

Evaluating the Implementation of SDG 2: Zero Hunger at Universiti Sains Malaysia Using Geographic Information Systems

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Abstract: Geographic Information Systems (GIS) provide powerful tools to evaluate food security, monitor agricultural productivity, and assess the impact of environmental and socio-economic factors on food systems. GIS can also be used to analyze spatial patterns of food accessibility by integrating spatial mapping to identify food insecurity hotspots and optimize resource distribution. Therefore, this study aims to evaluate the implementation of Sustainable Development Goal (SDG) 2: Zero Hunger at Universiti Sains Malaysia (USM) through the application of GIS. By utilizing QGIS 3.34.1, the study employs Kernel Density Estimation techniques to map and analyze the spatial distribution patterns of food banks across the USM campus. The research investigates the current distribution patterns of food banks at USM, assesses the impact of SDG 2 on students' quality of life, and identifies areas with potential for establishing additional food banks. Both quantitative and qualitative methods are used in this study, including direct observation, written data collection, and in-depth interviews with academic staff and relevant university stakeholders. The findings reveal that the existing food banks at USM are insufficient in number, unevenly distributed, and not adequately maintained, leading to limited access for students in need. Based on these findings, the study proposes several strategies to improve the effectiveness and accessibility of food banks on campus. These recommendations aim to enhance SDG 2 by addressing hidden hunger among students, improving the overall management and distribution of food, and fostering a sustainable campus environment. Ultimately, this research aligns with USM's commitment to higher education sustainability and aims to help the university maintain its standing as a leader in achieving SDG goals, particularly in the areas of hunger alleviation and social well-being.

Keywords: Food Bank; GIS; Improvement; SDG 2; Suitable

1.0 Introduction

According to Sultan et al. (2024), Sustainable Development Goals (SDGs) are a primary agenda designed to address global issues. The United Nations has stated that Sustainable Development Goal 2: Zero Hunger, aimed at ending hunger by 2030, addresses the issue of hunger. This is because food serves as an essential source of energy that helps individuals carry out their daily activities (Rozali et al., 2024). Every person has the right to access balanced food sources. Therefore, it is important to consume food that contains nutrients according to the food pyramid, ensuring each meal includes carbohydrates, proteins, vitamins, and fats. A balanced diet is crucial for maintaining good health. In this regard, a balanced diet among students is essential to produce healthy and successful graduates.

This study also contributes to the improvement of the university through the use of Geographic Information Systems (GIS). Indirectly, this research can enhance the quality of SDG 2 among students at Universiti Sains Malaysia (USM). The findings of this study can also assist relevant authorities in strengthening the management system of food banks across USM campuses, helping to address hidden hunger among students. Moreover, this research can support USM in maintaining sustainability on campus, aligning with the university's vision of "Transforming Higher Education for the Sustainability of Tomorrow." This demonstrates that USM ranks fourth globally for its achievements in three SDGs: SDG 1: No Poverty, SDG 2: Zero Hunger, and SDG 16: Peace, Justice, and Strong Institutions (Ramli, S., 2023).

In general, global food production has been steadily increasing each year. However, issues such as hunger, malnutrition, and food insecurity persist and continue to affect many regions. According to Mat, B., Othman, Z., & Ramli, R. (2013) in their study *Issues and Challenges in the Implementation of Food Security Policy in Malaysia 1981 - 2012*, food security issues pose significant threats to both society and the nation. This is further supported by Zarina (2004), who explains that food security issues can undermine the safety and well-being of communities and other stakeholders. The study also emphasizes factors contributing to the ineffective implementation of food security policies.

Firstly, Malaysia has lacked a clear and comprehensive policy since its independence. Secondly, the policies that have been developed are unbalanced and neglect the development of the agricultural sector. Thirdly, food security policies and strategies are not consistently implemented globally. Fourthly, global issues such as globalization disrupt food security. The study finds that the implementation of food security policies has led to a decline in food sector growth, resulting in increased dependence on international food markets. The methodology used in this study involved primary data collection through in-depth interviews with policymakers. Therefore, it is clear that food security is crucial for all parties involved.

Moreover, food security issues within communities interfere with individual health. This is evidenced in the study *Food Security Issues Before and During the COVID-19 Pandemic: A Case Study in New Zealand* by De Silva et al. (2021), which states that food security problems among New Zealand's population affected their health. They experienced food insufficiency, which in turn impacted their nutritional intake, mental health, and family relationships. The majority of those facing food access issues were from low-income backgrounds. According to the World Health Organization (2019), the effects of food security problems involve political instability, economic imbalance, and rising poverty rates. This study utilized a historical analysis approach based on both primary and secondary data and Kernel Density Estimation techniques to map and analyze the spatial distribution patterns of food banks across the USM campus using Geographic Information Systems (GIS). This research aligns with USM's commitment to higher education sustainability and aims to help the university maintain its standing as a leader in achieving SDG goals, particularly in the areas of hunger alleviation and social well-being.

2.0 Study Area

In this study, the researcher selected Universiti Sains Malaysia (USM) in Penang as the study area, with coordinates at longitude 100.2584244 and latitude 5.3555943. This location was chosen because the university emphasizes sustainability, which is instilled in both students and staff. This is demonstrated by the 2023 Times Higher Education (THE) Impact Rankings, which show that USM achieved the fourth-best ranking globally in this category. Furthermore, USM is ranked first in Asia for SDG 16: Peace, Justice, and Strong Institutions.

Therefore, this study was conducted at USM, where a significant amount of food is provided to students through the establishment of food banks, in alignment with SDG 2: Zero Hunger.



Figure 1: Study Area Map.

3.0 Materials and Methodology

This study employs several research instruments, including observation and in-depth interviews. The observation method is one of the earliest techniques often used before commencing research. According to Merriam (2002), observation is considered the best method for collecting primary data. Rutledge and Hogg (2020) state that in-depth interviews are a qualitative technique conducted in small groups. This method involved lecturers from the Centre for Global Sustainability Studies (CGSS). The interview questions were related to the patterns and levels of SDG 2: Zero Hunger at Universiti Sains Malaysia, focusing on the impact of food banks on students in the study area. This method also aims to identify potential areas suitable for additional food banks, ensuring that students have sufficient access to food in line with the goal of SDG 2: to end hunger. The type of in-depth interview used was unstructured, where the questions were open and general, allowing interviewees to express their views on hunger issues and the status of SDG 2 at Universiti Sains Malaysia.

Once the interviews were completed, the next step was transcribing the recorded conversations into written text to facilitate data analysis. To ensure accuracy and efficiency, NVivo software was used to transcribe the interviews. The transcribed data was then synthesized into the study's findings, linking qualitative insights to quantitative observations. In this research, it helped in identifying factors that influence the location of food banks at USM.

The study also used spatial analysis within the Geographic Information System (GIS) to visualize the distribution patterns of food banks at USM. Hotspot analysis was used to create hotspot maps to assess students' accessibility to food from these food banks. Furthermore, heatmap analysis was used to generate distribution coverage mapping to determine whether food banks are distributed comprehensively. Additionally, distribution coverage mapping helps identify potential areas for expanding the number of food banks and improving the existing ones around USM.

4.0 Results

4.1 Analysis of Distribution, Hotspot and Heatmap

The analysis produced several maps through distribution analysis, hotspot analysis, and heatmaps. The distribution analysis resulted in a map showing the distribution patterns of food cabinets at Universiti Sains Malaysia. The heatmap analysis generated a hotspot map to observe the concentration of food cabinets in specific areas. This analysis was also used to create a distribution coverage map to identify suitable areas for adding food cabinets around Universiti Sains Malaysia.

4.1.1 Distribution Patterns of Food Cabinets at Universiti Sains Malaysia

Based on Figure 2, a field survey and observations conducted over two weeks around Universiti Sains Malaysia revealed that food banks are provided at 16 locations throughout the university. The researcher obtained the locations of these food banks from the Center for Global Sustainability Studies (CGSS) through a sustainability officer. Subsequently, the researcher conducted a field survey at these locations to acquire the coordinates of the food banks using the Global Positioning System (GPS). These latitude and longitude coordinates were then translated into a geographic information system (GIS) for distribution analysis. From the mapping, the researcher found that the distribution pattern of the food banks is scattered and not comprehensive. Many locations still need to be considered for the placement of these food banks.

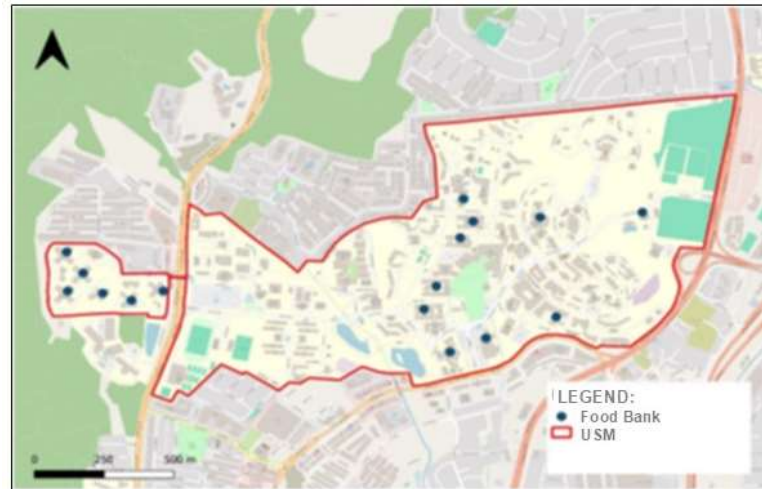


Figure 2: Map of the Distribution Pattern of Food Banks at Universiti Sains Malaysia

4.1.2 Hotspot for Food Banks at Universiti Sains Malaysia

The hotspot analysis revealed areas where food banks are concentrated among students. Figure 3 shows two types of concentration areas, represented in pink and blue. The pink areas indicate locations that are popular among students for accessing food from the banks. These areas are considered focal points due to their proximity, making it easy for students to obtain food. Additionally, these residential areas are home to USM students, meaning they are frequently present there. Moreover, the concentration of food banks is also influenced by their proximity to educational centers, which students regularly visit for classes. Based on the analysis, it can be concluded that the level of SDG 2 through the provision of food banks at USM is still insufficient and requires improvement to more holistically achieve the SDG 2 indicators.

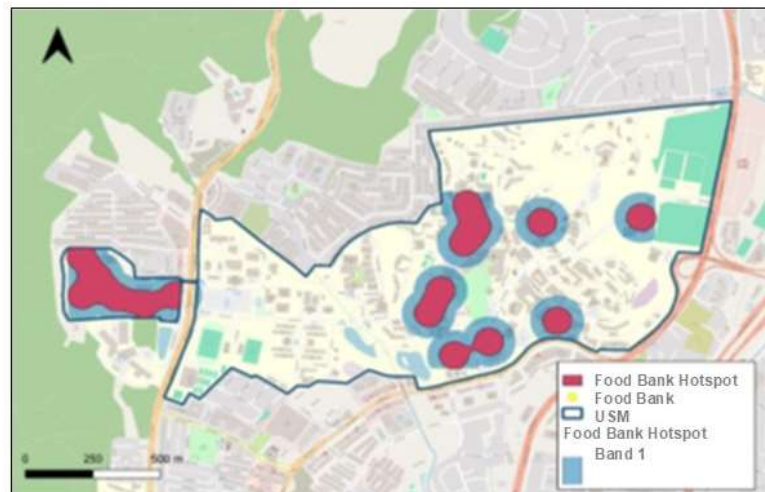


Figure 3: Hotspot Map of Food Banks at Universiti Sains Malaysia

4.1.3 Distribution Coverage of Food Banks at Universiti Sains Malaysia

The researcher mapped the distribution coverage using heatmap analysis with GIS applications, as shown in Figure 4. This distribution coverage map is used to assess the accessibility and level of student access to food banks in relation to achieving SDG 2 at USM. The map indicates that the blue areas represent locations plotted with points denoting food banks. These blue areas indicate high accessibility and ease of obtaining food from the food banks, attributed to their proximity to student residences, making it convenient for students to collect food. This accessibility helps address hunger issues among students, thereby contributing to the advancement of SDG 2. Additionally, the food banks situated near educational centers also assist students in addressing hunger before attending classes. The provision of these food banks is one of the initiatives undertaken by the university to combat hunger among financially disadvantaged students. Therefore, it can be concluded that the food banks around educational centers play a role in improving the level of SDG 2 at Universiti Sains Malaysia.

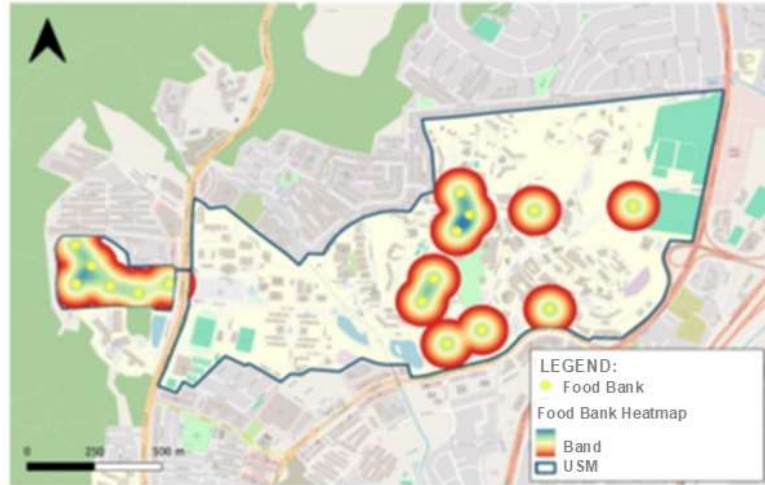


Figure 4: Heatmap of Distribution Coverage of Food Banks at Universiti Sains Malaysia

4.1.4 Distribution Coverage for Improvement Proposals of Food Banks at Universiti Sains Malaysia

The distribution coverage map aims to identify potential and suitable areas for placing food banks, as shown in Figure 5. This is supported by the results of the heatmap analysis, which indicate that many areas still lack food banks, particularly within the residential halls on campus. Additionally, some areas with existing food banks are not well maintained. Through this distribution coverage mapping, the researcher can identify strategic locations to increase the number of food banks, especially within student residential halls. This initiative could help ensure better access to food for students and address hunger more effectively.

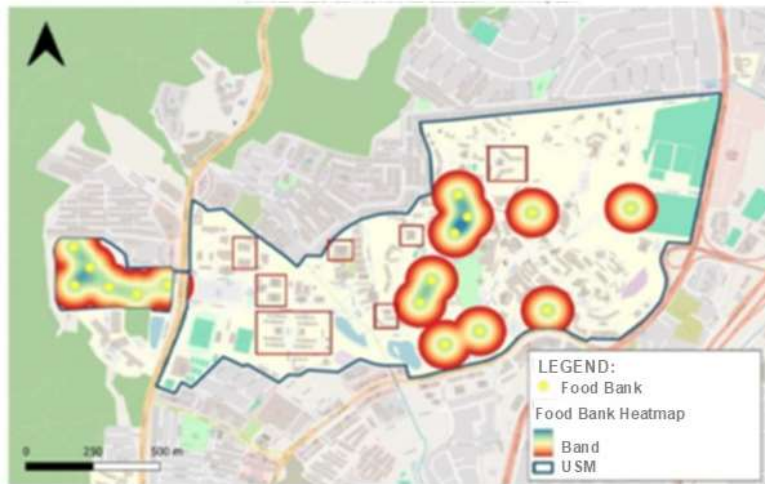


Figure 5: Map of Distribution Coverage for Improvement of Food Banks at Universiti Sains Malaysia

Based on the results presented in Table 1, the suitable and potential areas for placing food banks in the residential halls include the vicinity of Desasiswa Indah Kembara, Desasiswa Aman Damai, Desasiswa Cahaya Gemilang Harapan, and Desasiswa Bakti Permai.

Table 1 : Coordinates of Proposed Improvement Areas for Food Banks at Universiti Sains Malaysia

No	Location	Latitude	Longitude
1	Desasiswa Indah Kembara	5.35556	100.29542
2	Desasiswa Aman	5.35539	100.29416
3	Desasiswa Cahaya Gemilang	5.36042	100.30350
4	Desasiswa Fajar Harapan	5.35451	100.30036
5	Desasiswa Bakti Permai H12	5.35709	100.29922
6	Perpustakaan Hamzah Sendut 1	5.35741	100.30317
7	Perpustakaan Hamzah Sendut	5.35815	100.30298

Based on the coordinates collected by the researchers using GPS, several strategic locations have been identified as suitable for adding food banks. These locations are ideal due to their proximity and easy accessibility, allowing students to obtain meals with minimal effort. Additionally, the dormitories serve as residences for Universiti Sains Malaysia students, making it convenient for those in need to access food without having to walk far. Moreover, the Hamzah Sendut Library is an appropriate location as it attracts many students who visit to work on

assignments. Therefore, adding food banks around the library would be highly beneficial. Furthermore, since the library operates 24 hours a day for students, these food banks could play a significant role in reducing hunger issues among USM students.

4.2 Interview

This in-depth interview aims to identify the locations of food banks at Universiti Sains Malaysia (USM) and understand the impact of SDG 2 on students' quality of life. An officer from the Centre for Global Sustainability Studies (CGSS) stated that the trend regarding SDG 2 is still at a low level, though the situation is considered to be progressing well. However, the university continues to actively work on ensuring that students have access to adequate food. For instance, the officer believes that BHEPA is actively providing food assistance through the established food banks.

The CGSS officer also mentioned that the food provided often lacks sufficient nutritional value, with items like instant noodles still available in the food banks. This suggests that the food provided may not be sufficiently nutritious for students. He argued that the food should be more nutritious and balanced to ensure that USM students remain healthy. Additionally, the CGSS officer noted that food bank initiatives can help reduce hunger, particularly among financially disadvantaged students, including those from the B40 group. These food banks provide free food to students in need, which can help alleviate poverty by allowing them to access food and drinks at no cost.

There are several positive impacts of SDG 2 on students' quality of life at USM. One key impact is the improvement in students' quality of life through access to nutritious and adequate food. Access to balanced meals provides energy and ensures that students remain healthy while leading active lives on campus. To effectively address hunger issues and align with SDG 2, the healthy food bank program should continue, with food offerings that meet balanced diet standards, as emphasized by indicator 2.1, which focuses on universal access to safe and nutritious food.

However, there are challenges in maintaining the level of SDG 2 at USM. The main challenge is providing students with access to nutritious and balanced food. Financial constraints often lead students to choose cheaper, less nutritious food options. Despite the variety of food available in cafeterias, financial issues force many students to limit their food intake. For example, some students resort to eating instant noodles to save money. To effectively address this, the university should play a key role in ensuring that nutritious food is available at affordable prices in all cafeterias.

Additionally, the researcher conducted in-depth group interviews with representatives from the Student Representative Council (MPP), the Student Residential Council (MPD), student organizations, and other student representatives. The goal was to gain a deeper understanding of hunger issues among students. The findings indicated that student representatives agreed that the level of SDG 2 remains low, as many financially challenged students experience hunger and are forced to limit their food intake to survive on campus. They also shared that each MPD runs food bank programs within the residential halls to help students in need obtain sufficient food. For instance, a representative from the Saujana Residential Council mentioned the "Gerobok Rezeki" program, which provides food at the Gerobok Rezeki located in Blocks M03 and M04. This highlights one of the initiatives aimed at improving SDG 2 and addressing hunger among students.

The interview results also revealed suggestions for suitable locations for food banks, as shown in Table 1. These areas were chosen due to their strategic nature, being focal points for students. Residential hall areas were selected because they serve as student housing, making it easier for students to access food. The MPP also mentioned that some food banks are not well maintained, which calls for the university to be proactive in ensuring that these food banks are used more regularly to maximize the effectiveness of SDG 2.

5.0 Discussion

5.1 Distribution Pattern of Food Banks at Universiti Sains Malaysia

Based on interviews with sustainability officers from the Centre for Global Sustainability Studies (CGSS), Sustainable Development Goal 2 (SDG 2) aims to eliminate hunger, achieve food security, and improve nutrition, all of which significantly affect students' quality of life. One of the impacts of SDG 2 on students' quality of life is the potential to enhance their health and well-being. Providing food with balanced nutrition is essential for students' bodily health. Healthy eating is closely related to positive attitudes and habits, and maintaining healthy eating habits can foster better behaviors (Yang et al., 2020). Every student requires a balanced diet to ensure their body functions properly. Healthy food is crucial for students' overall health (Isa & Sarala, 2020).

5.2 Impact of SDG 2 on the Quality of Life of Students at Universiti Sains Malaysia

Based on the interviews conducted by sustainability officers from the Centre for Global Sustainability Studies (CGSS), Sustainable Development Goal 2 (SDG 2) aims to eliminate hunger, achieve food security, and improve nutrition, all of which significantly affect students' quality of life. One impact of SDG 2 on students' quality of life is the potential to enhance their health and well-being. Providing food with balanced nutrition is crucial for bodily health. Healthy eating is closely related to attitudes and habits, and maintaining healthy eating habits can foster positive behaviours (Yang et al., 2020). Every student requires a balanced diet to ensure their bodies function properly. Healthy food plays a vital role in students' health (Isa & Sarala, 2020).

Students' eating habits are influenced by several factors, including service quality and price (Verma, 2010). Many students opt for cheaper food options, such as fast food, to reduce their food costs while at university. However, consuming unhealthy foods like fast food can lead to psychological effects and chronic diseases (Ha & Caine-Bish, 2009). Therefore, strengthening SDG 2 through the provision of food banks can support students in need by offering access to nutritious food, which can enhance both their physical and mental health. Additionally, food banks for less fortunate students at USM can help reduce living costs. Some students still struggle to afford cafeteria food due to its high price. Initiatives from the university and the Student Representative Council (MPP) to provide nutritious food through food banks can alleviate the financial burden on students.

5.3 Proposed Potential Areas for Food Banks to Improve SDG 2 at Universiti Sains Malaysia

Mapping around USM has identified several potential areas for establishing food banks to improve SDG 2. Seven areas have been identified as suitable for increasing the number of food banks around USM. Strategic location factors can greatly facilitate students' access to food. Several key factors must be considered when selecting appropriate locations for food banks. First, the needs of the underprivileged student community, particularly those from the B40 group, should be prioritized. Food banks should be dedicated to those who are most in need to ensure they have adequate access to food. Additionally, food banks must be situated in areas that are easily accessible to students, allowing

them to obtain food without barriers. Furthermore, food banks need to be placed in safe and clean areas to prevent food contamination and avoid issues related to foodborne illnesses.

Ensuring a continuous food supply is also crucial for the long-term operation of food banks, allowing students in need to consistently access food over time. Therefore, the university and student representatives can seek food donations from various sources to keep the banks stocked. In conclusion, several key factors influence the selection of food bank locations on campus. These factors play a vital role in ensuring that students can access food more easily and quickly. Choosing strategic locations will also serve as an effective way to address hunger among students in need.

6.0 Conclusions

Overall, the increase in food cabinets around Universiti Sains Malaysia has significantly contributed to advancing Sustainable Development Goal 2, in alignment with Indicator 2.1, which focuses on universal access to safe and nutritious food. GIS applications enable mapping that helps identify the quantity and distribution patterns of food cabinets present at USM. Moreover, GIS applications can provide more accurate and detailed maps for selecting suitable and strategic locations to place food cabinets around the campus. In this study, GIS also offers engaging and clearer visualizations for proposing potential areas for these food cabinets. This demonstrates that researchers can conduct studies more effectively and systematically with the help of technology. The results of this study show that the provision of food cabinets can enhance the level of SDG 2 among students at Universiti Sains Malaysia. Therefore, this study underscores the importance of utilizing existing technologies, such as GIS and GPS software, to explore improvements to SDG 2: Zero Hunger at USM using Geographic Information Systems (GIS).

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Conflicts of Interest: The authors declare that there are no conflicts of interest.

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