

An Investigation of Urban Process and Mass Housing Estates Development Through Topographical Formations in Urban Peripheries: A Case Study of Famagusta, Cyprus

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Abstract: Problems in mass housing estates in Famagusta, Cyprus, have been an issue for urban planning and policy interventions for many years. Neighbourhoods were designed featuring modernist residential tower blocks and suburban row houses with insufficient green areas and no consideration of either the climatic features of the built site or of urban planning, regulations or law. This study discusses ongoing, uncontrolled construction trying to change the contemporary urban environment, based on the features of housing and urbanism. It investigates whether the natural landscape and extensions to topography have played decisive roles in the construction of mass housing estate developments and uses of the rural periphery of this city. The study develops a base case of urban transformation models representing the morphological characteristics of buildings from three distinct construction eras (the 1970s, 1990s and 2010s). The information collected is enriched and verified by site surveys. Through three case studies, the types of buildings in each era are analysed and evaluated in relation to a number of environmental factors, including analyses of the different context layers, to ascertain the existing strength of the urban block development configurations as well as to evaluate their shortcomings under the threat of urban sprawl. The findings not only provide ground research for developing urban retrofit scenarios, but also employ sustainable planning tools based on those urban processes.

Keywords: climate change; energy efficiency; housing estate; urban energy; retrofit

Abbreviations	
A/C	Air conditioning
ANOVA	Analysis of variance
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
BS	British Standards
CEA	Cyprus Electricity Authority
CIBSE	Chartered Institution of Building Services Engineers
CO ₂	Carbon dioxide
CY	Cyprus
DTS	Dynamic thermal simulation
EEM	Energy-efficiency measures
EPBD	Energy Performance of Buildings Directives
EPC	Energy Performance Certificate
EU	European Union
EUI	Energy-use intensity
EN	European Norm
GIS	Geographical Information Systems (software tool)
IEE	Intelligent Energy Use
LCCA	Life-cycle-cost assessment
M	Mean
MANOVA	Multivariate analysis-of-variance
MFH	Multi-family house
MM	Multi-objective
N	Normality
NAS	National Administration System
NC	Northern Cyprus
NV	Natural Ventilation
RTB	Residential tower block
SD	Standard deviation
SFH	Single-family house
SPO	State Planning Organisation
SME	Small-and-medium enterprise
SPSS	Statistical Package for the Social Sciences
STS	Socio-Technical-Systems
UBEM	Urban Building Energy Modelling

1. Introduction

This study considers the practical applicability of several theories on sustainable urbanism approaches, within the research context of large-scale mass housing estates in general and within the context of Famagusta and its urban agglomerations in particular. The study context is unique in addressing challenges of the coastal city of Famagusta's purpose-built residential buildings, urban renewal, neighbourhood approaches, implementation of sustainable conservation measures, housing policies and comparative research, especially considering the lack of contextual research which has been published with respect to all of these issues [1]. For review, the relevant literature was collected from similar case studies from other European countries. Many researchers have previously published on mass housing estates, so the relevant research topics include comparisons of estates in several countries, explanations of different applications of urbanism in mass housing estates, analyses of the

upgrading and planning of existing residential building stock in 29 European estates and explanations of the varied implementations of the notion of sustainable urbanism and the planning of mass housing in seven distinctive world cities [2-5].

Many other studies have compared estates within specific countries [6-8]. The selected examples were based on a study of European Union members, a study seeking to understand the planning process of mass housing estates in five western European countries and examinations of mass housing design principles in eastern European countries [9-11]. One study also analyses purpose-built residential buildings in 15 countries throughout all parts of Europe [12]. It is interesting to note that the planning and design processes of mass housing estate development and policy-making decisions are strongly related to examining the topographical formation features and characteristics of existing residential buildings, particularly in European countries. In addition to the above-mentioned studies, some researchers have focused on policies or implementation strategies for improving occupants' well-being as well as on the energy efficiency and energy performance of existing residential building stock [13]. At the same time, one study analyses applicable urban planning schemes for upgrading environmental design aspects during the early design stages of estates across Europe, while another study compares urban renewal programmes in nine countries and also focuses on northwest European implementation of sustainability design principles for mass housing estates [14].

A holistic urbanism approach to activities having to do with the economy and the mass production of housing involves a regional scale economy versus an urban economy [15]. This ideology studies the complex processes between man-made activities and the ecological urbanism approach on a globalised scale. In such a context, geography becomes crucial, and the notion of territory describes the relationship between the households' socio-demographic characteristics and urbanisation processes. Another approach is related to the logic of urbanisation processes which yield large-scale mass housing estate developments. For Thomson et al. (2017), the construction of gated developments and segregated societies raises issues through the transformation of urbanisation processes on a national scale related to the local authority and rights [15]. It is also important to note that in the ecological urbanism approach, the study of such uncontrolled urbanisation processes becomes central. Yet the aim is not to reveal changes to ecological characteristics nor topographical features of any context but to use this concept as a hypothetical tool by which to investigate another way of reading the contemporary urban environment in Famagusta and its unplanned urban agglomeration regions (e.g., the fenced of Varosha, Enkomi and Agious Loukas territories). This approach becomes crucial in urban planning and policies, particularly in this research context, because new political structures and social hierarchies have emerged between urban and rural and also between cities and peripheries. This situation has led to a change in the path of the urbanisation process, which does not consider the topographical features of the land. For this study, it is important to discuss the role of the topographical formations and the ecological characteristics in urbanisation processes, because this discussion will become a hierarchical documentation tool to understand the interactions between man-made activities and nature.

This paper is structured as follows. It will first discuss the background and justification of the research, followed by the hypothesised relationship with regard to the relevant literature. This is then continued with explanations of the methodology employed. Preliminary findings and discussions are given prior to the conclusion.

2. Literature review

The coastal city of Famagusta is directly connected to an intercontinental body of water in the Mediterranean Sea and, consequently, to its urban territory neighbours of Europe and the Middle East, as shown in Figure 1 [16]. Its strategic location between Eastern Europe, the Balkan route and Southern Mediterranean countries makes Famagusta an exposed frontline city, subject to constant changes in the construction industry, as shown in Figure 1.

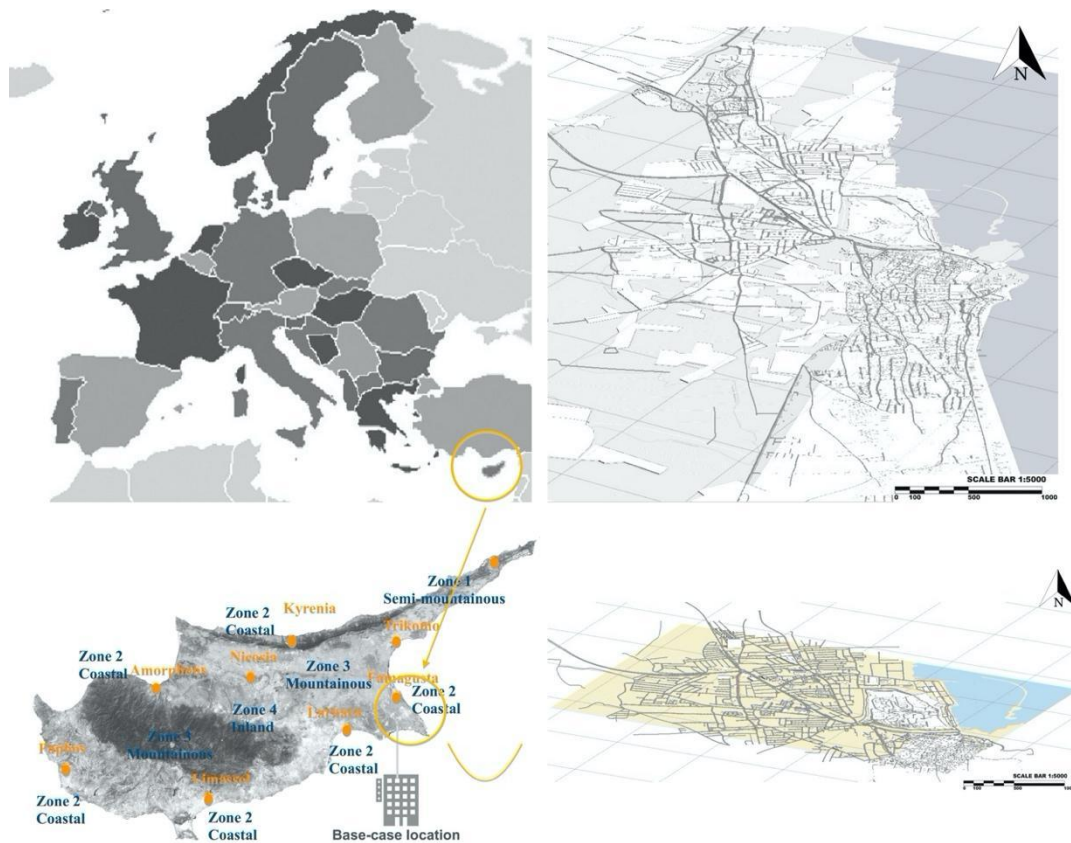


Figure 1. Geographical position of the Eastern Mediterranean Island of Cyprus in Europe; distribution of four climate regions across the island; location map of the coastal city of Famagusta; the coastal city and its urban agglomerations. **Source:** Illustrations of urban-tissue models extracted from ArcGIS Pro Version 2019.01 software suite, developed by Esri (UK) in 2019.

This coastal city is an anticipatory model for rapid urbanisation processes in evolving the urban morphology and ecological characteristics of the island, as shown in Figure 1. In order for the city centre core to function, it is dependent on a continuous, densely populated area which makes no allowances for either physical or social boundaries to sufficient urban expansion. As late as the 1970s, the present urban agglomerations of Famagusta were one of

the significant ecological regions in Cyprus, a rural area of small farms and agricultural lands [17]. However, due to the lack of stringent town planning regulations, after economic growth and its effects on the planning of large-scale mass housing estates, these rural settlements were transformed into an area of unplanned and uncontrolled urban development [18]. Today, the territory is characterised by an endlessly fragmented, repetitive stream of purpose-built or self-built residential areas and privately owned construction company-built mass housing estates, with no recognisable distinctions from the city centre [19].

The city's role as a secondary city to the capital of Nicosia provides an appropriate model for second- and third-tier cities as well as towns which are projected to be the areas of more significant growth and transformation in the future. It does so by offering alternatives for how these fragmented environmental areas may urbanise under the threat of rapid construction processes. Compared to other densely built Mediterranean coastal cities (i.e. Genoa in Italy, Barcelona in Spain and Porto in Portugal), Famagusta is dominated by large-scale residential developments, not only in the coastal regions but also in its semi-mountainous regions.

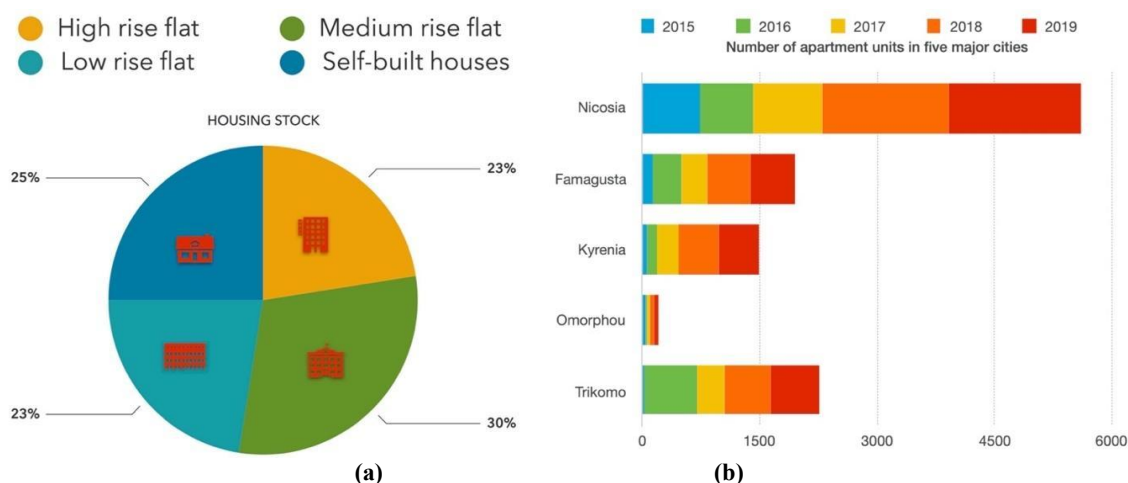


Figure 2. (a) Low-, medium- and high rise and self-built housing stock in Cyprus: **(b)** Apartment units were built in five densely built cities between 2015-2019 in Northern Cyprus. **Source:** State Planning Organisation, 2019, the charts are designed and edited by the author.

As shown in Figures 2 (a) and (b), almost half (25%) of the owner-occupied building stock comprises self-built houses, often detached. The rest are low-rise (23%) or high-rise flats (23%) [20]. Mass-scale residential tower block estate developments are developed and regulated by privately owned construction companies. Such projects are often the size of whole city districts but are rarely geared towards the concept of a socially and functionally diverse and structurally open city. Current problems are aggravated when taking account of the implementation of green urbanism scenarios. The case examples chosen for this study are intended to explore, in particular, the possibilities offered by the ecological features and topographical characteristics

in Famagusta in formulating sustainable urban growth in the city's densely urbanised territories. One approach is to consider urban-scale retrofit measures which are better suited to establishing a control mechanism within the construction industry and in residential sectors. For this reason, well-established tools and guidelines for retrofitting are required for mass housing developments. It is clear that the current supply of low-, mid- and high-rise residential building stock cannot match the environmental design principles of current housing conditions and the current tools, to link existing construction practices and the implementation of a sustainable approach to urbanism.

2.1 Urban sprawl and its impact on society

Famagusta is confused as an eponymous, immaterial city. The functioning city is a heterogeneous, continuous agglomeration, spreading through the districts of downtown Varosha, midtown Varosha, upper-town Varosha and beyond its neighbourhood districts, as shown in Figure 3. The vast expanse of low-density residential clusters scattered through the Varosha territory are representative of 1970s residential building stock. This area extends all the way to the Enkomi territory, which is called the city of Tuzla today, where purpose-built mass housing estates were built in the 1990s to tackle the housing crisis which had arisen from the demand for housing by the increased young population on the island. And more recently, in the 2010s, attention focused on the newly built mass housing estates in the city centre of Famagusta.



Figure 3. The coastal city of Famagusta is located on the horizontal axis through to the north to south which is facing to the Mediterranean Sea; the rampant urbanization process which has led to change the urban morphology characteristics radically. **Source:** Illustrations of urban-tissue models extracted from ArcGIS Pro Version 2019.01 software suite, developed by Esri (UK) in 2019; photographic images were taken by the author in 2018.

During this period, the housing and construction industry were characterised by social, economic and political changes, and political priority was given to uncontrolled mass housing production. This led to insufficient planning of layouts, of the design of mass housing estates and of land-use planning which considered the topographical formations of the built site. It is also worth mentioning that about 40% of the total residential building stock in Famagusta was built in the period 1950–1970. Peak production was achieved in 1972 and 1973, at over 1,500 houses a year [21]. According to these figures, the number of purpose-built houses in the pre-1974 period was twice the present volume of housing production. Most urban and suburban housing schemes were constructed in these territories on a mass scale; these schemes comprised uniform, mono-functional housing construction in the urban agglomerations of the city. Yapicioglu and Lawlor-Wright (2014) claim that this mass-scale unregulated growth boosted the property market, aiming for the quick benefit of selling these properties to international buyers by privately owned construction companies [22]. Although Yorucu and Keles (2007) explain that the outcomes of these ‘property boom’ years are evident where housing production reached a peak in the mid-2000s and early 2010s, not coincidentally, during these same years,

detached or semi-detached housing peaked as well [23]. Currently, housing estates are built as high-rise residential tower blocks in large quantities and at high speed. Many mass housing estate developments are built on vacant agricultural lands and in inappropriate locations, for example near river deltas or marshlands. The location depends on the initiative of the privately owned construction companies rather than the control mechanisms of the government. Hence, some estates are far from the city centre, while others are swallowed up by further urban agglomeration expansions. In addition to these problems, experts today also see suburbanisation as a twentieth-century lapse in urban design, as its heavy demand for space, materials and energy is difficult to reconcile with the sustainability goals of the twenty-first century [24].

2.2 Land use morphology and the characteristics of the urban peripheries in Famagusta

A study of the coastal city of Famagusta, particularly of its urban peripheries, indicates that the land use parcelling of rural or urban areas are articulated by the incentives of privately owned construction companies, including small- and medium- enterprises are also play key role to build mass high-rise residential tower block development estates [25]. Hence, the city has owned its unique ecological systems such as lakes, water reservoirs, river deltas to provide fertile agricultural lands across the horizontal axis to the waterfront. Today, these urban agglomerations could be engulfed with the rapid growth of the city due to its ecology, soil characteristics, water elements and its close proximity to education and recreational areas. As shown in Figure 4, mapping of the physical characteristics of the city demonstrates that ecological features are primary elements during the decision-making process but there is not any regulation or control mechanism implied by the local government to control the urban sprawl nor any action plans were put in place to provide effective land use planning regulation system both at local and national levels. This situation has led to change in the entire networking system in the construction sector. Throughout the space-syntax analysis, it was found that the city has expanded without considering the urban ecology, demography and population, by exploring the pros and cons of implementing holistic design approach in land use planning and urbanism.



Figure 4. Ecological characteristics and physical conditions of the coastal city of Famagusta; mapping of ecological regions to provide background for the development of effective holistic land use and urban planning schemes. **Source:** Illustrations of urban-tissue models extracted from ArcGIS Pro Version 2019.01 software suite, developed by Esri (UK) in 2019.

As previously mentioned, the initial phase of this research concentrates on the transformation of the peripheries of Famagusta; these resulted from the incorporation of rural areas into uncontrolled urban agglomeration regions. One of the main reasons this happened was that economic turmoil led the urbanisation processes of public development to coexist with

and be articulated by privately owned construction companies, based on the uncontrolled urbanisation process of development of mass housing estates in close proximity to the ecological lands in Famagusta [26]. The importance of this coexistence, or rather, this explosion of construction of mass housing estates, mainly as residential tower blocks across the city, is the focal point of this study. It attempts to emphasise a singularity which characterises the urban morphology of the city and attempts to explain public–private relationships which are not evident in the top-down approach of the state’s town planning incentives. Tracing back the relationship between privately and publicly owned land, one can see changes according to who held sovereignty over the island as a result of the political structure and economic conditions. As new inhabitants or settlers arrived on vacant properties, privileges passed into the hands of the new powers after the displacement of communities on the island [27]. The current relationship between private and public land is based on the laws and regulations of the Ottoman Empire in 1858 and of British Colonial Rule in 1929 [28]. Yorucu (2013) also explains that in a rural society, as Famagusta and the Varosha territory were in the late nineteenth and early twentieth centuries [29]. It should be noted that the fenced-off Varosha territory has become an attraction point of global citizens due to its geopolitical importance. One of the main reasons is that the abundance of housing stock was built between 1950-1974 [30]. High-rise purpose-built residential or hotel buildings were constructed to accommodate foreign home buyers and tourists so that this rapid urbanisation has led to a boost economy of local citizens [31]. However, after the closure of the city for human habitation up to now, this territory has been transformed into an untouched urban ecological area, which has great potential to turn into an ecological future and re-transforming the existing housing stock. This could be achieved by deep energy retrofitting of buildings and also implementing district scale retrofitting schemes. Several studies also discussed on improving urban climate quality of the city could be achieved by using the modular building design elements onto those building envelopes. Hence, this construction method helps to avoid any detrimental impact to the environment and also preserving both the nature and urban morphology of the fenced-off city [32].

2.3 Planning criteria, political expectations and directives for spatial structure and urban process

For this research, it is difficult to compare the urban settlements of Famagusta with those of other European states, because they are smaller in size, both in land use and in terms of population. The rapid urbanisation of cities and property boom in the suburban areas and their

impact on the residential building sector are closely connected, and these processes within the construction industry had an impact on land use and on the combustion of the industry through the inadequate spatial configuration of both urban and suburban systems [33]. In Cyprus, urbanisation started in the 1980s as a result of an increase in population which prompted a simultaneous increase in the demand for the residential building sector [34]. The establishment of residential tower block developments in both urban and suburban areas produced a surge in the construction of low-, mid- and high-rise apartment blocks across the city of Famagusta, as shown in Figure 5. The Department of Social Housing-TRNC (‘Sosyal Konut Mudurlugu-KKTC’ in Turkish) annual report in 2019 mentions that the government implemented three different social and private housing schemes between 1984 and 2017 in building 678,528 units [36].



Figure 5. Conditions of three representative housing stock which could result in shaping the urbanism in Cyprus. **Source:** Illustrations of urban-tissue models extracted from ArcGIS Pro Version 2019.01 software suite, developed by Esri (UK) in 2019; photographic images were taken by the author in 2018.

Katircioglu et al. (2014) describe how the mass housing enterprise was undertaken by privately owned medium- or large-sized construction developers with the intention of

involving local contractors in the process in order to encourage local enterprise and boost the economy [36]. Cyprus had an economy which was largely excluded from the international arena yet which was in desperate need of more international companies to deal with the rapid construction [37]. Consequently, these housing schemes suffered from inadequate control mechanisms, insufficient design quality and inadequate infrastructure. Thus, the social housing experience produced some insufficient housing stock and infrastructure [38]. It is clear that the purpose-built residential building projects led to a change in the environment because the majority of the buildings required major refurbishment to meet the necessary safety standards [39]. Due to the lack of building control mechanisms in Cyprus, many construction systems were changed without considering energy efficiency and similar materiality to protect the standards of the housing units [40].

In spite of the current situation of the residential building sector, the early property boom showed how the privately owned construction companies tackled the demand for housing, at the same time creating a knowledge gap in the design of sustainable urbanism approach between 1980 and 2016. Statistics from the Association of Cyprus Turkish Building Contractors (‘Kıbrıs Türk İnşaat Mühendisleri Birliği’ in Turkish) show that the number of contractors working in the sector increased from 171 in 2003 to 678 in 2016 [41]. Studies indicate that the overall rates of construction projects in the housing sector were a 68.4% share in 2007 and 71.1% in 2008 [41]. Overall construction interest rates also rose steadily from 71.5% to 83.2% between 2007 and 2008, as shown in Figures 6 (a) and (b) [41].

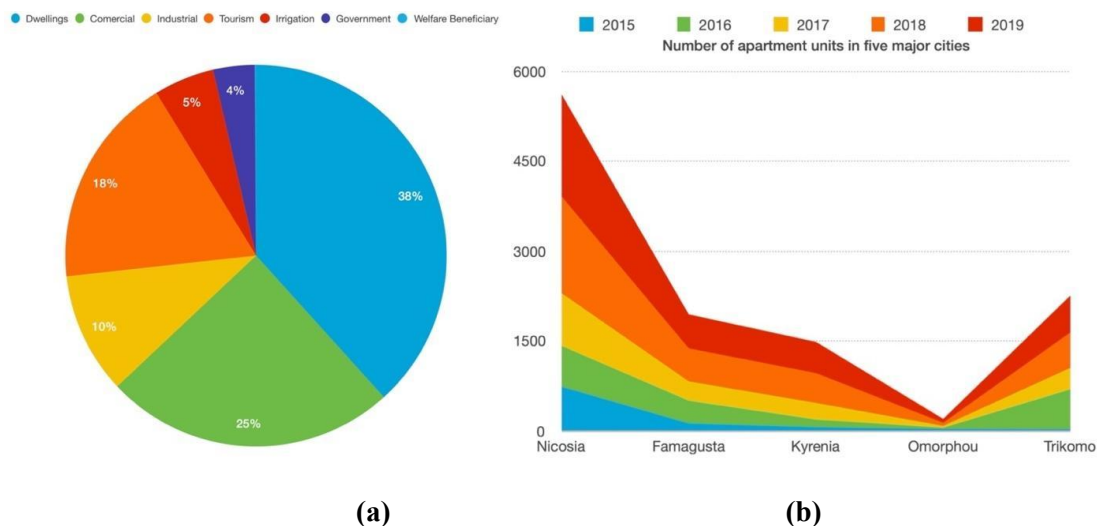


Figure 6. (a) Proportional percentages of building types constructed in Famagusta between 2015-2019; **(b)** total number of flat units completed in five densely-built cities in Northern Cyprus between 2015-2019. **Source:** State Planning Organisation, 2019, the charts are designed and edited by the author.

On the other hand, the State Planning Organisation-TRNC (‘Devlet Planlama Orgutu’ in Turkish) annual report in 2019 states that the construction industry was not sufficiently large and did not have capacity to that of the international industry to respond to the growing demand for housing between 2002 and 2006 [41]. This statistical information underlines our new understanding that the ‘property boom’ changed the structure of the construction industry and had a significant impact on the urban process. Land and property prices varied from region to region across the divided island. The construction boom took place mostly in the suburban areas of the cities. Firstly, in Kyrenia because of its mountains and coastline and then in Famagusta because it too had many seashore attractions and was a prominent, well established tourist destination before 1974 and where land prices were always the highest on the island. Figures 7 (a) and (b) show the price of land in the Famagusta area and the neighbouring coastal villages increased by 241% in 2005 [41]. However, after the Annan Plan was rejected, Kyrenia became more expensive than other areas within Northern Cyprus. Evcil and Vafaei (2017) identify the urban and suburban areas around Kyrenia as the zones where there was the fastest increase in land prices [42]. The statistical data shows that in Kyrenia, asking prices for land increased by 705%, comparing the first half of 2003 with the first half of 2006. At the same time, property prices increased by 502% [42].

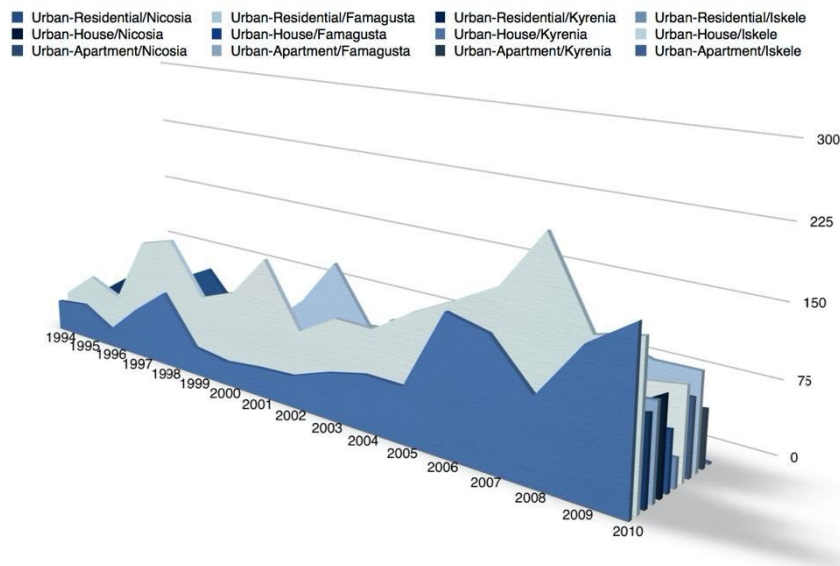


Figure 7 (a). The number of housing projects between 1994 and 2010 in urban areas. **Source:** State Planning Organisation, 2019, the chart is designed and edited by the author.

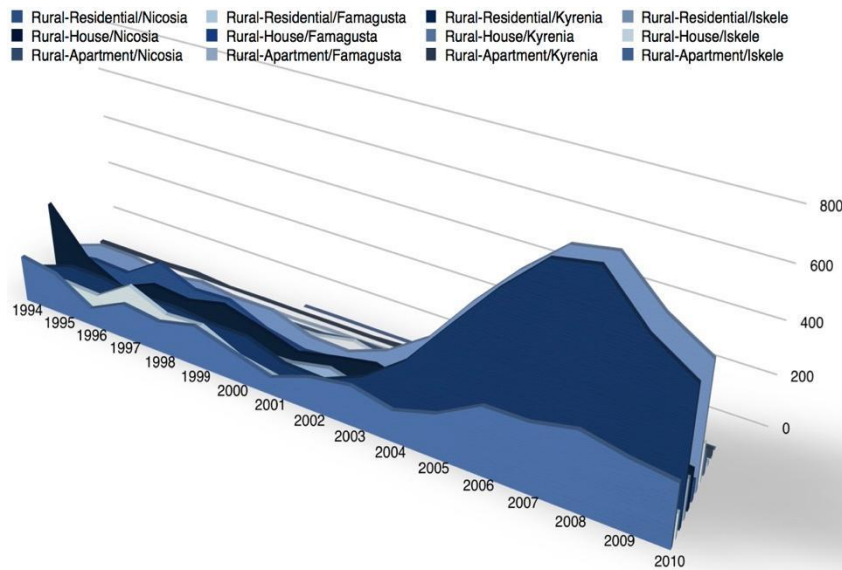


Figure 7 (b). The number of housing projects between 1994 and 2010 in suburban areas. **Source:** State Planning Organisation, 2019, the chart is edited and designed by the author.

The aim of the structure of the Town Planning Law, in the present public ownership land that had no immediate possibilities of agricultural development and therefore remained without an owner until after the 1974 civil war in Cyprus [43]. It is important to highlight that the generic structure of non-cultivable land was determined by the soil and geological characteristics, including sharp hills or mountainsides, barren areas with hard limestone rock, riverbeds, marshland etc. [44]. This particular category was described in the Ottoman Land Code (as ‘Arazi’ in Turkish or ‘Mevat’ in Ottoman Turkish) and by the British Colonial period (as ‘Dead Land’ in English or ‘Hali Arazi’ in Turkish) [45]. It is currently known as ‘No Man’s Land’ and can be found in a number of regions in the peripheries of the city. The cultivable privately owned expenses were handed down from generation to generation over centuries through a parcelling-out process. This parcelling process led to the creation of smaller and smaller parcels of land which, the nearer they got to the inhabited areas of the city, particularly in Varosha, the more they were built on for habitation [46]. In the 1960s, further to this, privately owned land was subject to a new parcelling-out procedure, that of creating building plots and introducing them into the real estate market. Figure 8 demonstrates the urban morphological characteristics and social housing schemes between 1985 and 1993 in Cyprus.

In fact, this is a model of development seen in several Mediterranean cities, particularly in Greece and Italy [47]. In Cyprus, however, there was also the British influence and references to urban policy and planning strategies [48]. This led to the creation of a homogenous urban landscape on the peripheries of the city, with roads and plots of equal size and developments for detached buildings, mostly self-built one- or two-storey residential units in the fenced-off

Varosha territory [49]. This process of creating a homogenous landscape from formerly cultivable and no cultivable urban agglomerations is constantly extended through rural areas to be incorporated into the evolving city. The role of the no cultivable territories such as natural lakes and ponds, which were integrated into the general category of ‘Dead Land’, changed when they were incorporated into the spreading urban tissue [50]. This change generated the uncontrolled urban process of privately owned or owner-occupied land. The no cultivable urban agglomeration regions such as the ancient city of Enkomi – which is known as Tuzla in modern society in fact became areas for the placement of mass housing estate developments, from the need for land expropriation or any kind of general urban planning, without considering the inclusion of local parameters during the decision-making process. In summary, the features of the natural landscape, in an indirect yet definitive way, produced a kind of relationship between residents in mass housing estates and the construction process in the city. This relationship is often described as ‘irrational’ or ‘uncontrolled’ in a top-down urban planning approach, but it is rather rational in a sort of district scale retrofitting approach.

3. Methodology

For review, the literature was obtained using a combination of descriptive and explanatory research methods to inform the research background and elaborate the justification of the research context in terms of the researcher’s knowledge and experience. The descriptive approach was used to give a clear indication of the problem. But an explanatory research method supports the underlying approach of this study in a systematic manner. Thus, the research is conducted through a literature review based on these key drivers to support the theoretical framework and provide information on the construction industry and its impacts on the urban process in Famagusta, Cyprus. It details the integration of the sustainable urbanism approach into geographical formations in the land-use planning of the residential buildings under review, in order to understand how European Union objectives regulate the housing sector, as a way to improve both policy and practices. Based on these theoretical foundation methods, the literature survey was conducted through a collection of periodicals, mainly reports, journals and articles on European Union urban planning schemes, implementations and policy documents. Related sources on other European Union states’ sustainable urbanism approaches were also studied to understand the role of European Union objectives, allowing for a better understanding and identification of the research problem.

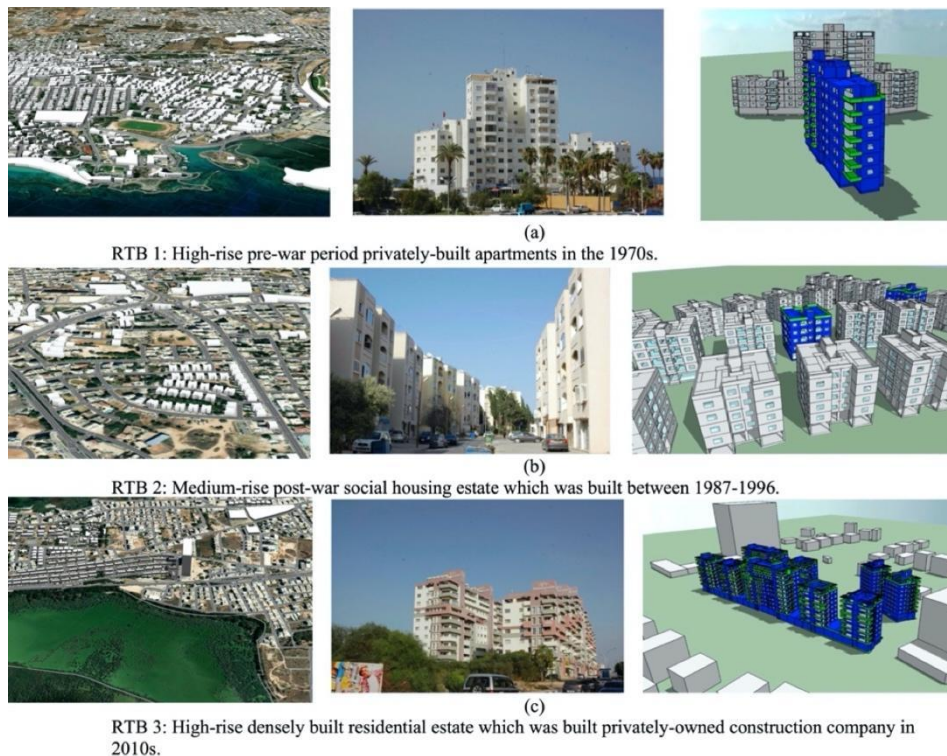


Figure 8. Three nationally representative mass housing estate developments and its close proximity to the sea and natural lake areas across the coastline city of Famagusta. **Source:** Illustrations of urban-tissue models extracted from ArcGIS Pro Version 2019.01 software suite, developed by Esri (UK) in 2019; photographic images were taken by the author in 2018; building renderings are illustrated by using the Integrated Environmental Solutions Virtual Environment (IES-VE) software suite and it was modelled by the author in 2020.

The explanatory case study approach involves explaining first-hand experiences to understand the current problems of both existing and recently built housing projects and their impacts on urban planning. These observations are based on the collection of data relating to each selected case study, including urban and suburban expansions in the field. After the collection of the necessary data through on-site observations, on-site thermal imaging survey, the study uses a case study approach to analyse the worst-case residential development project sites in three different regions of Famagusta. The case studies show different variations and purposes representing common problems in similar housing projects built by privately owned construction companies in three distinct periods, the 1970s, 1990s and 2010s, as shown in Figure 8. In parallel, three densely built urban areas were chosen as case studies for this research. In order to examine the geographical features of these representative built sites, in-depth study shows the ecological urbanism features which might change the character of the development of mass housing estates may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

3.1. Rationale for selecting case study residential tower block development

In Cyprus, residential building stock comprises around 4,750 representative buildings, in a combination of sample buildings and archetypes. Archetype buildings are statistical composites of the features found within a category of buildings in the stock, whereas sample buildings represent actual buildings with data obtained from field studies and on-site documentation. According to the State Planning Organisation, Economic and Social Indicators statistics in 2019, the Follow Up and Coordination Department in Cyprus comprises 1,384 households, of which 1,200 privately owned construction company-built and owner-occupied houses were eligible for the sampling criteria [51]. Figure 9 demonstrates housing typology classification by using census data for the EU. In Cyprus, in 2019, 26% of the population lived in flats and 18% lived in semi-detached or terraced houses. An average of 47% of the EU-27 population lived in flats [51]. This data highlights that flats (apartments) are the most representative housing archetype for Cyprus which is noteworthy in developing aggregate building energy models for energy policy design.

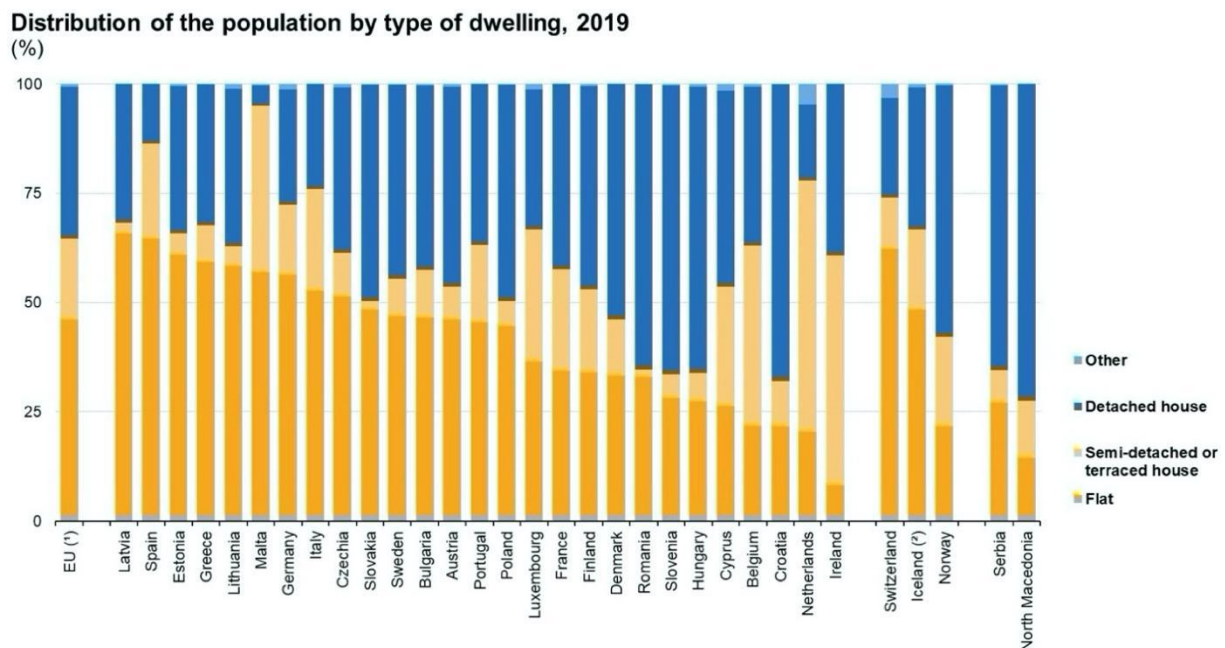


Figure 9. Distribution of population by dwelling type in EU member states in 2018 – data on the distribution of population by degree of urbanisation, dwelling type and income group extracted from 2018 European Union Statistics on Income and Living Conditions (EU SILC) survey in Eurostat database. **Source:** Eurostat, 2018.

The sample fraction initially aimed for was 30% of the total selected building stock; however, the newly built residential tower block developments were successfully recruited for the study, constituting 10% of the total, which is still a relatively reasonable fraction. These

buildings were chosen by the Board of Housing, Building and Planning in cooperation with Statistics by the State Planning Organisation as statistically representative of the Mediterranean island of Cyprus residential building stock. The number of residential buildings corresponds to 13 categories with respect to combinations of type, age and location [52]. The building types cover both the newly built and existing residential building stock. The age corresponds to construction year and is divided into four periods: the 1950s, 1970s, 1990s and 2010s [53]. Buildings built in the 1970s comprise new archetypes defined to include residential tower block developments.

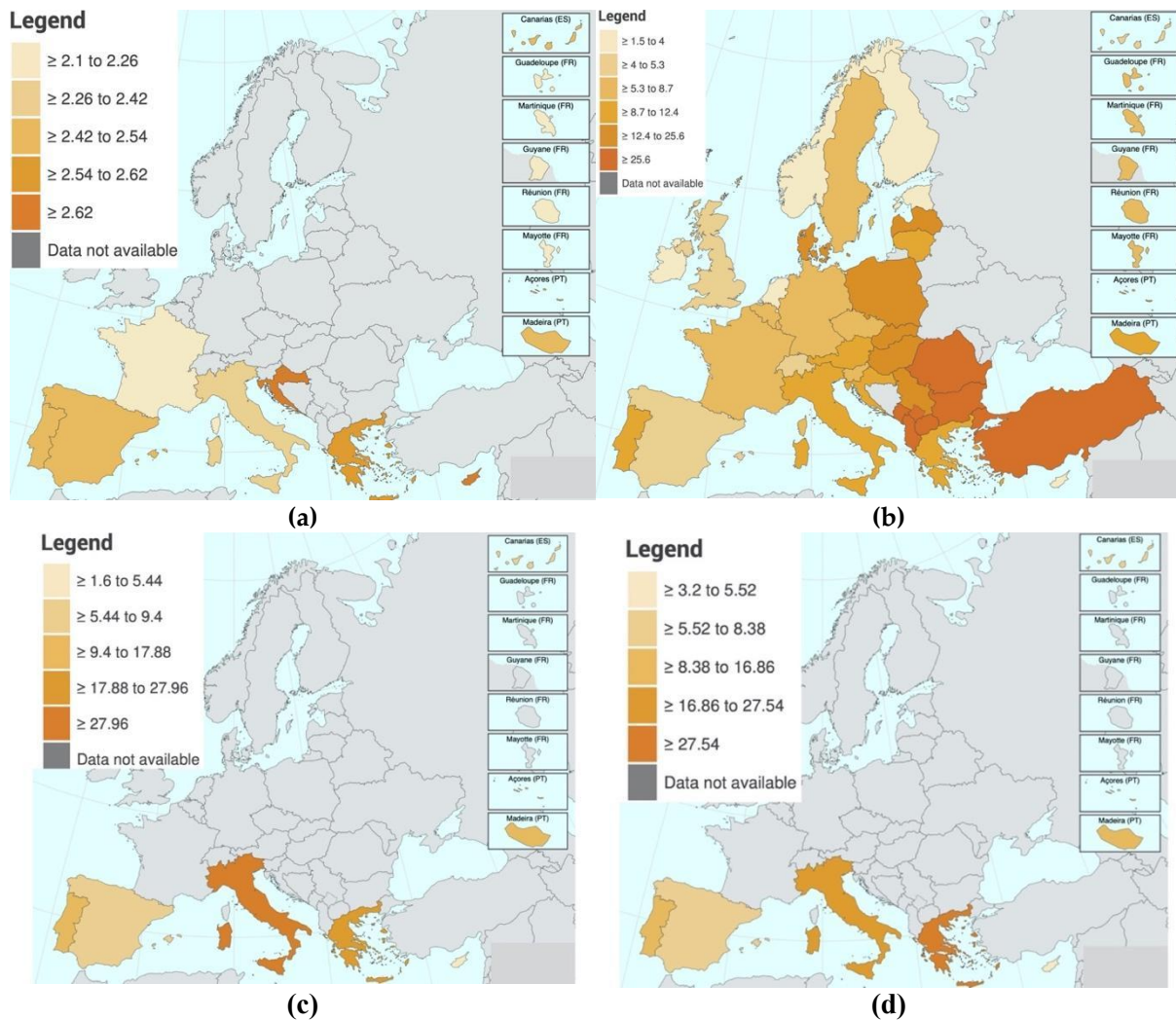


Figure 10. (a) Mapping of household type in the Mediterranean basin; (b) Map of the physical conditions of EU housing stock in general; (c) Map of urbanisation in Mediterranean cities; (d) Map of urbanisation in towns and suburban areas. **Source:** Eurostat, 2018, illustrations extracted from the open-source Eurostat database and edited by the author in 2022.

Figure 10 (a) demonstrates occupancy density in residential buildings in the South-eastern Mediterranean basin. An average of over 2.62% people per household was recorded both in Cyprus and Croatia; this data should be considered when identifying representative occupancy

profiles in building energy models. In this present study, the representative occupancy profiles were identified using both the Eurostat data and the data gathered from the questionnaire survey findings on post-war social housing estates in order to validate the data concurrently [54]. Figure 10 (b) maps the physical conditions of housing stock. It can be seen that Cypriot housing stock falls in the range of 1.5 to 4, and this is the lowest ranking category across Europe. This factor is due to the presence of mostly newly built housing stock across the island, while, in other EU countries, the housing stock dates back to the post–World War II era. Figure 10 (c) maps the degree of urbanisation in countries in the Mediterranean basin. Cyprus shows the smallest degree of urbanisation, between 1.6 to 5.44 – the data represents percent of the population that lives in urban versus rural environments, in comparison to the other EU countries. This is due to the relatively small population size of Cyprus compared to other European countries with larger populations and high numbers of housing stock [55]. Figure 10 (d) shows a map of degree of urbanisation in towns and suburban areas in Mediterranean countries. In Cyprus, 3.2% to 5.52% of households live in towns and suburban areas. In comparison to data presented in Figure 10 (d), this data proves that very low Cypriot households are located in towns due to the geographical conditions of the island [56]. This is the reason that the identified post-war social housing stock were built the same in both cities and suburban areas without distinction to form. This representative archetype typology can therefore be applied to either urban or suburban regions for developing energy-policy design.

3.2. Research Design

This study refers to an ongoing uncontrolled construction process attempting to change the contemporary urban environment in Famagusta, based on the characteristics of the second case concerning the notion of the ‘sustainable urbanism approach’. In the first category of factors, the study includes the understanding of the main ecological value of the built environment within its main purposes of land-use planning and the planned spatial layout design of mass housing estates. Another essential factor is the examination of the building typology to understand how the construction industry impacts urban growth and development, as shown in Figure 11.

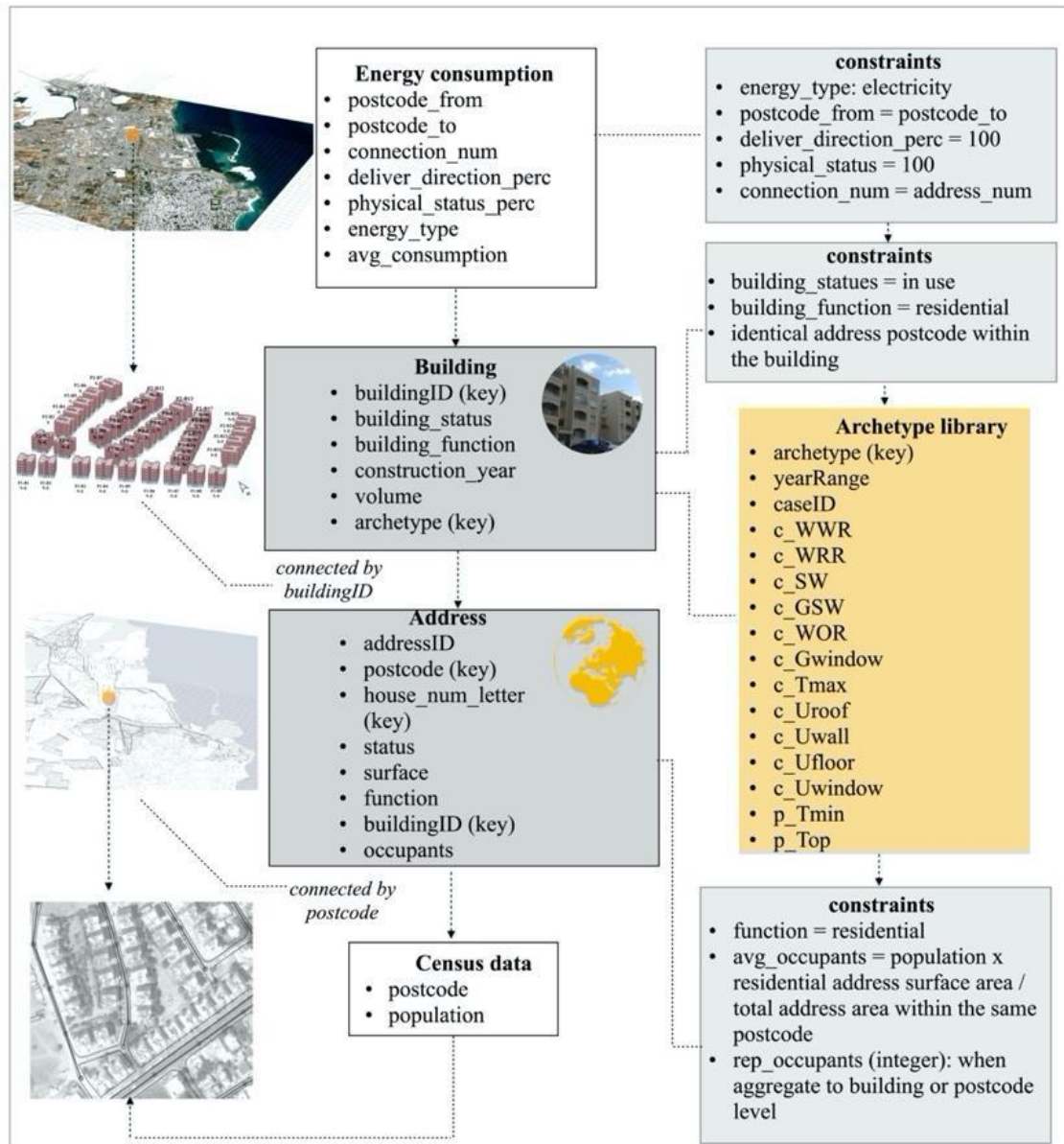


Figure 11. Step-by-step development of the identification of representative mass-housing estates and study variables. **Source:** Illustrations of urban-tissue models extracted from ArcGIS Pro Version 2019.01 software suite, developed by Esri (UK) in 2019; the flow diagram designed by the author in 2022.

The study deliberately focuses on the application of environmental design principles to housing and urbanism. The third factor in the typological study is the geographical formations of the land and their impacts on the planning process. The case study approach aims to illustrate that the selected cases have been subject to a definitive presence, considering sustainable urban schemes in developing mass housing estates. The diversity of the building typology and land-use planning resulted in changes to the characteristics of the urban tissue. The fourth and final category is the evaluation and highlighting of the impact on ecological urbanism features, which changes the interface of a sustainable urbanism approach. The case examples chosen for

this study are intended to explore in particular the possibilities which the ecological features and its impact on the densely built representative urban agglomeration regions to formulate sustainable urban growth.

3.3. Prototype residential tower block developments as base case scenario

3.3.1. Building selection

As previously stated, the key criterion in the representative case study building selection was that the sample was representative of the insufficient post-war medium- or high-rise residential tower block developments built in the 1970s, 1990s and 2010s. These were examined in terms of location, geographical characteristics of buildings' location within the city, construction style/architecture and land-use policy considerations in highlighting the importance of the physical transformation of mass-scale housing areas throughout the decades. It is also necessary to have sufficient existing building data and scope for a survey, to allow a comprehensive study. Three case study buildings were selected from the coastal city of Famagusta, Cyprus, in accordance with these criteria. The definition of three representative residential tower blocks' (RTBs') typologies was derived with reference to the year of construction, the urban/suburban morphology of the block, the number of floors in the building and the number of dwellings per floor. Sub-typologies were also identified in order to understand the impact of rapid construction activity on the transformation of urbanisation and land-use characteristics of the city. The application of the above-mentioned typologies and sub-typologies to the city of Famagusta was conducted by visiting the different suburbs and urban areas and analysing the buildings, using on-site photographic documentation together with confirmation from existing cadastral maps and Google Earth. A representative sample of residential buildings was also selected, and the buildings were inspected by infrared-radiometer thermography (IRT) to verify their constructive features and that they fit in with the corresponding sub-typologies. Due to the repeatability of the typologies both in spatial plan layout organisation and the construction features found the features of the existing RTBs could be identified. Table 1 shows building typologies identified as a base-case scenario for 1970–2018 residential buildings: linear block (T1), H-shaped tower (T2) and rectangular box-shaped tower (T3) [57].

Table 1. Characteristics of typologies and sub-typologies defined in this research context.

	<i>Year of construction</i>	<i>Height</i>	<i>Dwellings per floor</i>	<i>M² dwelling</i>	<i>Orientation</i>
<i>T1 linear block</i>					
<i>T1.1 Grouped in quarter</i>	1950-1973	< GF+4	2	60-118	Double 180°
<i>T1.2 Linear not grouped</i>	1960-1972	< GF+4	2	54-125	Double 180°
<i>T1.3 Linear with 1 orientation</i>	1950-1971	< GF+4 < GF+10	4	59-94	One
<i>T1.4 Linear with minimum courtyard</i>	1962-1973	< GF+6	2	70-130	Double 180°
<i>T2 H-shaped tower</i>					
<i>T2.1 H-tower with lateral courtyard</i>	1985-1993	< GF+5	2	55-107	Double 180°
<i>T2.1 without courtyard</i>	1989-1993	< GF+5	2	<90	Double 90°
<i>T3 Rectangular box-shaped tower</i>					
<i>T3.1 Block in 'Square'</i>	1995-2005	< GF+8	4	55-107	Triple
<i>T3.2 Block in 'Rectangular'</i>	2005-2018	< GF+15 > GF+20	2-8 8-16	25-120	One-Triple

**T= Tower Block **GF=Gross Floor area*

Famagusta has three suburban/urban neighbourhoods with large-scale residential tower block developments: The Varosha territory, with 36,124 homes from 1950 to 1973, the Engomi territory, with 32,721 and the Agios Loukas territory, with 22,135 homes [58]. To conduct an in-depth analysis of the topographical features considering the land-use characteristics of the mass housing project sites and the socioeconomic characteristics of the residents, the above-mentioned locations were selected as representative for the application of the methodology.

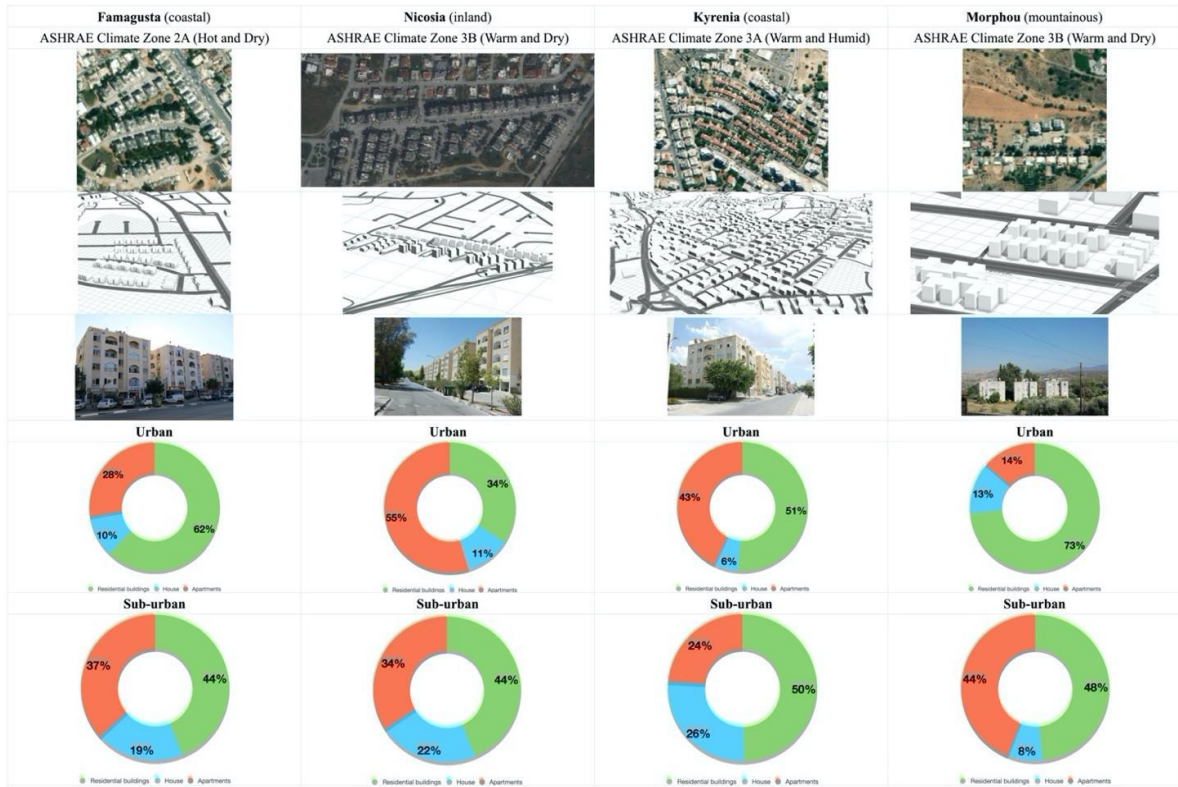


Figure 12. Mapping the nationally representative mass housing estates both in urban and suburban regions across the island. **Source:** Illustrations of urban-tissue models extracted from ArcGIS Pro Version 2019.01 software suite, developed by Esri (UK) in 2019; photographic images were taken between 2015-2019 by the author; the charts are designed by the author in 2021, the data extracted from the State Planning Organisation, 2019.

As shown in Figure 12, these suburban/urban areas were chosen because of the high percentage of RTBs constructed between 1970 and 2018 and because they have very repetitive building typologies in terms of architectural style and land-use characteristics. The apartment units from this time period occupy most of the area of the densely built city centre of Famagusta and its urban agglomerations, and these dwellings also coexist with more modern ones, as in other suburban areas [59]. In this way, two types of urban areas were studied as well as one type of suburban area, with results which could be extrapolated to the remainder.

4. Analysis: Investigations of Urban Climate Adaptation in Urban Peripheries in Famagusta

4.1. Case study 1: Correlation between the condition of housing stock and topographical characteristics in the Varosha territory

A horizontal axis line of the Mediterranean Sea crosses the northern periphery of Famagusta from east to west, as shown in Figure 13. It crosses the former villages, which are now part of the greater urban agglomeration. This urban agglomeration region is characterised

by hard-surface calcareous rock which is a well-known ancient geological stone type in Cyprus and by a constantly changing difference in elevation between the upper and lower downtown areas, a difference often from 5 to 10 metres, as shown in Figure 13. This densely-built residential and tourism areas, originally privately owned land, has become a longitudinal zone for the placement of residential tower blocks throughout the coastline which was built between 1950s and in the early 1970s. The width of the coastline and the privately owned land along this zone varies due to the land ownership and its purpose-built characteristics (e.g., tourism, residential, commercial or self-built seashore houses). In many rural areas, it is limited to narrow urban corridors, while in others, it widens out to plateau on the upper or lower level of the downtown regions because this territory has been dominated by harvesting agricultural products across the island. Additionally, the upper-town areas were set to open foreign investors to build-up luxury hotels and high-end shopping districts in order to feed the lower-town regions and develop further urban agglomeration expansions up to Paralimni area. Beginning from the south to the east of the city, particularly in the downtown Varosha territory, the following major uses can be identified: residential tower blocks, mass housing estates, self-built residential buildings, a narrow linear public green space and a council estate project for state employees. Further to the west, there is the Lagoon territory, which is surrounded by sea residences at the top of the rocky waterfront, as shown in Figure 13.

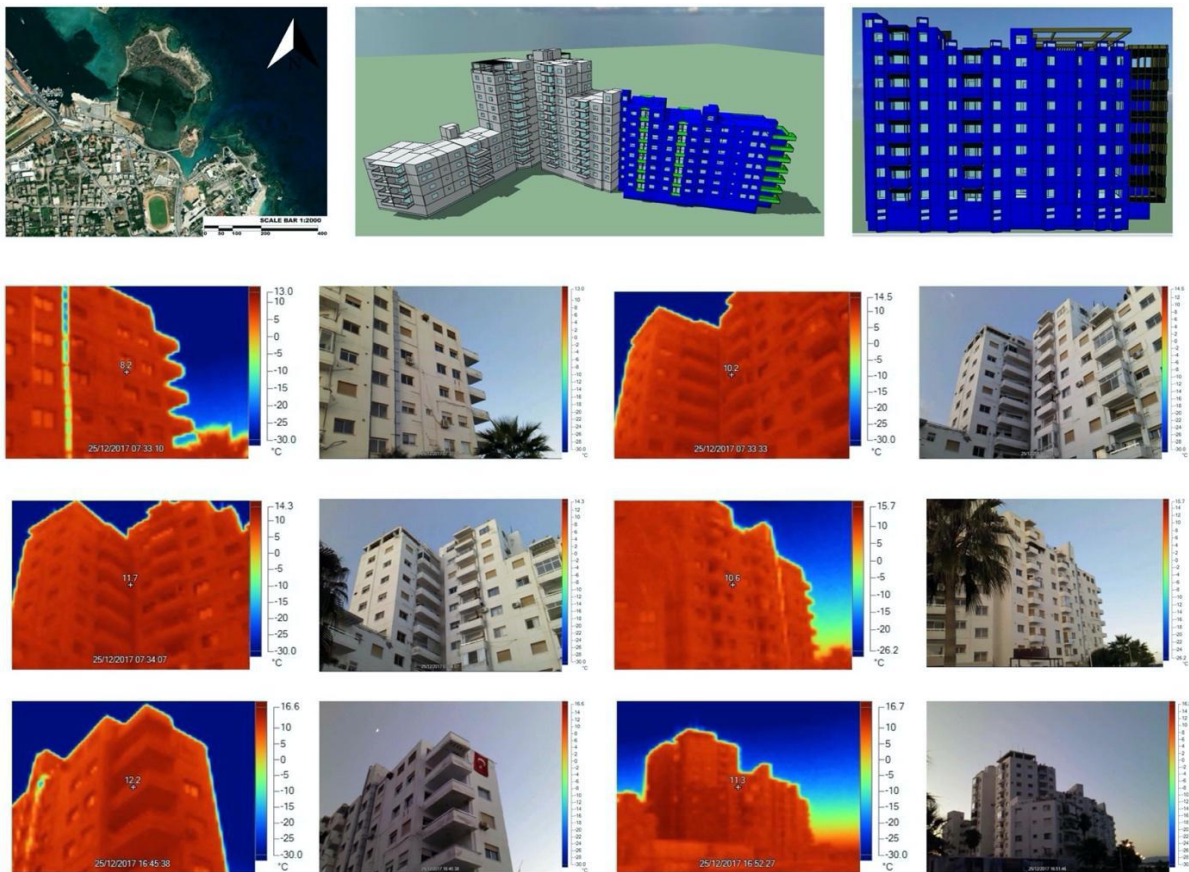


Figure 13. Physical conditions and urban climate characteristics of the archetype housing stock built in the 1970s. **Source:** Building renderings are illustrated by using the Integrated Environmental Solutions Virtual Environment (IES-VE) software suite and it was modelled by the author in 2020; the thermal-imaging recordings were undertaken in January 2018.

Further south, at the top of the rocky coastline regions, is an expanse of education and administrative buildings. The main university campus was established in early 1970s but due to the political situation emerged and the first educational buildings were built in early 1990s and today this university has become the biggest university campus in Cyprus which has been recognised by international bodies and accreditation schemes in recent years. At the same time, most of the administrative buildings such as Famagusta Municipality and supreme court were built between 1960-1974 which offers the best example of tangible modernist architectural heritage in Cyprus.

Further west is the fenced-off area, and finally, Famagusta’s shipyard, isolated in its surrounding green areas. The main reason for this isolation is that this area is used for industrial purposes. This is an extraordinary, densely built area of the city of great urban and ecological importance, something like a ‘catalyst’. It is indeed a topographical threshold which was transformed into an urban threshold, a privately owned territory, afterwards known as ‘No

Man's Land' territory, cutting the private, homogenous urban tissue of the city, as shown in Figure 13. What is really interesting at this point is the fact that this privately owned state is not evident to the residents of the city who are aware of the threat of urban sprawl. Further, no governmental body's urban planning scheme has ever been put forward here, to implement European Union directives in an urban planning process.

4.2. Case study 2: Correlation between the condition of housing stock and topographical characteristics in the city centre of Famagusta and its agglomeration

The second case study is located at the north edge of the Famagusta agglomeration, a vast agricultural land shown in Figure 14. It is a newly-developed urban agglomeration region on a much larger scale than that of case study 1. At the same time, it retains its natural not yet densely urbanised form but this area has been transformed rapidly in the mid-1980s due to the housing shortage and increasing younger population just after the physical division of the island. When we examine its geographical feature, there is a height difference of 8–12 metres between its higher and lower levels, as shown in Figure 14. It is scarcely planted, with quite a smooth slope and a hard-rock top edge because of its proximity to the old-walled city of Famagusta. The fortifications were built on the top-surface of calcareous rock and the sandstone made walls were constructed over the centuries by different civilisations (Lusignans and Venetians). This urban agglomeration region has led to change the physical transformation and land-use planning layout of the urban expansions. Notably, this area has the same geological characteristics as in the first case, in the Varosha territory, but on a much wider scale.

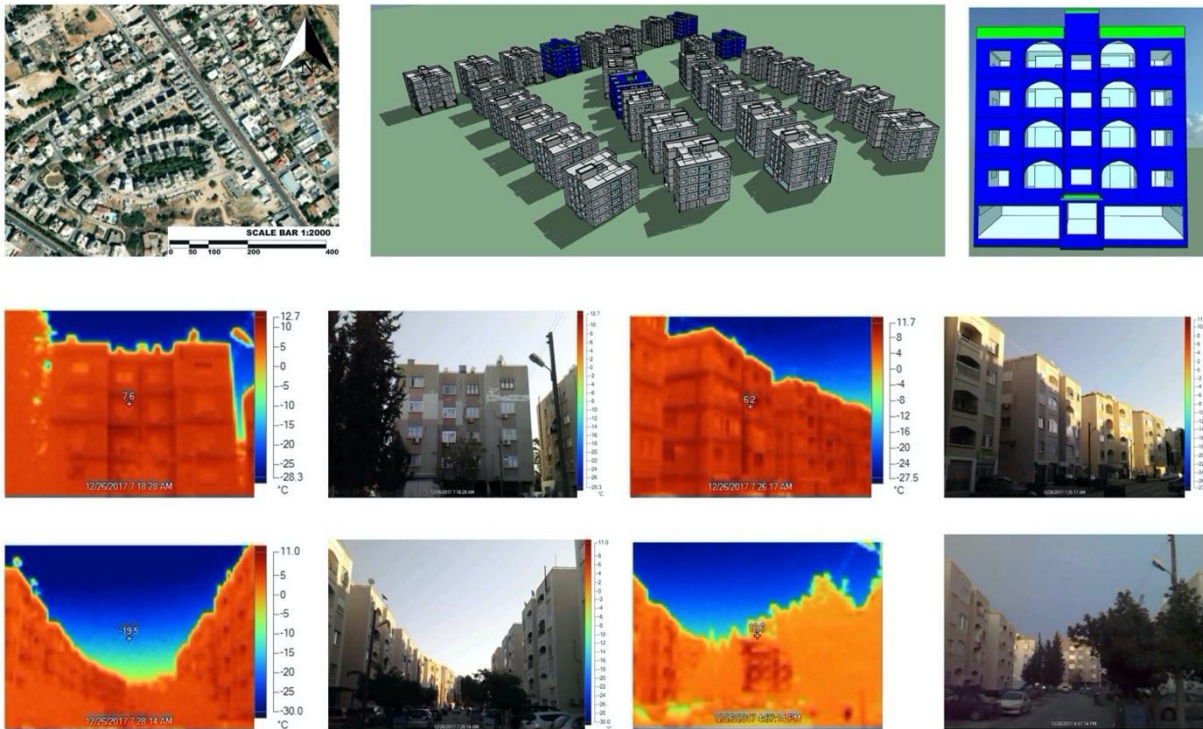


Figure 14. Physical conditions and urban climate characteristics of the archetype housing stock built in the 1990s. **Source:** Building renderings are illustrated by using the Integrated Environmental Solutions Virtual Environment (IES-VE) software suite and it was modelled by the author in 2020; the thermal-imaging recordings were undertaken in January 2018.

This urban agglomeration territory is, in fact, part of the edge of the main inner plateau of the coastal city. This large-scale geographical terrain runs east to west and then infiltrates through the north, creating all sorts of plain valleys and scattered land-layout. Along its southern side on the lower level of the territory, there are various scattered mass housing estate developments which are being incorporated into the larger urban agglomeration of Famagusta. One of these purpose-built residential estates is the Enkomi territory, located on the river delta and marshlands between the southern parts of the ecological land, as shown in Figure 14. The ending point of the River Pedieos has flown through the coastline and it divides Famagusta city and it is the largest urban expansion of Agios Sergios. This area has grown rapidly due to the rise of interest in buying mass-housing estates which were built by privately-owned construction companies today. Many local citizens also prefer buying their second-home in these urban agglomeration regions because of its close proximity to nature and it provides a slightly liveable environment alternative to the city centre. Hence, the abundance of poorly-built housing stock has led to change the physical characteristics of the city and it has led to bringing urban ghettos where the minority ethnic groups were living and working in these deprived areas.

This region is in fact a strategic point at which to cross into the inland plateau since the geophysical feature (mud-clay soil type) has a sort of natural entrance with its transition to the rapid high-rise residential tower blocks through the horizontal axis towards the Enkomi territory. So this suburban expansion has also traditionally functioned as the last stopover before the entry to the inland plateau. The reason for examining this specific part of the geophysical feature, on the one hand, is that it is the point of connection between the top and bottom areas of the city expansion and on the other hand, that it allows an investigation of the impact of construction activity through the uncontrolled urbanisation process.

The rapid urbanisation of Famagusta has created purpose-built or self-built residential areas, both seasonal and permanent, sprawled between the lower level of the downtown and the rest of the city, separated, in fact, by a highway which functions as a peripheral road. The upper part of the city is not yet developed, because the urbanisation pressure has not reached that point. It is also interesting to note, in the case of the Enkomi territory, that there are a few more major reasons for constructing an abundance of mass housing estates. First, one part of this ecological terrain is the northern edge of an inland fertile agricultural area, and further east, it becomes the residential border between public and private services, including education, industrial services and healthcare. There is a threshold point between these zones, and most of the land is regulated by privately owned construction companies, in order to tackle the demand for housing, as shown in Figure 14.

4.3. Case study 3: Correlation between the condition of housing stock and topographical characteristics in Agios Loukas territory and its agglomeration

The geographical feature of the Agios Loukas territory which is known as Canakkale Goleti in Turkish stretches west to east. In some cases, it has a rocky top edge which extends all the way down to the densely built city centre and its expanses of the university campus, as shown in Figure 15. It is similar to the Varosha territory case but is much higher because of the inclined valleys. Its height ranges between 8 and 25 metres, as shown in Figure 15.

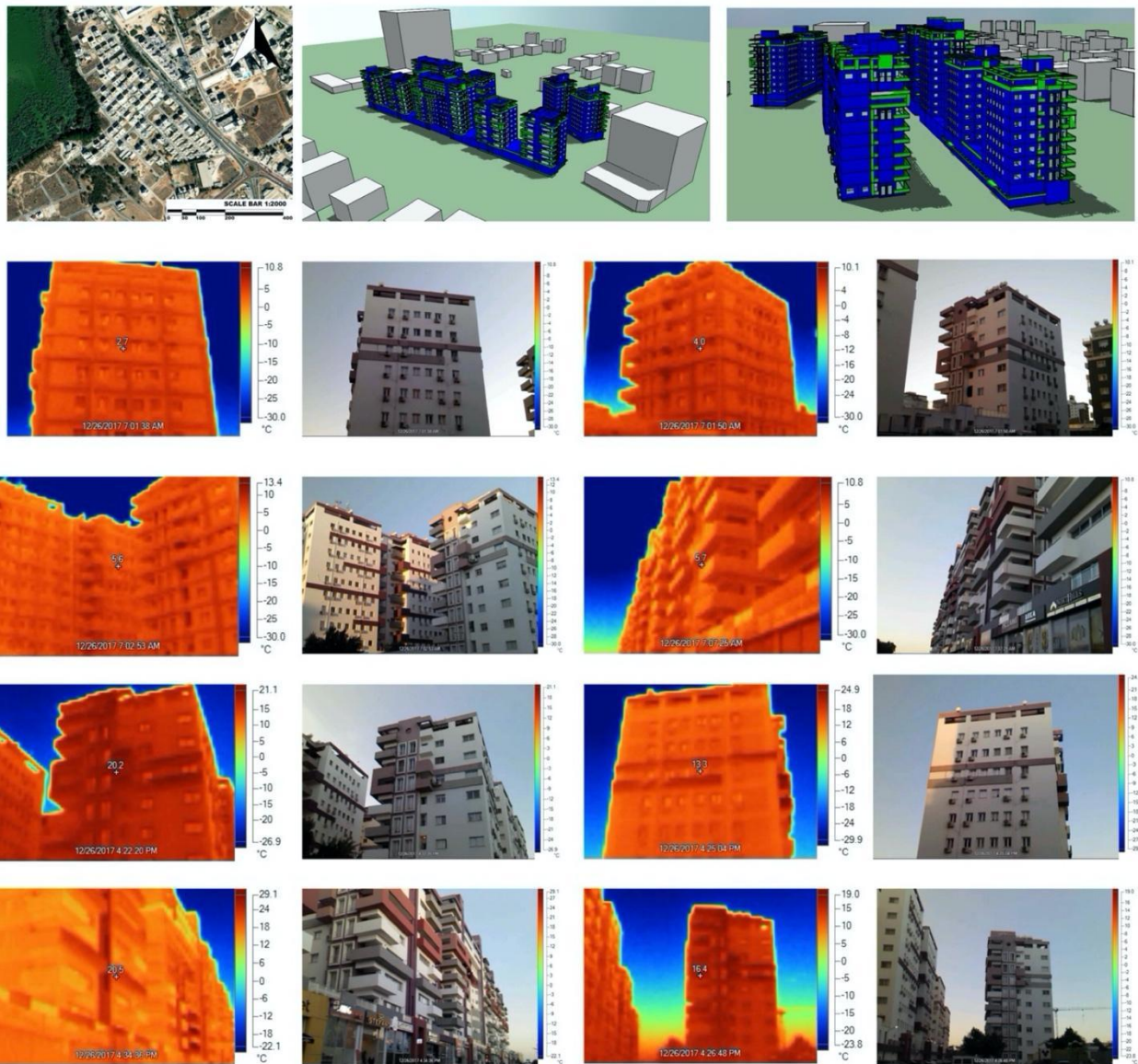


Figure 15. Physical conditions and urban climate characteristics of the archetype housing stock built in the 2010s. **Source:** Building renderings are illustrated by using the Integrated Environmental Solutions Virtual Environment (IES-VE) software suite and it was modelled by the author in 2020; the thermal-imaging recordings were undertaken in January 2018.

This territory's geographical feature has an already imprinted presence in the everyday life of the city. In this case, the city was developed on the top of the plateau of the city, leaving undeveloped the area of the inner lake, which stretches all the way to the coastline. The rapid development which began in the 1980s has taken over this undeveloped lower land, starting, in fact, from the seashore. In this way, a paradoxical outcome has occurred. The urban periphery is not on the geographical periphery of Famagusta's agglomeration but at its centre, between the government's social housing development region on the lowland and the old walled city of Famagusta on the upland of the land surface. This is a sort of inverted peripheral condition. What is interesting about this urban territory is that it has become an explicit

uncontrolled urban district since the construction peaked during the ‘property boom’. The industrial area is located on the foot of the territory at the edge of the old city. At the same time, many British Colonial public and residential buildings are situated on the top of the mud-soil characteristics of the land, parallel to its edge. In some areas where the height difference between upland and lowland is less than 8 metres, the land has become privately owned, with the edge of the territory transformed into a residential district to accommodate the growing young population. In other areas further west, the public space extends all the way to the edge for creating threshold points.

At the down-town regions of the territory, low-, mid- and high-rise residential tower blocks were built which interlocked urban layout from organisation across the main way of access to the old part of the city on top of the plateau. Further west of the old city lies an abundance of privately owned construction company-built residential tower blocks, which expand up to the Agios Sergios urban agglomeration region. Most of the upper-middle income and high-income household groups living there now are local or foreign buyers. Then, a densely built residential tower block development region is located further west, as in the Varosha territory case. The ecological feature at that area is spectacular and has become an attraction point. The reason is that it is in close proximity to the coastline, and most of the apartment units have a sea view. It is also worth noting that a couple of roads have been created at spots allowed by the topography, connecting the top part of the city and linking the ecological areas with densely-built mass housing estates. But the isolation of the top and bottom of the territory has created different urban conditions at the two levels, for example seeing mostly purpose-built high-rise residential tower blocks for high-income foreign buyers and mid-rise apartment units for middle- or upper-middle income local buyers on the lowland.







Moving towards the eastern part of the old city centre, one encounters the main connection road between the higher and lower plateau, which allows access to the main gateway of the commercial and industrial zones. Further east, in close proximity to the cultural heritage site, a residential area of both old and newly built low-rise buildings is located, extending up to the edge of these urban agglomeration expansions. Because this territory is protected under legislative rules and building regulations, building residential units higher than two storeys is not allowed, to protect the view of the fortifications. This is the first residential settlement outside of the historic city part with planning extensions of the city in 1960s throughout the further east. The height difference between lowland and highland is around 6 metres, creating spectacular views of the heritage site. The territory extends all the way east to another threshold point, which has been incorporated into the urban agglomeration area. Compared with the

Varosha territory, this area does not have many accessible roads anywhere along its stretch, even though it must be used more frequently to access the city centre than does the Varosha expansion. At the same time, privately owned residential units, mainly one- or two-storey residential buildings and privately owned construction company-built residential towers, are in closer proximity to each other in terms of land-use planning and architectural design characteristics. The main reason is that the vacant properties in the Varosha territory need to consider the challenges of implementing European Union directives with respect to urban planning, considering a sustainable urbanism approach and sustainable policies.

5. Discussion: Role of Uncontrolled Urbanisation Process and Construction Activity for the nationally representative urban agglomerations

It is becoming clear from the three case studies that the geographical feature plays a decisive role in the relations between privately owned land and the rapid construction activities in the urban peripheries in Famagusta. Table 2 summarises the ecological landscape elements and the progress of their adaptation into the development of large-scale high-rise housing development schemes. Four main points open up the scope of this research and provide a ground-breaking study for policymaking in the future.

Table 2. Analysis of the structure of topographical formations in urban peripheries in Famagusta, Cyprus.

Case Study 1	Case Study 2	Case Study 3
Urban morphological characteristics of existing residential building stock		
Low-rise linear block development.	Medium-rise H-shaped tower block development.	High-rise box-shaped tower block development.
Ecological landscape integration to the existing residential building stock		
		
Development of privately owned construction company-built residential tower blocks and self-built one- and two-storey residential building stock on the calcareous rock in the 1970s.	Development of government's social housing units on main agricultural land areas in the city centre in the 1980s.	Development of the densely populated volumetric housing schemes on the expansion of wetland areas in 2010s.
Mapping of rapid construction of residential tower block developments in the natural forestation and lake regions		
		
Expansion of vacant residential buildings into Old Harbour of Famagusta and Lagoon territory.	Natural lake district and expansion of wetland area where it's accessible to inhabit medium-rise tower blocks.	Greater Agios Loukas lake and natural reservoir of freshwater areas, including

fertile agricultural land expansions for urban agriculture.

The geographical characteristics and their integration into the ecological landscape



Representative base-case residential tower block development on the calcareous rock in the Lagoon territory, with close proximity to the urban agglomeration area. Today, it is the only accessible waterfront area for public use in Famagusta.



The natural lake district accommodates a variety of endangered animals and indigenous species, with rapid mass-scale housing estate developments occurring in this area, particularly on the expansion of the wetland area and its fertile ground areas.



Invasive mass-scale high-rise residential tower block developments lead to transforming of agricultural land areas into urban ghettos without concerning land-use planning schemes of development of volumetric housing projects across the densely built city centre.

The soil characteristics of the land in urban peripheries



The transformation of calcareous rock across the coastline of Famagusta Bay.



Expansion of wetland areas in close proximity to the residential district.



Expansion of river delta is divided between archaeological heritage sites and agricultural land areas.

The natural forestation and lake regions and urban threshold points of the city



The Lagoon territory leads to a divided variety of small-scale island transformations from the mainland.



Expansion of wetland areas provides fertile ground for urban agriculture.



Mass-scale privately owned two-storey residential estate was built in close proximity to the wetland area, without consideration of soil quality for construction of buildings.

Source: Illustrations of urban-tissue models extracted from ArcGIS Pro Version 2019.01 software suite, developed by Esri (UK) in 2019; photographic images were taken between 2015-2019 by the author.

First, the formulation of analytical tools is achieved based on the investigation of the ecological landscape through urban processes [60]. These tools have revealed the relation between construction activities and their impacts both on the landscape characteristics and on urban growth in this fragile environment [61]. The issue to investigate is how such tools can be transformed and used to implement European Union directives into the urban planning process. Could such tools enhance the organisational role of the geographical features of the city and its urban agglomerations, on both a small and large regional scale? Then, second, one issue to

investigate is the potential to implement feasible and sustainable urban schemes to upgrade sufficient land-use planning for the existing residential building stock as well as construction companies' decisions regarding the implementation of applicable urban incentive projects. Given the fact that the urbanisation is rapidly evolving and that its main characteristic is the fragmentation of land, there is an urgent need to rethink the possible urban scenarios — particularly sustainable urbanism approach schemes, which could involve specific planning laws, policies and directives for both existing and recently built housing stock [62-65]. Indeed, one can begin to see the city of Famagusta as a large urban agglomeration after the construction of very efficient housing schemes. What kinds of implementation phases are needed, and what impact could these ecological features have in such a context?

The third point has a political aim. Given the fact that the city is divided, and there is a search for a political solution which brings together and merges these three selected case study territories with respect to efficient sources, plans and infrastructure, there is a great necessity to create platforms of communication and construct common references for the future urban environment. Could ecological urbanism study approaches on both sides of the city play a role, then, as tools for the construction of housing stock, through sustainable urban planning approaches? Such an aim is based on two hypotheses. First, such ecological elements are present all over the geographical and physical characteristics of the city's man-made environment, particularly due to economic growth and a demand for housing. Second, a much more ground-breaking hypothesis is an understanding of the challenges of the implementation process of green urbanism schemes through planning and legislative constraints [66].

Lastly, referring specifically to the three case studies, some initial suggestions can be made. Concerning case study 1 in the Varosha territory, rehabilitation of the vacant properties by employing prefabricated energy-efficient building materials or components can be conducted, which could allow the reinhabiting of the existing self-built residential units and the residential tower block developments in the territory [67]. In case 2 in the Enkomi territory, the issue to tackle is how the rehabilitation of the river delta could become an urban incubator, and what sort of incubator it would be. Through the feasible urban retrofit scenario, there is an attempt to investigate a potential environmental role for the existing building stock, which could upgrade the qualities of the entire agglomeration [68]. Such a proposal needs to improve the bottom-up development plans, which have not yet turned in that direction. Concerning case study 3 in the Agios Loukas territory, there is a question of linking the densely built high-rise residential tower block developments along the stretch of the land surfaces simultaneously, which is a much more difficult undertaking than the proposals for the Varosha territory, since

this area is regulated by the privately owned construction company-built residential tower block developments and mass housing estates. Could the morphological and ecological characteristics of the city become a sort of tool, then, used to investigate green urbanism scenarios in such a fragmented environment? The construction sector is aware of the fact that there is a problem in implementing urban planning schemes. It is also aware that there are regulations and corresponding implementations for the residential building sector in general in the European Union, but due to the lack of urban retrofitting implementations, regulations and laws, the practice of building these mass-scale low-, medium- or high-rise residential tower block developments in Cyprus continues without any control mechanisms. The application of retrofitting strategies, from the base-case prototype residential tower block developments to the regional-scale urban retrofitting of purpose-built housing units, will result in immeasurable sustainability benefits for the households and the surrounding environment. The impact of implementing feasible urban retrofitting scenarios will be beneficial for the society, as these scenarios will result in the development of sensitive and engaging constructed habitats which sustainably evolve the social, economic and natural ecologies of their contextual sites. The consideration of offering green urbanism solutions is important, because it enables households to focus on all the benefits from fulfilling the single objective of environmental integration [69-72]. This study may provide both theoretical and practical answers to the question of what the effects of systemic urban retrofitting will be on sustainability and society. The study can also be used as a base case for the formation of policies and then for their implementation, for the purpose of changing residential building designs and construction systems for similar Mediterranean regions in general.

6. Conclusions

The main objective of this study is to propose concrete solutions, to bring control mechanisms into housing and urban planning schemes, aiming to counter the effects of uncontrolled construction activity, and to strengthen the implementation of a green urbanism approach in the retrofitting of the existing residential building stock. Besides this objective, the study tries to explore the importance of integrity and a transition between the built environment and the ecological characteristics of the city, to consider the historic urban development of social housing development schemes and their impacts on the society. The role of an architect/urban planner and his/her influence on the decision-making process are crucial in such a green urbanism approach to retrofitting housing development projects. The decisive role of

architects/urban planners is to enable households to identify and implement technical solutions to improve their level of well-being in their properties.

At the same time, considering collaborative communication between urban planners and communities, the well-integrated decision-making process could allow the design and optimisation of an economically viable, sustainable urbanism policy. In general, the motivation and reasons for investigating rapid construction activity and its impacts on the ecological landscape are related more to the improvement of comfort, the quality of life and the necessity of improvement to certain building systems than they are about energy savings. It can be observed that in most cases, in the situation currently in existence and with particular regard to the insufficient building stock, the occupants' well-being is the primary consideration. However, meeting these needs still does not satisfy the basic principles of urban planning policies. The future is challenging, and much attention must be paid to the implementation of green urbanism approaches in retrofitting schemes rather than to the level of obsolescence achieved by uncontrolled construction activity. Therefore, this study offers significant added value to the internal effort to bring control mechanisms into recently built mass-scale housing stock.

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Graphical Abstract: Representative methodological framework of the development of novel UBEM framework in the South-eastern Mediterranean Europe.

References

- [1] Ozarisoy, B., & Altan, H. (2017a). Adoption of energy design strategies for retrofitting mass housing estates in Northern Cyprus. *Sustainability (Switzerland)*, 9(8), 1477. <https://doi.org/10.3390/su9081477>
- [2] Abokersh, M. H., Spiekman, M., Vijlbrief, O., Goch, T. A. J., Vallès, M., & Boer, D. (2021). A real-time diagnostic tool for evaluating the thermal performance of nearly zero energy buildings. *Applied Energy*, 281. <https://doi.org/10.1016/j.apenergy.2020.116091>
- [3] Abrahão, A. C., Fábio, G., Teixeira, L., Denise, D., & Silva, H. (2021). The recent residential apartment buildings' thermal performance under the combined effect of the global and the local warming. *Energy and Buildings*, 110828. Retrieved from <https://doi.org/10.1016/j.enbuild.2021.110828>
- [4] Aguacil, S., Lufkin, S., Rey, E., & Cuchi, A. (2017). Application of the cost-optimal methodology to urban renewal projects at the territorial scale based on statistical data—A case study in Spain. *Energy and Buildings*, 144, 42–60. <https://doi.org/10.1016/j.enbuild.2017.03.047>

- [5] Ozarisoy, B., & Altan, H. (2017b). Energy Performance Development of Non-regulated Retrofit Mass Housing Estates in Northern Cyprus. *Design Journal*, 20(sup1), S1765–S1781. <https://doi.org/10.1080/14606925.2017.1352697>
- [6] Fine, J. P., & Touchie, M. F. (2020). A grouped control strategy for the retrofit of post-war multi-unit residential building hydronic space heating systems. *Energy and Buildings*, 208. <https://doi.org/10.1016/j.enbuild.2019.109604>
- [7] Fokaides, P. A., Christoforou, E. A., & Kalogirou, S. A. (2014). Legislation driven scenarios based on recent construction advancements towards the achievement of nearly zero energy dwellings in the southern European country of Cyprus. *Energy*, 66, 588–597. <https://doi.org/10.1016/j.energy.2013.12.073>
- [8] Pignatta, G., Chatzinikola, C., Artopoulos, G., Papanicolas, C. N., Serghides, D. K., & Santamouris, M. (2017). Analysis of the indoor thermal quality in low income Cypriot households during winter. *Energy and Buildings*, 152, 766–775. <https://doi.org/10.1016/j.enbuild.2016.11.006>
- [9] Åkerman, M., Halonen, M., & Wessberg, N. (2020). Lost in building design practices: The intertwining of energy with the multiple goals of home building in Finland. *Energy Research and Social Science*, 61. <https://doi.org/10.1016/j.erss.2019.101335>
- [10] Arbolino, R., Boffardi, R., & Ioppolo, G. (2019). The effectiveness of European energy policy on the Italian system: Regional evidence from a hierarchical cluster analysis approach. *Energy Policy*, 132, 47–61. <https://doi.org/10.1016/j.enpol.2019.05.021>
- [11] McKenna, R., Merkel, E., Fehrenbach, D., Mehne, S., & Fichtner, W. (2013). Energy efficiency in the German residential sector: A bottom-up building-stock-model-based analysis in the context of energy-political targets. *Building and Environment*, 62, 77–88. <https://doi.org/10.1016/j.buildenv.2013.01.002>
- [12] Escandón, R., Silvester, S., & Konstantinou, T. (2018). Evaluating the environmental adaptability of a nearly zero energy retrofitting strategy designed for Dutch housing stock to a Mediterranean climate. *Energy and Buildings*, 169, 366–378. <https://doi.org/10.1016/j.enbuild.2018.03.079>
- [13] Simões, N., Manaia, M., & Simões, I. (2021). Energy performance of solar and Trombe walls in Mediterranean climates. *Energy*, 234. <https://doi.org/10.1016/j.energy.2021.121197>
- [14] Kyprianou, I., Serghides, D. K., Varo, A., Gouveia, J. P., Kopeva, D., & Murauskaite, L. (2019). Energy poverty policies and measures in 5 EU countries: A comparative study. *Energy and Buildings*, 196, 46–60. <https://doi.org/10.1016/j.enbuild.2019.05.003>
- [15] Thomson, H., Snell, C., & Bouzarovski, S. (2017). Health, well-being and energy poverty in Europe: A comparative study of 32 European countries. *International Journal of Environmental Research and Public Health*, 14(6). <https://doi.org/10.3390/ijerph14060584>
- [16] Ozarisoy, B., & Altan, H. (2021). Developing an evidence-based energy-policy framework to assess robust energy-performance evaluation and certification schemes in the South-eastern Mediterranean countries. *Energy for Sustainable Development*, 64, 65–102. <https://doi.org/10.1016/j.esd.2021.08.001>
- [17] Altan, H., & Ozarisoy, B. (2022a). An Analysis of the Development of Modular Building Design Elements to Improve Thermal Performance of a Representative High Rise Residential Estate in the Coastline City of Famagusta, Cyprus. *Sustainability*, 14(7), 4065. <https://doi.org/10.3390/su14074065>
- [18] Ozarisoy, B., & Altan, H. (2022b). Significance of occupancy patterns and habitual household adaptive behaviour on home-energy performance of post-war social-housing estate in the South-eastern Mediterranean climate: Energy policy design. *Energy*, 244. <https://doi.org/10.1016/j.energy.2021.122904>
- [19] Ozarisoy, B., & Altan, H. (2022c). Bridging the energy performance gap of social housing stock in south-eastern Mediterranean Europe: Climate change and mitigation. *Energy and Buildings*, 258. <https://doi.org/10.1016/j.enbuild.2021.111687>
- [20] SPO-State Planning Organization of North Cyprus (2018). Sectoral Distribution of GNP, GDP and Macroeconomic Indicators/2010-2018. [Online.] Available at: <https://www.devplan.org/seg-en.html> [Accessed: December 2020].
- [21] Statistical Office of Republic of Cyprus. (2019). Annual Report of Population and Housing Census [Online]. Available at: [https://www.mof.gov.cy/mof/cystat/statistics.nsf/All/6C25304C1E70C304C2257833003432B3/\\$file/Demographic_Statistics_Results-2019-EN-301120.pdf?OpenElement](https://www.mof.gov.cy/mof/cystat/statistics.nsf/All/6C25304C1E70C304C2257833003432B3/$file/Demographic_Statistics_Results-2019-EN-301120.pdf?OpenElement) [Accessed: February 2021].
- [22] Balkiz, Y., & Therese, L.-W. (2014). Small but Complex: The Construction Industry in North Cyprus. *Procedia - Social and Behavioral Sciences*, 119, 466–474. <https://doi.org/10.1016/j.sbspro.2014.03.052>

- [23] Yorucu, V., & Keles, R. (2007). The construction boom and environmental protection in Northern Cyprus as a consequence of the Annan Plan. *Construction Management and Economics*, 25(1), 77–86. <https://doi.org/10.1080/01446190600902356>
- [24] Cogaloglu, M., & Turkan, Z. (2019). Plan organization in XX. Century housing architecture in North Cyprus. *Amazonia Investiga*, 8(22), 381–388. Retrieved from <https://www.amazoniainvestiga.info/index.php/amazonia/article/view/738>
- [25] Mehmet, O., & Yorucu, V. (2008). Explosive construction in a micro-state: Environmental limit and the Bon curve: Evidence from North Cyprus. *Construction Management and Economics*, 26(1), 79–88. <https://doi.org/10.1080/01446190701708272>
- [26] Oktay, D. (2007). An analysis and review of the divided city of Nicosia, Cyprus, and new perspectives. *Geography*. <https://doi.org/10.1080/00167487.2007.12094203>
- [27] Yorucu, V. (2003). The Analysis of Forecasting Performance by Using Time Series Data for Two Mediterranean Islands. *Review of Social, Economic & Business Studies*, 2(January 2003), 175–196. Retrieved from <https://www.researchgate.net/publication/255584205>
- [28] Oktay, D. (2002). The quest for urban identity in the changing context of the city Northern Cyprus. *Cities*, 19(4), 261–271. [https://doi.org/10.1016/S0264-2751\(02\)00023-9](https://doi.org/10.1016/S0264-2751(02)00023-9)
- [29] Yorucu, V. (2013). Construction in an Open Economy: Autoregressive Distributed Lag Modeling Approach and Causality Analysis—Case of North Cyprus. *Journal of Construction Engineering and Management*, 139(9), 1199–1210. [https://doi.org/10.1061/\(asce\)co.1943-7862.0000714](https://doi.org/10.1061/(asce)co.1943-7862.0000714)
- [30] Pulhan, A., Yorucu, V., & Sinan Evcan, N. (2020). Global energy market dynamics and natural gas development in the Eastern Mediterranean region. *Utilities Policy*, 64. <https://doi.org/10.1016/j.jup.2020.101040>
- [31] Pulhan, H. & Numan, I (2005). The transitional space in the traditional urban settlement of Cyprus. *Journal of Architectural and Planning Research*, Vol. 22, No. 2, Theme Issue: Planni. *Journal of Architectural and Planning Research*, 22(2), 160–178.
- [32] Varoglu, L., Temel, S., & Yilmaz, A. (2018). Knowledge, attitudes and behaviours towards the environmental issues: Case of Northern Cyprus. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(3), 997–1004. <https://doi.org/10.12973/ejmste/81153>
- [33] Çelik, T., Kamali, S., & Arayici, Y. (2017). Social cost in construction projects. *Environmental Impact Assessment Review*. Elsevier Inc. <https://doi.org/10.1016/j.eiar.2017.03.001>
- [34] Ozarisoy, B., & Altan, H. (2021). Regression forecasting of ‘neutral’ adaptive thermal comfort: A field study investigation in the south-eastern Mediterranean climate of Cyprus. *Building and Environment*, 202. <https://doi.org/10.1016/j.buildenv.2021.108013>
- [35] SPO-State Planning Organization of North Cyprus (2019). Gross National Product Statistics [Online]. Available at: https://www.devplan.org/index_en.html [Accessed: December 2020].
- [36] Katircioglu, S. T., Feridun, M., & Kilinc, C. (2014). Estimating tourism-induced energy consumption and CO2 emissions: The case of Cyprus. *Renewable and Sustainable Energy Reviews*. <https://doi.org/10.1016/j.rser.2013.09.004>
- [37] Şafakli, O. (2011). An overview of the construction sector in Northern Cyprus. *African Journal of Business Management*, 5(35). <https://doi.org/10.5897/ajbmx11.015>
- [38] Panayiotou, G., Charalambous, S., Vlochos, S., Kyriacou, O., Theofanous, E. & Flippou, T. (2013). Increase of the energy efficiency of 25 low-income households in Cyprus. doi:10.13140/2.1.4935.3607
- [39] Serghides, D. K., Dimitriou, S., & Katafygiotou, M. C. (2016). Towards European targets by monitoring the energy profile of the Cyprus housing stock. *Energy and Buildings*, 132, 130–140. <https://doi.org/10.1016/j.enbuild.2016.06.096>
- [40] Savvides, A. L. (2017). The provision of socially minded housing in Cyprus: Examining historical references and addressing recent challenges from an architectural perspective. *Critical Housing Analysis*, 4(2), 84–98. <https://doi.org/10.13060/23362839.2017.4.2.389>
- [41] Yapicioglu, B. (2014). Management for resilience: The case of the North Cyprus construction industry. The Faculty of Engineering and Physical Sciences, School of Mechanical, Aerospace and Civil Engineering, University of Manchester, United Kingdom. [Online.] Available at: [https://www.research.manchester.ac.uk/portal/en/theses/management-for-resilience-the-case-of-the-north-cyprus-construction-industry\(2e83e6db-455c-43db-b2a3-7b54f43c7d9e\).html](https://www.research.manchester.ac.uk/portal/en/theses/management-for-resilience-the-case-of-the-north-cyprus-construction-industry(2e83e6db-455c-43db-b2a3-7b54f43c7d9e).html)[Accessed on February 2021].
- [42] Evcil, A., & Vafaei, L. E. (2017). A comparative survey of the energy performances of dwellings across Cyprus. *Energy and Buildings*, 148, 15–22. <https://doi.org/10.1016/j.enbuild.2017.05.008>

- [43] Evcil, A. (2012). An estimation of the residential space heating energy requirement in Cyprus using the regional average specific heat loss coefficient. *Energy and Buildings*, 55, 164–173. <https://doi.org/10.1016/j.enbuild.2012.08.014>
- [44] Tselika, E. E. (2019). State housing, social labelling and refugee identities in Cyprus. *Cyprus Review*, 31(1), 239–263.
- [45] Ciftcioglu, G. C. (2017). Social preference-based valuation of the links between home gardens, ecosystem services, and human well-being in Lefke Region of North Cyprus. *Ecosystem Services*, 25, 227–236. <https://doi.org/10.1016/j.ecoser.2017.05.002>
- [46] Hoskara, Ş. Ö., Tevfikler, B. Ç., & Ongul, Z. (2009). Legal frameworks and housing environments in North Cyprus. *Middle East Technical University Journal of the Faculty of Architecture*, 26(1), 81–100.
- [47] Lacher, H., & Kaymak, E. (2005). Transforming identities: Beyond the politics of non-settlement in North Cyprus. *Mediterranean Politics*, 10(2), 147–166. <https://doi.org/10.1080/13629390500124341>
- [48] Ersozer, F. (2017). The Limits of Europeanisation and Liberal Peace in Cyprus: A Critical Appraisal of the European Union’s Green Line Regulation. PhD Thesis. The Faculty of Humanities, School of Social Sciences, Politics, University of Manchester, United Kingdom. [Online] Available at: [https://www.research.manchester.ac.uk/portal/en/theses/the-limits-of-europeanisation-and-liberal-peace-in-cyprus-a-critical-appraisal-of-the-european-unions-green-line-regulation\(57dba13d-095f-462b-9a8e-aa92de02517b\).html](https://www.research.manchester.ac.uk/portal/en/theses/the-limits-of-europeanisation-and-liberal-peace-in-cyprus-a-critical-appraisal-of-the-european-unions-green-line-regulation(57dba13d-095f-462b-9a8e-aa92de02517b).html) [Accessed: February 2021].
- [49] Egemen, M., & Mohamed, A. N. (2006). Clients’ needs, wants and expectations from contractors and approach to the concept of repetitive works in the Northern Cyprus construction market. *Building and Environment*, 41(5), 602–614. <https://doi.org/10.1016/j.buildenv.2005.02.021>
- [50] Çarkoğlu, A., & Sözen, A. (2004). The Turkish Cypriot general elections of December 2003: Setting the stage for resolving the Cyprus conflict? *South European Society and Politics*, 9(3), 122–136. <https://doi.org/10.1080/1360874042000271898>
- [51] Eurostat. (2018a). Report on the Housing Statistics in EU-27 [Online]. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Housing_statistics#Type_of_dwelling [Accessed on January 2021]
- [52] Gulotta, T. M., Cellura, M., Guarino, F., & Longo, S. (2021). A bottom-up harmonized energy-environmental models for Europe (BOHEEME): A case study on the thermal insulation of the EU-28 building stock. *Energy and Buildings*, 231. <https://doi.org/10.1016/j.enbuild.2020.110584>
- [53] Eurostat. (2018). Distribution of population by degree or urbanisation, dwelling type and income group - EU-SILC survey [Online]. Available at: https://ec.europa.eu/eurostat/databrowser/view/ilc_lvho01/settings_2/table?lang=en [Accessed on January 2021]
- [54] European Commission. (2019b). Clean energy for all Europeans package completed: good for consumers, good for growth and jobs, and good for the planet. https://ec.europa.eu/info/news/clean-energy-all-europeans-package-completed-good-consumers-good-growth-and-jobs-and-good-planet-2019-may-22_en accessed on 09/01/2020
- [55] Statistical Office of North Cyprus. (2019). Annual Statistical Report: Population and Housing Census of Northern Cyprus. [Online]. Available at: <http://www.stat.gov.ct.tr/IST-YIL-2019.aspx> [Accessed: February 2021].
- [56] Statistical Service of Republic of Cyprus. (2019) Latest Figures: Results of the Census of Population, 2011 [Online.] Available at: http://www.mof.gov.cy/mof/cystat/statistics.nsf/index_gr/index_gr?OpenDocument [Accessed on 21/01/2021].
- [57] Statistical Office of Republic of Cyprus. (2019). Annual Report of Population and Housing Census [Online]. Available at: [https://www.mof.gov.cy/mof/cystat/statistics.nsf/All/6C25304C1E70C304C2257833003432B3/\\$file/Demographic_Statistics_Results-2019-EN-301120.pdf?OpenElement](https://www.mof.gov.cy/mof/cystat/statistics.nsf/All/6C25304C1E70C304C2257833003432B3/$file/Demographic_Statistics_Results-2019-EN-301120.pdf?OpenElement) [Accessed: February 2021].
- [58] Statistical Office of North Cyprus. (2020). Building Construction Statistics [Online]. Available at: <http://www.stat.gov.ct.tr/IST-YIL-2019.aspx> [Accessed: February 2021].
- [59] Ghosh, B. N., & Aker, S. L. (2006). Future of North Cyprus: An economic-strategic appraisal. *Futures*, 38(9), 1089–1102. <https://doi.org/10.1016/j.futures.2006.02.013>.
- [60] Fang, Y., & Zhao, L. (2022). Assessing the environmental benefits of urban ventilation corridors: A case study in Hefei, China. *Building and Environment*, 212. <https://doi.org/10.1016/j.buildenv.2022.108810>

- [61] Chen, X., Lin, C., Hou, X., Xiong, J., Wu, Z., Yan, G., & Wang, S. (2022). Spatiotemporal differences in pond evolution under different regional development patterns: A remote sensing-based perspective. *Journal of Cleaner Production*, 359. <https://doi.org/10.1016/j.jclepro.2022.132129>
- [62] Amoruso, F. M., Sonn, M. H., & Schuetze, T. (2022). Carbon-neutral building renovation potential with passive house-certified components: Applications for an exemplary apartment building in the Republic of Korea. *Building and Environment*, 215. <https://doi.org/10.1016/j.buildenv.2022.108986>
- [63] Doorga, J. R. S., Rughooputh, S. D. D. V., Chung, S. Y., & McGivern, A. (2022). A geospatial approach for addressing long-term solid waste management issues: Extracting value from waste. *Journal of Cleaner Production*, 334. <https://doi.org/10.1016/j.jclepro.2021.130282>
- [64] Fischer, E., Detommaso, M., Martinico, F., Nocera, F., & Costanzo, V. (2022). A risk index for assessing heat stress mitigation strategies. An application in the Mediterranean context. *Journal of Cleaner Production*, 346. <https://doi.org/10.1016/j.jclepro.2022.131210>
- [65] Gao, Y., Zhao, J., & Yu, K. (2022). Effects of block morphology on the surface thermal environment and the corresponding planning strategy using the geographically weighted regression model. *Building and Environment*, 216. <https://doi.org/10.1016/j.buildenv.2022.109037>
- [66] Kebede, Y. S., Alene, M. M., & Endalemaw, N. T. (2021). Urban landfill investigation for managing the negative impact of solid waste on environment using geospatial technique. A case study of Assosa town, Ethiopia. *Environmental Challenges*, 4. <https://doi.org/10.1016/j.envc.2021.100103>
- [67] Liu, W., Qian, Y., Yao, L., Feng, Q., Engel, B. A., Chen, W., & Yu, T. (2022). Identifying city-scale potential and priority areas for retrofitting green roofs and assessing their runoff reduction effectiveness in urban functional zones. *Journal of Cleaner Production*, 332. <https://doi.org/10.1016/j.jclepro.2021.130064>
- [68] Cusenza, M. A., Guarino, F., Longo, S., & Cellura, M. (2022). An integrated energy simulation and life cycle assessment to measure the operational and embodied energy of a Mediterranean net zero energy building. *Energy and Buildings*, 254. <https://doi.org/10.1016/j.enbuild.2021.111558>
- [69] Xu, Q., Shi, Y., Qian, L., Zhou, X., Wang, J., & Ke, L. (2022). Tiered ecological risk assessment combined with ecological scenarios for soil in abandoned industrial contaminated sites. *Journal of Cleaner Production*, 341. <https://doi.org/10.1016/j.jclepro.2022.130879>
- [70] Rao, Y., Zhang, J., Wang, K., & Jepsen, M. R. (2021). Understanding land use volatility and agglomeration in northern Southeast Asia. *Journal of Environmental Management*, 278. <https://doi.org/10.1016/j.jenvman.2020.111536>
- [71] Park, J. I., & Kim, J. O. (2022). Does industrial land sprawl matter in land productivity? A case study of industrial parks of South Korea. *Journal of Cleaner Production*, 334. <https://doi.org/10.1016/j.jclepro.2021.130209>
- [72] Nault, E., Waibel, C., Carmeliet, J., & Andersen, M. (2018). Development and test application of the UrbanSOLve decision-support prototype for early-stage neighborhood design. *Building and Environment*, 137, 58–72. <https://doi.org/10.1016/j.buildenv.2018.03.033>