Food Security Mapping in Padang City Using Geographical Information Systems (Case Study: Beef)

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ARTICLE INFORMATION

ABSTRACT

In Indonesia, the cattle agricultural business is one of the most significant food commodities for comply nutritional needs. The variable availability of cattle supplies is a challenge that the Padang City Agriculture Service must tackle. As a result, to establish the state of food security in Padang City, food security indicators must be calculated and analyzed. Food Security Quotient (FSQ) approach was used in this study to map the logistical network and beef food security. Following that, an information system based on a Geographic Information System (GIS) was created to represent the flow of the beef supply chain in Padang City. It was discovered from direct observations beef supply chain network in Padang City comprises of a fresh beef and a frozen beef supply chain. Beef suppliers from other regions, local breeders, feed lotters, slaughterhouses, wholesalers, retail traders, hotel / supermarket /restaurant/ catering consumers, rendang processing industry consumers (MSMEs), home consumers small-scale dining, and household consumers are all involved in the fresh beef supply chain. The analysis of the level of food security in Padang City revealed that three sub-districts were in the secure state, three were in a moderate state, and five were in a vulnerable state. The developed GIS is supposed to aid decision making in Padang City on food security predictions.

Keywords: beef, food security, logistics, mapping

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ABSTRACT

Industri pertanian ternak di Indonesia menjadi salah satu komoditas pangan terpenting untuk memenuhi kebutuhan gizi. Kondisi ketersediaan pasokan daging sapi yang tidak menentu menjadi tantangan yang harus dihadapi oleh Dinas Pertanian Kota Padang. Oleh karena itu, perlu adanya perhitungan dan analisis indikator ketahanan pangan di Kota Padang guna mengetahui kondisi ketahanan pangan di Kota Padang. Penelitian ini melakukan pemetaan terhadap jaringan logistik dan pemetaan ketahanan pangan daging sapi menggunakan metode Food Security Quotient (FSQ). Selanjutnya dilakukan perancangan sistem informasi untuk menampilkan aliran rantai pasok daging sapi di Kota Padang berbasis Geographic Information System (GIS). Berdasarkan hasil observasi langsung didapatkan jaringan rantai pasok daging sapi di Kota Padang terdiri dari rantai pasok daging sapi segar dan daging sapi beku. Aktor yang terlibat pada rantai pasok daging sapi segar yaitu pemasok sapi dari daerah lain, peternak lokal, feedloter, rumah potong hewan, pedagang besar, pedagang eceran, konsumen hotel/supermarket/resto/catering, konsumen industri olahan rendang (UMKM), konsumen rumah makan skala kecil, dan konsumen rumah tangga. Analisis tingkat ketahanan pangan di Kota Padang didapatkan hasil bahwa 3 kecamatan berada dalam kondisi tahan pangan, 3 kecamatan dalam kondisi sedang dan 5 kecamatan berada dalam kondisi tidak tahan pangan. GIS yang dirancang diharapkan mendukung pengambilan keputusan terhadap prediksi ketahanan pangan di Kota Padang.

Keywords: daging sapi; logistic; ketahanan pangan; pemetaan.

INTRODUCTION

Cattle farming industries in Indonesia becomes one of the most important food commodities to meet nutritional needs. Indonesia's current economic growth such as: population growth, increased income, improved public welfare, and increased public awareness of the importance of animal protein, have a direct impact on heightening beef consumption [1]. This issue is in the top priorities listed on strategic plan of the Ministry of Agriculture 2015-2019 [2]. West Sumatera is in 5th place as the highest province produce beef nationwide. The demand for beef in West Sumatra Province, especially Padang City, tends to increase from year to year and is also ranked highest in West Sumatra. In 2017 beef production in Padang City was 3,125,738 kg, 3,056,468 kg in 2018 and 3,165,636 kg in 2019. This situation is followed each year with cattle population is soaring, shown in Table 1 [3].

Table1. Cattle population in Padang City 2021

No.	District	Cattle Population
1	Bungus Teluk Kabung	1.636
2	Lubuk Kilangan	1.835
3	Lubuk Begalung	434
4	Padang Selatan	165
5	Padang Timur	165
6	Padang Barat	-
7	Padang Utara	366
8	Nanggalo	1.327
9	Kuranji	7.547
10	Pauh	2.708
11	Koto Tangah	5.432

Note: Qualitatively refers to department of agriculture,
animal husbandry,plantations, and forestry of Indonesia

However, Indonesia's economic growth is not accompanied by production growth. UNICEF released a report stating that Indonesia remains to struggle with food issues, particularly with obesity, wasting, stunting, and malnutrition [4]. Some obstacles such as capital, low human resources, insufficient feed intake are the causes of the case. So, beef production has been unable to satisfy rising demand [5]. Therefore, to meet beef requirements is include in Strategic Plan of Ministry of Agriculture in 2009-2014 and continued in 2015-2019, and it is targeting self-sufficiency for beef to be ready by 2026. Going forwards, Ministry of National Development Planning states to have growth of beef production level is above 10,8 percent per year. In 2021, beef production is 487.80 thousand tons, out of a total meat production of 4,546.96 thousand tons or contributing up to 10.73% to national meat production [6]

According to Central Bureau of Statistic of Indonesia, beef consumption in Indonesia was 0,038 kg per capita per month in March 2021. This data is decrease by 2,6% from March 2020 which was 0,039 kg per capita per month. Consumption decline was due to increasing in prices. from March 2020 which was 0.039 kg per capita per month. The decline in consumption was due to an increase in prices. Hence, still many middles- and lower-income people find it difficult to consume beef. By 2023, West Sumatra placed 9th as the province with the highest beef consumption in Indonesia, with 198.500 ton [7]. The amount of food and nutrients required by each individual and community group to maintain their current state of health and wellbeing is known as food security [8]. Food security is achieved when everyone has easy and economically viable access to food. This is to enable the achievement of an active and healthy life [9]. The three sub-systems of food security are as follows [10]

a. Food availability with the main source of supply from domestic production and food reserves. Achieved when enough food is available to all individuals.

b. Food access by the whole community, both physically and economically. Ensured when households and all individuals within them have adequate resources to obtain appropriate foods for nutritious diet.

c. Food utilization to improve the quality of food consumption and nutrition, including the development of food safety.

Padang Agriculture Office faces a hurdle when providing data and analyzing information on cattle: the unpredictability of the availability of cattle supplies. Interpretation of cattle supply condition in Padang City can be done by applying Geographic Information System (GIS). A Geographic Information System (GIS) is a network of hardware, software, and persons that enable the entry, manipulation, analysis, and presentation of data associated with a specific location on Earth's surface [11].The usage of the Internet as an extensive tool for communication and administration of geographic data has contributed to the vertiginous advancement of GIS currently. GIS have been used, among other things, to solve issues with navigation, earth sciences, military logistics, and architecture [12]. This mapping is then used as a reference for Padang Agriculture Office for the decision-making process in food security of meat.

METHOD

To analyze condition of food security, in this study is beef, using the modification of Location quotient (LQ) to Food Security Quotient (FSQ). FSQ can identify basic commodities, in order to choose and sort prioritized and non-prioritized variables that are utilized as cumulative so that a comparison between Padang sub-districts can be displayed [13]. Calculation results of FSQ will indicate the level of food security condition of an area according to its indicators. FSQ formulation is divides the city or district variable value by the total variable value and it is shown below:

$$FSQ = \frac{x_r/_{RV_r}}{x_n/_{RV_n}} \qquad \ldots\ldots (1)$$

The results of the FSQ calculation are divided into 5 categories to be more specific about the condition of food security in each region, shown in Table 2.

Table 2. Food security indicators [14]

FSQ Value	Categories	Colour Indicators
≤ 0,25	Highly vulnerable	Red
> 0,25 – 0,5	Vulnerable	Pink
> 0,5 – 0,75	Moderate	Yellow
>0,75 – 1	Secure	Light green
> 1	Highly secure	Dark green

This research started with value chain analysis of beef in Padang City, which refers to [15] analyze beef cattle value chain focus on actors, relationship, opportunities and bottleneck and suggesting the specific areas of intervention to develop the value chain in Bangladesh; [16] and [17] identify beef cattle value chain actors and their roles and investigate the determinants of quantity of beef marketed in Ethiopia. Next step, this research conducted to develop Geographic Information System (GIS) as a facility to make decision making in term of Food Security of Beef in Padang City; sch as research by [18] GIS for food security of rice and [19] GIS for food security of coconut. A geographic information system is designed to display the results of food security in Padang. By using the color indicators in table 2, Geographic Information System is designed to make it easier for the Padang Agriculture Office to make decisions according food availability, food access and foo utilization.
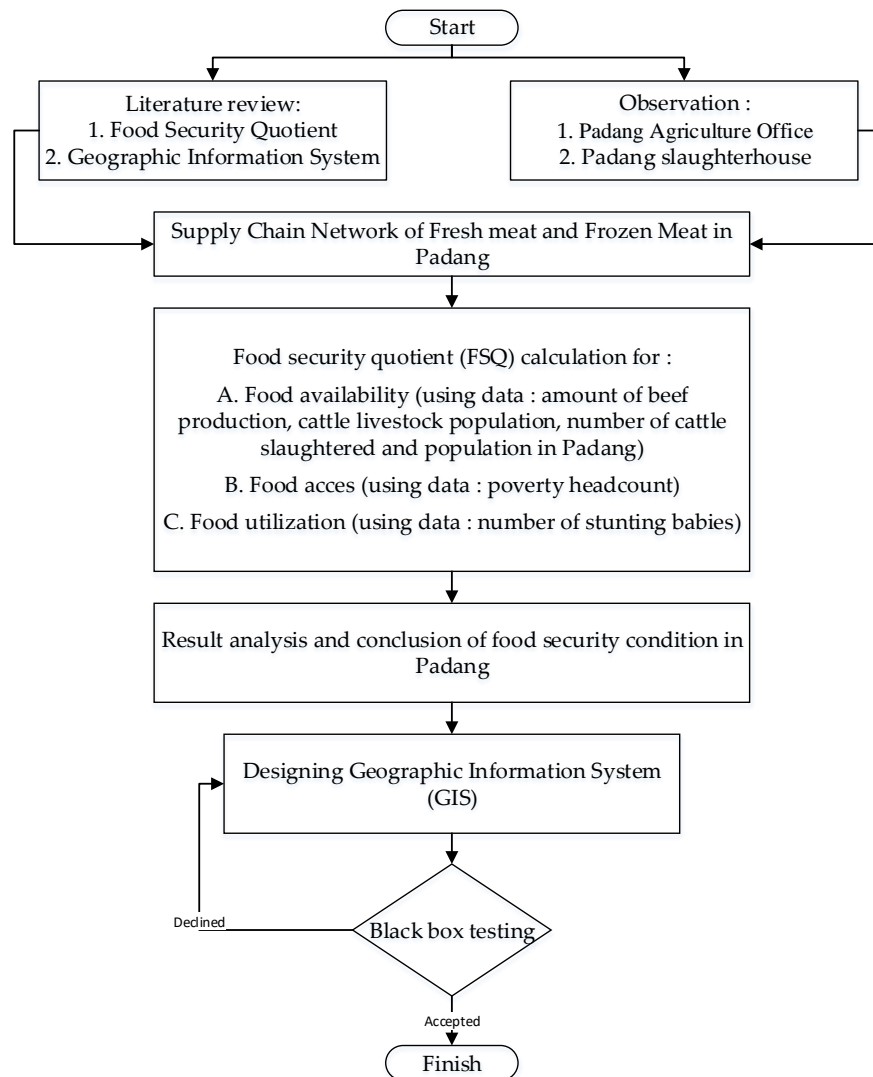
Figure 1. Flowchart of the study

Fresh meat supply chain network flows from upstream to downstream. The first stage is cattle suppliers who come from outside regions (Australian breeds bred in Lampung) and local farmers. Second level is in the slaughterhouse where certified butchers are provided to slaughter the cattle known as *JuLeHa* (Juru Sembelih Halal). The third one is whole sellers, retailers and consumers. Unlike the product flow, the financial flow will move from downstream to upstream. Financial flows can be in form of invoices, payment agreements, checks, etc. Information flow between the parties is information related to suppliers, beef supply location, quality, quantity of beef supply, and market price. Information related to suppliers, beef purchase locations, beef quality, beef inventory flows between abattoirs and large traders as beef producers. while information related to market prices flow from retailers in traditional markets to whole sellers and vice versa.
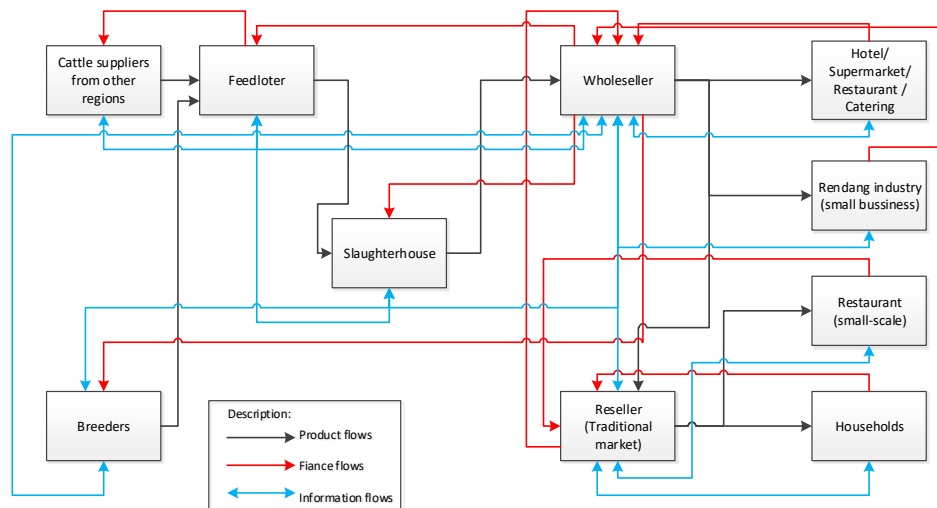
Figure 2. Supply chain network for fresh meat in Padang

In addition to fresh meat, frozen meat is also available in the market in Padang. Frozen meat is imported from other countries including Australia, New Zealand, Brazil, Spain, and India where the five countries are free from Foot and Mouth Disease. Bulog as a state-owned public company in terms of food security control has the right to a frozen meat import. Product flow is beginning with importers who place orders for meat from overseas and then distributing it to wholesalers in city/regency. Finance flow moves from consumer's stage to suppliers. And information flow occurs between actors in the supply chain network to ensure product flow can move to the consumer level. To ensure compliance with administrative criteria pertaining to product eligibility documentation, including microbiological content and hygiene. supply chain network for frozen meat in Padang shown in Figure 3.
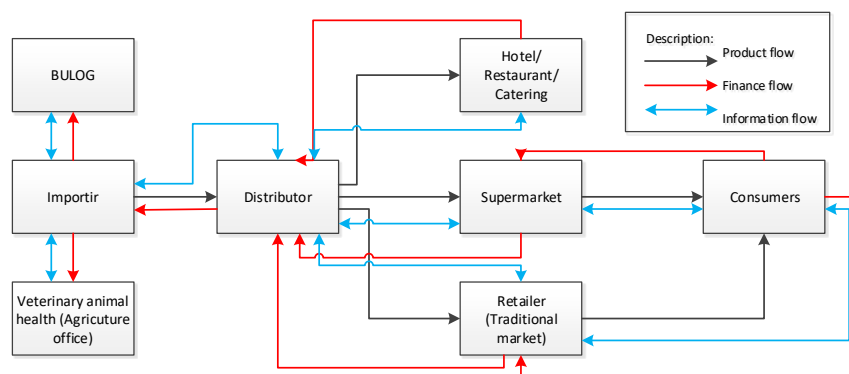

Figure 3. Supply chain network for frozen meat in Padang

RESULT AND DISCUSSION

Primary data has been collected from Agriculture office and slaughterhouse in Padang. Meanwhile, secondary data obtained through the Central Bureau of Statistics (Badan Pusat Statistik Indonesia) in 2023. The Indonesian constitution No. 8/2012 stipulates that the fulfillment of national food needs through imports and domestic production depends on food availability. If these sources are insufficient to meet national food needs, import activities can be carried out. Food availability, specifically beef, is measured using four variables that are closely related to the availability factor which are:

  a. Amount of beef production,
  b. Cattle livestock population
  c. Number of cattle slaughtered, and
  d. Population in Padang.

Table 3 displays an overview of the findings from the FSQ food availability computation.

Table 3. FSQ calculation for food availability

No	District in Padang	FSQ amount of beef prod.	FSQ Cattle livestock population	FSQ no. cattle slaughtered	FSQ Padang population	Average FSQ per district	Categories
1	Bungus Teluk Kabung	0,0395	1,6287	0,0396	0,1903	0,4745	Vulnerable
2	Lubuk Kilangan	0,1204	1,8278	0,1209	0,3705	0,6099	Moderate
3	Lubuk Begalung	0,8636	0,4319	0,8670	0,6422	0,7012	Moderate
4	South Padang	0,1591	0,1641	0,1597	0,3820	0,2163	Highly vulnerable
5	East Padang	0,7338	0,1653	0,7367	0,6288	0,5661	Moderate
6	West Padang	0,2232	0,3644	0,2241	0,5050	0,3292	Vulnerable
7	North Padang	0,1055	0,0000	0,1060	0,5298	0,1853	Highly vulnerable
8	Nanggalo	0,1818	1,3213	0,1825	0,4332	0,5297	Moderate
9	Kuranji	0,4480	7,5160	0,4498	0,8796	2,3233	Highly secure
10	Pauh	0,5657	2,6962	0,5679	0,3480	1,0445	Highly secure
11	Koto Tangah	2,5822	5,4006	2,5923	1,2273	2,9506	Highly secure

The average value of FSQ in Padang is 0.9082 which is categorized as secure in food availability. This condition is bolstered by Padang City's cow population, which is the biggest of any city in West Sumatra, ensuring that meat will always be available. Meanwhile, the smallest FSQ value is 0.1853, which is categorized as highly vulnerable or food insecure is found in district West Padang. It is due to the absence of beef cattle population in West Padang that can cause shortage. This condition should be a major concern and priority for the Agriculture Office considering the population in West Padang is quite large at 78,449 people. Analysis related to food access is needed to verify that households or individuals consume the food supplied. Food access is one of the food security sub-systems that connect food availability to consumption. Food access is good when all households have sufficient resources to obtain food in terms of quantity, quality and food diversity. FSQ calculation for food access use poverty headcount as indicator showing people's buying power in each district. The lower FSQ value is, the higher district ability to afford beef because there are fewer poor people. FSQ food access computation result is shown in Table 4.

Table 4. FSQ calculation for food access

No	District	Population per district	Poverty headcount	FSQ	Categories
1	Bungus Teluk Kabung	29.569	1.314	0,2454	Highly secure
2	Lubuk Kilangan	57.554	2.558	0,4776	Secure
3	Lubuk Begalung	99.772	4.434	0,8280	Vulnerable
4	South Padang	59.351	2.638	0,4925	Secure
5	East Padang	97.688	4.341	0,8107	Vulnerable
6	West Padang	78.449	3.486	0,6510	Moderate
7	North Padang	82.308	3.658	0,6830	Moderate
8	Nanggalo	67.298	2.991	0,5585	Moderate
9	Kuranji	136.655	6.073	1,1341	Highly Vulnerable
10	Pauh	54.061	2.403	0,4486	Secure
11	Koto Tangah	190.671	8.474	1,5823	Highly Vulnerable

The results of FSQ calculation shows the lowest value is 0.2453, which means people's buying power in Bungus Teluk Kabung district is highly secure. In contrast, the highest FSQ calculation result is in Koto Tangah district with 1, 5823 points. It implies the condition of people's buying power in Koto Tangah district is highly vulnerable.

The last FSQ sub-system is Food Utilization. Food utilization will generate human resources quality, which is one of the key elements for successful development. This is accomplished by eating a varied, wholesome, and well-balanced diet. Quality indicators related to public health and nutrition intake. For this study it represents with number of stunting babies. Given the higher FSQ score and the high proportion of stunted infants, the area is considered to have non-nutritious diet. Instead, if the FSQ score is low, it correlates with a low percentage of stunted babies, so it can be said that people in the area are healthy starting early as toddlers. Table 5 shows FSQ calculation for food utilization.

Table 5. FSQ calculation for food utilization

No	District	Percentage of stunting babies	Number of stunting babies	FSQ	Categories
1	Bungus Teluk Kabung	0,39%	456	0,2459	Highly secure
2	Lubuk Kilangan	0,76%	888	0,4786	Secure
3	Lubuk Begalung	1,32%	1.540	0,8297	Vulnerable
4	Padang Selatan	0,79%	916	0,4936	Secure
5	Padang Timur	1,29%	1.508	0,8124	Vulnerable
6	Padang Barat	1,04%	1.211	0,6524	Moderate
7	Padang Utara	1,09%	1.270	0,6845	Moderate
8	Nanggalo	0,89%	1.039	0,5597	Moderate
9	Kuranji	1,81%	2.109	1,1365	Highly Vulnerable
10	Pauh	0,72%	834	0,4496	Secure
11	Koto Tangah	2,52%	2.943	1,5857	Highly Vulnerable

Food utilization as indicated by the percentage of stunted babies in Bungus Teluk Kabung is at 0.2459 points, meaning this district is included in highly secure categories. Meanwhile, the largest FSQ value of 2.943 is in Koto Tangah considered to be highly vulnerable. The three indices of food availability, food access, and food utilization are compiled in one total data set. All data per district has been classified featured in Table 6.

Table 6. FSQ of beef in Padang

No	District	FSQ Food Availability	FSQ Food Access	FSQ Food Utilization	Final Categories
1	Bungus Teluk Kabung	Vulnerable	Highly secure	Highly secure	Secure
2	Lubuk Kilangan	Moderate	Secure	Secure	Secure
3	Lubuk Begalung	Moderate	Vulnerable	Vulnerable	Vulnerable
4	Padang Selatan	Highly vulnerable	Secure	Secure	Moderate
5	Padang Timur	Moderate	Vulnerable	Vulnerable	Vulnerable
6	Padang Barat	Vulnerable	Moderate	Moderate	Moderate
7	Padang Utara	Highly vulnerable	Moderate	Moderate	Vulnerable
8	Nanggalo	Moderate	Moderate	Moderate	Moderate
9	Kuranji	Highly secure	Highly Vulnerable	Highly Vulnerable	Vulnerable
10	Pauh	Highly secure	Secure	Secure	Secure
11	Koto Tangah	Highly secure	Highly Vulnerable	Highly Vulnerable	Vulnerable

This study uses GIS to display the position of beef food security in Padang according to the calculation using Food Security Quotient (FSQ) method that has been done previously. The system is generate in Bahasa.
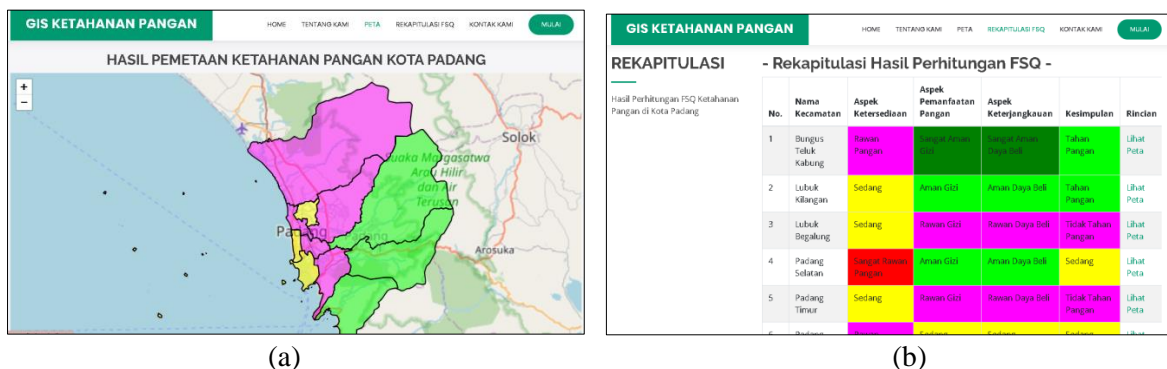

(a)   (b)

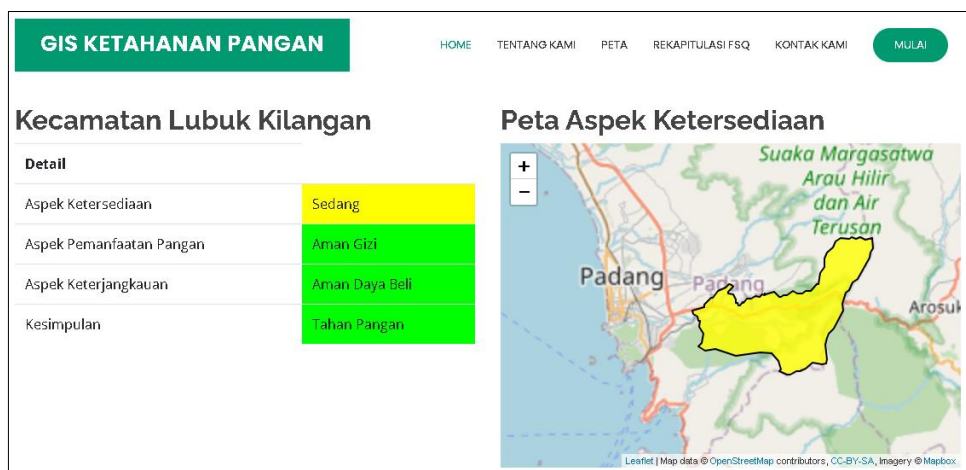Figure 4. (a) Geographic inforation system (GIS) homepage, (b) FSQ calculation

Figure 5. Food security mapping for Lubuk Kilangan District

This geographic information system (GIS) is expected to be used by the Padang Agriculture Office in terms of decision making regarding the availability, utilization and access of beef in Padang. The gap between sub-districts can be reassessed. Basic testing of GIS is carried out using the Black Box Testing method. Table 7 displays the tests.

Table 8. Black box testing

Test Activities	Expected result	Result	Conclusion
Homepage	Connected with API Google Maps	A map of Padang appears	[x] Accepted [ ] Declined
Click the "About Us" button	Explanation about the system appears	A description of the Padang Food Security GIS appears	[x] Accepted [ ] Declined
Click the "Maps" button	Overall mapping results appears	There is an FSQ classification for each district in Padang, marked	[x] Accepted [ ] Declined

Test Activities	Expected result	Result	Conclusion
		with a different color.	
Click the "Rekapitulasi" button	Recapitulation table are shown up	The result of FSQ calculation for each district appears	[x] Accepted [ ] Declined
Click "Lihat Peta" in recapitulation menu	District maps and resilience conditions appear	Emerging FSQ results related to resilience in selected districts	[x] Accepted [ ] Declined

CONCLUSION

In this research, there are two objectives that can be achieved in building a food security system related to beef in the city of Padang. The objectives are to understand the condition/level of food security in each district and to depict these findings in a digital visualization that is easily accessible, reliable, and up-to-date. From the mapping observed in the supply chain network for fresh meat in the city of Padang, it is evident that there are several stakeholders involved in providing policy and implementing administrative procedures according to SOP. This includes cattle suppliers, slaughterhouses, traders, and end consumers. From the analysis of the supply chain network mapping, an analysis of the food security level in each district was conducted based on three aspects: the condition of beef availability, the utilization of beef, and the affordability of beef. Each aspect has its own indicators that show the level of food security. From the overall recapitulation data processed using the FSQ method; it is evident that only 3 districts are at a food-resilient level. There are five districts that are in a non-food resilient condition out of a total of 11 districts in the city of Padang. This certainly affects the policies of local governments and related departments that will be taken in the future regarding food security issues for beef. The results of the food security level are then visualized into a Geographic Information System to facilitate mapping and big capture of the security level of each aspect and overall recapitulation.

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