

# Analysis of the Spatial Distribution of Cannabis Establishments Based on Usage Patterns in Mueang District, Surat Thani Province of Thailand

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## Abstract

*The societal acceptance of cannabis in various regions of Thailand has greatly increased its legal use. In July 2021, the Thailand Government Gazette authorized the use of cannabis for medical, cosmetic, food and beverage, and smoking purposes. This development might lead to easier access to cannabis, especially among adolescents, resulting in higher prevalence. This survey research aimed to investigate and visualize the spatial distribution of cannabis establishments based on usage patterns in the Mueang District of Surat Thani Province, Thailand, using geographic information systems (GIS). The cannabis establishments were explored and analyzed using GIS to visualize their locations and buffer maps. The location map illustrated the distribution of cannabis establishments, categorized by patterns of cannabis use. Additionally, the buffer map visualized the radius of cannabis establishments around five educational institutions. Data collection was conducted between May and June 2024. The locations of the establishments and educational institutions provided in the researchers' data collection were used to generate coordinates on Google Maps and visit the places of establishments. These specifics were imported for analysis using ArcGIS version 10.5. The spatial distribution analysis indicated the presence of 61 cannabis establishments in the study area, which were categorized by the pattern of cannabis use, including 43 cannabis smoke establishments, 10 cannabis-contained beverage establishments, and 8 cannabis-contained food and beverage establishments, as depicted on the location map. Cannabis establishments were strategically situated in areas with higher population density, likely reflecting increased demand for use. Buffer maps were created within a 500 to 1000-meter radius around educational institutions to demonstrate the accessibility of cannabis, especially for adolescents. These findings have the potential to influence government policies and initiatives aimed at preventing and regulating adolescent access to cannabis. Specifically, regulations concerning the proximity of cannabis-selling establishments to educational institutions could be evaluated and implemented appropriately.*

**Keywords:** Adolescents, Cannabis, Geographic Information Systems, Pattern, Spatial Distribution

## 1. Introduction

Cannabis is a genus of flowering plants in the Cannabaceae family. It consists of three main species: *Cannabis sativa*, *Cannabis indica*, and *Cannabis ruderalis*. The plant contains active compounds called cannabinoids. The most notable ones are Tetrahydrocannabinol (THC), which is the primary psychoactive substance that induces a "High," and Cannabidiol (CBD), a non-psychoactive

compound recognized for its potential therapeutic benefits [1]. Cannabis is one of the most widely used drugs globally, with over 200 million users [2]. According to data presented at the Center for Addiction Studies' ninth academic conference in February 2022, cannabis use in Thailand has doubled compared to previous years.

Research indicates that approximately 1.9 million Thais aged 18 and older, or about 4.28% of the adult population, are currently using cannabis, up from around 1 million users in 2020 [3].

The prevalence of cannabis use is expected to rise as cannabis-related laws change in various countries [4]. In Thailand, the government has issued a notification to the Ministry of Public Health under Category 5 of the Narcotics Act B.E. 2565 (2022), which removes cannabis from the list of narcotics. This category previously included substances with a high potential for abuse and no accepted medical use. Consequently, this change has allowed for the legal and relatively unrestricted sale of cannabis to anyone aged 20 or older [5]. The recent change in the law allows for the use of cannabis for medical, research, traditional, commercial, recreational, and cosmetic purposes. This includes infused food and beverages as well as smoking for recreational use. Most cannabis users usually smoke the substance by inhaling the smoke from joints, pipes, or bongs [6]. This method is popular among both recreational and medical users because of its quick onset of effects [7]. Alternatively, consuming cannabis-infused edibles such as foods or beverages results in delayed but more sustained effects. This approach is preferred by individuals who choose to avoid smoking or vaping [8].

The legal permission of cannabis can increase its usage among the entire population, making it easily accessible to consumers, especially adolescent groups [9]. Adolescents may experience more pronounced adverse effects compared to adults due to their still-developing brains, which are vulnerable to addictive substances [10]. For short-term effects, cannabis use can impair memory, attention, and decision-making skills temporarily. It may also cause mood swings, anxiety, or paranoia shortly after consumption, as well as increased heart rate, dry mouth, red eyes, and impaired motor coordination, increasing the risk of accidents [11]. Additionally, long-term effects include impacts on brain development, such as decreased IQ, memory problems, and difficulties with learning and problem-solving [12]. Moreover, chronic cannabis use during adolescence has been linked to an increased risk of developing psychiatric disorders, such as schizophrenia, depression, and anxiety disorders later in life [13] and [14].

Mueang District, Surat Thani province, located in the Southern part of Thailand, is recognized for its extensive cannabis cultivation. The population includes a mix of ages, with many young people. The urban areas are more densely populated than rural regions. This urban area is a focal point for economic activities, with businesses ranging from local markets

to international hotels and restaurants catering to tourists. With the new legal framework, numerous cannabis-related companies have been established, including dispensaries, cafes, restaurants, and wellness centers. This growth has made it easier for residents and tourists to purchase and consume cannabis [15]. Additionally, the urban areas of Mueang District are more densely populated, which facilitates the opening of more cannabis establishments to meet local demand. Urban residents have easier access to these establishments compared to rural areas. Various establishments in the area visibly sell cannabis in several forms, including smoking products, food items, and beverages [16]. The urban population here is diverse, which may influence cannabis consumption habits, particularly among adolescents, who are considered a high-risk group [17]. This study aimed to investigate and visualize the spatial distribution of cannabis establishments based on usage patterns in the Mueang District of Surat Thani Province, Thailand, employing GIS. Interestingly, GIS allows for gathering, storing, integrating, and managing spatial data concerning cannabis establishments, including their location coordinates and types. Additionally, GIS enables the creation of maps that visually display the spatial distribution of cannabis establishments. It can also be used to create buffer zones around these establishments to assess their proximity to sensitive areas like schools or residential neighborhoods [18].

The gap in the study is the limited number of studies on the spatial distribution patterns of cannabis use through GIS in Thailand. Previous research has focused solely on investigating cannabis-infused food and beverage establishments [19], whereas this study focused on various types of cannabis establishments including those serving food, beverages, and smoking. Some studies have described the positive and negative effects of cannabis and cannabinoids on health [20], while this study surveyed cannabis establishments to describe their spatial distribution and explore patterns, and trends related to cannabis establishments. Furthermore, previous research has been conducted on the current cannabis-related situation in the Asia-Pacific region. This research describes the changes in the legal status of cannabis and determines to what extent these changes are leading to increased numbers of users, oversupply, and health risks [21]. Hence, this study differed from previous studies. In conclusion, the Mueang District of Surat Thani Province has various types of cannabis establishments due to factors such as legal support, favorable agricultural conditions, tourism demand, economic opportunities, and cultural acceptance.

The findings from this study can inform decision-making and health policy development. Local authorities can use the study results to monitor and enforce regulations related to the location and operation of cannabis establishments.

## 2. Material and Methods

### 2.1 Study Design

This study is survey research aimed at exploring cannabis establishments based on usage patterns in the Mueang District, Surat Thani Province, Thailand. GIS was adopted to visualize the locations and buffer maps. The location map illustrated the distribution of cannabis establishments, categorized by patterns of cannabis use and population density (ppl/sq.km.). The buffer map visualized the radius of cannabis establishments located around five educational institutions.

### 2.2 Study Area

Mueang District is the central district of Surat Thani Province, located in the Southern part of Thailand. The district is characterized by a diverse landscape, including coastal plains, river basins, and limestone mountains. Mueang District in Surat Thani Province is divided into 11 sub-districts: 1.) Talat 2.) Makhm Tia 3.) Wat Pradu 4.) Khun Thale 5.) Bang Bai Mai 6.) Bang Chana 7.) Khlong Noi 8.) Bang Sai 9.) Bang Pho 10.) Bang Kung, and 11.) Khlong Chanak. This area covers an area that includes both urban and rural landscapes. Mueang District has seen a noticeable increase in cannabis use following recent legislative changes in Thailand that have decriminalized the plant. The removal of cannabis from the narcotics list has led to its more widespread acceptance and use across various demographics [22]. This district, with its urban environment and diverse population, reflects these trends in cannabis consumption, particularly among adolescents. Importantly, the increase in cannabis establishments in Mueang District has raised concerns about the impact on adolescents. The accessibility and visibility of cannabis can potentially influence youth behaviors and attitudes toward the drug [23].

### 2.3 Data and Mapping

The data were collected from May to June 2024 to explore cannabis establishments in the Mueang District of Surat Thani Province, Thailand. The study area, Mueang District of Surat Thani Province, is divided into 11 sub-districts, as depicted in Figure 1. Shapefiles for the Mueang District were sourced from <http://www.DIVA-GIS.org> [24]. This area is in UTM Zone 47N and includes the geographic region of Mueang Surat Thani. The geographic coordinates

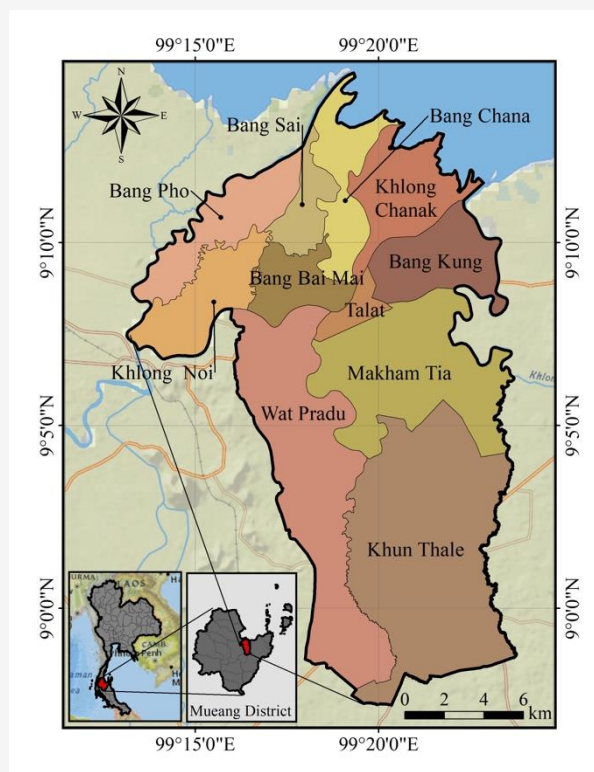
were obtained from Google Earth for the locations of cannabis establishments and educational institutions. The researcher validated the geographic coordinates from Google Maps using additional data sources as follows: The researcher visited the location, using a GPS device or smartphone to navigate to the exact coordinates, and observed the surroundings to ensure that key landmarks (buildings, roads, natural features) matched the expected location. Upon arrival, the researcher pressed and held on the exact spot in the app to drop a pin, then compared the coordinates from the dropped pin with the original coordinates obtained. During the visit, the researcher documented the process and noted any significant findings.

### 2.4 Instrument of the Study

The interview form was divided into two sections: one for collecting socio-demographic data and another for examining cultural attitudes toward cannabis. The specifics of each section are detailed below:

Part 1: The socio-demographic interview form included both open-ended and closed-ended questions to gather information about the socio-demographic characteristics of entrepreneurial representatives of cannabis establishments. The form consisted of eight items, covering age, gender, marital status, monthly income, educational level, duration of establishment operation, reasons for starting the establishments, and ownership structure.

Part 2: The cultural attitudes towards cannabis interview form; This tool was designed to collect cultural attitudes towards cannabis of entrepreneurial representatives of cannabis establishments. These ten questions were developed after reviewing relevant literature [16] and [17]. The questions were designed on a Likert scale with three levels: agree, unsure, and disagree with scoring criteria of 3, 2, and 1. Score interpretation was divided into three levels according to Best's criteria [25]: mean scores ranging from 1.00 to 1.66 indicated low cultural attitudes, mean scores from 1.67 to 2.33 indicated moderate cultural attitudes, and mean scores from 2.34 to 3.00 indicated high cultural attitudes toward cannabis. The validity of the interview form was evaluated by three field experts, who reviewed and assessed the form, assigning an Index of Item-Objective Congruence (IOC) score. The IOC scores were 0.90 for part 1 and 0.95 for part 2. Reliability was tested with a trial run involving 30 cases that did not include participants. After finalizing the cultural attitudes toward cannabis interview form, Cronbach's alpha was determined to be 0.95.



**Figure 1:** Map of Mueang District in Surat Thani Province

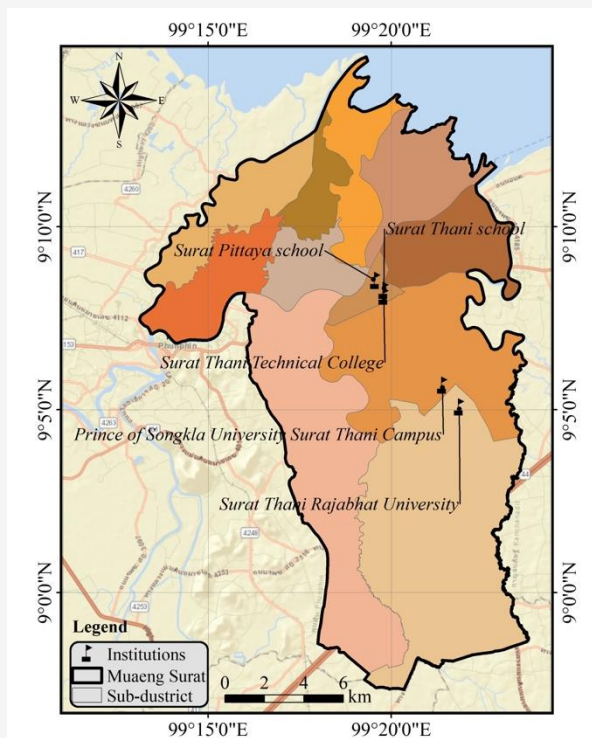
### 2.5 Data Collection

As defined by GIS, spatial distribution helps understand spatial relationships, make informed decisions, and solve geographic problems [18]. The researchers employed thematic mapping to depict the spatial distribution of cannabis establishments across various sub-districts within the Mueang District. This section illustrated spatial distribution using a location map to examine the distribution of cannabis establishments categorized into smoking, infused beverages and infused food and beverages and visualize the location of cannabis establishments by population density (ppl/sq.km.). Shapefiles for the Mueang District were sourced from <http://www.DIVA-GIS.org> [24]. The geographic coordinates were obtained from Google Earth by surveying various types of cannabis establishments by visiting the locations and pinning them on Google Maps. In addition, this spatial analysis depicted a buffer map showing a 500 to 1000-meter radius around cannabis establishments located near five educational institutions in the Mueang District. The educational institutions included Surat Thani School (ST), Surat Pittaya School (SRP), Surat Thani Technical College (SRTC), Surat Thani Rajabhat University (SRU), and Prince of Songkla University Surat Thani Campus (PSU) shown the location as Figure 2. GIS spatial analysis allows us to examine

the proximity and spatial relationships between different geographic features. In this scenario, the goal is to visualize the proximity of cannabis establishments to educational institutions using a buffer map. This part involves determining if any part of the buffer zones overlaps with the locations of educational institutions. This analysis helps to understand the proximity of cannabis establishments to these institutions. Using GIS, we created 500 to 1000-meter buffer zones around each cannabis establishment to visualize their potential impact on nearby educational institutions. Moreover, the researcher collected socio-demographic data, and cultural attitudes toward cannabis using interview forms with entrepreneurial representatives of cannabis establishments.

### 2.6 Statistical and Spatial Analysis

The data analysis utilized SPSS 29.0 for Windows to describe the socio-demographic data, cultural attitudes toward cannabis, and characteristics of cannabis establishments through descriptive statistics. The Chi-square test was performed to explore the relationship between socio-demographic variables and cultural attitudes toward cannabis. The locations of cannabis establishments and educational institutions in the researchers' data collection were used to generate coordinates on Google Maps.



**Figure 2:** Locations of educational institutions in Mueang District, Surat Thani Province

The cannabis establishments were accurately located in Mueang District, Surat Thani Province, Thailand, using geographic coordinates to ensure precise spatial placement. Spatial distribution analysis was conducted using ArcGIS version 10.5. This analysis segment included visualizations of both the location map and the buffer map.

### 2.6 Ethical Consideration

The human research component of this study received approval from the Research Ethics Committee at Suratthani Rajabhat University. The research project was assigned project number 023/2567 and REC No. SRU-EC 2024/04 received certification on March 21, 2024. The results of this study were presented as a comprehensive overview; no identifying information was collected or included in the report. Establishment anonymity was ensured by using codes instead.

### 3. Results

The socio-demographic data of entrepreneurial representatives of cannabis establishments in Mueang District, Surat Thani Province, as shown in Table 1, revealed that the 61 individuals had an average age of 38.4 years (SD. = 7.9), with 73.8% belonging to the 20-35 age group. The majority of the sample were male (95.1%), married (42.3%), had a monthly income of more than 30,000 baht/month

(60.7%), and held a Bachelor's degree (65.6%). Additionally, most participants reported that the establishment had been in operation for more than 3 years (62.3%), and 100% owned their businesses. The majority of entrepreneurial representatives started their establishments due to personal passion (34.4%), followed by cultural and lifestyle trends (26.2%), and changes in legislation and regulatory frameworks (19.6%). Cultural attitudes toward cannabis were reported in Table 2. The findings indicated that the highest proportion of respondents had a high level of cultural attitudes (47.6%), followed by a moderate level (39.3%), and a low level (13.1%). Considering the top two sub-districts with the most cannabis establishments: in the Talat sub-district, the majority of entrepreneurial representatives had a high level (46.1%) of cultural attitudes toward cannabis, followed by moderate (38.5%), and low levels (15.4%). Similarly, most respondents in the Makham Tia sub-district exhibited high levels (50.0%) of cultural attitudes, followed by moderate (38.9%), and low levels (11.1%). This is consistent with the overall attitudes of all participants. Additionally, factors that remained significantly associated with cultural attitudes toward cannabis were monthly income ( $\chi^2 = 7.345$ ,  $df=1$ ,  $p < 0.001$ ) and the reasons for starting the establishments ( $\chi^2 = 8.111$ ,  $df=4$ ,  $p < 0.001$ ) (Table 3).

**Table 1:** The socio-demographic variables of entrepreneurial representatives of cannabis establishments (n= 61)

Variables	Number (%)
<b>Age (Years);</b> Mean± SD.= 38.4 ± 7.9, Min-Max= 28-57	
20-35	45 (73.8)
36-59	16 (26.2)
<b>Gender</b>	
Female	3 (4.9)
Male	58 (95.1)
<b>Marital status</b>	
Single	22 (36.1)
Married	27 (42.3)
Widowed/Divorced/Separated	12 (19.6)
<b>Monthly income (Baht/month)</b>	
< 30,000	24 (39.3)
≥ 30,000	37 (60.7)
<b>Educational level</b>	
Diploma/High Vocational Certificate	7 (11.5)
Bachelor's degree	40 (65.6)
Higher Bachelor's degree	14 (22.9)
<b>Duration of establishments operation (Years)</b>	
< 3	23 (37.7)
≥ 3	38 (62.3)
<b>Reasons for starting the establishments</b>	
Profit potential	5 (8.3)
Market demand	7 (11.5)
Personal passion	21 (34.4)
Changes in legislation and regulatory frameworks	12 (19.6)
Cultural and lifestyle trends	16 (26.2)

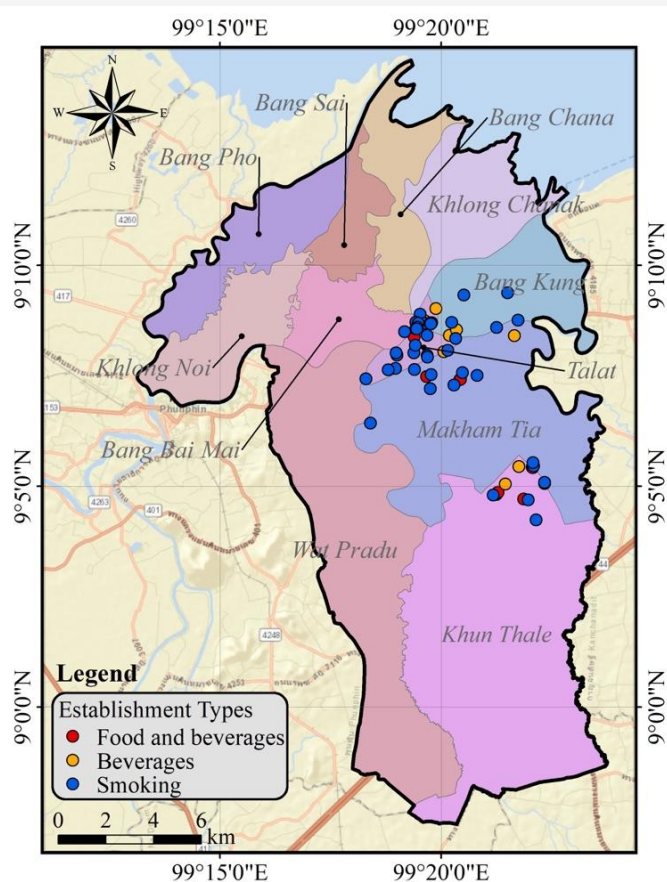
**Table 2:** The level of cultural attitudes toward cannabis divided by sub-districts (n= 61)

Sub-Districts	Cultural attitude toward cannabis level: n (%)			
	Low	Moderate	High	Total
Talat	4 (15.4)	10 (38.5)	12 (46.1)	26 (100.0)
Makham Tia	2 (11.1)	7 (38.9)	9 (50.0)	18 (100.0)
Khun Thale	1 (11.1)	3 (33.3)	5 (55.6)	9 (100.0)
Bang Bai Mai	0 (0.0)	1 (100.0)	0 (0.0)	1 (100.0)
Bang Kung	1 (14.4)	3 (42.8)	3 (42.8)	7 (100.0)
<b>Total</b>	8 (13.1)	24 (39.3)	29 (47.6)	61 (100.0)

**Table 3:** The relationship between socio-demographic variables and cultural attitudes toward cannabis (n= 61)

Variable	$\chi^2$	df	p-value
Age	2.212	1	0.105 <sup>a</sup>
Gender	3.312	1	0.330 <sup>b</sup>
Marital status	2.295	2	0.221 <sup>a</sup>
Monthly income	7.345	1	<0.001 <sup>a</sup>
Educational level	2.295	2	0.891 <sup>a</sup>
Reasons for starting the establishments	8.111	4	<0.001 <sup>a</sup>
Duration of establishment operation	2.301	1	0.342 <sup>a</sup>

**Observation:** <sup>a</sup>Chi-square test, <sup>b</sup>Fischer's Exact test



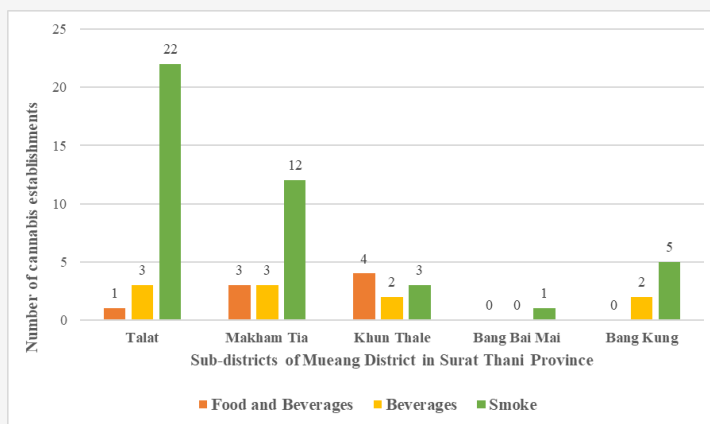
**Figure 3:** Locations of cannabis establishments in Mueang District, Surat Thani Province

**Table 4:** The cannabis establishments divided by usage patterns and sub-districts (n = 61)

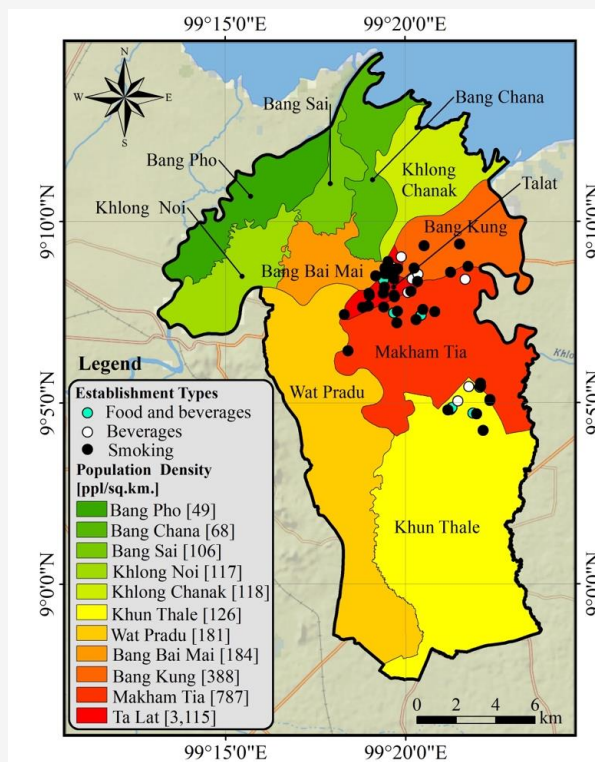
Sub-Districts	Type of Cannabis Establishments n (%)			
	Food and Beverages	Beverages	Smoke	Total
Talat	1 (3.9)	3 (11.5)	22 (84.6)	26 (42.6)
Makham Tia	3 (16.7)	3 (16.7)	12 (66.6)	18 (29.5)
Khun Thale	4 (44.5)	2 (22.2)	3 (33.3)	9 (14.8)
Bang Bai Mai	0 (0.0)	0 (0.0)	1 (100.0)	1 (1.6)
Bang Kung	0 (0.0)	2 (28.6)	5 (71.4)	7 (11.5)
<b>Total</b>	<b>8 (13.1)</b>	<b>10 (16.4)</b>	<b>43 (70.5)</b>	<b>61 (100.0)</b>

The results from exploring the distribution of cannabis establishments using GIS indicate the presence of 61 cannabis establishments in the study area. The spatial distribution analysis categorized these establishments based on the pattern of cannabis use. The majority of cannabis establishments were 43 cannabis-smoke establishments (70.5%), followed by 10 cannabis-infused beverage establishments (16.4%), and 8 cannabis-infused food and beverage establishments (13.1%), as shown on the location map (Figure 3). Table 4 illustrates that when considering the 11 sub-districts of Mueang District, Surat Thani Province, it was observed that the majority of cannabis establishments were located in the Talat sub-district (42.6%).

This was followed by the Makham Tia sub-district (29.5%), Khun Thale sub-district (14.8%), Bang Kung sub-district (11.5%), and Bang Bai Mai sub-district (1.6%). The emphasis in the Talat sub-district revealed that most cannabis establishments were cannabis smoke establishments (84.6%), followed by cannabis-infused beverage establishments (11.5%), and cannabis-infused food and beverage establishments (3.9%). The Makham Tia sub-district indicated that most cannabis establishments were cannabis smoke establishments (66.6%), followed by cannabis-infused food and beverage establishments (16.7%), and cannabis-infused beverage establishments (16.7%).



**Figure 4:** Number of cannabis establishments divided by usage patterns and sub-districts (n = 61)



**Figure 5:** Locations of cannabis establishments and population density

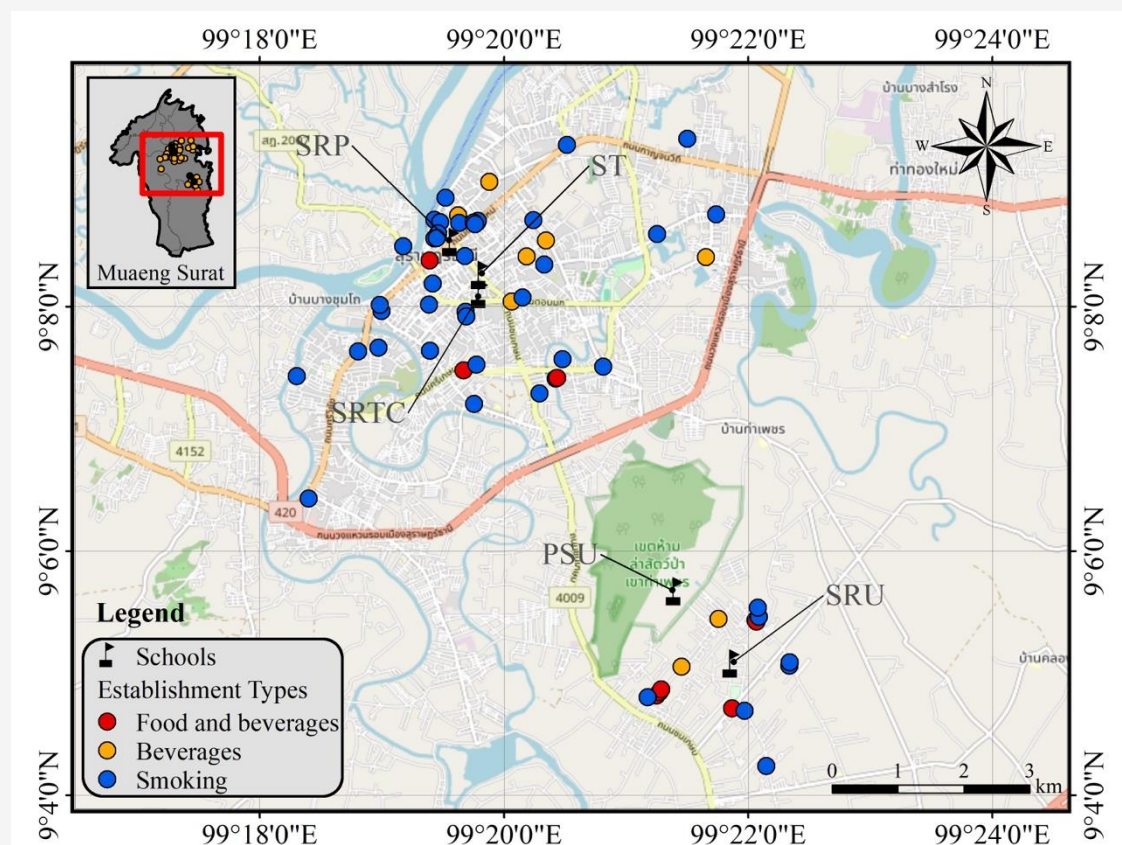
In the Khun Thale sub-district, the majority of cannabis establishments were cannabis-infused food and beverage establishments (44.5%), followed by cannabis smoke establishments (33.3%), and cannabis-infused beverage establishments (22.2%). In the Bang Kung sub-district, the majority of cannabis establishments were cannabis smoke establishments (71.4%), followed by cannabis-infused beverage establishments (28.6%) (Figure 4). An analysis of spatial distribution was performed to map the locations of cannabis establishments in Mueang District, Surat Thani Province. This analysis illustrated the organized distribution of 61 cannabis establishments, and depicted population density per

square kilometer (ppl/sq.km) across eleven sub-districts. This analysis shows that the distribution of cannabis establishments is linked to the varying levels of population density across different sub-districts. These results indicated that the distribution of cannabis establishments is correlated with the different levels of population density in various regions. Importantly, it shows that sub-districts with higher population density tend to have a greater concentration of these cannabis establishments. Figure 5 indicates that 26 cannabis establishments were located in the Talat sub-district (42.6%), which has the highest population density of 3,115 ppl/sq.km.

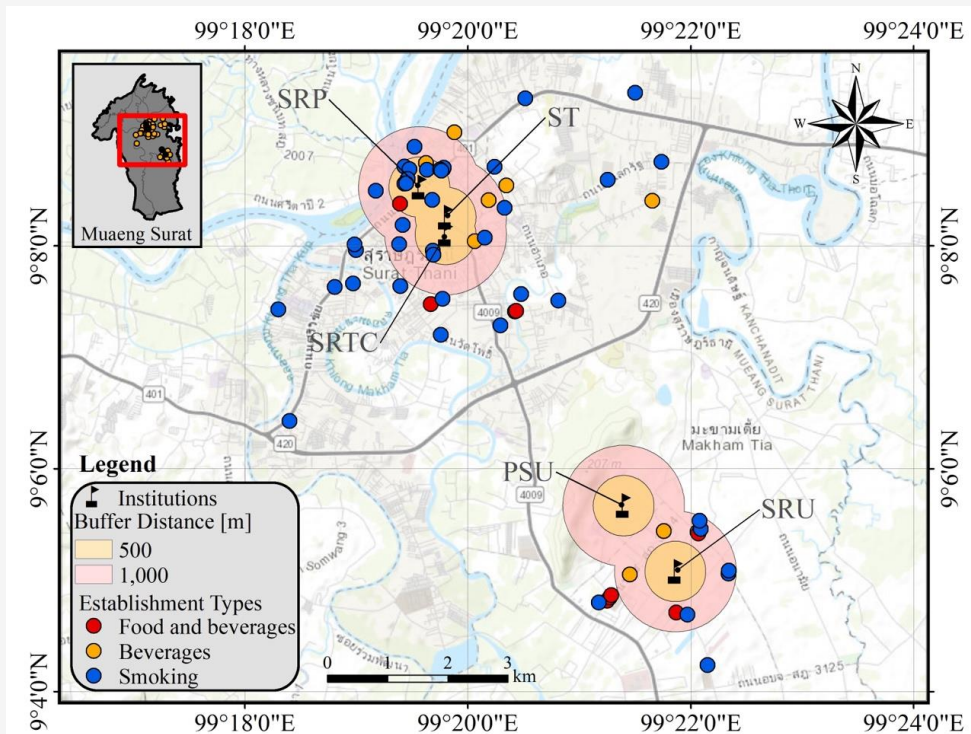
Additionally, 18 cannabis establishments were situated in the Makhm Tia sub-district (29.5%), with the second-highest population density of 787 ppl/sq.km., and 7 establishments were found in the Bang Kung sub-district (11.5%), which the third-highest population density of 388 ppl/sq.km.

Moreover, the positions of five educational institutions (ST, SRP, SRTC, SRU, and PSU) and the locations of cannabis establishments were identified on the map. It was indicated that the cannabis establishments are located close to the educational institutions (Figure 6). The proximity of these establishments necessitates careful monitoring and assessment of any potential impacts on the environment and student activities at these institutions. The potential influence of population density and the presence of educational institutions on the distribution of cannabis establishments is illuminated by this spatial analysis. In conclusion, these establishments are strategically positioned in areas with higher population density and are found close to educational institutions, potentially driven by increased consumer demand or other influencing factors. According to Mueang District, Surat Thani Province has seen a noticeable increase in cannabis

use following recent legislative changes in Thailand. The removal of cannabis from the narcotics list has led to its more widespread acceptance and use across various demographics. This district, with its urban environment and diverse population, reflects these trends in cannabis consumption, particularly among adolescents. This study depicted buffer maps showing a 500 to 1000-meter radius around five educational institutions, illustrating the accessibility of obtaining cannabis products for students in Mueang District, Surat Thani Province (Figure 7). The increase in cannabis establishments around educational institutions has raised concerns about the impact on adolescents. The buffer maps indicate that accessibility and visibility of cannabis can potentially influence youth behaviors and attitudes toward the drug. There are concerns about the long-term effects on adolescent brain development and the potential for increased recreational use among this vulnerable age group. This finding underscores the importance of ensuring that cannabis establishments are not located near educational institutions or residential areas and monitoring the operations of these establishments to ensure compliance with national laws and regulations.



**Figure 6:** Locations of cannabis establishments and educational institutions



**Figure 7:** Distances radiating cannabis establishments from educational institutions

#### 4. Discussion

This study examined the spatial distribution of cannabis establishments based on usage patterns in Mueang District, Surat Thani Province, Thailand. Researchers identified and documented the locations of these establishments throughout the district. GIS was utilized to create visual representations of this data, including location maps and buffer maps. Additionally, it was found that many cannabis establishments were situated near educational institutions, potentially making them easily accessible to students. Interestingly, GIS is a set of tools and techniques used to collect, store, analyze, manage, and visualize geographical data. In examining the spatial distribution of cannabis establishments based on usage patterns, GIS plays a crucial role in understanding and interpreting the spatial relationships and trends within a given geographic area [26]. In summary, the GIS effectively allows for the creation of detailed maps that visually represent the locations of cannabis establishments, making it easier to identify patterns and trends [27]. It is consistent with the previous research highlighted that spatial distribution analysis using GIS can be effectively utilized to determine the distribution of COVID-19 [28]. Moreover, this aligns with a prior study that suggested that based on the spatial analysis of vaccine center coverage in Jeddah for 2020 and 2021, spatial analysis and GIS

technology can be effectively applied to evaluate the equitable distribution of points of dispensing [29].

The location map illustrated the spatial distribution of cannabis establishments, categorizing them based on patterns of cannabis use and population density. This visualization provided a clear picture of where cannabis establishments were concentrated and how their presence correlated with population density in different sub-districts. This map illustrated the distribution of cannabis establishments in Mueang District, in proximity to five educational institutions. The main findings identified 61 cannabis establishments, comprising 43 cannabis smoke establishments (70.5%), 10 cannabis-infused beverage establishments (16.4%), and 8 cannabis-infused food and beverage establishments (13.1%). Surprisingly, 26 of these establishments (42.6%) are located in the Talat sub-district, near ST, SRP, and SRTC. Meanwhile, 18 establishments (29.5%) are situated in the Makham Tia sub-district, where PSU is located. Additionally, 9 establishments (14.8%) are in the Khun Thale sub-district, where SRU is located. Therefore, the proximity of these cannabis establishments facilitates access for students from the five nearby educational institutions and residents in the surrounding areas [30].

Similar to the earlier findings in Washington State, USA, the location of marijuana retailers is highly regulated and varies by jurisdiction. The summary findings indicated that GIS can analyze the spatial distribution of recreational marijuana dispensaries and assess their clustering or dispersion across different geographic regions [27]. Also, similar to former research demonstrated that GIS has been used to map cannabis cultivation sites in California and Southern Oregon, helping to understand their environmental impacts and inform law enforcement and resource management efforts [31]. Moreover, this aligns with earlier academic work that reported a systematic review and meta-analysis of the global prevalence of cannabis use. The finding indicated that the prevalence of cannabis use varied between 0.42% and 43.90% across 33 European countries, 1.40% to 38.12% across 15 North and South American countries, 0.30% to 19.10% across 16 Asian countries, and 1.30% to 48.70% across 18 Oceania and African countries [32].

Highlighting unique patterns observed in the Mueang District compared to other study areas demonstrated that the majority of cannabis use involved smoking. When cannabis is smoked, tetrahydrocannabinol (THC) is absorbed directly into the bloodstream through the lungs, leading to a much faster onset of effects, often within minutes. Additionally, cannabis smoking is often viewed as a social activity among adolescents, with the ritual of passing a joint or bong being ingrained in many social circles. This immediate, shared experience can enhance the perception of smoking's effectiveness. Adolescents may associate cannabis smoking with cultural images of rebellion or independence, reinforcing the idea that smoking is a more powerful or preferred method of cannabis consumption. This finding is consistent with earlier research that described that the pattern of cannabis use is predominantly through smoking. Additionally, cultural and developmental factors contribute to smoking cannabis being perceived as more effective for adolescents compared to consuming it through food or drink [31]. Similarly, the study by prior investigations demonstrated that most people use cannabis through smoking more than through other methods [27].

The buffer map showed the radius of cannabis establishments around five educational institutions in the district. This aspect of the analysis highlighted the proximity of cannabis establishments to educational institutions, raising potential concerns about accessibility and visibility to students [33]. Moreover, the buffer maps can evaluate how educational institutions relate spatially to cannabis establishments, particularly those located within a

specified radius [34]. The buffer map reveals patterns of clustering or dispersion of cannabis establishments. Some institutions may be surrounded by a high density of establishments within the 500 to 1000-meter buffer, indicating a need for targeted policy interventions in those areas [35]. The 500 to 1000-meter buffer zone is critical for understanding immediate proximity and direct accessibility for students who are on or near school grounds. The buffer map revealed a varied distribution of cannabis establishments, indicating that ST, SRP, SRTC, SRU, and PSU are located within regions of these establishments, promoting ease of access for undergraduate students. It became evident that these five educational institutions are situated within areas with a diverse concentration of establishments within a 500 to 1000-meter radius. This map can be used to consider the potential impact of the availability of cannabis establishments on student behavior [36]. Increased proximity might correlate with higher accessibility. This analysis is consistent with earlier findings indicated that spatial distribution analysis provides distinct insights compared to aspatial techniques. They discussed various spatial analysis methods, such as buffering, interpolation, and kernel density analysis, and emphasized their importance. Spatial analysis can be applied in various fields, including public health management [37].

Many jurisdictions have regulations specifying minimum distances between cannabis establishments and sensitive locations such as educational institutions. The buffer map helps authorities ensure compliance with these regulations by visualizing the proximity of cannabis establishments to educational institutions. It allows policymakers, educators, and community members to assess the potential impact of cannabis establishments on students and school communities. This includes understanding whether students might be exposed to cannabis-related activities or influences, which could impact educational environments and student well-being. The consumption of cannabis by adolescents in various forms, including smoking and ingesting infused foods and beverages from cannabis establishments, must be taken seriously to prevent negative effects on brain development and learning. This aligns with the Royal College of Pediatricians of Thailand's recommendation to mitigate the effects of cannabis use on adolescents by controlling the locations for cannabis production and sale. Additionally, children and youth under the age of 20 are prohibited from using cannabis [38]. Importantly, U.S. laws stipulate that cannabis establishments must be located 500-1000 meters away from educational institutions [39] and [40], while Thailand currently lacks legislation on this matter.

Moreover, the Ministry of Education in Thailand has set regulations requiring all educational institutions to closely monitor the situation and display notices banning any cannabis products. Currently, it is essential to confirm the buyer's eligibility by checking their ID card and ensuring that individuals under 20 years old are not allowed to consume cannabis products.

The spatial distribution of cannabis establishments in Mueang District is shaped by a combination of legal frameworks and cultural attitudes toward cannabis use. The legal framework can be described as follows: The legal status of cannabis in Thailand has created a more permissive environment for establishing cannabis businesses: 1) Cannabis establishments are likely subject to local zoning regulations, which determine where businesses can operate. 2) Legal frameworks may restrict cannabis establishments from operating near schools, religious sites, or residential areas. The study identified that commercial establishments were nearly located near educational institutions. This situation may lead to cannabis establishments being situated around sensitive areas, as confirmed by the buffer map. Additionally, the cultural attitude toward cannabis plays a critical role in how widely cannabis establishments are accepted: 1) In sub-districts where cannabis use is more culturally accepted, such as Talat and Makhm Tia, there may be a higher density of cannabis establishments. Positive cultural attitudes toward cannabis make these areas more attractive for business owners. 2) In communities where cannabis is seen as an economic opportunity, cultural attitudes toward cannabis may shift toward acceptance, especially if residents recognize the potential for job creation and revenue.

This could lead to more establishments opening in economically motivated areas. In conclusion, tourist-heavy areas often have more relaxed attitudes toward recreational cannabis, and businesses here can benefit from higher demand among tourists and younger residents. Additionally, in the Talat and Makhm Tia sub-districts, where cultural attitudes toward cannabis are generally favorable, a higher concentration of establishments exists compared to more conservative areas. In these regions, cultural acceptance aligns with more lenient local regulations, creating a conducive environment for business growth. As a limitation, this study focused on usage patterns, acknowledging that the impacts of cannabis establishments can vary significantly across different neighborhoods and populations. Therefore, generalizing findings from the Mueang District to other regions or districts may not be appropriate. Moreover, cannabis establishment locations can change over time due to regulatory changes, market

dynamics, or other factors. A static analysis may not capture these temporal variations, affecting the validity of long-term conclusions.

## 5. Conclusion

The spatial distribution analysis of cannabis establishments through mapping can be beneficial for public health authorities. They can develop targeted educational programs about the risks and benefits of cannabis use, focusing on areas with a high concentration of cannabis establishments. Additionally, public health authorities can organize community outreach programs to inform residents about safe cannabis consumption practices and available health services. The GIS data on cannabis establishments can be used to inform government policies by providing insights into their locations and usage patterns. This information can guide policymakers and regulatory bodies in making decisions on zoning regulations, licensing, and enforcement strategies related to cannabis use and distribution. Additionally, spatial distribution analysis can be beneficial for school administration to integrate education about the risks and effects of cannabis use into school curricula to inform and protect students. Establishing systems for monitoring and reporting any suspicious activities related to cannabis use around school premises. The findings can be applied to conduct longitudinal studies to track changes in the distribution of cannabis establishments over time. This can provide insights into trends and the effects of policy changes. Advanced geospatial modeling techniques should be used to predict future locations of cannabis establishments based on current patterns and socio-economic factors. Future research should compare the spatial distribution patterns in Mueang District with those in other districts or provinces in Thailand to identify unique characteristics or common trends. Additionally, future studies should develop and evaluate preventive programs aimed at reducing cannabis use among students and other vulnerable groups.

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