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# Where to build? A suitability modelling approach for university campuses location-allocation in Japan

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**Abstract:** *This research underscores the impact of university campuses, encompassing physical, economic, cultural, and social dimensions of their surroundings. Consequently, the selection of a suitable campus location should consider both the physical appropriateness and the preferences of key users, namely the students. This paper presents a suitability model employing the geographical information system (GIS) weighted overlay methodology to address this concern. The model employs criteria such as land use, land value, accessibility, and the mix of land uses to identify appropriate locations for university campuses in four Japanese cities. Findings reveal that suitable sites are predominantly found in the suburban areas of these cities, potentially leading to a studentification trend and social segregation between students and non-student residents. Additionally, placing campuses on city peripheries could strain university resources by incurring higher infrastructure costs. Therefore, decision-makers must carefully weigh location suitability against the ensuing social and economic implications to foster a successful campus-city relationship.*

**Keywords:** Campus design; urbanization; weighted overlay; mixed-use index; studentification.

## 1. INTRODUCTION

Since the location of a university campus defines the extent to which a university can benefit from the different types of services and facilities available in the surroundings, locating them is considered as a decision of critical importance [1], [2]. Furthermore, the location of a campus plays a significant role in the publicness of the university, as previous research has shown that universities located closer to the down-town area of a city have higher degrees of publicness compared to other rural campuses [3]. Moreover, campuses located close to their respective cities are more capable of fulfilling students' space-choice needs due to the convenience and wide variety of services and amenities that cities may offer [4]. Additionally, campus location has proven to impact students' academic performance in several direct and indirect ways. For example, previous research has shown that campuses located in areas with high degrees of tree cover increase students' productivity and reading performance [5].

Additionally, the increase in student population around university campuses creates a high demand for accommodation which cannot be fulfilled by universities alone. Therefore, the private rented sector benefits from the situation by offering several residential options for students which enriches the economic environment and real estate market around the campus [6]. Therefore, the location of the campus needs to respond sufficiently to students and staffs' needs of amenities and services as well as accommodation. Additionally, the proximity of a campus to the surrounding railroad stations impacts students and staffs' transportation modes, as public transport has shown to be one of the most common modes of transportation for university attendants [7]. Moreover, campus's location in walkable areas encourages students to walk or cycle to their schools which helps them be more connected with communities around the campus [8]. Therefore, locating a campus is not an arbitrary decision. However, it should be taken with consideration to the interests of students as key users.

Table 1. Materials and methods used for modelling university campus location selection suitability

| Data | Platform | Processed data | | | | | |
|---|---|---|---|---|---|---|---|
| | | Data description | Data collection time | | | | Data delivery |
| | | | Fukuoka City | Sapporo City | Chiba City | Maebashi City | |
| Land use | ArcGIS Desktop 10.4 | Land uses and current condition | 2017 | 2020 | 2016 | 2016 | Provided on request |
| Land value | | Land price survey points | | | | | Downloaded |
| Accessibility | | Railroad stations | | | | | Downloaded |
| MXI | | Footprint area and uses of buildings | | | | | Provided on request |

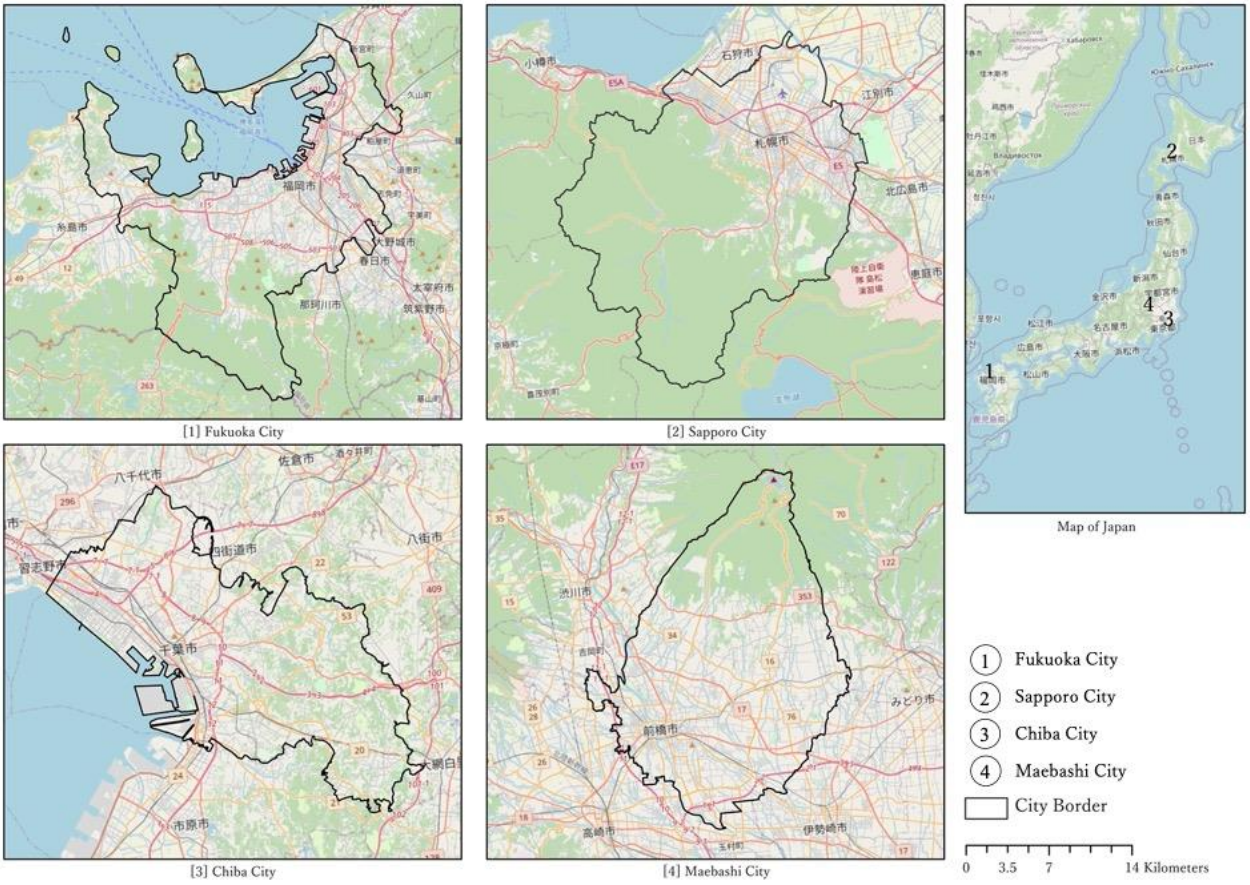


Figure 1. Map shows the location of selected cities (© OpenStreetMap contributors, CC BY-SA)

### 1.2. University campuses location-allocation

From an economic perspective, universities located close to the city benefit from the role that cities play as proactive and connectors of ideas and knowledge, which, in turn, provides universities with the resources needed for university-lead spin-off firms. Accordingly, universities should be located in cities that offer incentives for young entrepreneurs and dreamers such as tax waiver benefits, rental co-working spaces, and start-up accelerators and incubators to encourage students and alumni to have an impact on the society as well as the local economy [9]. From a social perspective, campuses located in cities with strong presence of community engagement initiatives and powerful local governments contribute greatly to the development of the campus [10]. As, universities are known for two main missions which are education and scientific research. However, their third mission lies in the impact brought by the university outside its borders. Therefore, university-driven social initiatives that connect local communities with the academic community bring numerous benefits to the city on micro, meso, and macro levels [11]. Consequently, siting a university within a livable urban environment that encourages active public participation contributes significantly to the city's transformative process, leading to a profound makeover. [12]. Furthermore, allocating university-influenced urban landscapes around a campus contributes to the knowledge economy and expands the impact of the university from a city-wide impact to a nation-wide [13].

From a cultural perspective, the existence of international student population enriches the cultural atmosphere in university's surroundings. However, such a cultural diversity could lead to the displacement of local cultures if left unmonitored, which can be avoided if campuses are located with students' residential occupation in mind [14]. Accordingly, students' distribution and the following studentification trends need to be managed to avoid super or aggressive gentrification [15]. From a physical perspective, universities need to be in harmony with the physical environment where it is located, otherwise it will end up being out of the space in a phenomenon known as *placelessness* [16]. Consequently, well-positioned university campuses maximize the potential of their respective cities by contributing to the urban land expansion and population growth resulting from gentrification trends caused by the existence of large student population [17]. Therefore, campuses and cities are known to be in constant negotiation and dynamic relationship that evolve over time. This proves that university campuses play a significant role in shaping the image of the city which can be seen in the shift happening in several European universities from a traditional historical campus model to a more contemporary one to correspond to the hue and identity of the city [18].

As mentioned earlier, allocating a suitable location for a university campus is dependent on many social, economic, cultural, and physical factors. Some of these factors can be managed and controlled and the others could be considered as a by-product that depend on the performance of the university and its scale. Hence, this paper focuses mainly on the physical aspect of the surrounding environment which can be examined in advance before selecting the location of the campus. Furthermore, the physical characteristics of candidate

locations for a university campus can be assessed and compared spatially and quantitatively which makes suitability models applicable and relevant to be used for other cases. Therefore, the physical perspective has been selected to be the core focus of this paper.

Table 2. Overlay weights

| Suitability layer | Weight value | | |
|---|---|---|---|
| | 1st Scenario | 2nd Scenario | 3rd Scenario |
| Land use | 50% | 20% | 35% |
| Land value | 20% | 50% | 35% |
| Accessibility | 15% | 15% | 15% |
| Mixed-use index | 15% | 15% | 15% |

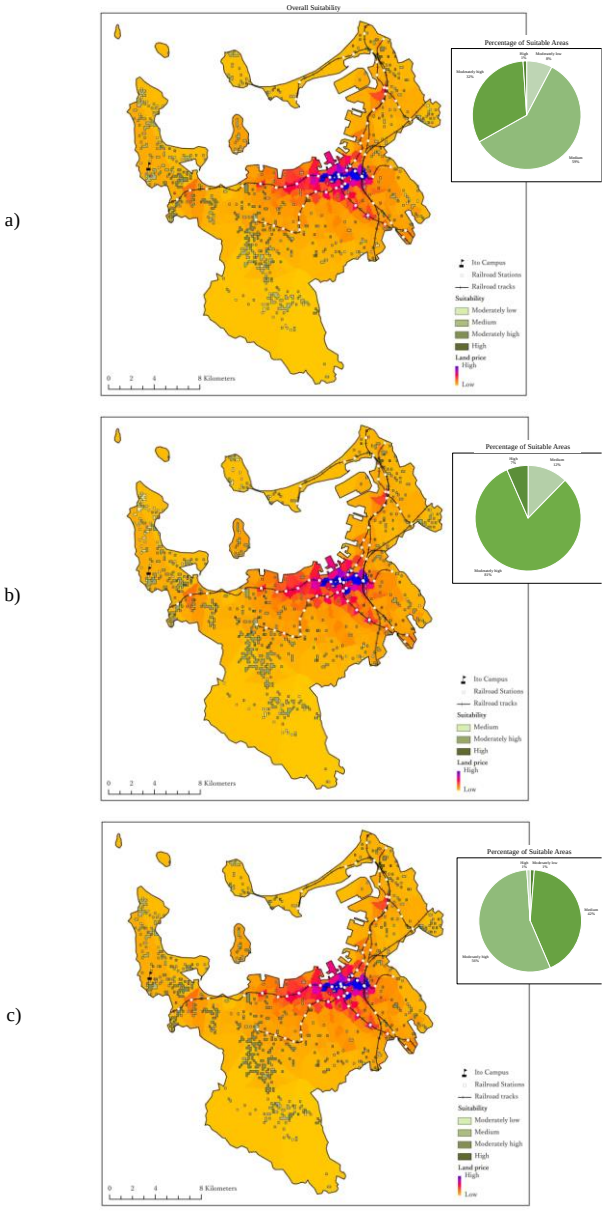


Figure 2. University campus location-allocation suitability modelling of Fukuoka City: a) first scenario b) second scenario c) third scenario.

## 2. MATERIALS AND METHODS

### 2.1. Study area

Four different Japanese cities have been selected for the proposed suitability model: Fukuoka, Sapporo, Chiba, and Maebashi cities (Figure 1). Selected cities were chosen based on two different reasons. First, they were selected to ensure a variety in the population and locations to allow for a comprehensive examination of the proposed model. Second, selected cities' geographic information system (GIS) data were made available which contributed greatly to the examination and validation of the proposed model using such a plenty of data (Table 1). GIS data of Fukuoka, Sapporo, Chiba, and Maebashi Cities were collected from cities' municipalities and urban bureaus. In addition to some data collected from the Japanese National Land Survey Database [19]. Comparing the results would provide planners and decision makers a holistic vision of the impact of different cities' attributes on the overall campus location selection suitability.

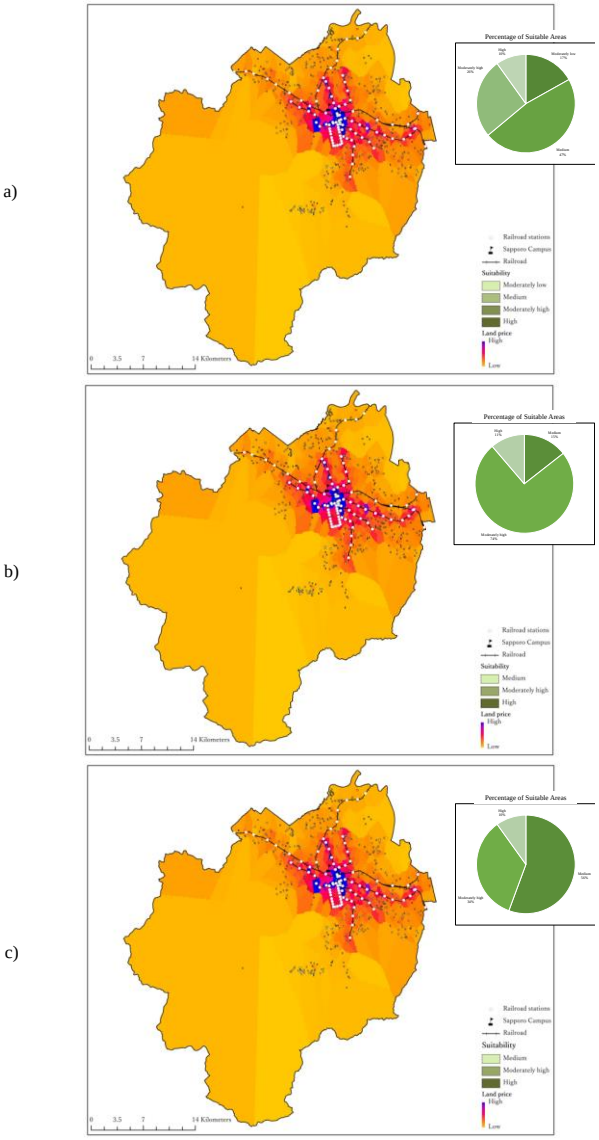


Figure 3. University campus location-allocation suitability modelling of Sapporo City: a) first scenario b) second scenario c) third scenario.

### 2.2. Weighted overlay suitability modelling

In order to determine the suitability of a location for a new university campus, certain criteria need to be determined to be able to define what is highly suitable from what is fairly suitable and what is not suitable at all. Therefore, based on the literature discussed earlier, four

different criteria have been selected: land use and land value as essential criteria in addition to accessibility and mixed-use index (MXI) as optional ones. Land use is considered as an essential criterion based on the fact that universities need to be flexible to adapt to any future needs for expansion [20], [21]. Accordingly, choosing a vacant or agricultural land surrounded by an ample of open spaces and available lands would contribute greatly to the autonomy and flexibility of the campus in the future. Moreover, land value is also considered as an essential factor that determines the suitability of a location based on the fact that the construction of a new campus requires a wide large area to host universities' laboratories, classrooms, facilities, and infrastructure [22]. This means the larger the land, the more expensive it is expected to be. Therefore, affordable areas of the city would be preferred to be able to purchase a large area suitable for the scale of the university especially for public and national universities which are known to have limited funds [23], [24]. For optional criteria, MXI was used as an urban index that represents the degree of mixed land uses in an area based on nine different levels: mono housing, mono amenities, mono working, bifunctional (housing + amenities), bifunctional (housing + working), bifunctional (amenities + working), mix 10% amenities + housing + working, mix 20% amenities + housing + working, and mix 30% amenities + housing + working [25]. MXI is represented as a raster map by calculating the percentage of each of the three main functionalities (i.e., housing, working, and amenities) in urban blocks or fabrics using building floor area [26]. Furthermore, campus accessibility and proximity to railroad stations was also considered as an optional criterion to represent campus accessibility.

Some criteria are considered more essential than the others. For instance, essential criteria such as land use and value are considered more important in determining the suitability of a location than other optional criteria such as accessibility or MXI. For example, a campus could be located in a rural suburban area if the land use and availability are considered suitable. As, bus stops and railroad stations could be established later after the campus is built [2], [27]. However, a campus cannot be in an accessible area if there are no vacant affordable lands to occupy. Moreover, essential criteria can also be weighted differently. For example, land use could be weighted more than land value since a campus can be established in a vacant suitable area even though it would cost more. Accordingly, different weights need to be given for different criteria. Therefore, weighted overlay has been selected to model university campuses' location suitability. For the analysis, raster overlay methodology was used due to the nature format of MXI layers and the abstract representation of raster layers which makes it easy to interpret and analyze. Accordingly, the model presented in this paper uses raster weighted overlay method using ArcGIS Desktop 10.4 software.

For land use, layers were converted first to raster layers, then classified to five different classes of suitability from the most suitable with a value of 5 to the least suitable with a value of 1. Suitability values were assigned based on the condition of each land use. For example, vacant lands were given a value of 5, and rice fields were given a value of 3. However, vacant lands assigned for residential purpose were assigned a value of 1 assuming that a possible change of use may be allowed if needed. Other land uses were given a value of "restricted". For land value, data were provided in form of points. Therefore, they were converted to Thiessen polygons, then polygons were rasterized and classified as the cheapest with a value of 5 and the most expensive with a value of 1. For accessibility, three polygons were created to represent different levels of proximity: within 2km, 5km, and more than 5km from the nearest railroad station. Polygons were then rasterized and a value of 5 was given to the areas that lie within 2km from the stations (20-minute walk distance) and a value of 3 was given for the areas that lie within 5km from the station (20-minute cycling distance). The rest was given a value of 1. MXI raster layers were classified so multi-functional lands were given a value of 5, where bi-functional areas were given values of 4 and 3, and mono-functional areas were given values of 2 and 1 respectively.

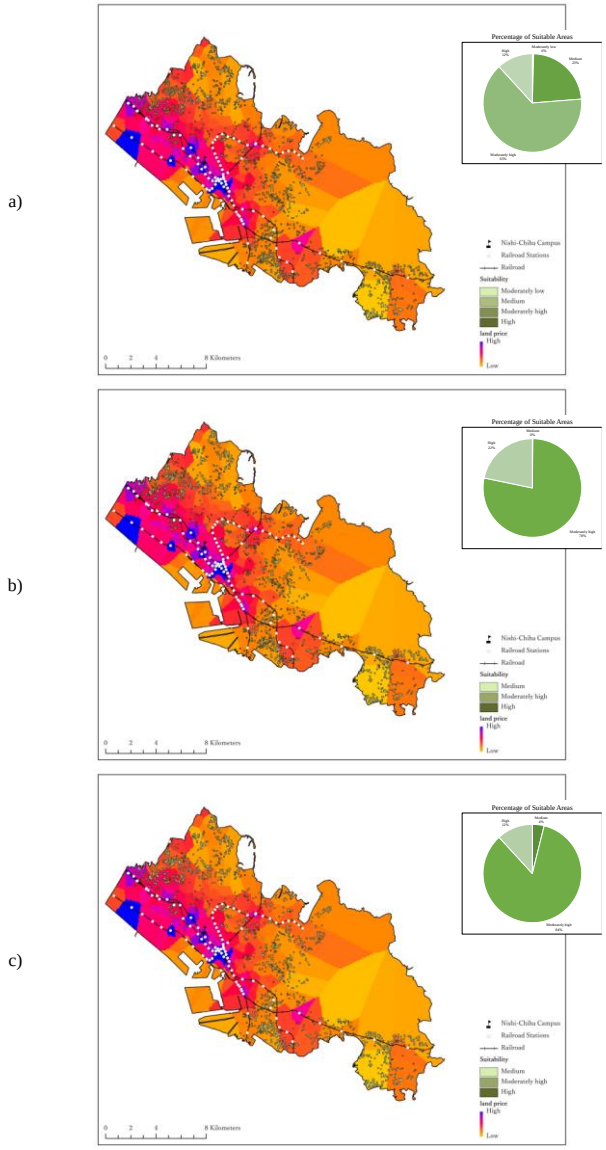


Figure 4. University campus location-allocation suitability modelling of Chiba City: a) first scenario b) second scenario c) third scenario

For layer weights, three different scenarios were applied to assess the impact of layer weights on the resultant degree of suitability. In the first scenario, land use was weighted more than land value. However, in the second scenario, land value was weighted more than land

use in case a university has limited resources to be spent on an expensive piece of land. In the third scenario, land use and value were weighted equally. In all three scenarios, accessibility and MXI were weighted equally since the establishment of a new university campus brings different mix of land uses in addition to new bus stops and railroad stations [28], [29]. Furthermore, in all three scenarios, land use and land value were weighted more than other criteria based on being essential criteria for university location selection. Weights' values were selected based on several trials to ensure a wide spectrum of suitability values (Table 2).

## 3. RESULTS

### 3.1. Fukuoka City

For Fukuoka City, the three scenarios have shown the same suitable locations with variations in the degree of suitability for each scenario. In the first scenario, 32% and 1% of suitable areas are considered to have moderately high and high levels of suitability respectively. In the second scenario, around 81% and 7% of suitable areas are considered to have moderately high and high levels of suitability. However, in the third scenario, moderately high and highly suitable areas are occupying 56% and 1% of the total suitable areas respectively. Most suitable areas have shown to be located in the suburbs of the city (Figure 2). However, the western part of the city is considered to be more suitable in terms of accessibility due to its proximity to railroad stations. Furthermore, several suitable areas have shown to exist close to the current location of Kyushu University's Ito Campus, which validates the proposed model. It also indicates that the location of Ito Campus may have been allocated using similar criteria. Furthermore, results have shown that there are some areas that are considered suitable by the model, but in real life they are not an appropriate location for a university campus. For instance, suitable areas located in the island to the north coast of the city are unrealistic for a university campus. In this case, an additional transportation method is needed in that case (i.e., a ferry) which is time consuming, costly, and impractical for most students or staff. This is also one of the shortcomings of weighted overlay method.

### 3.2. Sapporo City

The resultant suitable areas are considered relatively small which makes them suitable for a satellite campus, but not a large one. As, in the first scenario 26% and 10% of suitable areas are considered to be moderately high and highly suitable respectively. For the second scenario, 74% and 11% of suitable areas are with moderately high and high levels of suitability. On the other hand, the third scenario has shown that 34% and 10% of suitable areas are considered to be with moderately high and high levels of suitability respectively. The resultant suitable areas are also scattered all over the city with some areas located in accessible parts of the city near railroad stations with relatively low land value (Figure 3). However, interestingly, Hokkaido University's Sapporo Campus, which is one of the largest campuses in the city, has shown to be located in the heart of the city in a high valued area, which could be explained according to the unique location of the campus in an accessible area with different types of railroad transportation surrounding it. One common finding between Fukuoka and Sapporo cities' results is that most suitable areas are found to be located in the rural parts of both cities. In that case, locating a new campus in the suburbs would be a reasonable decision.

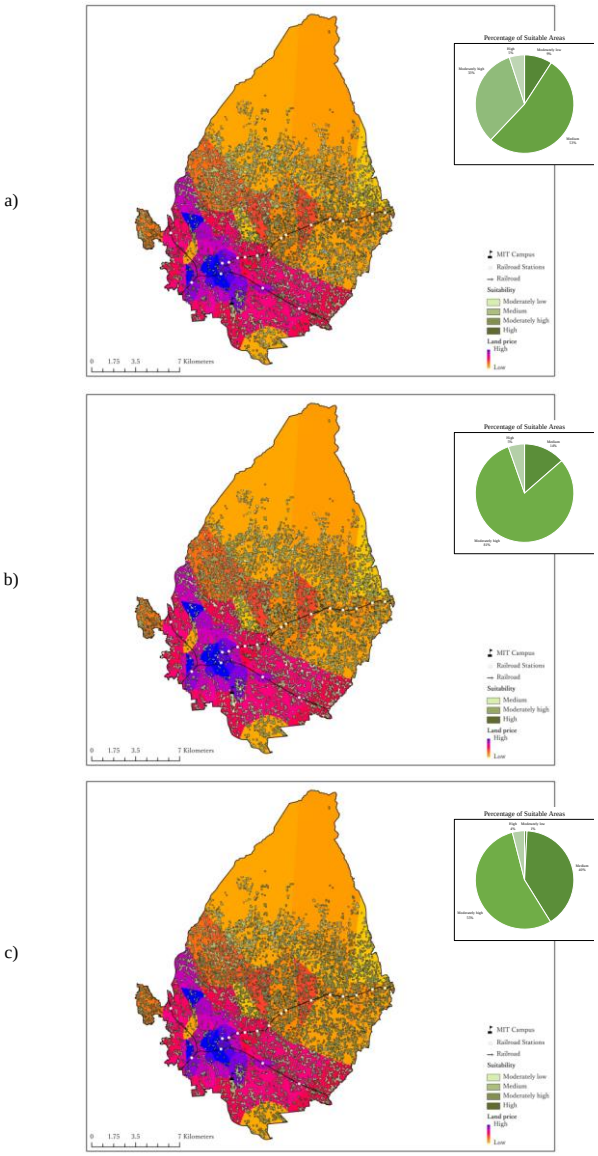


Figure 5. University campus location-allocation suitability modelling of Maebashi City: a) first scenario b) second scenario c) third scenario

### 3.3. Chiba City

For Chiba City, results have shown that 65% and 12% of suitable areas in the first scenario are considered moderately high and highly suitable areas respectively. On the other hand, in the second scenario, 78% and 22% of suitable areas are considered to have moderately high and high levels of suitability respectively compared to 84% and 12% in the third scenario. Results have also shown that most suitable areas in Chiba City are scattered in different parts of the city with some located in accessible areas along railroad (Figure 4). However, some of these areas are found to be located in moderately high valued lands. Moreover, Chiba University's Nishi-Chiba Campus was found to be located in an area with a relatively high land price. Therefore, no suitable areas were located nearby the campus. Moreover, similar to Fukuoka, and Sapporo cities, several suitable areas were located in rural areas.

Table 3. Cumulative area of suitable lands for a university campus

| City | Scenario | Area ($m^2$)* | | | |
|---|---|---|---|---|---|
| | | Moderately low | Medium | Moderately high | High |
| Fukuoka | 1st Scenario | 1,882,449 | 14,508,352 | 7,876,810 | 260,443 |
| | 2nd Scenario | N/A | 3,011,145 | 19,924,352 | 1,592,560 |
| | 3rd Scenario | 318,530 | 10,366,276 | 13,582,808 | 260,443 |
| Sapporo | 1st Scenario | 1,532,895 | 4,266,164 | 2,380,431 | 895,256 |
| | 2nd Scenario | N/A | 1,297,307 | 6,693,737 | 1,013,058 |
| | 3rd Scenario | N/A | 5,045,106 | 3,134,382 | 895,256 |
| Chiba | 1st Scenario | 70,000 | 3,870,000 | 10,720,000 | 1,960,000 |
| | 2nd Scenario | N/A | 30,000 | 12,980,000 | 3,610,000 |
| | 3rd Scenario | N/A | 640,000 | 14,020,000 | 1,960,000 |
| Maebashi | 1st Scenario | 6,950,000 | 40,260,000 | 25,080,000 | 3,820,000 |
| | 2nd Scenario | N/A | 10,320,000 | 61,720,000 | 4,070,000 |
| | 3rd Scenario | 600,000 | 30,750,000 | 41,720,000 | 3,040,000 |

*Areas were calculated by converting the raster layer to polygons, then calculating the cumulative resultant areas for each level of suitability

### 3.4. Maebashi City

Results have shown that 33% and 5% of suitable areas in the first scenario are considered to be moderately high and highly suitable respectively compared to 81% and 5% in the second scenario. However, the third scenario has shown that 55% and 4% of suitable areas are considered to be moderately high and highly suitable respectively. Results have also shown that Maebashi City is considered to be filled with abundance of suitable areas for a new university campus due to the greenery landscape of the city (Figure 5). Furthermore, Maebashi Institute of Technology (MIT) was found to be located in an area with lots of suitable areas for the establishment for a new university campus. This also indicates that the selected criteria and proposed model provides some valid results regarding university campus location-allocation.

## 4. DISCUSSION AND REFLECTION

Although results show the credibility of the proposed model to allocate suitable locations for a university campus, proposed model is considered as a starting point that paves the way for university campus location-allocation decision. As there are some other essential factors that need to be considered to decide on which of the suitable areas could be considered as the most appropriate. For example, planning and construction costs play a role in finalising the decision. As, choosing a vacant or agricultural land is considered more suitable and costs less than choosing an occupied land that may need a deconstruction or reform operation. Moreover, campuses located away from their respective cities may create extra loads on the resources of the university to offer needed infrastructure such as network services, telecommunications, or transporting supplies and materials [30]. Therefore, the resultant suitable areas produced by the model need to go through a round of assessment to determine what location is considered more appropriate.

Additionally, population density plays an important role in determining where the campus could be built. As, results have shown that suitable areas in the four cities were located mostly in the suburbs. Accordingly, locating a campus in such an area would cause a studentification trend, as students would be the main residents in the area [31]–[33]. This, in turn, would increase students' residential occupation, as they are the main type of residents that are willing to live in such a rural area to save on the costs spent on commuting to their schools [34]. Furthermore, the gentrification trend caused by establishing a campus in a rural area would lead to more negative consequences that may damage the image and milieu of the neighborhood such as noisiness, students walking intoxicated late at night, littering…etc. [35], [36]. Such minor incidents make residents to stay away from the so-called *student areas* which might lead to social segregation between student and non-student residents [37]. Therefore, student-oriented housing policies need to be implemented with the establishment of the campus to control any negative impacts and monitor students' residential occupation. Moreover, results have shown that the higher the population, the lower the cumulative suitable area might be (Table 3). In other words, it may be challenging for cities with high population density to find a variety of suitable locations to choose from to establish a new university campus.

Furthermore, the second scenario has shown to produce a high percentage of moderately high suitable areas which indicates that weighting land value more than other criteria produce high levels of suitability in the output. This could be understood according to the fact that vacant lands or empty fields are usually located in the countryside part of the city which are cheaper than other lands. Accordingly, when land value is weighted more than other criteria, the resultant output is more likely to be suitable. In summary, the proposed suitability model could be used by urban planners as a tool to better allocate the location of university campuses based on the criteria that meets the needs and interests of decision makers as well as students to offer them the needed capacity of services and facilities to satisfy their needs. However, decision makers need to bear in mind that such a model does not necessarily provide the optimum solution, however it paves the way to find the most appropriate one. Therefore, other factors related to campus's running costs as well as the social and demographic characteristics of the area (i.e., population density) need also to be taken into consideration before finalizing the decision.

## 5. CONCLUSION

Since universities are considered as institutions with major academic and scientific impact, locating them in the cityscape is a decision of crucial importance. Therefore, modelling suitable candidate locations using weighted overlay provides planners and decision makers a blueprint of where to start thinking about the most appropriate location for the planned campus. However, criteria chosen for modelling should include essential criteria in addition to some optional ones on what need to be considered for the new campus. Essential criteria could include some basic yet determinant ones such as land use and land value in addition to elevation, weather condition, or any other criteria that are deemed as essential by the decision maker. Moreover, optional criteria need to be considered as well such as accessibility or the mix of land uses to ensure that the interests of beneficiary parties (i.e., students) are also included. Based on the selected criteria, results have shown that suitable location are located mostly in the suburbs of several Japanese cities, as rural areas are credible to host projects of that scale. However, there are few challenges that are accompanied with such a result. The rural surroundings of a campus mainly attract student residents which leads to a studentification trends that may cause a social segregation between student and non-student residents. However, such a challenge could be managed by adopting student-oriented housing policies to monitor and control students' residential occupation under the supervision of cities' municipalities.

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