



# City and campus: Exploring the distribution of socio-spatial activities of students of higher education institutes during the global pandemic

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## ABSTRACT

Cities with integrated university campuses can become dependent on their student population to function properly. Restrictions caused by the COVID-19 pandemic put a temporary halt to the presence of the student population in some cities. The current study explores this short-term paradigm shift on the relationship between three higher education institutes and their host cities in the northern part of Cyprus. The analysis uses the spatial distribution of Twitter feeds in the academic semester before the pandemic as the baseline and makes a comparison with the following semesters when the education was mostly done via online remote platforms. The findings indicate a rapid decline in diversity and granulation of urban activities among students during the pandemic. This, in turn, is shown to impact the commercial zones of the host cities, shifting many leisure activities farther from the city. Furthermore, the degree of spatial integration between the urban fabrics and the campuses is shown to be influential in rendering emerging equilibrium when facing a crisis that restricts mobility.

## 1. Introduction

Higher education institutes (HEI) have significant relationships with their host cities and vice versa. This co-dependency between the two makes the relationship highly influential in urban planning and policy-making (Goddard & Vallance, 2013). From a historic standpoint, many cities co-evolved with their associated university campuses (Burke, 2013). The advantages and disadvantages of this relationship, both in the long and short term, are points of debate in the related literature (Antiado et al., 2016; Matahir & Tang, 2017). Nevertheless, it cannot be denied that HEIs and the globalization of education have contributed to increasing attractiveness of cities and urbanization processes (Allinson, 2006). The students of HEIs are not mere visitors of the host cities; their extended periods of integration with the city make them an ongoing part of it. In addition, student life often is not limited to the campus spatial structure; rather, it extends to the city and beyond. Urban land use and amenities are often transformed to generate capital when addressing students' needs, redefining everyday life of the city in the process. Furthermore, the students' activities might affect other cities, sites, and amenities. Although there is an extensive body of literature on large-scale student mobility (Chan, 2012; Choudaha, 2017), their smaller scale interactions with spaces that are representative of everyday life of

the cities have remained understudied.

The global COVID-19 crisis introduced a paradigm shift to the relationship between society and space (Adey et al., 2021). Peoples' desires—their necessity—to interact with public space was able to overcome the initial spatial restrictions (Askarizad et al., 2021). Although the form of these interactions might be subject to transformation, their spatial existence is an intrinsic quality of urban life (Holloway & Hubbard, 2014). Here, the study used the global COVID-19 pandemic as an occasion to explore the changing dynamics of the relationship between students and urban HEI spatial structures. The pandemic forced educational activities to shift toward distance-learning methods, leaving many campuses largely deserted around the world. Accordingly, the current paper aims to explore the following hypothesis in three case studies within a two-year span: *The COVID-19 pandemic has significantly changed the relationship between HEI campuses and their host cities.*

Within the scope of this hypothesis, the study aims to address the following research questions:

- How did the spatial distribution of student activities change during the pandemic?
- Did the move to online education methods play a role in the relationship between campus and host city?

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- What was the extent of these transformations at the larger regional scale?

The study explores the plausibility of the hypothesis by comparing the pre-pandemic period (serving as a baseline) with the three subsequent semesters and the varying degrees of restrictions at HEIs. The study used geotagged Twitter data as indicators by targeting students of three HEIs in the northern part of Cyprus.

### 1.1. Host cities, campuses, and students

Cities are complex multi-layered, multi-functional, and interconnected structures containing the various dimensions of everyday life. The seminal work of Jacobs (1961) identified cities as *problems of organized complexity*, constantly evolving to address the emerging social, spatial, cultural, and economic dimensions of human life. Urban university campuses and student populations are a part of this contextual complexity. They bring capital, culture, lifestyle, and a youth cohort to their host cities, encouraging incremental changes (Meusbürger et al., 2018).

The student population is transient by nature. In a unique way, while it is not permanent, also it is not short-lived. Most undergraduate programs require four years of study. This period does not fit into the traditional definition of tourism or edu-tourism, nor does it fit within the parameters of long-term residency. The significant period of time students spend in a city for their schooling makes them a part of the context. This is not a passive or observational period; rather, students are an active part of the everyday life of the host city. Prazeres (2018) showed how students develop a sense of belonging in the host cities, considering themselves as insiders, not tourists. The peculiarity with an urban student population is the fact that despite their temporary status, they attempt to interact, personalize, and make the city their home (Ghosh & Wang, 2003; Waters & Leung, 2013). Students' successful interactions with urban spaces increase the sense of belonging and elevate the relationship between the city and its campus (Wilkinson & Badwan, 2021). In general, it is expected for students of HEIs to gain independence, experience life, and broaden their perspectives via this temporary residency. This process, however, might be different from non-student daily life pushing against the status quo of the context (Dwyer et al., 2021). It has been argued that the student population is an integrated aspect of host cities and must not be seen, or analysed, as an independent social group (Collins, 2008). The host city, consequently, goes through incremental changes to address the demands of the student population. This has been shown to be influential on urban morphology and growth (Ho, 2014; Önal et al., 1999).

Students of HEIs bring significant capital to the host city. This capital often facilitates development that is more oriented toward serving the campus. The urban experience along with weather, culture, and natural environment are significant attractors influencing the student's choice of university destination (Llewellyn-Smith & McCabe, 2008). Accordingly, the educational experience is not contained on campus; the city itself is a part of the image of any HEI and vice versa (Roostika, 2017). The desire for the urban experience, in turn, motivates many students to seek housing outside the campus. Demand for off-campus accommodations has the potential to change the socio-spatial urban fabric of the host city (Hubbard, 2009). This *studentification* process increases the density of the student population in clusters around the campus and pushes residential units for locals away (Allinson, 2006). The studentification of urban spaces could become a source of gentrification and financial segregation (Smith & Hubbard, 2014); inflation of rent in proximity to the campus could force (or motivate) the local population to relocate (Revington & August, 2019). Nevertheless, this is not always the case; Malet Calvo (2017) showed that proper distribution of student accommodations can bring positive culture and diversity to the city.

### 1.2. Student populations during the global pandemic

The global pandemic of 2020 highlighted the importance of building flexible educational methods suitable for responding to emerging crises (Rashid & Yadav, 2020). For most HEIs around the world, this flexibility manifested as virtual classrooms and distance learning (Daniel, 2020). However, higher education is more than an academic curriculum; to some extent, it is a lifestyle that extends beyond the classroom (Jamieson et al., 2005). Peer learning and social interactions are aspects of a hidden curriculum that are as significant as the transfer of knowledge (Margolis, 2001). In most cases (albeit not for the lab-based or field-based courses), the classroom curriculum could be transferred into a digital space. That said, the virtual classroom is a poor substitute for peer learning, the campus atmosphere, and social interactions. The physical spaces of campus and city encourage and facilitate experiential learning. The socio-spatial structure of the host city is where most non-academic learning transpires. Accordingly, the spatial restrictions induced by COVID-19 negatively affected not only the city but also the students' educational experiences.

The spatial restrictions utilized to mitigate the spread of the pandemic particularly changed the mobility patterns of international students, which alone was a positively anticipated life experience a year before. COVID-19 turned mobility into a source of potential danger and uncertainty (Cairns et al., 2021). Although some international students took the chance to travel home and continue their education online while local students stayed home from campus for the online period, a significant portion of international students were stranded and unable to leave. Correspondingly, the stranded ones also were unable to take part in campus life (Bilecen, 2020). Significant increases in loneliness and deterioration of socio-spatial interactions were some of the temporary consequences of this event (Alan et al., 2020; Conrad et al., 2021). All of the non-pharmaceutical measures against COVID-19 have socio-spatial dimensions—calling for more isolation, keeping distanced, and avoiding crowded places. These measures changed peoples' daily movements and consequently the daily life of the city (Jensen, 2021; Salazar, 2021). The push for virtual classrooms (albeit temporarily effective as a pandemic control measure) made the campuses and the host cities less vital (Valizadeh & Iranmanesh, 2021). Therefore, it is advantageous for this critical period to be used for deliberating the socio-spatial relationships between cities and campuses.

### 1.3. Reading urban complexities via social media

Regardless of the pandemic, the contemporary city had already faced a paradigm shift in the past two decades. The integration of mobile devices and increasing accessibility to the Internet forged a new layer on the existing complexity of cities. This emerging layer is still in the process of becoming and needs to be integrated into more studies that consider socio-spatial relationships. In light of the recent development of WEB 2.0, the digital and physical city can no longer be considered separable entities. This is, in part, due to the integration of geo-located metadata into the Internet (Jiang & Miao, 2015).

The availability of the social media data produced in platforms such as Twitter makes it possible for nuanced studies to unveil developing urban patterns (Arribas-Bel et al., 2015). Location-based social networking data has been shown to render an accurate and comprehensive reading of human mobility, socio-spatial interactions, land use, and behavioural patterns in dense urban environments (Chen et al., 2019; García-Palomares et al., 2018; Martín et al., 2019). Although Twitter data is limited and cannot be considered representative of the entire city population, it has been shown to be a reliable sample for reading movement across urban spaces (Osorio-Arjona & García-Palomares, 2019). The diversity of the data makes it invaluable for bringing insights to the reality of today's urban spaces (Doran et al., 2013). The effectiveness of social media is not limited to research and planning, but small businesses and individuals can benefit from it for conducting more

informed interactions with their cities (Tasse & Hong, 2017).

Furthermore, the profiles of higher education students, who are often well versed in the uses of social media and are frequent users of it, make location-based social media data a viable tool for exploring their relationships with their campuses and host cities. Twitter data, which is used in this study, has the potential of providing insights into the users' experiences concerning urban spaces, including user profiles, locations, and temporal signatures. As Yuan et al. (2020) wrote, metadata can reveal the 'who, where, when, and what' of urban social-spatial activity. The use of this data in addressing crises has precedent in the literature, especially regarding scenarios in which other data types are scarce or unavailable (Cervone et al., 2017; Shelton et al., 2014).

**2. Materials and methods**

To test the hypothesis and address the research questions, a comparative study was conducted targeting three major HEIs (Near East University: NEU, Girne American University: GAU, and Eastern Mediterranean University: EMU) in three major cities in the northern part of

Cyprus (Fig. 1). Although the political sovereignty of the region is not recognized internationally, the HEIs of the region have become major destinations for international students (Alipour et al., 2020; Kenfack & Öztüren, 2021). The region is a desirable choice for students due to a variety of environmental, economic, accessibility, and socio-political reasons (Abubakar et al., 2014; Mehtap-Smadi & Hashemipour, 2011). The selected cases are the largest HEIs in their respective host cities.

The COVID-19 pandemic became a serious concern on the island in February 2020. All gatherings and face-to-face educational activities came to an abrupt stop in early March. The closure of borders and mobility restrictions in the northern part of the island saw the number of cases drop to zero in June 2020 (Iranmanesh & Alpar Atun, 2020a). Nevertheless, upon reopening of borders, the pandemic reappeared locally, and with it, mobility restrictions and distance education recommenced. Among the limitations that such a crisis imposes on research is the difficulty of obtaining reliable data. To overcome this challenge, the study monitored and collected available geotagged Twitter data since it has been shown to be a reasonably reliable source for addressing socio-spatial interactions with urban spaces.

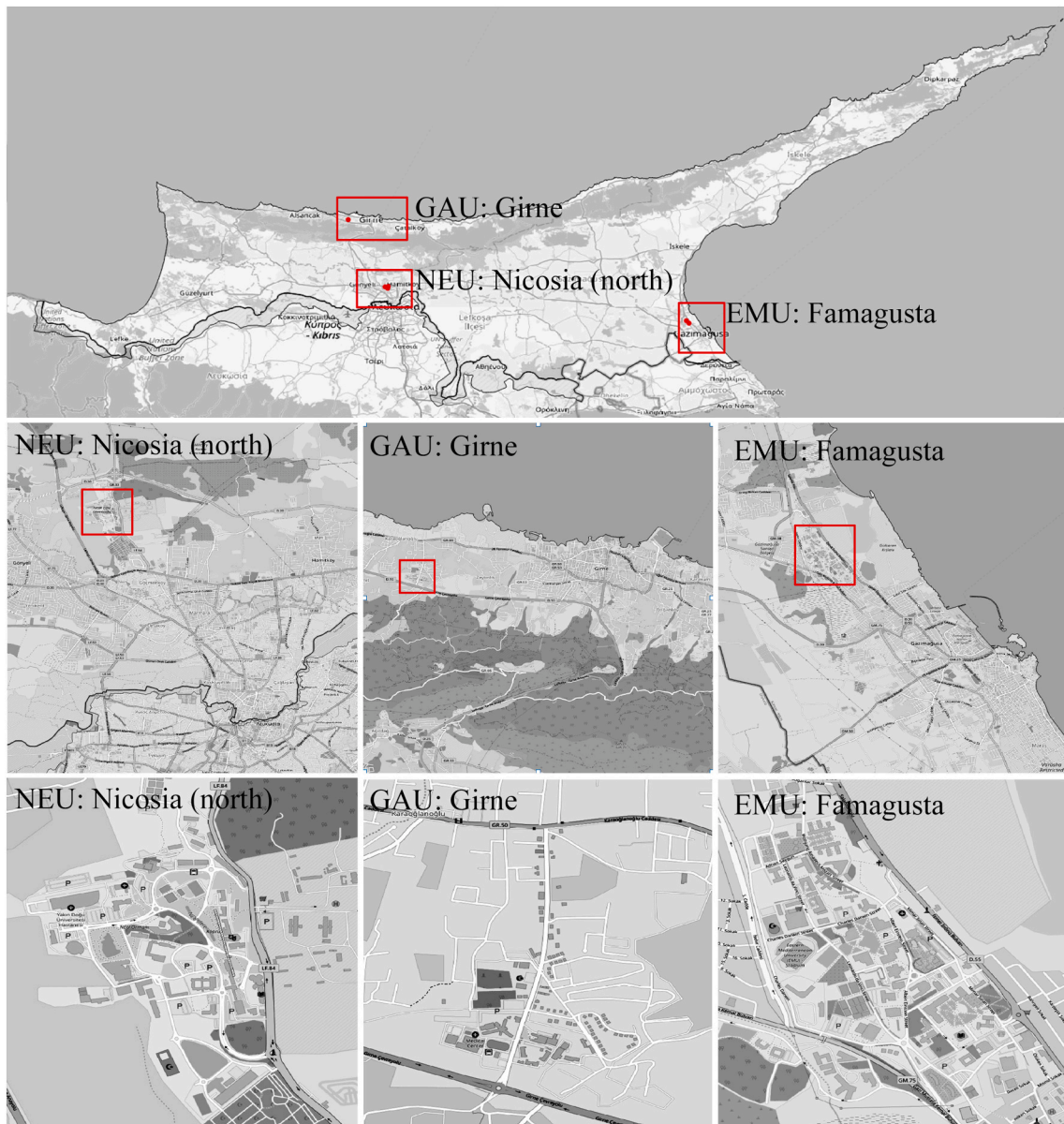


Fig. 1. Location of the three campuses in their host cities.

Different platforms are better for different studies depending on their openness, popularity, and type of use (Gao & Lee, 2017). Geotagged Twitter data was utilized for this study due to its widespread and manageable public content and the platform's friendly approach toward research (Twitter., 2021a). NodeXL software was used to collect the data (Hansen et al., 2010). One challenging aspect of this data collection was identifying active students of the selected institutes who have geotagged tweets from before and during the pandemic. Considering the small portion of tweets available at Twitter's public API, an even smaller number of tweets include precise geotagged metadata (Haffner et al., 2018; Kumar et al., 2014). Coupled with the temporal and student status conditions, this limited the potential target users. The student status of the users was determined based on tweets geo-located at dormitories before the pandemic, checking into classes and exams, and user age range. The method worked in this case due to the small number of users who met all criteria (NEU: 64 users, GAU: 48 users, and EMU: 56 users) (also see Córdoba et al., 2021).

The study only used the data that was publicly available. The data collection was conducted remotely following the Twitter Privacy Policy, which indicates the public nature of the tweets and the possibility of voluntarily sharing location metadata (Twitter., 2021b). The Twitter handles were removed from the collected dataset, making the data presented in this paper anonymous. Similar utilization of geotagged Twitter data has a strong precedent in emerging urban literature (Córdoba et al., 2021; García-Palomares et al., 2018; Khan et al., 2020; Martín et al., 2019; Osorio-Arjona & García-Palomares, 2019). It must be noted that the study does not advocate that this sample is a homogeneous representation of all students; it might be subject to some biases but it remains within the specified criteria for the study. Furthermore, selecting for this target group has reduced the risk of including irrelevant data points in the final dataset.

Tweets were collected from the final target group within the restrictions imposed by the Twitter API (limited to 1800 historic tweets per handle). The collected data was separated into four timeframes. First is the pre-pandemic semester (Fall 2019–2020), which serves as a baseline for normal student activities. Second is the beginning of the pandemic, which included the halt of face-to-face education in March and was followed by strict movement restrictions (Spring 2019–2020 semester). Third is the fall semester of 2020–2021 when different approaches such as attempts at re-opening and hybrid classrooms were explored by the different institutes. Fourth is the spring semester of 2020–2021 when the number of COVID-19 cases had increased and all educational activities returned to distance education (Fig. 2: left). In these cases, the dataset shows that the number of geotagged tweets declined each semester as the outdoor activities became limited and less interactive (Huang et al., 2020; Iranmanesh & Alpar Atun, 2021). This decline appears only in the number of geotagged tweets that are linked with outdoor urban spaces and it does not account for all tweets (Iranmanesh & Alpar Atun, 2020c).

In aiming to understand the spatial distribution of the data points, Kernel Density Estimated (KDE) was produced for the four timeframes in each of the three cities (Fig. 3). KDE is used to render a smooth gradient representation of the point data density (Silverman, 1986). It is a density function, and it is used to report the spatial distribution of the collected data in this case. The method, also referred to as heat mapping, has a significant presence in urban and geographical studies (Thurstain-Goodwin & Unwin, 2000) and in interpretation of the spatial dimensions of Twitter data (Iranmanesh et al., 2021; Wu et al., 2018).

The raw output reveals that the extent of spatial distribution loses its granularity and condenses around a few select locations: open public spaces, beaches, places of worship, and university dormitories. This output was further investigated by analysing the content of tweets. All tweets that were linked to a land use were counted (see Lansley & Longley, 2016). These tweets often have check-in metadata or start with 'I'm at' followed by a specific location. Commercial activities account for more than 40 % of all tweets before the pandemic (baseline: Fall

2019–2020 Semester) and show a rapid decline during the two following semesters (Fig. 2: right). The spring semester of 2020–2021, however, shows a gradual return to the baseline ratio. Interestingly, this recovery seems to be more rapid in cities that are less dependent on their student populations (Girne and Nicosia). Famagusta, which has a larger proportion of student population, shows weaker signs of returning to baseline. These results mean that the main hypothesis cannot be rejected. Accordingly, the study proceeded to explore the research questions in more detail.

The range of spatial distribution was further analysed using the Nearest Neighbour Analysis index (NNA). NNA measures the average distances to the closest points (mean distance) and compares them with the maximum spatial distribution (expected distance). The outcome is a number ranging from 0 representing maximum clustering (when all the points overlay) to 1 representing the maximum randomness (Li et al., 2017). The method has precedent in the literature for analysing clusters of social media point data (Lee et al., 2015; Su et al., 2020). In these cases, the most dominant change occurred in the fourth timeframe when all educational activities were entirely performed as distance education. Furthermore, the successful implementation of measures against the spread of COVID-19 in the spring semester of 2019–2020, which saw the number of new COVID-19 cases reach 0 for a short time in June 2020. However, NNA is influenced by the concentration of tweets associated with a few urban hotspots (public places, restaurants with outdoor sitting areas, etc.). Hence, the data must be cross-referenced with the KDE that shows a different pattern in terms of the declining variety of smaller points of interest. For this purpose, KDEs were cross-referenced with and evaluated against NNAs.

The generated KDEs were compared with each other via a simple linear regression mainly to see how well the datasets in the later timeframes may be predicted by the baseline. The result shows a variety of patterns (Table 1). In general, the predictability of the spatial distribution of geotagged Twitter data by the baseline (pre-pandemic semester) drops each semester following emergence of the pandemic. In Table 1, the pre-pandemic semester (Fall 2019–2020) is considered as a baseline and the predictability of the following semesters' KDEs represent the changes in the spatial distribution of Twitter data. According to the cross-referencing in the correlation table, KDEs and the NNA reveal two influential factors in the transformation of these interactions over time: spatial integrations of the campus with its host city and the manner of teaching approach during the pandemic.

### 2.1. Relationships between host cities and their campuses

Previous analysis points to the fact that each of the selected cases has a unique spatial relationship with its host city. This uniqueness in the relationship has precedent in the literature (den Heijer & Curvelo Magdaniel, 2018; Gumprecht, 2008). Accordingly, the nature of the relationship between the campus and the spatial structure of its host city as a potential critical indicator needed further analysis.

To explore the nature of this relationship, the study further explored the relationship between commercial land use and Twitter data. The commercial land-use data was collected using Open Street Map (OSM), which provides reasonable accuracy and has precedent in the literature (Brovelli & Zamboni, 2018; Iranmanesh & Alpar Atun, 2020b; Jökar Arsanjani & Vaz, 2015). KDE was generated for the commercial land-use data (Fig. 4). The correlation coefficient between commercial KDE and Twitter KDE was explored for the four timeframes in all case studies (Fig. 5). It is evident that Famagusta, which has the highest proportion of student population to locals, saw the most rapid decline in the correlation between the spatial distribution of tweets and commercial activities. In Girne and Nicosia, this decline is less dominant and slowing down. This also aligns with the aforementioned decline and recovery in the proportion of commercial activities. However, although the ratio of commercial tweets seems to be rapidly recovering to the baseline, the spatial distribution of commercial tweets shows a slower tendency

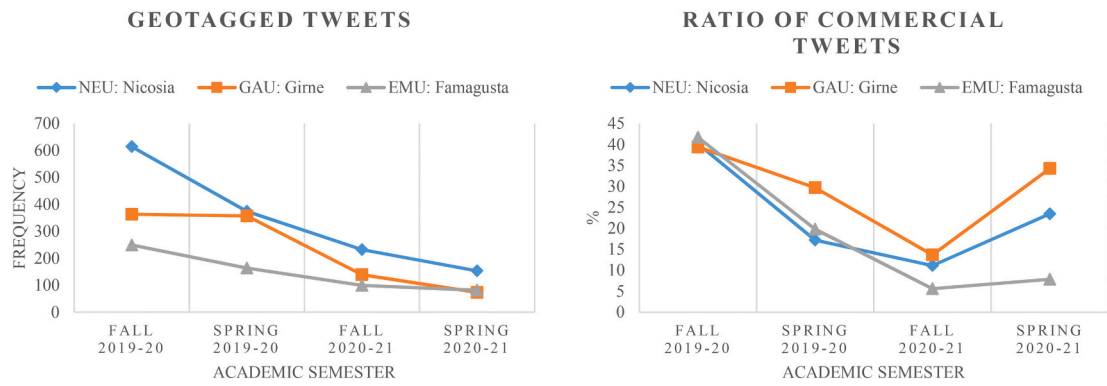


Fig. 2. Left: the overall number of collected geotagged tweets from the final target group for the three case studies and four timeframes, right: the ratio of geotagged commercial tweets to all geotagged tweets.

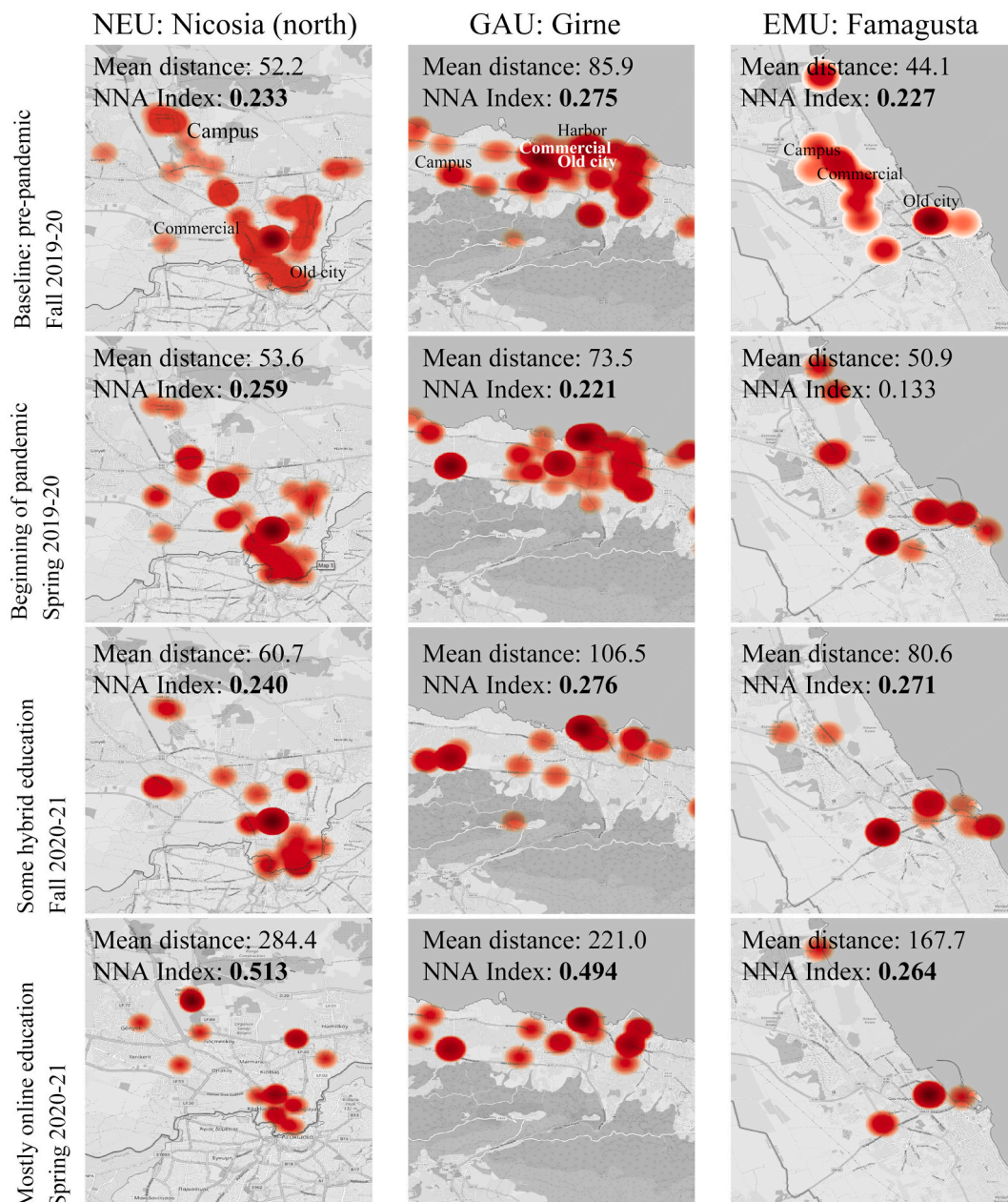


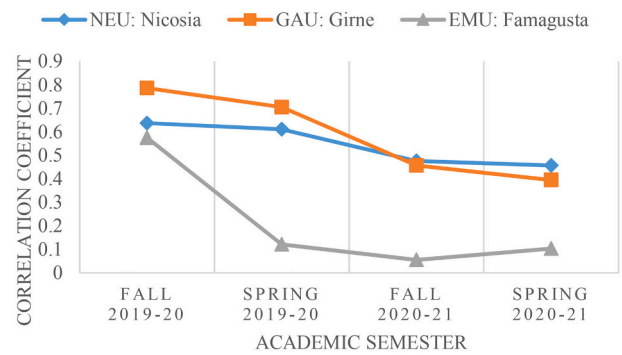
Fig. 3. The spatial distribution of geotagged tweets in four timeframes was represented via KDE with 500 m bandwidth.

**Table 1**  
Predictability of selected timeframes with one another for the three cases.

		Fall 2019–20	Spring 2019–20	Fall 2020–21	Spring 2020–21
		Baseline: before the pandemic	Beginning of the pandemic	Hybrid education systems, fewer restrictions	Fully online education
NEU Nicosia	Fall 2019–20		0.776**	0.564*	0.152*
	Spring 2019–20	0.776**		0.318*	0.14
	Fall 2020–21	0.564*	0.318*		0.082
	Spring 2020–21	0.152*	0.14	0.082	
GAU Girne	Fall 2019–20		0.335**	0.329*	0.307*
	Spring 2019–20	0.335**		0.858**	0.686**
	Fall 2020–21	0.329*	0.858**		0.868**
	Spring 2020–21	0.307*	0.686**	0.868**	
EMU Famagusta	Fall 2019–20		0.339*	0.245*	0.381*
	Spring 2019–20	0.339*		0.911**	0.725**
	Fall 2020–21	0.245*	0.911**		0.709**
	Spring 2020–21	0.381*	0.725**	0.709**	

\*\* Correlation is significant at 0.01.  
\* Correlation is significant at 0.05.

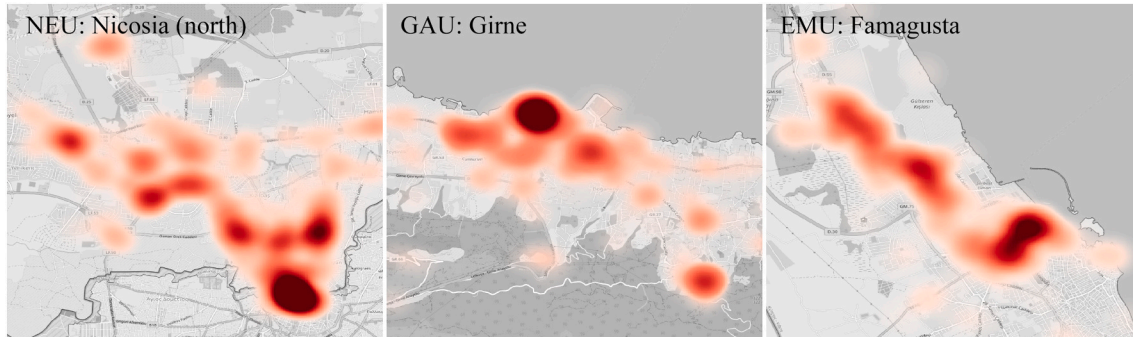
### GEOTAGGED TWEETS VS COMMERCIAL LAND USE



**Fig. 5.** The correlation between the spatial distribution of geotagged tweets and commercial land use.

closest main road for each case as well as the availability of public transportation services<sup>1</sup> (see Figs. 1 and 4). Although public transportation is available from each campus at regular intervals, pedestrian accessibility seemed to play a significant role in how students engaged with the city. The isolated characteristic of the university campus in this case, might be a desirable characteristic when facing a viral pandemic since it is more practical for quarantining and self-isolation in case of an outbreak. However, in terms of micro-economic activities, lack of integration with urban grid might not contribute to the everyday life of the city or its inhabitants who have come to rely on the student population.

GAU shows some walkable interaction with the urban fabric, however, it is also far from the urban core (see Fig. 1). Similar to NEU, the



**Fig. 4.** The spatial distribution of commercial land use extracted from OSM.

toward full recovery.

The degree of similarity between the studied semesters' KDEs remained the highest for the three cases as long as some face-to-face educational activities remained active (NEU and GAU during the first three timeframes). The similarity dropped significantly in the fourth semester when the majority of educational activities were transferred to distance learning platforms.

NEU is the most isolated campus of the cases; it is outside the city and there is an approximate 2 km distance to the closest city road. Hence, NEU's location does not facilitate easy travel to other parts of the urban fabric. It resembles a satellite college town with plenty of amenities and accommodations within the campus.

The study investigated the distance between the city centre and the

two major consistent points of interest seem to be the campus and the old part of the city (which in the case of Girne is the public harbour). The historic parts are active pastime and pedestrian destinations in all three cases. Furthermore, the reduction of tourists during the pandemic made many of these areas less crowded and more desirable for locals (see Koh, 2020). The other less dominant and less central urban spaces arose less frequently in the dataset during the pandemic. Interestingly, the correlations table shows that, in these cases, although the post-pandemic semesters cannot be sufficiently predicted by the baseline, they are highly correlated with one another.

Among the cases, EMU seems to be the most pedestrian-friendly and its campus is the most integrated with the city. Furthermore, EMU had the clearest restrictions in transitioning to distance education.

<sup>1</sup> NEU: <https://bus.neu.edu.tr/index-en.html>; GAU: [https://www.gau.edu.tr/en/services/bus\\_shuttle\\_service](https://www.gau.edu.tr/en/services/bus_shuttle_service); EMU: <https://transportation.emu.edu.tr/en/bus-services>.

Consequently, its KDEs for the second through fourth semesters show the most significant changes when compared with the baseline data for Famagusta. The variations in the data cannot be explained only by spatial integration; therefore, the study must also consider the academic approaches.

### 2.2. Approach toward teaching practice during the pandemic

Although the intimidating rise of COVID-19 cases forced all educational activities on the island to online platforms during the second semester of the study (Iranmanesh & Onur, 2021), not all schools followed this process in the subsequent fall and spring semesters of 2020–2021. As the cases in the north part of the island dropped to zero in June 2020 (Iranmanesh & Alpar Atun, 2020a), many schools and their affiliated businesses moved toward reopening. Ultimately, this was not entirely possible due to the limitations at borders, the global restrictions, and worried parents who did not want their youth to travel under such conditions. Accordingly, NEU and GAU conducted a hybrid method in which both online and face-to-face attendance to classes were made available to the students. Meanwhile, EMU followed an online-only method after the March 2020 outbreak and continued the same practice in both the fall and spring semesters of 2020–2021. This distinction shows itself in the data as well. The higher predictability of the second semester with the baseline semester for NEU and GUA could be explained by the higher number of tweets coming from these campuses since they were partially open. It must be noted that no data regarding the proportion of physical attendance to virtual attendance were made available on the related HEIs' websites. Additionally, the study was unable to find a reliable source regarding the ratio between the students who remained on the island and those who returned home to continue with online education. Thus, the results of this study are based on the selected target group that was present on the island before and during the pandemic.

### 2.3. Mobility across the island

The scope of interactions and movements of the students were not limited to their campuses or host cities. The data shows a vibrant and complex relationship of target users in various parts of the island according to their geotagged tweets. Consequently, the study further investigated these interactions. First, the data tagged inside the host city was contrasted with tweets geotagged outside the city. The municipal boundary of each city was used for this classification. Fig. 6 shows the relative percentage of inside versus outside tweets for each timeframe. The overall analysis reveals that the proportion of tweets coming from outside the city increased during the COVID-19 pandemic or rather that the tweets coming from inside the city declined in comparison.

However, these shifts seem to be dependent on the proximity of the cities on the regional scale. For instance, 42.3 % of all outside tweets coming from NEU students were tagged in Girne (26.7 km away) compared to just 10.1 % of tweets by EMU students in Girne (75.2 km away).

The study repeated the heat mapping for the island-scale analysis. In this step, a 5 km bandwidth was used to generate the heat maps (Fig. 7). It is clear that the range of movement for the student population is not limited to their local areas and extends into the other parts of the region including other cities, rural areas, parks, beaches, and other points of interest. Although tweets coming from outside the city do not account for the majority, they might be significant for addressing tourism and destination management policies. Unlike for the city-scale analysis, at the regional scale NNA variation renders a clearer image, indicating that the range of movement was limited at the beginning of the pandemic—due to the limitations imposed on movement between cities—and was followed by a relaxing of intercity restrictions and increased mobility in the third and fourth timeframes.

This is not the case for all three cases. The NNA index indicates that the centrality of the city in the region could be influential in the spatial distribution of tweets. The NNA has the most significant increase for the furthest separated city (EMU: Famagusta), revealing that students' internal activities were overridden by students' external activities. This NNA increase is followed by Girne's, which, to some extent, may be caused by the centralization of activities and services in Nicosia.

### 3. Discussion

In the past two decades, social media—and Twitter in most cases—has shown to be a significant influencer in planning and policy-making processes (Mossberger et al., 2013). The utilization of these platforms is a part of the natural evolution of city management (Gao & Lee, 2017). In this study, the pandemic was a timeframe when field collection of spatial data became impractical due to the measures mitigating the spread of COVID-19. Although these limitations also limited the number of active students present in the host cities, the outcome of analysis using the social media metadata is shown to be potentially insightful in reading urban spaces during a time of crisis (Chen et al., 2020). The transparency, accessibility, and expansion of WEB 2.0 have created the possibility of consistent interactions regardless of spatial or temporal restrictions for who Bryer and Zavattaro (2011) called *omni-competent citizen[s]*. WEB 2.0 is enriching the possibility of being involved in urban issues.

Visualization and analysis of the data revealed different patterns for the three case studies though they belonged to the same region. Therefore, it can be argued that contextual spatial structures of HEIs and institutional approaches to life-changing events, such as pandemics, need to be explored with the specific characteristics of host cities in

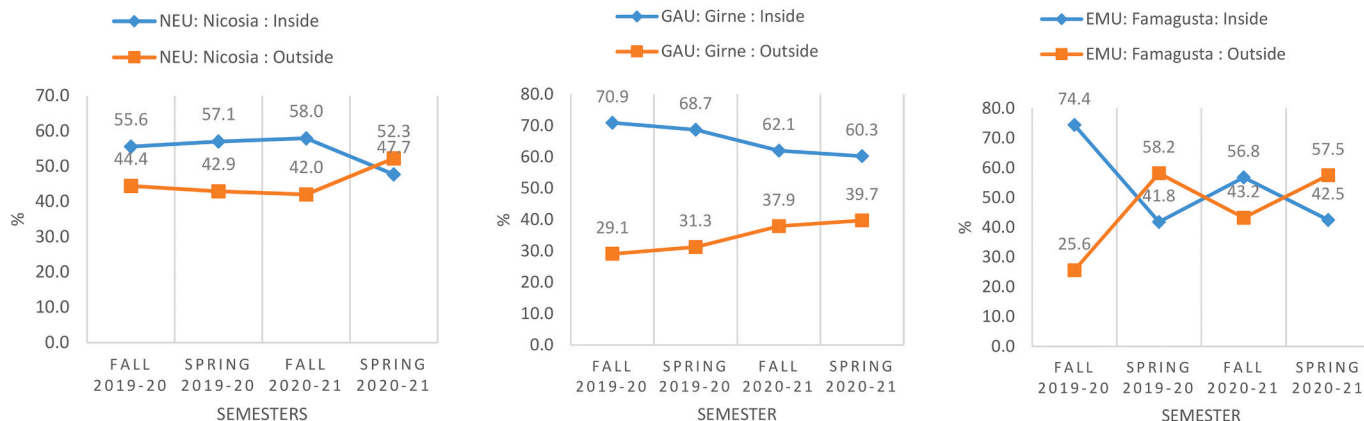


Fig. 6. Proportion of tweets geotagged inside versus outside the boundaries of the host city.

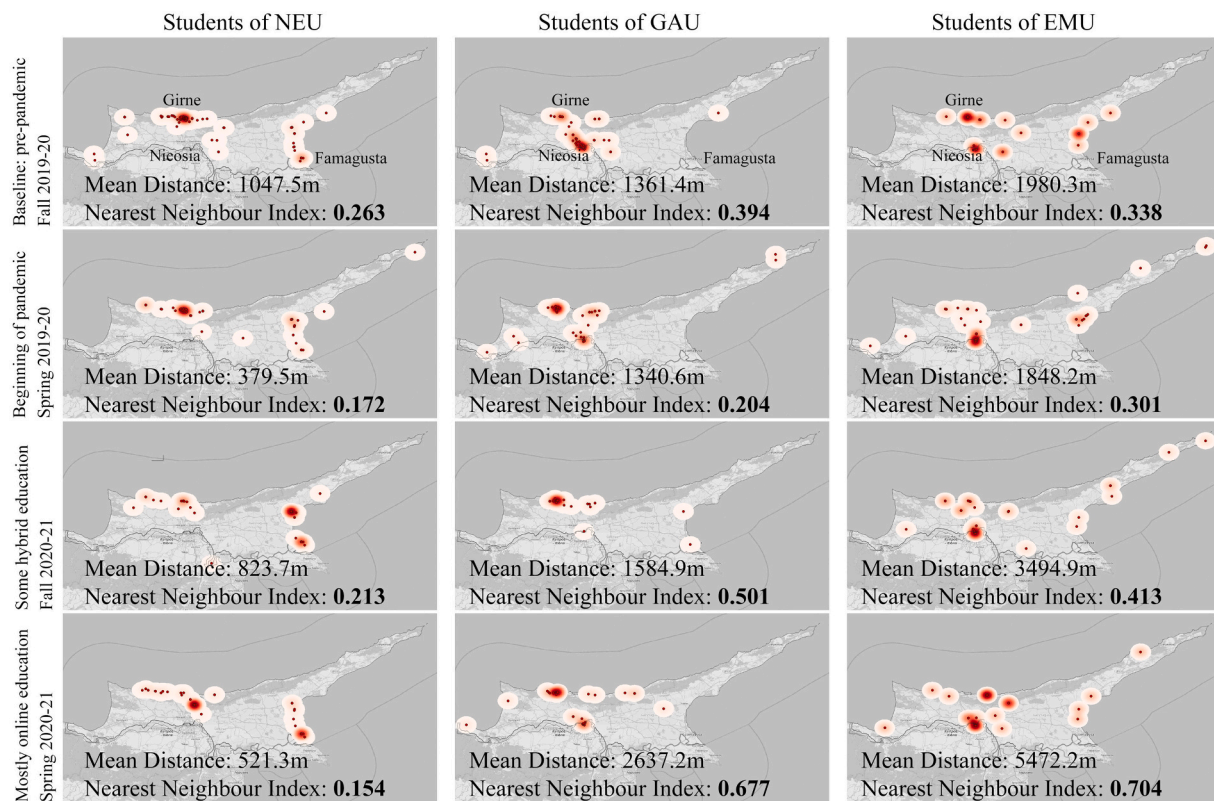


Fig. 7. The island-scale distribution of geotagged tweets returned from outside host cities (host city tweets are removed).

mind (also see [den Heijer & Curvelo Magdaniel, 2018](#)). In the case of Famagusta, for instance, geotagged commercial activities (i.e. going to cafes, restaurants, and shops) almost entirely disappeared at the onset of the pandemic, which seems to be related to the city's larger proportion of students and EMU's distinct approaches to online education. However, activities that could be mapped and remained relatively consistent throughout the four timeframes are those located in the historic parts of the cities and their public waterfronts (marked in [Fig. 3](#)).

Management and organizational approaches to higher education in a time of crisis also seem to be significant contributors to the spatial distribution of activities. In EMU cases where distance education was followed strictly throughout all timeframes, the least number of geotagged tweets was observed. In this case, geotagged tweets nearly disappeared from the campus and most commercial areas. However, the historic public areas and core of the city remained vital in all cases before and during the pandemic. The urban university campus has the potential to be a part of urban public space ([Gumprecht, 2007](#)). The temporal analysis, in this study, showed the potential susceptibility of an HEI campus as an urban public space during the COVID-19 crisis compared to more integrated public spaces of the city. This might be due to the minimization of previously prominent residential populations on campus (students) that made the campus appear deserted and undesirable as a public space destination. The core concept of city is built upon socio-spatial interactions ([Gehl, 2011](#); [Jacobs, 1961](#)), and this concept is similarly applicable to most urban HEIs. The abrupt transition to a world that frowned upon physical social interaction created a strange moment in contemporary urban discourse ([Freudental-Pedersen & Kesselring, 2021](#)).

Because the commercial activities in HEI host cities are closely tied to the student population, this relationship affects the land use ([Gumprecht, 2003, 2008](#); [Iranmanesh et al., 2021](#)) with the developers in the city often trying to gain the most profit from students' preferences ([Miessner, 2020](#)). The COVID-19 pandemic presented a research opportunity to explore the extent of this relationship.

The rapid decline in urban activity as observed via geotagged Twitter data was explored in four parts. First, the number of geotagged tweets declined precipitously as the circumstances of the pandemic unfolded. The target group was selected specifically from among those with geotagged metadata in all four timeframes. Nevertheless, the gradual decline in the number of Geotagged tweets appears to continue though at a slower rate. Second, the ratio of tweets relating to commercial land use declined after the pandemic and started to recover in the spring semester of 2020–2021; this indicates a potential tendency to restore the interactions to the baseline level. Third, the spatial distribution of tweets was observed to lose their diversity and granularity during the pandemic when compared to the baseline characteristics. In addition, the mean distance between tweets was observed to expand in all three cases during the pandemic. Forth, the correlation between land-use data and the distribution of commercial activities showed a gradual decline that now seems to be returning to baseline. This decline was more dominant in the smallest host city with a higher student proportion, and it was less dominant in the larger cities.

Moreover, the analysis of tweet distribution inside versus outside the host city showed the potential extent of students' interactions at a regional scale. Similar analysis might provide a perspective on the potential effects that an HEI can have on parts of its broader host region.

#### 4. Conclusion

Campuses of higher education institutes are closely tied to their host cities and peripherally tied to their host regions. The revolving populations that HEIs import are often highly motivated to expand their spatial movements into the host city and surrounding areas. The student population is transient by definition, but not by nature, meaning that students form strong bonds with their host city, influencing all dimensions of its daily life. This study tried to use the pandemic period as a point of comparison to explore three cities regarding the strength of the presence of their student populations. The original hypothesis 'The



COVID-19 pandemic has significantly changed the relationship between HEI campuses and their host cities' has shown to have significant merit. The findings suggest a rapid though temporary decline in the relationship between university campuses and host cities in the three cases during the COVID-19 pandemic.

The restrictions that were imposed on the cities, which aimed to mitigate the effects of the COVID-19 pandemic, brought many urban problems to the fore. Among these is the impact of HEI students' interactions on their host cities, which has been explored in this paper. The study used geotagged Twitter data to represent the students' interactions with the city during four different timeframes. These timeframes helped delineate the state of interactions before and during the pandemic. Furthermore, commercial land-use-related data was extracted from OSM and superimposed on the existing data layers. The analysis was conducted both on the city scale and on the larger regional scale. Kernel Density Estimation (KDE), Nearest Neighbour Analysis (NNA), and the correlation coefficient were used to explore the transformation of the collected data before and during the pandemic in the four consecutive timeframes.

The findings suggest that urban activities became less diverse and less frequent following the onset of the pandemic. This was not merely caused by the closure of urban functions since many of those functions reopened during the second timeframe. The common denominator among the three cases is the decreasing granularity of urban points of interest (as observed from geotagged tweets). Furthermore, the approach toward online teaching is a potential indicator of the pace of recovery toward baseline. The spatial distribution of tweets was less affected in cases with hybrid education models (NEU and GAU), and levels of urban interactions were less affected by the pandemic in their host cities compared to the case (EMU) that adopted a fully online model.

On the regional scale, results indicate the spread of outdoor activities (when movement was not restricted) into the countryside. In general, the granularity of longer movements did not decline. In two cases (NEU and EMU), the proportion of tweets coming from outside the city boundary outweighed the tweets from inside during the fourth timeframe. The expansion of the mean distance between tweets shows that the students found alternatives for pastime activities when city life became less active. This was further verified in the three cases by cross-referencing Twitter data with commercial land-use data. The city with a larger student to local resident ratio (EMU) showed a more rapid decline and incline in the correlation between commercial land use and the spatial distribution of tweets.

In this study, the geotagged Twitter data showed promising results for reading the density and spatial extent of activities before and during different stages of the pandemic. It is necessary to highlight that the findings tell a different story for each city. In this light, the materials and methods used in this study can be utilized to explore other cases.

#### 4.1. Limitations and future studies

Ultimately, it must be noted that Twitter data can contain some internal biases and inconsistencies such as heterogeneity in the representation of age, education, or socio-economic demographics among others (Longley & Adnan, 2016; Stephens & Poorthuis, 2015). While sampling biases are inevitable, the biases can be alleviated by identifying the target group (Yuan et al., 2020). In this paper, we thoroughly filtered the target group; thus, the criteria that were set for the data collection and the scope of the study targeting a specific student demographic helped mitigate some of these shortcomings. Nevertheless, the insights this study produced seem to be potentially useful for better understanding the complex relationship between HEI campuses and host cities. Future studies might look deeper at the content of the tweets to pinpoint the intentions and the precise type of relationship between the data and the urban space.

In terms of land use, the current study only explored commercial

activities in detail using content analysis and OSM. Future studies can expand the discussion by taking other layers of data such as census, official land-use maps, and public amenities into account.

#### CRedit authorship contribution statement

Both authors have equally contributed to the conceptualization and development of the final draft.

#### Declaration of competing interest

The authors declare that they have no competing interests. The authors are not affiliated with any of the higher education institutes mentioned in the study.

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