use are extended at the expense of forest and agricultural zones only in flatlands; however, this is not the case in fertile mountainous areas as in the Mount Lebanon zone. Additionally, the conclusion could be extended to assert that the urban expansion could not take place in arid mountains.

**Fig. 15** Evolution of land use Areas between 1984 and 2019



In fertile mountainous areas as in the Mount Lebanon zone, the abandonment of cultivated land would be the main cause for the degradation of green areas. The behavior of abandoning the cultivation in fertile lands was asserted by an interview conducted with the Governor of Mount Lebanon region [59]. He indicated that the majority of Lebanese people, as well as Mount Lebanon residents, perceive the revenues of investing in built-up development as one of the much wealthier economic trades in Lebanon; and that the revenues of this trade are greatly surpassing those of the cultivation profession. Moreover, the risk of rural fires in these areas represents an additional factor that leads to the degradation of forests.

## 5 Conclusion and recommendations

This paper investigates the influence of the socio-economic, security, and political conditions in addition to the applied policies on urban development, and particularly the evolution of built-up land use. The evolution of built-up land use dynamics was monitored during the period extended between the years 1984 and 2019 and shows five linear phases. The causing factors were identified by conducting qualitative and quantitative analyses. The qualitative analysis was performed by comparing the trend of each of the five phases within the evolution of built up land use with the concurrent events. The results show that the economic stability, the capitalistic dynamics and the supply-demand balance represent the main factors that control the land use changes. Likewise, the structural equation model (SEM) representing the quantitative analysis, stressed the previous conclusion by showing a significant causal effect of the banking sector on the real estate market. It is to be noted also that the SEM shows a significant negative covariance between the banking sector and the governance indicators of the state; and a non-significant covariance between the governing indicators and the estate industry. This means that the growth of the estate and banking sectors is happening in coincidence with reduced governmental effectiveness, which is confirmed by the data collected on the political and security events.

Further investigations were conducted to explore the spatial expansion of urban development and the spatial interactions between the land covers: built up, green areas, and bare soil. As one of the main findings of this additional investigation is that the global amount of green areas increases slightly over time. This validated the hypothesis indicating that the total area of natural green zones and agriculture areas are expanding spatially, and in some cases, they are retaking place in new locations to reconstitute their consumed and abandoned areas. Additionally, the

analysis gives also several deductions with regard to the second hypothesis indicating that the built-up land use is expanding at the expense of green zones. The general belief that the areas of built-up land use are extended at the expense of forest and agricultural zones is asserted only in flat lands as the case of the Bekaa zone, North, and South Lebanon. However, this is not the case in watery and fertile mountainous lands as in the Mount Lebanon zone. Moreover, the conclusion could be extended to affirm also that the expansion of built-up land use is not taking place in arid mountains as in the mountains of Bekaa zones. The difference in land use dynamics in the studied areas indicates that a single land use policy could not be applicable for all zones, but rather specific land use policies should be enacted for each zone. Moreover, these policies must seek a balance between the need for urban development, on one side, and the preservation of natural resources and good environmental conditions, on the other side. In that way, the negative impacts of these needed urban developments could be reduced. These policies should comprise (1) the preservation of natural zones as forests and watery areas; (2) the subsidization of the cultivation profession; (3) subsidizing the urban densification instead of horizontal sprawl; (4) restricting the urban sprawl in fertile green areas; and (5) directing the urban development towards limited bare soil lands with no/reduced risk of negatively affecting the environment (as limiting the recharge of groundwater or contaminating the water resources). Further studies are needed to explore the effects of different cultural perceptions in terms of the people's attachment to their lands and to the cultivation professions (also food industry) on the change and the degradation of agricultural zones. Moreover, further researches should be conducted to discover the effects of Socio-Economic characteristics and lifestyle opportunities on land use changes.

### Declarations

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.

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