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Original article

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ABSTRACT

Thanks to the leading role of universities in cities as knowledge and innovation hubs, many cities rely on their universities to face their economic and social challenges. On the other hand, universities need their cities to fulfil the capacity needed to satisfy student and staff needs for services and facilities. Therefore, the university-city relationship is considered to be intercorrelated and overlapping. However, due to the need for expansion, universities tend to move out and build larger campuses causing different trends of studentification and de-studentification in the city. These trends impact a city's urban growth and transformation over time. This study analyses the impact of four different campuses of Kyushu University from 1993 to 2017 to understand the morphological impact of old and new campuses on their surroundings. A spacematrix and a mixed-use index were used to produce raster maps that helped to visualize temporal trends of urban density and the mixed use of functions in areas surrounding campuses. Results have shown that moved out campuses have the potential to impact the surrounding mixed use of functions. However, new campuses have the potential to impact a city's urban density, therefore, trends in de-studentification can impact the campus-city functional relationship. Conversely, studentification trends can impact the campus-city physical relationship. Thus, university campuses could be considered as indirect agents that contribute to the urban physical and functional change of the city.

KEY WORDS: Spacematrix, mixed-use index, urbanization, campus planning, urban agent

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1. Introduction

Universities are known to play a major role in harnessing innovation and knowledge in the local community of their respective cities. Therefore, the role of higher education institutions has changed to become the driving force of knowledge and innovation instead of being place-based institutions (PERRY ET AL., 2009). Moreover, due to the expansion and internationalisation of universities, new campuses are built which require new facilities and amenities to cover the capacity needed for students and staff. Therefore, university campuses are known to be accompanied by a physical and functional change in the surrounding environment. This is also why universities are described as being extensive landholders that can transform the surrounding built environment (LARKHAM, 2000). The relationship of the university campuses within the city could be defined as a physical or functional relationship (DEN HEIJER & MAGDANIEL, 2018). The campus-city physical relationship is described as the topological location of the campus according to the city and its impact on the surrounding built environment as campuses could exist outside the city, gated within the city, or integrated with it (MAGDANIEL ET AL., 2018). On the other hand, the campus-city functional relationship refers to the available types of services and facilities that the university and the city need to offer a successful partnership. Campuses and their respective cities can offer a wide range of services and amenities that range from academic services, residential facilities, infrastructure, leisure, and related businesses.

Both the campus-city physical and functional relationships are considered interconnected and overlapping. Hence, universities that are located near to the city benefit from a wide range of available services unlike self-sufficient autonomous campuses that depend on generating their own functional and social life (HEBBERT, 2018). This interrelated connection between universities and cities is considered to be an agent that accelerates urban physical and functional change based on the extent of the impact brough by the campus to the city (DEN HEIJER, 2011; BERG, 2021).

1.1. Studentification and de-studentification

Due to the influx of post-secondary students that is usually associated with the existence of university campuses, a noticeable change occurs which is known as studentification (Smith, 2005). Studentification also refers to the different social, physical, cultural and economic changes that are associated with the existence of student within neighbourhoods near the institution. Studentification can be seen through its social impact on the neighbourhood by the segregation that happens between original residents and students which results from the increased number of problems caused by students such as littering, noise or walking home drunk (MOSEY, 2017). On the other hand, studentification can also be seen in the cultural diversity caused by the existence of international students in the area (KURTULUS & GRIFFITHS, 2017). However, the physical and economic impacts of studentification are considered to be the most important due to their ability to transform the built environment in a visible way. As institutions can't fulfil the required capacity for student accommodation alone. Real estate agencies make use of the situation by building new apartments to cover student needs which in turn changes the physical structure of the surrounding area of campuses in a noticeable way (RUGG ET AL., 2000; MOOS ET AL., 2019). Moreover, the housing and amenity demands of students encourage different forms of economic variations in the area which in turn facilitates to the urbanization of the area (HE, 2014). Therefore, studentification is considered to be a by-product that accelerates city growth in different ways.

De-studentification is considered to be the opposite of studentification. However, the impact of de-studentification on the city is not necessarily the counter effect of studentification. Due to high land prices and the expansion of universities, new campuses are built, and universities move out from their old campuses which is followed by students emigrating from the area resulting in de-studentification. The impact of de-studentification appears first as an imbalance between housing supply and demand (KINTON ET AL., 2016). However, its impact might include other significant aspects such as closing businesses and restaurants that were specifically targeting students. Student areas are known to be preferred by students due to the wide variety of affordable services and amenities. Therefore, campuses relocating affect the economic atmosphere in the area. Moreover, the differences that result from the transition of a student area to a non-student area affects city's urban development by facilitating the usage of the surroundings of the old campus (DONALDSON ET AL., 2014). Moreover, the impact brought to the urban space from studentification is considered to be relative according to the location of the campus. For example, changes brought by studentification in Poland have proven to corrupt the public space (GRABKOWSKA & FRANKOWSKI, 2016). However, studentification that occurred in Australia has proven to positively affect a city's economy (HOLTON & MOUAT, 2020). Furthermore, student participation has also been shown to have a positive impact on safer public spaces if student's role in local communities is highlighted (MOHAMMED & HIRAI, 2021; SAYED, 2021). Therefore, the counter impact of de-studentification might also be positive or negative based on the context.

1.2. Research context

In order to examine the impact of studentification and de-studentification on a city's urban growth, this article conducts a morphological analysis of four different campuses of Kyushu University to visualise the impact of new and old campuses on the urban physical and functional change. By analysing the morphology of the surroundings of Kyushu University's new campus, the impact of studentification on the area can be reflected, whereas de-studentification can be examined through the impact resulting from the move-out process from Kyushu University's old campuses to the new one. By doing this, patterns of urban physical and functional change caused by university campuses could be assessed and visualised to provide an evidence-based validation of the role of universities as urban agents.

1.3. Research aim

Based on the hypothesis that university campuses play a significant role in city's urban transformation, this article aims to uncover the physical and functional impact brought by university campuses

on their respective cities. To validate the research hypothesis, two different objectives need to be achieved:

1) Assessing the impact of de-studentification by analysing the morphological and functional change in old campuses' surroundings.
2) Assessing the impact of studentification by analysing the morphological and functional change in new campuses' surroundings.

By doing so, a better understanding of the role of university campuses in city's urbanization could be reached. Moreover, new perspectives and lessons could be learned to come up with better decision making for a sustainable campus planning and development.

2. Urban growth of Fukuoka City

In order to understand the role of Kyushu University in the urban growth of Fukuoka City, the urban transformation of Fukuoka City needs to be highlighted. Fukuoka City is the capital of Kyushu Island and considered to be one of the major cities in Japan. According to its official website Fukuoka City has been through seven major phases since the 19th century which helped it to become the city that we know now (FUKUOKA MUNICIPAL ADMINISTRATION, 2019). These phases witnessed several events, incidents and mega projects that helped in forming the urban structure of the city:

1) 1st Phase (Birth of Fukuoka City): The birth of Fukuoka city was in July 1871 when the Fukuoka region officially became Fukuoka Prefecture. The city was born over an area of 5.09 km^2 and a population of 58,847 residents living in 9440 households (FUJITA & HILL, 1993).

2) 2nd Phase (Urbanization and Expansion): The second phase of Fukuoka city's urban growth started in 1924 when Kyushu Railroad Company opened a high-speed railroad between Fukuoka and Kurume which further enhanced public transport services in Fukuoka Prefecture. Moreover, different department stores started to open such as Matsuya and Iwataya. Furthermore, the beginning of the second phase of Fukuoka city's urban growth had a remarkable event which was the establishment of Kyushu Imperial University in 1911 (now Kyushu University) (FRÉDÉRIC, 2002).

3) 3rd Phase (Recovery from the Scorched Earth): Until the end of the second phase, Fukuoka city was growing fast and strong and urbanization had reached the city peripheries. However, on 19th June 1945, more than 200 B-29 aircrafts filled the sky of the city and a big part of it was destroyed by what was called the 'Fukuoka Great Air Raid'. After the raid, the city started to rebuild back gradually.

4) 4th Phase (Becoming the Core City of Kyushu Island): The fourth phase of the urban growth of the city started in 1972 when the city was designated by government ordinance (SHAPIRA ET AL., 1994). After that the ward system was enacted with five wards: Nishi, Higashi, Chuo, Hakata and Minami. In March 1975, the city officially became the core of Kyushu Island with the establishment of the Sanyo Shinkansen Line which connected Fukuoka city with the capital Tokyo in less than seven hours.

5) 5th Phase (An Evolving City): The fifth phase of city transformation witnessed a significant change in the urban landscape of the city similar to the urban change that occurred in the second phase before the air raid. However, the most remarkable change that happened in this phase was the end of the Fukuoka tram as it was replaced by the city's subway that opened in 1981. The new subway helped to transform the street network of the city. Therefore, the fifth phase of the city's growth had the biggest impact on the physical aspect of the urban form.

6) 6th Phase (From Showa to Heisei): The Heisei era started with new facilities and tall buildings such as Fukuoka Tower being built which contributed to the internationalisation of the city. In 2005, Kyushu University decided to move out from Hakozaki old campus and to build one of the largest campuses in Japan in Nishi Ward. The first school built in Ito campus was the Engineering School in 2005. Then, other schools moved one after another from Hakozaki campus and the move-out process was completed by 2018. Moreover, in 2009 Kyushu University's Ropponmatsu campus also moved out to Ito campus.

7) 7th Phase (From Reiwa to the Future): In 2018, the city witnessed a new era which was the Reiwa era that started with the new Emperor of Japan. With this new era, the city started to think globally by introducing new projects such as 'Tenjin Big Bang' and 'Hakata Connected' (FUKUOKA CITY GOVERNMENT, 2021a, 2021b). These projects aimed to transform the morphological structure of the core of the city after increasing the floor gross area 1.5 times.

Kyushu University played a significant role in the urban transformation process of Fukuoka City since its 2nd phase of growth. Moreover, in the 6th phase, Kyushu University's old and new campuses started to transform the city with emergent trends of studentification and de-studentification that had the potential to change the economic and morphological structure of the city as the link between universities and cities can pertain to physical, geo-political,

economic and cultural facets of the city (WIEWEL & PERRY, 2015; WAY, 2016; NAMVAR ET AL., 2019). Furthermore, the literature has shown that university campuses have a strong potential to contribute to the local economy; and universities have become seen not only as higher education institutions, but also as a mainstay for city transformation (RAUCH, 1993; GLAESER, 1998; SIMON, 1998; MATHUR, 2016; OXFORD ECONOMICS, 2017). Therefore, any trends of studentification and de-studentification caused by campuses moving in and out would considerably affect the surrounding environment which was worth investigating over a long period of time. Accordingly, Kyushu University has been considered to be a suitable case study due to its emergent trends of studentification and de-studentification and the unique role that it plays in its respective city. Therefore, different analytical methodologies have been used to examine the surroundings of Kyushu University's campuses to assess the extent of the impact that university campuses bring as agents for urban change.

3. Materials and methods

In order to analyse the morphological structure of the surroundings of Kyushu University campuses, two different indicators have been used to assess the morphological and functional change caused by the campuses: spacematrix and mixed-use index (MXI). Moreover, datasets for buildings around Kyushu University campuses from 1993 till 2017 have been provided by Fukuoka City Urban Affairs Bureau. The use of different morphological indicators and the availability of a wide range of data have made it possible to have a holistic overview of the morphological form of the areas around campuses since 1993. Table 1 illustrates the different materials and methods used in this paper in detail.

Table 1. Materials and methods

Method	Platform	Processed data			
		Data type	Data collection time	Data source	Data delivery
Spacematrix	ArcGIS	Footprint area and number of floors for buildings in 1.2 km radius buffer area around Kyushu University campuses	1993, 1998, 2003, 2008, 2012 and 2017	Fukuoka City Urban Affairs Bureau	Provided by request
Mixed-Use Index (MXI)		Footprint area and uses of buildings in 1.2 km radius buffer area around Kyushu University campuses			

3.1. Study area

Four different campuses of Kyushu University were selected for comparison of the different impacts of old and new campuses on the morphological structure of the surroundings (Table 2). Hakozaki campus, which is the oldest campus of Kyushu University, was established in 1911 and moved out to Ito campus in 2018. Ropponmatsu Campus, which is located near to the core of Fukuoka City, was established in 1921 and moved out to the new campus of Ito in 2009. By analysing the surroundings of Hakozaki and Ropponmatsu campuses from 1993 till 2017, patterns of the impact of de-studentification on the city could be visualised in two different stages of moving out: at the beginning of the move-out process such as in the Hakozaki campus area and after the move-out process in the Ropponmatsu campus area. On the other hand, Kyushu University's newest campus, Ito campus, was selected to visualise the impact of studentification caused by new campuses on the surroundings. Moreover, Ohashi campus was also selected for the analysis in order to study the socio-spatial temporal change around university campuses over a long period of time. By doing so, a holistic understanding of the morphological change around university campuses at different stages of studentification and de-studentification could be reached.

For the analysis, a 1.2 km radius buffer area around the campuses was selected. As 1.2 km is equal to a 15 minutes' walk; and students and staff would probably be interested in living within 15 minutes' walk from their campuses. Moreover, business owners and decision makers would also be interested in investing within 15 minutes' walk from campuses to gain more student foot traffic for their student-oriented businesses. Therefore, a 1.2 km radius buffer area was found to be suitable for the analysis (Fig. 1). Furthermore, building height and building use datasets from 1993 to 2017 were used for the analysis to map where and how the temporal change occurred over a 24-year period. Since 1985 Fukuoka City Urban Affairs Bureau conducts socio-economic surveys every five years

and these data were made available for researchers upon request in the year following the 5-year interval. These datasets have been analysed using two different urban morphology indicators: spacematrix and mixed-use index. By applying these methods, the temporal change in urban density and building functionalities could be visualized.

Table 2. A comparison of Kyushu University campuses

Info.	Hakozaki campus	Ropponmatsu campus	Ito campus	Ohashi campus
Campus model	Gated campus	Gated campus	Open campus	Gated campus
Location	Higashi Ward	Chuo Ward	Nishi Ward	Minami Ward
Area	627,430 m²	86,640 m²	2,717,130 m²	63,058 m²
No. of schools	7	1	9	1
Established	1911	1921	2005	1968
Moved-out	2018	2009	-----	-----

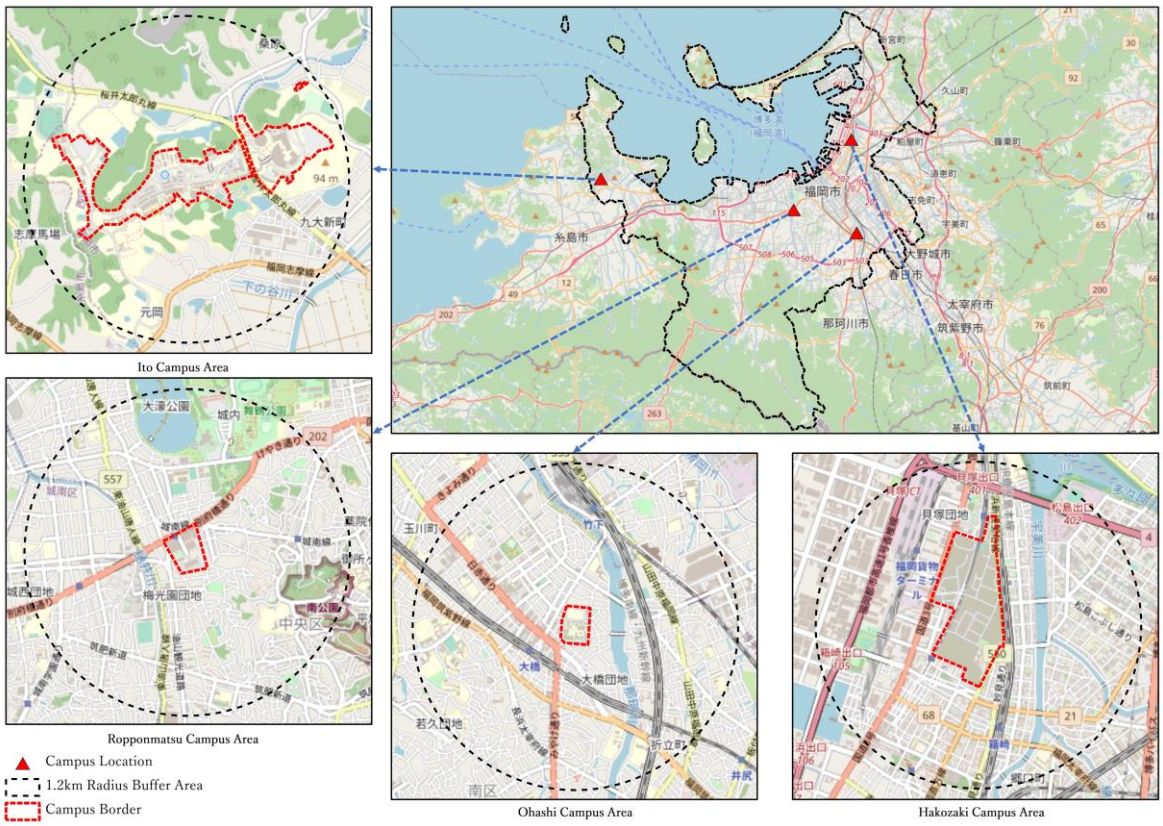

Fig. 1. Map showing the location of selected campuses in Fukuoka City (derived from OpenStreetMap [2022-02-07])

3.2. Spacematrix

A spacematrix is a multi-variant index that is used to represent urban density according to the urban form in a quantitative way. Although research has shown the limitation of a spacematrix, it is still used as one of the common indices in urban practice to represent the morphological structure in a simplified easy to read way (ALEXANDER, 1993; FORSYTH, 2003). The spacematrix correlates a ground space index (GSI) with a floor space index (FSI) to have nine different types of urban forms: low-rise point, low-rise strip, low-rise block, mid-rise point, mid-rise strip, mid-rise block, high-rise point, high-rise strip, and high-rise block (Fig. 2). Other measurements can also be retrieved from a spacematrix such as number of layers (L) and open space ratio (OSR). The use of a Geographical Information System (GIS) can easily calculate FSI and GSI values using building datasets. Spacematrix values can be calculated using the following equations (BERGHAUSER & HAUPT, 2010):

$$FSI_f = F/A_f$$

F = sum of floors area in m², A_f = area of urban fabric in m².

$$GSI_f = B/A_f$$

B = building footprint in m², A_f = the area of urban fabric in m².

OSR and L can also be calculated from the following equations:

$$L = FSI_f / GSI_f$$

$$OSR_f = (1- GSI_f) / FSI_f$$

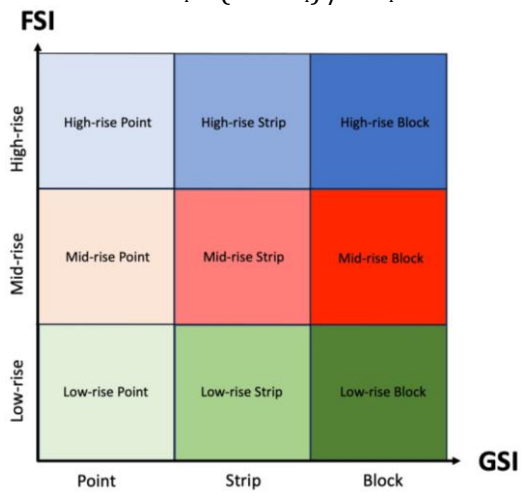

Fig. 2. Spacematrix

For the analysis, values of FSI and GSI for selected areas of study were calculated using ArcGIS Desktop 10.4 software (ESRI, 2001) and building datasets for 1993, 1998, 2003, 2008, 2012 and 2017. In order to make the readability of FSI and GSI maps comparable, maps were rasterized with a cell size of 100 m x 100 m which was considered suitable to cover most large buildings in the areas of study. Importantly, the spacematrix results are considered as relative values not absolute ones. The spacematrix classifies the urban density of the urban fabric in relation to other urban fabrics within one system, therefore, the spacematrix results show the urban density in the areas under study in relation to the rest of the urban fabric in Fukuoka City. The resultant maps have been classified into nine different categories that represent different types of urban density. By comparing these maps, temporal changes in urban density around the campuses could be visualised and patterns of change could also be examined.

3.3. Mixed-use Index (MXI)

The Mixed-use Index (MXI) is another common index that is widely used in urban practice to represent the functionality of the urban fabric and to distinguish mono-functional, bi-functional, and multi-functional urban blocks (VAN DEN HOEK, 2010). Urban blocks or buildings that have one function are classified as mono functional. Mono functionality in the MXI is classified as housing, amenities or work places. The functionality of amenities includes shops, stores, leisure, sports facilities, schools, recreational facilities, universities, and related building uses. However, the functionality of work places includes industrial facilities, workshops, factories, farms, agricultural facilities, and related building uses. Accordingly, a mix of two of those functionalities is described as bi-functional, and a mix of three functionalities is classified as multi-functional (Fig. 3). In some cases, it is difficult to classify building uses according to the MXI. For example, coffee shops could be considered as amenities or work places depending on the context and the user. Although it has its limitations, MXI is still considered as one of the pragmatic necessities of urban practice to represent functionalities in a simplified way. MXI values have been calculated based on the percentage of each functionality in the urban fabric using building floor area (VAN NES ET AL., 2012). For a better readability, MXI values were calculated based on a raster cell size of 100 m x 100 m and represented as raster maps using the raster calculator and spatial analyst tools in ArcGIS Desktop 10.4 software (ESRI, 2001). MXI maps have been created for 1993, 1998, 2003, 2008, 2012 and 2017. By comparing the resultant maps, temporal changes in building uses could be visualised to then assess the impact of studentification and de-studentification on the socio-economic surroundings of the campuses.

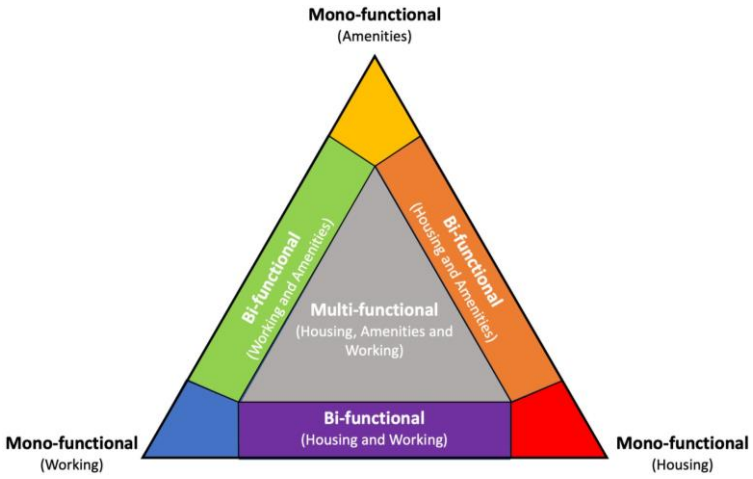

Fig. 3. Mixed-use Index (MXI)

4. Results

The spacematrix has been classified into low-rise point, low-rise strip, low-rise block, mid-rise point, mid-rise strip, mid-rise block, high-rise point, high-rise strip and high-rise block. On the other hand, MXI values have been classified into mono housing, mono amenities, mono working, bi-functional (housing + amenities), bi-functional (housing + working), bi-functional (amenities + working), multi-functional (10% amenities + housing + working), multi-functional (20% amenities + housing + working) and multi-functional (30% amenities + housing + working). Therefore, this section compares the spacematrix and MXI results over the years in a descriptive way instead of a numerical way. In order to enhance the readability of the spacematrix and MXI abstract maps Figure 4 provides the latest available dataset for 2017 of building footprints and land use accompanied by surrounding street names and train stations to understand the functional and social links between the campus and its surroundings.

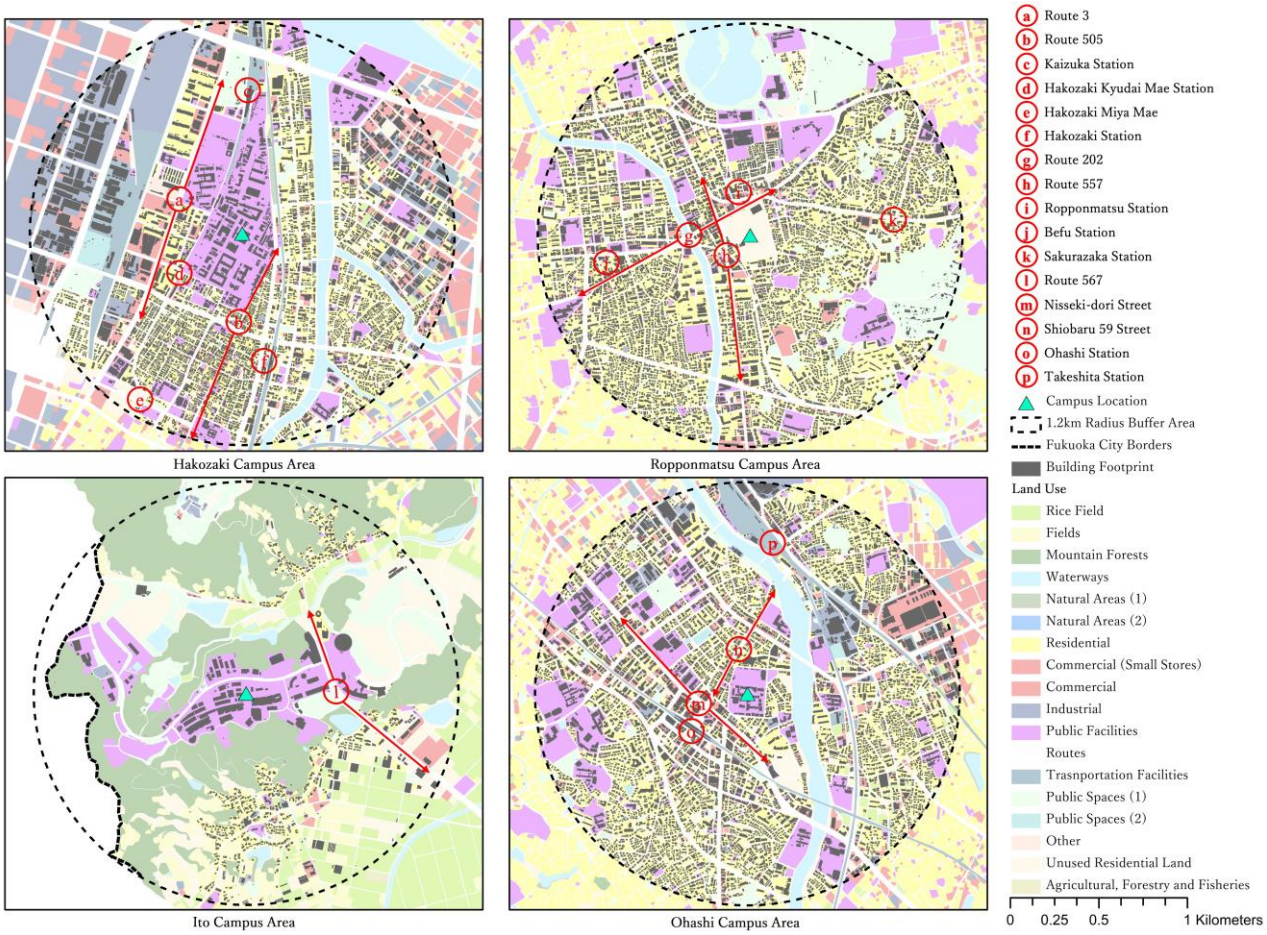

Fig. 4. Building footprints and land uses accompanied by surrounding street names and train stations (2017 Dataset)

4.1. Hakozaki campus

The move-out process at the Hakozaki campus started in 2005 and ended in 2018. Therefore, results show the early stages of the impact of de-studentification on the urban morphological form in the area. Figure 5 shows that the number of cells that belong to higher degrees of urban density started to decrease over time especially mid-rise and high-rise cells. This means that other areas of Fukuoka City started to have higher degrees of urban density which caused the area around Hakozaki campus to have relatively lower values of urban density. Similarly, Figure 6 shows that the overall number of bi-functional cells started to decrease overtime. However, if we have a closer look at raster maps, we notice that the distribution and location of the spacematrix and MXI values started to take a different pattern (Fig. 7). Spacematrix raster maps have shown that since 1993 there was a cluster of mid-rise strip cells located between the campus, Hakozaki station and Hakozaki Kyudai Mae station. However, over the years this cluster started to be considered as relatively low-rise cells. This shows that the area started to have a relatively lower degree of urban density compared to other parts of the city. Similarly, the area around Kaizuka station along Route 3 used to have high rise point

cells. However, over the years the urban density in the city changed and these high-rise point cells became mid-rise ones. Moreover, MXI raster maps have also shown that the area between the campus, Hakozaki station and Hakozaki Kyudai Mae station used to have a higher degree of multi-functional cells in 1993. But, over time lower degrees of multi-functional cells started to appear. Although, the morphological change appeared in the area before the campus move-out process took place, the move-out process may have contributed to this change in a direct or indirect way. Taking into consideration that the decision to move out from the campus was taken in the early 1990s, this could have influenced decision makers, stakeholders, investors, and business owners.

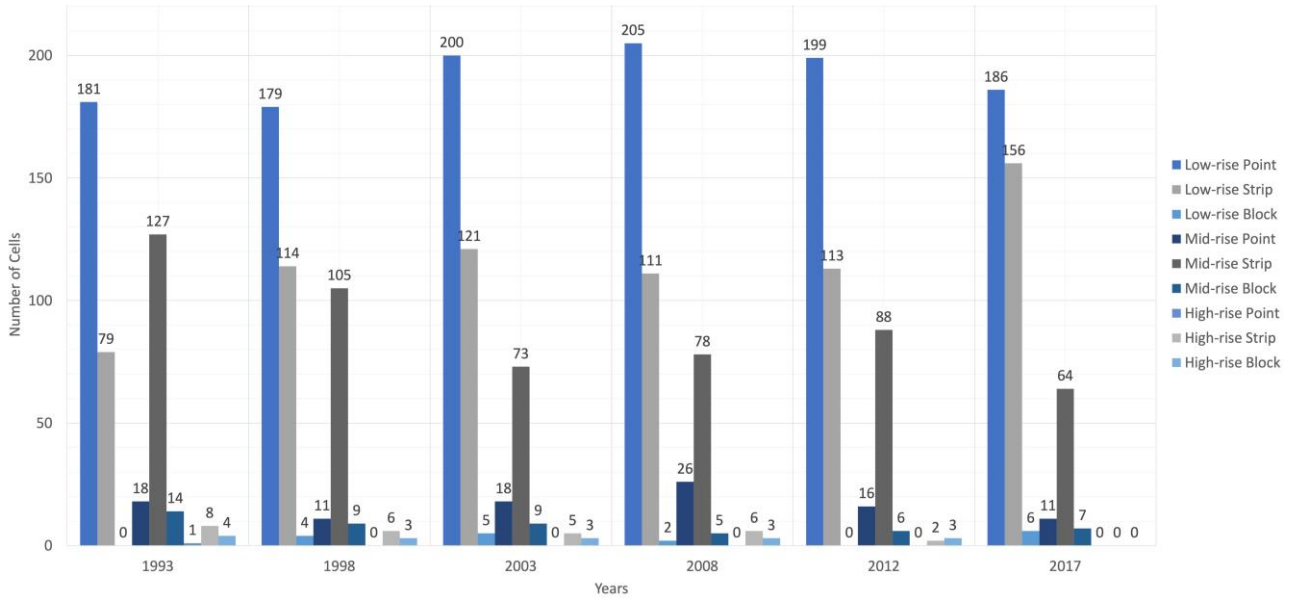

Fig. 5. Classification of Spacematrix values (Hakozaki campus)

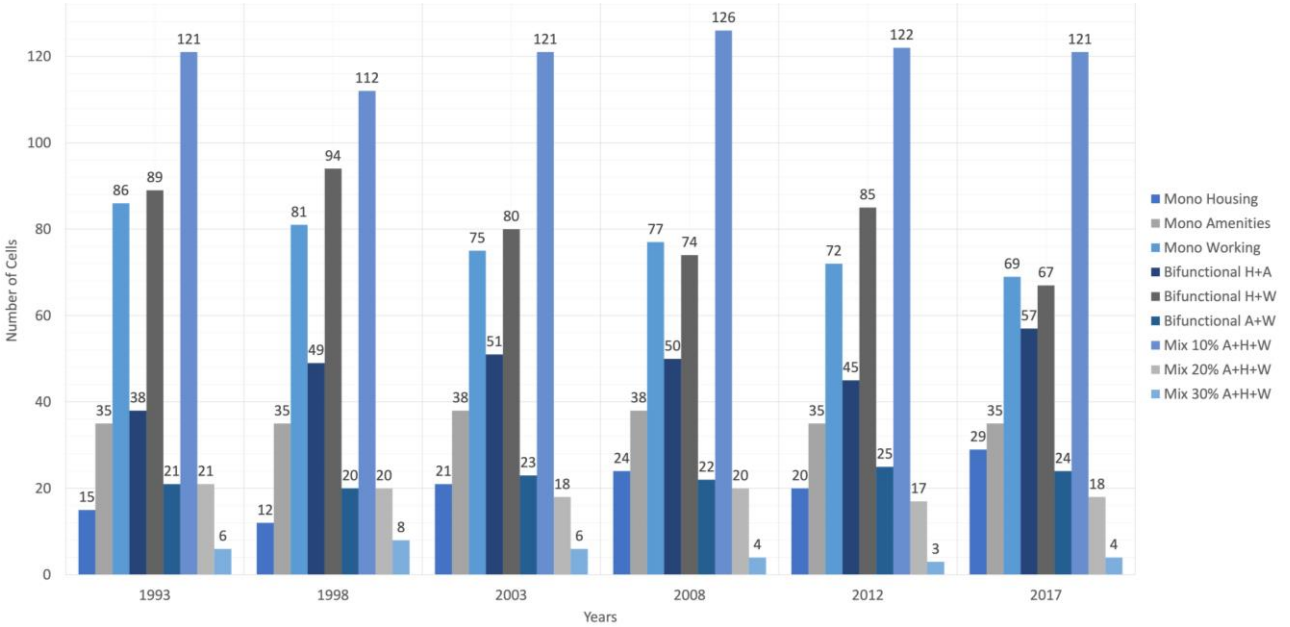

Fig. 6. Classification of MXI values (Hakozaki campus)

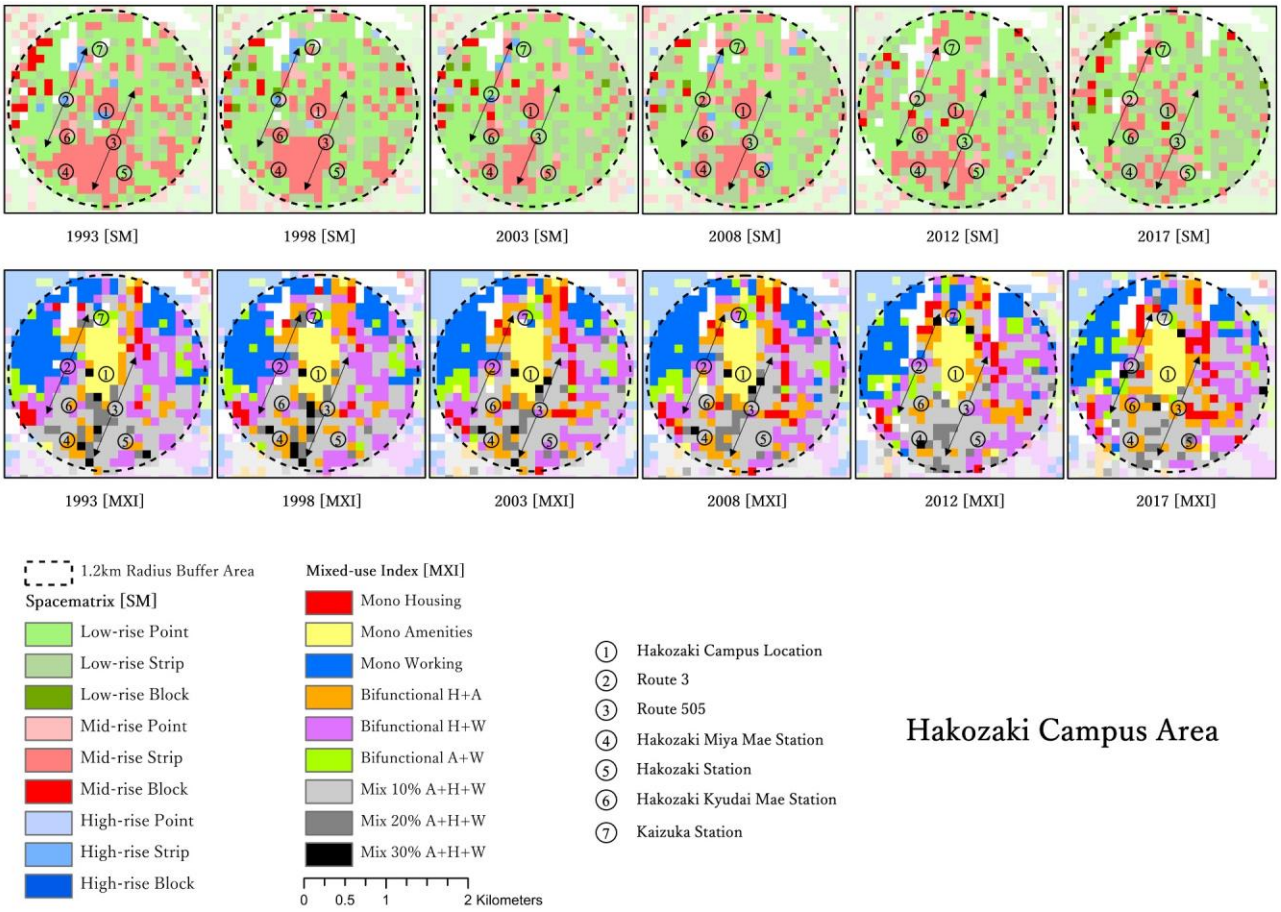

Fig. 7. Spacematrix and MXI maps for Hakozaki campus

4.2. Ropponmatsu campus

Ropponmatsu campus moved out of the area in 2009. Therefore, the results show the impact of de-studentification on the area over 8 years since the campus moved. Like Hakozaki campus, the spacematrix results have shown a noticeable decrease in mid-rise cells (Fig. 8). This shows that the area started to have a low urban density by that time in relation to other parts of the city. On the other hand, MXI results have shown that the area around Ropponmatsu campus continued to have relatively similar degrees of functionality over the years except that there was a sudden decrease in bi-functional cells in 2012 that was followed by a slight increase in 2017 (Fig. 9). However, the spacematrix and MXI raster maps have shown that the distribution of cells has changed over the years (Fig. 10). In the spacematrix maps, mid-rise strip cells started to be considered as low-rise cells over time. However, mid-rise strip values remained concentrated along Route 202 and around Ropponmatsu and Befu stations. Moreover, the area around the campus along Route 557 retained mid-rise strip cells. This could be explained because in 2005 three new stations opened in the area Ropponmatsu, Befu and Sakurazaki. Both Ropponmatsu and Befu stations are located near to the campus which allowed the area to keep its middle values of urban density. On the other hand, MXI maps also show that the area around the campus was surrounded with high degrees of multi-functional cells. However, in 2012, three years after the campus moved out, the area adjacent to the campus had relatively lower degrees of multi-functional cells. Moreover, the area along Route 202 has retained multi-functional cells over years. This could also be explained by the fact that Route 202 is considered to be one of the main routes in Fukuoka City that connects the city's wards from east to west.

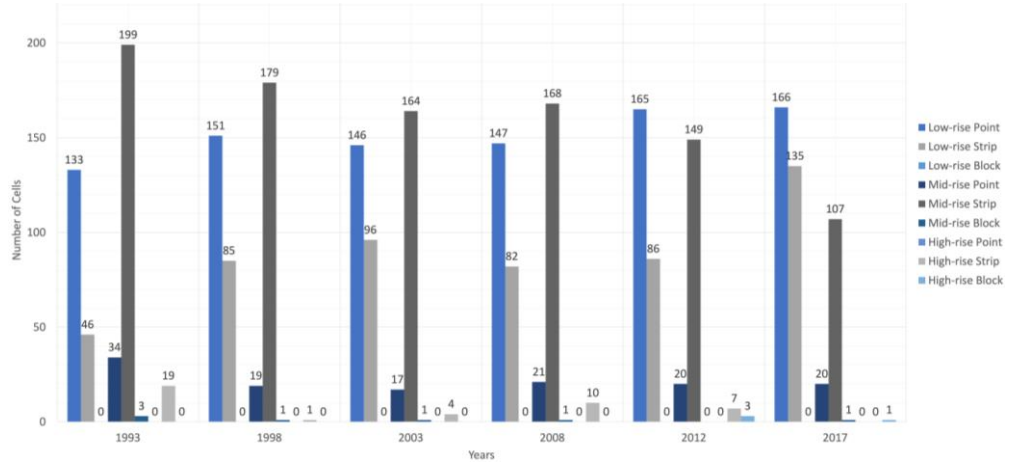

Fig. 8. Classification of Spacematrix values (Ropponmatsu campus)

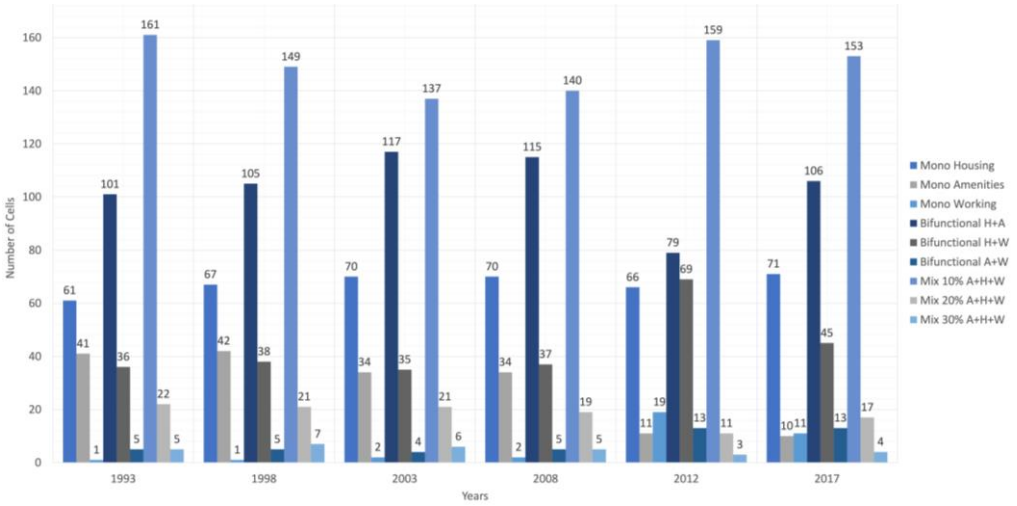

Fig. 9. Classification of MXI values (Ropponmatsu campus)

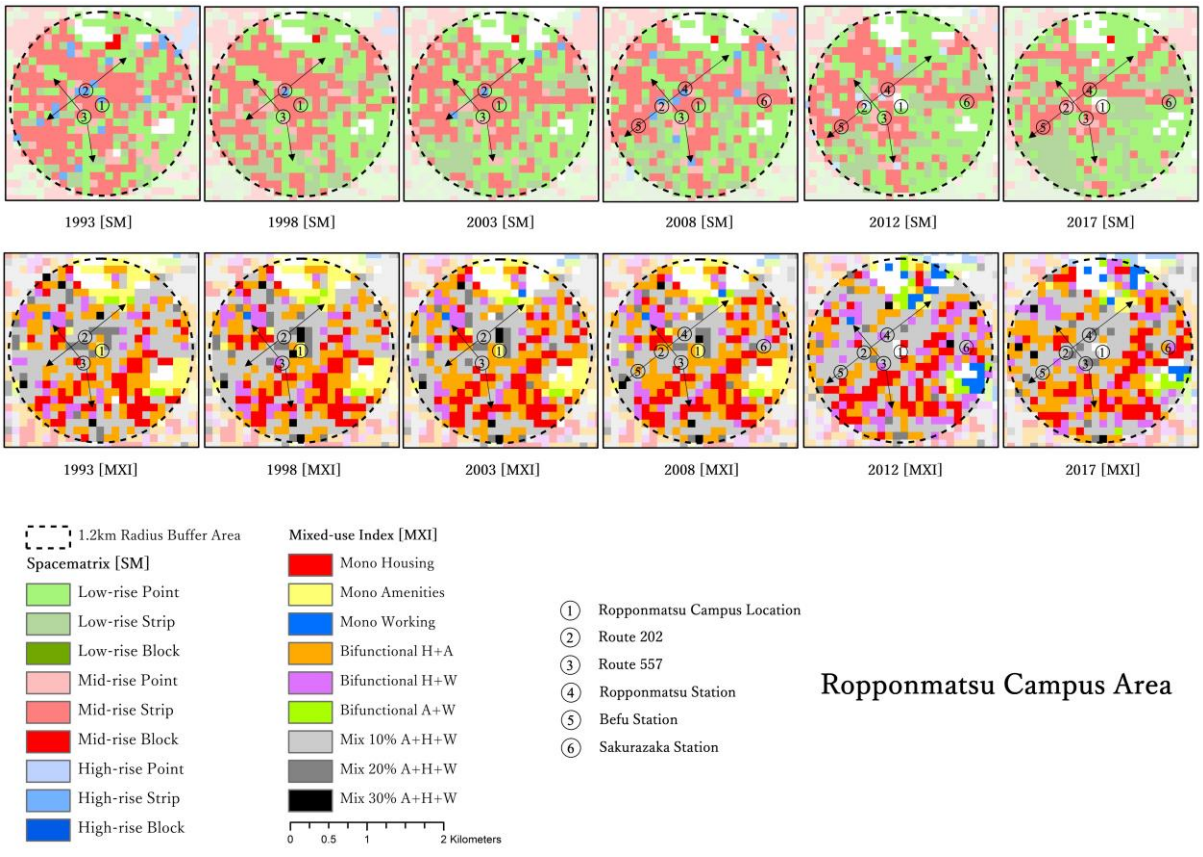

Fig. 10. Spacematrix and MXI maps for Ropponmatsu campus

4.3. Ito campus

Unlike Hakozaki and Ropponmatsu campuses, Ito campus is the newest campus of Kyushu University that was started in 2005 and finished in 2018. Therefore, results show the early impact of studentification on the area. The impact caused by the campus here is considered more visible, as the campus was built in the suburban outskirts of the city. Spacematrix values have shown steady increases over the years and new types of cells have appeared for the first time such as mid-rise and high-rise strip cells (Fig. 11). On the other hand, MXI values have shown a decrease in mono housing cells accompanied by an increase in other types of cells (Fig. 12). Furthermore, there was a noticeable increase in amenity cells caused by the construction of the campus over time. Spacematrix maps have shown that mid-rise strip and high-rise strip cells have appeared for the first time in the area in the years after the campus was established (Fig. 13). This shows that the existence of the campus has contributed to the urban density in the area especially along Route 567. Conversely, MXI maps have shown that the area started having mono amenity cells caused by the existence of the campus. However, bi, and multi-functional values remained relatively similar over the years. This shows that the establishment of the campus has contributed to the urban density more than the degree of mix of functions.

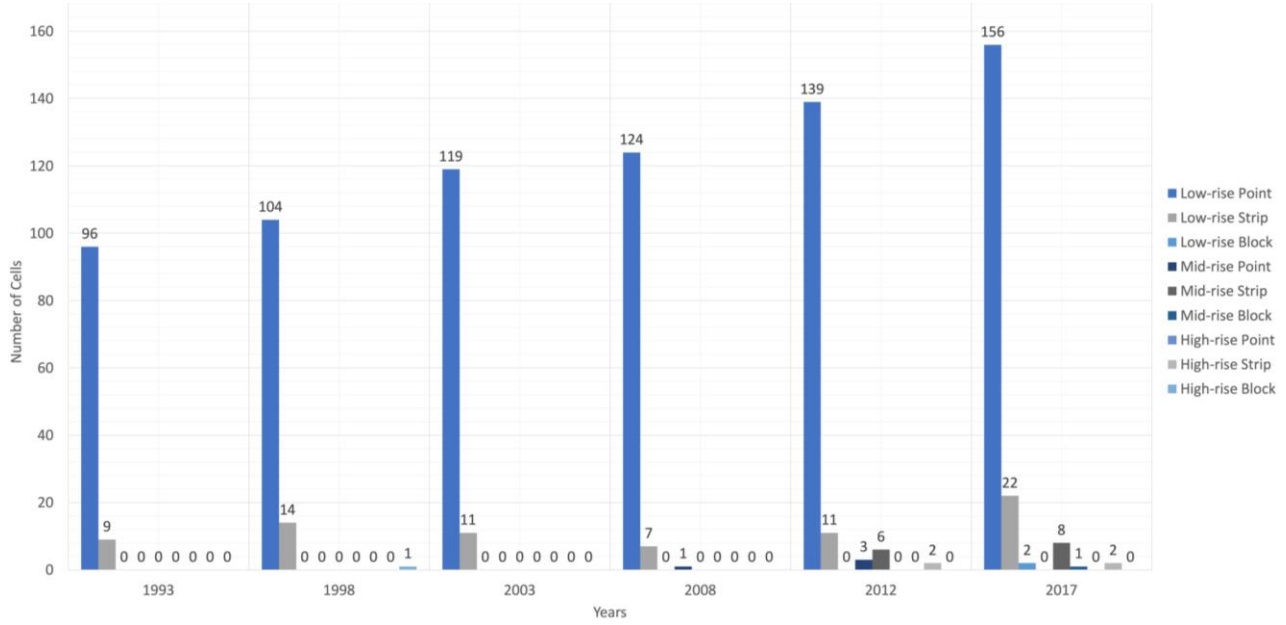

Fig. 11. Classification of Spacematrix values (Ito campus)

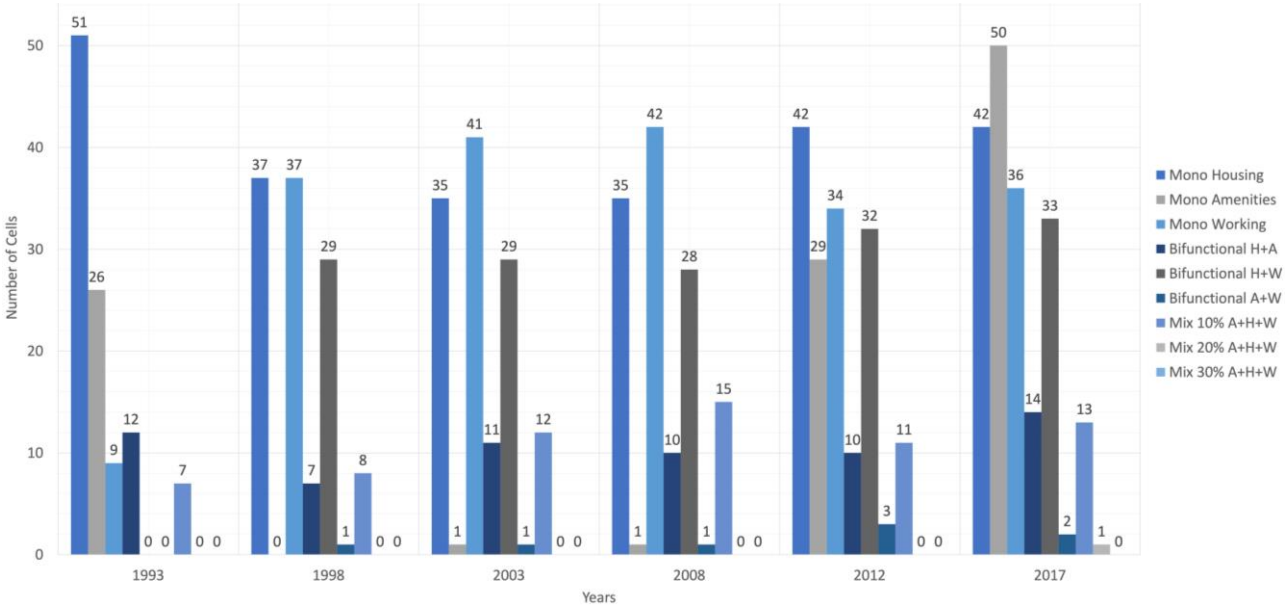

Fig. 12. Classification of MXI values (Ito campus)

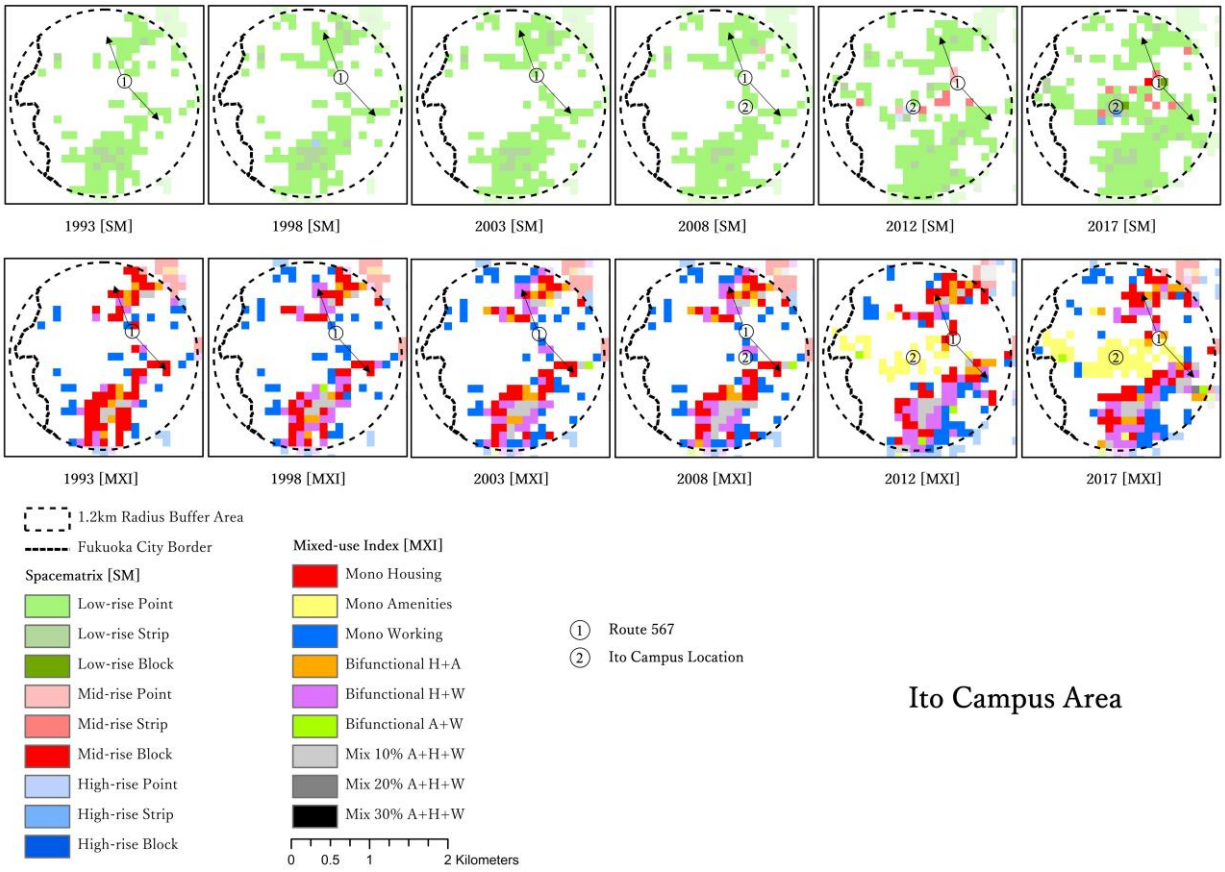

Fig. 13. Spacematrix and MXI maps for Ito campus

4.4. Ohashi campus

Ohashi campus was established in 1968 as Kyushu Institute of Design. However, in 2003, it merged with Kyushu University to become the School of Design. Therefore, the Ohashi campus results show the impact of the existence of the university campuses on the area over a long period of time. By doing so, a better understanding of the trends of other campuses moving in or out could be reached and then compared. Like Hakozaki and Ropponmatsu campuses, the spacematrix results have shown a decrease in mid-rise strip cells accompanied by an increase in low-rise strip cells (Fig. 14). On the other hand, MXI values have remained relatively similar over the years (Fig. 15). Furthermore, the distribution of mid-rise strip cells in spacematrix maps have remained concentrated around the campus and along Nisseki Dori Street especially near to Ohashi station (Fig. 16). Moreover, MXI maps have shown that the distribution and location of cells is relatively similar over the years with no significant change unlike previous case studies. Due to the unique location of the campus near to Ohashi station, high degrees of multi-functional cells have existed over years around the campus along Nisseki Dori and Shiobaru 59 Streets.

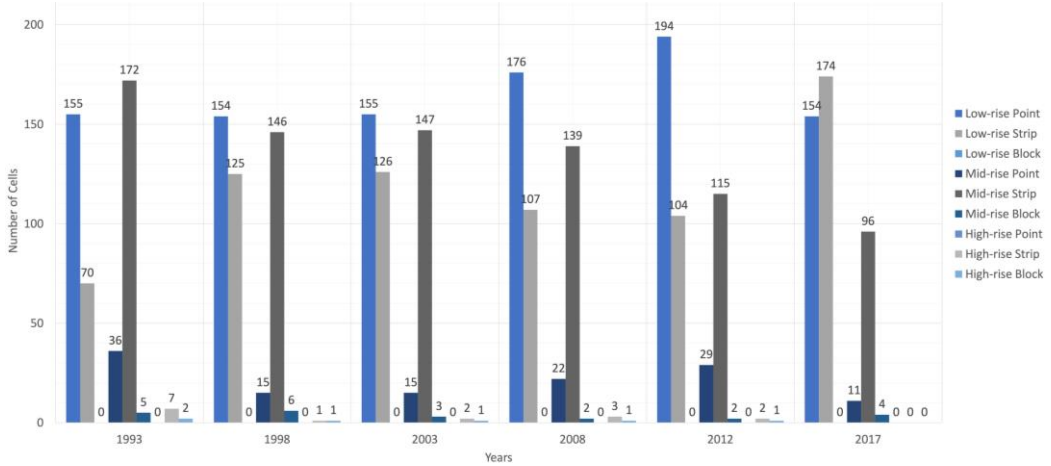

Fig. 14. Classification of Spacematrix values (Ohashi campus)

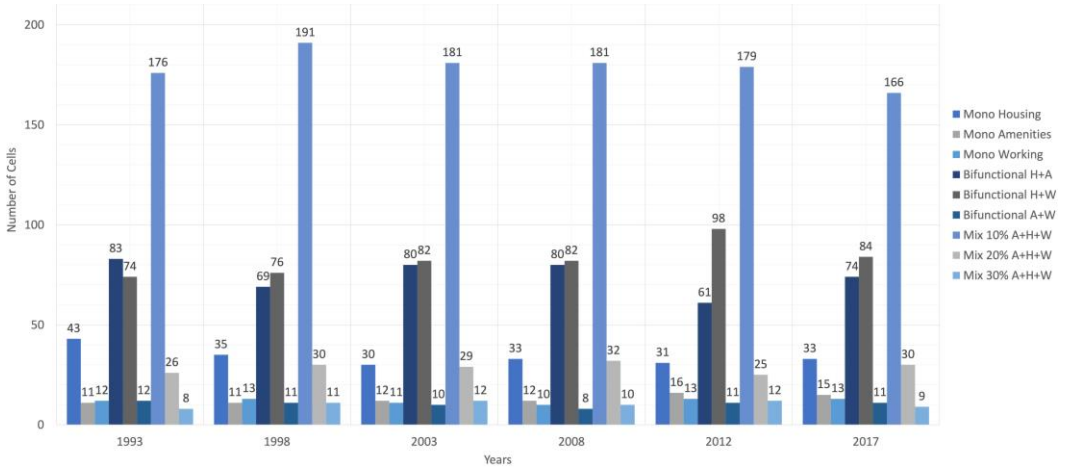

Fig. 15. Classification of MXI values (Ohashi campus)

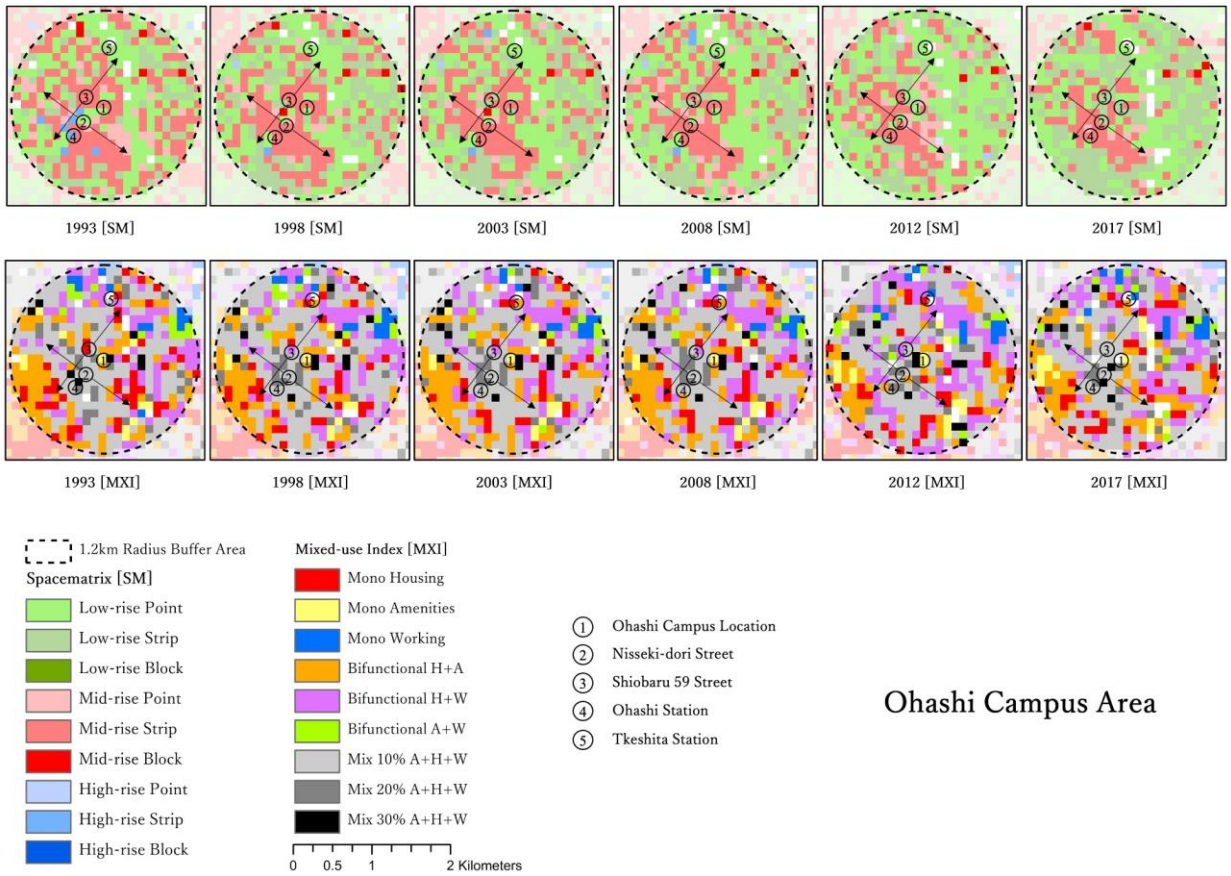

Fig. 16. Spacematrix and MXI maps for Ohashi campus

5. Discussion

By comparing the results of the spacematrix and MXI for Hakozaki, Ropponmatsu, Ito and Ohashi campuses, the impact of different trends of moving in and out could be understood. Hakozaki and Ropponmatsu campuses have shown similar trends in their impact on the surrounding mixed use of functions. The high values of multi-functional cells (mix 30% Amenities + Housing + Working) were replaced with mid and low values of multi-functional cells (mix 20% Amenities + Housing + Working and mix 10% Amenities + Housing + Working). Although the move-out process of Ropponmatsu campus was completed in 2009 and Hakozaki campus was still moving out, their impact on the surrounding mixed use of functions is relatively similar. This could be understood according to the fact that the impact of campuses moving out on their surroundings starts before the campus has moved out. Investors, business owners, decision makers and stakeholders may behave according to "word of mouth" in a way that would make the impact of the move-out

processes on the area start early (BUTTLE, 1998). On the other hand, the spacematrix middle values for areas around Hakozaki and Ropponmatsu campuses have also been shown to decrease over time. However, this was also noted in the area around Ohashi campus. When Fukuoka city started having taller buildings and a higher urban density in its core, especially at the end of its 6th phase of growth, this affected the relative urban density in other parts of the city. Therefore, the change happening in the urban density here is considered a general phenomenon in the whole city that is not necessarily related to the moving out process of campuses.

The impact caused by campuses moving out on the surrounding mixed use of functions can be understood in the context of campus-city functional relationship. As campuses are usually accompanied by a high demand of services and amenities in addition to housing. The capacity needed to cover the needs of students stimulates the mixed use of functions. Therefore, high concentrations of students are usually associated with economic changes that would result in high degrees of multi-functional buildings (MACINTYRE, 2003). This also confirms that universities have been described as the main driver of the revitalization of cities (STOKER ET AL., 2015). Therefore, when Hakozaki and Ropponmatsu campuses moved out, the gap between supply and demand increased in a way that affected the surrounding mixed use of functions which is considered to be one of the common after-effects of de-studentification (KINTON ET AL., 2016). Therefore, the impact of campuses moving out on their functional relationship within the city is considered more significant than their impact on the physical relationship. Although Hakozaki and Ropponmatsu campuses were in a uniquely accessible location near to different train and subway stations, their impact on the surrounding mixed use of functions was still noticeable. This shows the extent to which moved out campuses impact the mixed use of functions of their surroundings.

On the other hand, the area around Ito campus has witnessed mid-rise and high-rise strip cells for the first time over 24 years. Most of these mid/high-rise buildings belong to the campus. However, their existence contributed to the construction of other mid/high rise buildings in the area. Therefore, Ito campus as a new campus has accelerated the urban density in the area which is known as the natural urban transformation process (VAN NES & YE, 2014). Also, according to the theory of natural urban transformation, higher degrees of urban density stimulate mixed urban land use (VAN NES ET AL., 2012; YE & VAN NES, 2013). However, this was not the case for Ito campus as MXI values have shown no significant change except for the new amenity cells that belong to the campus buildings. This could be understood in the context of campus accessibility. As shown in Figure 4, there is no subway or train station near to the campus only bus stops, so, the area around the campus is considered less accessible in comparison to other campuses, therefore, the accessibility attribute has potentially hindered the stimulation of mixed land use in the area (MOHAMMED & UKAI, 2021).

We can conclude that Ito campus has been shown to impact the urban density of the area more than the mixed use of functions. Therefore, the impact of new university campuses on their physical relationship with the city is more significant than their impact on the functional relationship. This also confirms that universities have been described as extensive landholders that are capable of changing the urban landscape of the city (LARKHAM, 2000; BORSI & SCHULTE, 2018). Thus, we can summarize that the move-out process affects the mixed use of functions in the area. On the other hand, the move-in process affects the urban density of the area. Furthermore, there are other factors that should be taken into consideration that might affect the impact of campuses on their surroundings such as the accessibility attribute, the size of the campus, the location of the campus and campus openness. Therefore, we can say that new campuses have the potential to act as agents for urban physical change. However, moved out campuses have the potential to act as agents for urban functional change. Since there are various other factors that could facilitate more to the urban morphology such as laws and legislation, developers, builders, planners and architects, university campuses could be considered as indirect agents of change (OLIVEIRA, 2016).

6. Conclusion

University campuses have been known to play a significant role in the urban development and the landscape of innovation of their respective cities. However, due to the expansion and internationalisation of universities, they move out of old campuses and expand to larger new campuses in a process that is accompanied by studentification and de-studentification trends. These emergent trends impact the surroundings of campuses in a way that could affect physical and functional change in a city. Therefore, this study examined the impact caused by Kyushu University's old and new campuses to assess their effect on

the surroundings. Spacematrix and MXI analytical methodologies have been used to be able to visualise the morphological change caused in the area by measuring the urban density and the mixed-use functions from 1993 till 2017. Results have shown that the move out of campuses such as the Hakozaki and Ropponmatsu campuses have impacted the mixed-use functions in the surrounding area as high values of multi-functionality have been replaced with less multi-functionality. Despite the unique locations of the Hakozaki and Ropponmatsu campuses close to train and subway stations, their impact on the surroundings was still visible. On the other hand, new campuses such as Ito campus has shown to accelerate the urban density in its surrounding area due to its mid and high-rise buildings.

This study has also shown the potential of university campuses to act as indirect agents for change. However, this research needs to be expanded in the future to go beyond its limitations and to take into consideration other factors such as the accessibility, openness, and size of the campuses. Future research could also assess the impact caused by the old and new campuses on the surrounding social environment from the point of view of its citizens to give a more holistic view of the role of campuses in their respective cities. A comparative analysis of other case studies from different cities could also help in reaching a better understanding of the global role of campuses in cities worldwide as university campuses are one of the common urban settlements that exist in most cities. Therefore, by understanding the role of campuses in the transformation of a city and its associated urban growth, better decision making of their location and integration with the city could be reached especially in the early stages of campus development.

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