

# Mapping the vulnerability of stunting in toddlers based on water, sanitation, and hygiene (WASH) indicators in South Sumatra Province by 2023: descriptive spatial analysis

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## Abstract

**Submitted:**

May 9th, 2025

**Accepted:**

July 10th, 2025

**Published:**

July 22nd, 2025

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**Purpose:** This study was conducted to map stunting vulnerability in children under five years of age by district/city based on stunting prevalence and WASH indicators. **Methods:** The research method employed was descriptive spatial analysis using a Geographic Information System (GIS) application with a scoring method, incorporating natural breaks in QGIS software. **Results:** As a result, Empat Lawang and South Ogan Komering Ulu districts are high-priority districts for an immediate response to stunting. Additionally, four districts/cities were classified as high-priority areas, three as medium-priority areas, five as low-priority areas, and three as very low-priority areas. **Conclusion:** Therefore, the government and communities are expected to increase efforts to prevent and handle stunting in children under five by prioritizing districts/cities with a very high level of vulnerability through expanding the availability of clean drinking water source and proper sanitation, and promoting clean and healthy living through optimal use of clean water and hand washing with soap.

**Keywords:** hygiene; sanitation; stunting; vulnerability; water

## INTRODUCTION

One of the health problems highlighted by the government is stunting in toddlers. Stunting is a physical condition characterized by children who have a height-for-age (TB/U) or length-for-age (PB/U) z-score ratio of less than 2 standard deviations (<-2SD) according to the World Health Organization (WHO) 2005 standards. This condition remains crucial, as in 2022, there were 148 million toddlers worldwide who were stunted, and in Southeast Asia, 3 out of 10 toddlers were stunted (prevalence 30.1%) in the same year [1]. In Indonesia, the prevalence of stunting in

toddlers, as reported in the Indonesian Nutrition Status Survey (SSGI) in 2022, was 20.6% [2]. This figure decreased by 0.1% based on the results of the 2023 Indonesian Health Survey (SKI), to 20.5%. However, several provinces experienced an increase from 2022 to 2023 [3].

One of the provinces that experienced an increase in stunting prevalence is South Sumatra Province. During the one year, there was a 1.7% increase in the prevalence of stunting among toddlers, from 20.3% in 2022 to 22.0% in 2023, in South Sumatra [3]. This increase certainly needs to be a concern, considering that stunting has a significant impact on the future of children. In the short term, stunted children can

experience impaired brain development, metabolism, intelligence, and other physical problems. On the other hand, in the long term, stunted toddlers who are not treated can experience cognitive and psychomotor decline, decreased immunity, and increased risk of obesity and cardiovascular disease. In the workplace, they tend to be less productive and less competitive than their peers [4].

Furthermore, risk factors for stunting can originate from various sectors, including environmental health factors such as water, sanitation, and hygiene (WASH). Hartika et al. (2024) found that latrine ownership, access to clean water, and the habit of handwashing with soap are associated with the incidence of stunting in toddlers [5]. Families with access to adequate drinking water sources have a lower risk of having stunted children [6]. Pradana, Suparmi, and Ratnawati (2023) also found that the associated factors of stunting in toddlers are personal hygiene, water availability, and environmental sanitation [7]. According to Rahayu and Darmawan (2019), poor environmental sanitation is closely related to the incidence of stunting in toddlers [8]. Other studies have also identified that the condition of the house floor, ceiling, ownership of access to clean water, and type of toilet are associated with the incidence of stunting in toddlers [9]. These environmental health factors are closely related to the incidence of infections in children, which can lead to stunting.

Currently, the government is working to accelerate the prevention and reduction of stunting through the National Action Plan for the Acceleration of Stunting Prevention and Reduction (P3S) 2025-2029. To support a targeted program, it is necessary to map areas of vulnerability to stunting based on various variables. Mapping vulnerability is an effort to visualize regions based on multiple factors presented using geographic information system (GIS) technology. GIS is a computer-based system that can process and present spatial information, such as regional mapping [10]. The utilization of vulnerability mapping has previously been carried out by Fatmawati and Siregar (2025) to see the vulnerability of stunting in toddlers in Depok. As a result, based on the summation of 12 risk factors for stunting, it was found that areas prone to stunting were in the southwestern and southeastern parts of Depok city [11]. Sakti, Makful, and Dewi (2023) also mapped the vulnerability of stunting in toddlers in Aceh based on nutrition and health factors. As a result, six districts/cities are priority areas for addressing stunting, assessed based on the sum of stunting categorization scores and risk factors [12].

The mapping of stunting vulnerability priorities can help quickly identify areas that should be prioritized

for immediate stunting management, including in South Sumatra. However, mapping of stunting vulnerability in terms of stunting prevalence and environmental health factors in South Sumatra has not been done. Therefore, this study maps stunting vulnerability priorities based on environmental health factors, including access to proper sanitation, use of clean water sources, and handwashing with soap (HWWS) habits, in South Sumatra. This is expected to provide an overview of areas that can be prioritized for immediate stunting treatment, allowing stunting cases in South Sumatra to continue being reduced.

## METHODS

This study is a descriptive spatial study that maps stunting vulnerability based on the prevalence of stunting and environmental health factors associated with stunting in toddlers. The location of this study is in the province of South Sumatra, which has a geographical location between 1° and 4°S and 102° and 106°E, and consists of 17 districts/cities. In general, the topographical description of this province in the eastern region is characterized by its coastline, which is primarily influenced by swamps and tides. In contrast, the central region consists of lowlands and valleys, while the western region features hills and mountains of the Bukit Barisan chain [13].

Furthermore, the variables studied include the prevalence of stunting in children under five, access to proper sanitation, the use of clean drinking water sources (SAM) by households, and the percentage of families with the habit of washing hands with soap. All data used in this study is aggregated secondary data for 2023. This study utilized the 2023 Indonesian Health Survey report to determine the prevalence of stunting in children under five years old by district/city. In addition, data on the percentage of families with HWWS habits were obtained from the 2023 South Sumatra health profile, while other variables used data from the 2023 National Socio-Economic Survey results accessed from the BPS South Sumatra website. The shapefiles used in this study were obtained from the Indonesia Geoportal website.

The descriptive spatial data in this study were processed using QGIS software version 3.40.4. This software is open-source and can be accessed and downloaded from the [qgis.org](http://qgis.org) website. Furthermore, the categorization of stunting, access to proper sanitation, use of clean SAM, and families with HWWS habits was carried out using natural breaks (jenks) in the QGIS feature into four levels, in which a score of 1 indicates very low severity (lowest prevalence of stunting, but highest percentage of access to proper

sanitation, clean SAM usage, and families with HWWS habits), while a score of 4 indicates the opposite (highest prevalence of stunting, lowest percentage of access to proper sanitation, clean SAM usage, and families with HWWS habits). Natural breaks were chosen because this feature can group data based on their similarity, where within the group, there is minimal variation, even though the values between data points vary. In this research, each variable lacks a standard grouping, and there is even a variable whose values are not reported. Therefore, the grouping will be determined based on the similarity of data between regions using this categorization.

This study also presents a priority map of stunting vulnerability in toddlers to determine priority areas for handling it. This variable is obtained by summing up all the scores of the four previous variables. The total scores of the last four variables were categorized into five categories using natural breaks. The results of these categories were then labeled, with a score of 1 representing a very low level of vulnerability and a score of 5 representing a very high level of vulnerability.

**Table 1. Scoring levels for stunting vulnerability based on environmental and health indicators**

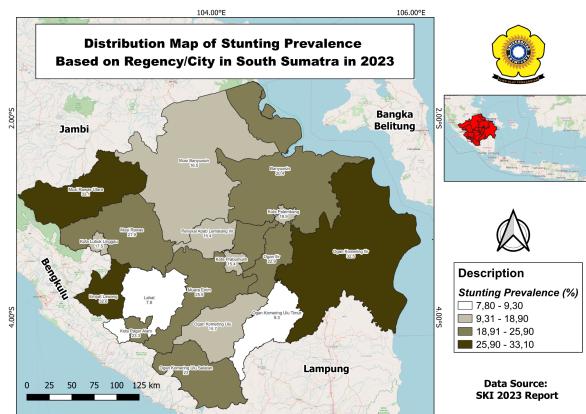
Co-de	Variables			
	Stunting	Access to proper sanitation	Clean SAM usage	Families with HWWS habits
1	7,80 - 9,30	88,25 - 96,44	72,41 - 97,85	86,8 - 100
2	9,31 - 18,90	76,18 - 88,25	62,61 - 72,40	46,0 - 86,7
3	18,91 - 25,90	63,21 - 76,17	44,75 - 62,60	38,0 - 45,9
4	25,90 - 33,10	61,28 - 63,20	28,31 - 44,74	Not available

SAM = sumber air minum (drinking water sources);

HWWS = handwashing with soap

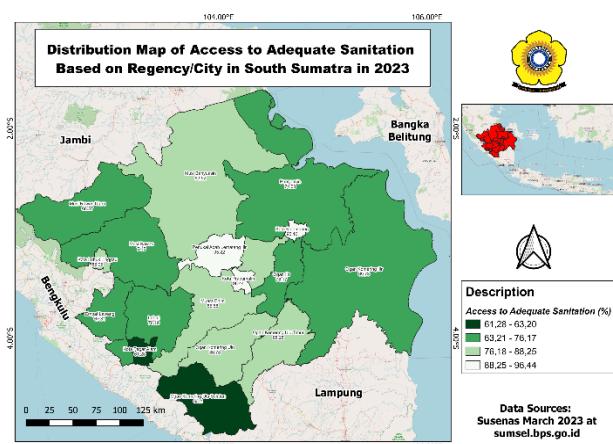
## RESULTS

The prevalence of stunting in South Sumatra reached 20.3% in 2023, spread across 13 districts and four cities. Figure 1 shows a map of the distribution of stunting prevalence by district/city, where the higher the prevalence, the darker the brown color. Based on Figure 1, the highest prevalence of stunting (25.90% to 33.10%), marked with a solid brown color, is observed in North Musi Rawas District (33.1%), Empat Lawang District (32.6%), and Ogan Komering Ilir District (32.5%). On the other hand, the regions with the lowest prevalence (7.8%-9.3%), marked in white, are the Lahat District (7.8%) and the East Ogan Komering Ulu District (9.3%). Overall, 6 out of 17 districts/cities have a stunting prevalence ranging from 18.91% to 25.90%.



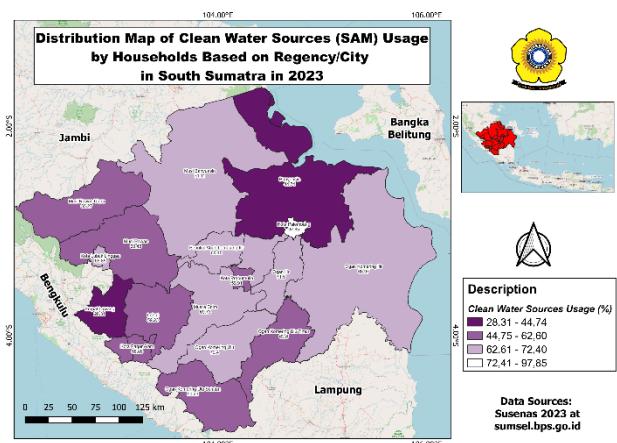
**Figure 1. Distribution map of stunting prevalence in South Sumatra in 2023**

The first environmental factor studied was access to proper sanitation. In South Sumatra Province, the percentage of access to improved sanitation reached 80.54%. Figure 2 then shows the distribution map of access to adequate sanitation by district/city, where the higher the percentage of access to adequate sanitation, the brighter the color (white), indicating more comprehensive access to improved sanitation in the area, and vice versa. Regions with the most comprehensive access to proper sanitation (88.25%-96.44%) are marked in white on the map: Prabumulih City (96.44%), Penukal Abab Pematang Ilir District (95.22%), and Palembang City (95.16%). On the other hand, Pagar Alam City (61.28%) and South Ogan Komering Ulu District (63.2%) are the areas with the lowest sanitation access (61.28% - 63.20%) marked in solid green. When viewed on the map, the two regions with the lowest proper sanitation are located in the southwest, while those with good sanitation are concentrated in the center. Of the 17 districts/cities, 7 have a percentage of access to improved sanitation ranging from 63.21% to 76.17%.



**Figure 2. Distribution map of access to adequate sanitation in South Sumatra in 2023**

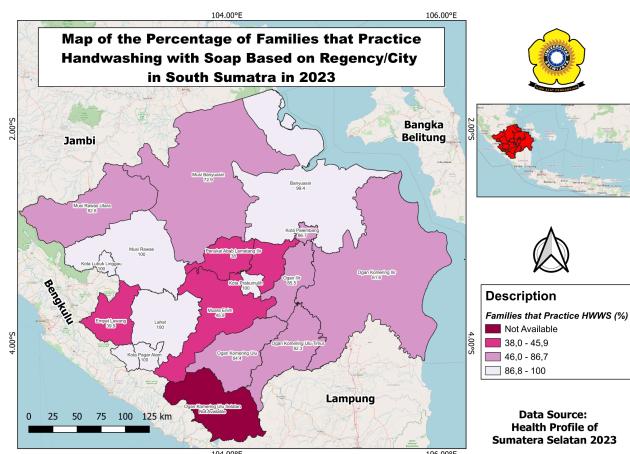
The following environmental variable is the percentage of clean SAM used by households. A total of 67.54% of households in South Sumatra have utilized clean SAM in 2023. To visualize the distribution by district/city, Figure 3 presents a distribution map of the use of clean SAM by households, where the higher the percentage (white), the higher coverage of clean water utilization, and vice versa (solid purple). Based on the map, the only region with the highest percentage of clean SAM use by households (72.41% - 97.85%) is Palembang City (97.85%), which is marked in white on the map. Furthermore, the regions with the least utilization of clean SAM (28.31% - 44.74%) and marked in solid purple are Empat Lawang District (28.31%) and Banyuasin District (44.74%). When viewed on the map, there is a grouping of regions with clean SAM usage of 62-61% - 72.40% in the center, such as Penukal Abab Lematang Ilir (68.48%), Ogan Komering Ilir (69.97%), Muara Enim (69.73%), Musi Banyuasin (71.11%), Ogan Ilir (71.5%), and Ogan Komering Ulu (72.4%). Lubuk Linggau city is also in this category (66.85%), but it is located on the border of South Sumatra and Bengkulu. In general, seven districts/cities have a percentage of clean SAM usage ranging from 62.61% to 72.40%.



**Figure 3. Distribution map of clean water sources usage by households in South Sumatra in 2023**

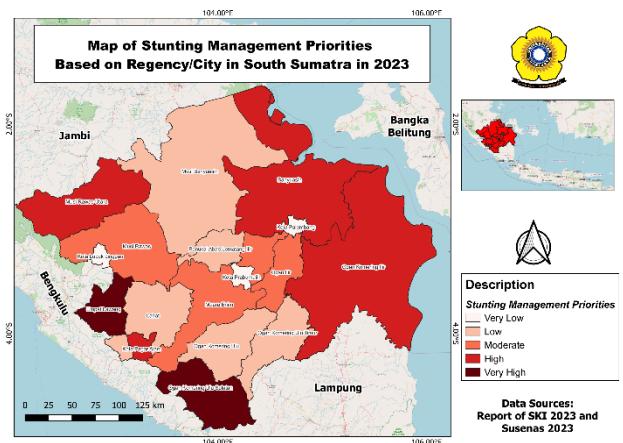
Furthermore, the variable studied is the habit of washing hands with soap. In general, in South Sumatra in 2023, the percentage of families with the habit of washing hands with soap reached 75.8%. Figure 4 shows the percentage of families with HWWS habits, where the darker the color (solid maroon), the worse the district/city (the lowest rate). According to the map, South Ogan Komering Ulu District is the worst district in this variable, as the data is not available. Furthermore, Penukal Abab Lematang Ilir District (38%), Empat Lawang District (39.9%), and Muara Enim

Districts (45.9%) also have low percentages, ranging from 38.0% to 45.9%. In contrast, there are already six districts/cities that have the highest rate of handwashing habits marked with bright colors, Banyuasin District (99.4%), Prabumulih City (100%), Lahat District (100%), Pagar Alam City (100%), Musi Rawas District (100%), and Lubuk Linggau City (100%), while the other seven districts/cities are between 46.0% - 86.7%. When viewed, several regions with the same category are clustered and close to each other.



**Figure 4. Map of the percentage of families that practice handwashing with soap in South Sumatra in 2023**

Finally, this study also identified priority areas for addressing stunting in children under five years old, which were calculated based on the total score of the four previous variables, as shown in Figure 5. As a result, there are two areas with a very high priority for addressing stunting (total score 14): Empat Lawang District and South Ogan Komering Ulu District. Empat Lawang District is a priority area for handling stunting because it has 32.6% stunting cases (score 4), access to proper sanitation 67.81% (score 3), use of clean SAM by households 28.31% (score 4), and HWWS habits 39.9% (score 3). Furthermore, South Ogan Komering Ulu District is also a very high priority area because it has a stunting prevalence of 23% (score 3), access to proper sanitation of 63.2% (score 4), use of clean SAM of 50.23% (score 3), and HWWS habits 0/not reported (score 4). In addition, there are four high-priority districts (with a total score of 11-12): Banyuasin District, Ogan Komering Ilir District, North Musi Rawas District, and Pagar Alam City. On the other hand, areas with a very low priority, scoring 6-7, include Palembang City, Prabumulih City, and Lubuk Linggau City.



**Figure 5. Map of stunting management priorities in South Sumatra in 2023**

## DISCUSSION

Nutritional problems are among the numerous health issues prevalent in the community, including stunting. According to the results of stunting prevalence mapping, North Musi Rawas Regency, Empat Lawang Regency, and Ogan Komering Ilir Regency are the three districts with the highest prevalence rates in 2023. When compared to the SSGI results in 2022, the three regions experienced an increase in prevalence in 2023, with differences of 12.9% in North Musi Rawas District, 14.1% in Empat Lawang District, and 17.4% in Ogan Komering Ilir District [2]. This significant increase may be due to differences in the surveys used as data sources. Another study also found that the prevalence of stunting among under-fives in one sub-district in Empat Lawang District reached 36.8% [14].

Meanwhile, Ogan Komering Ilir District is one of the focus areas for stunting intervention and requires active surveillance to accelerate the reduction of its prevalence [15]. This is because stunting can have various impacts, both in the short and long term, which in turn can cause short-term cross-generational effects [16]. On the other hand, various environmental risk factors can encourage an increase in stunting cases in the community.

First, access to sanitation has a significant impact on the incidence of stunting in children under five. Access to proper sanitation refers to the percentage of households that use toilets with a gooseneck design and dispose of feces in wastewater treatment plants (WWTP) or septic tanks, compared to all households [17]. As of the end of 2024, the percentage of households with access to proper sanitation in Indonesia has reached only 83.60%, while in South Sumatra Province, it is 82.36%, indicating a slight increase from 2023 [18]. Of all the districts/cities, Pagar

Alam City is the one with the lowest ability of its people to access proper sanitation by 2023, as 38.72% of households still lack access to adequate sanitation. The percentage of septic tank use as a final disposal site for feces in Pagar Alam City in 2023 only reached 58.45% [19]. Muhdar (2019) revealed that poor sanitation can increase the risk of inhibited physical and brain growth of children [20]. Poor sanitation causes human and animal waste to be improperly covered and managed, thereby increasing children's exposure to various pathogenic bacteria, such as *Escherichia coli*, which causes intestinal inflammation [21]. If this condition occurs repeatedly, it can inhibit the absorption of nutrients in the child's body [22]. Another study revealed that toddlers without access to latrines are at a 21.551 times higher risk of experiencing stunting compared to toddlers whose mothers have access to latrines [5].

Not only sanitation, but also the quality of drinking water, affects the incidence of stunting in toddlers. Based on the research, it was found that the areas with clean SAM utilization by the community were Empat Lawang District (28.31%) and Banyuasin District (67.30%). On the other hand, access to proper sanitation in Empat Lawang Regency is 65.94%, and in Banyuasin Regency, it is 80.66%, which is indeed lower than in other regions [23]. Clean water is one of the primary needs of humans, especially drinking water, which is essential for sustaining human life. According to Rara (2022), the quality of drinking water is influenced by both the source of the water and the location where it is stored [24].

Furthermore, inadequate drinking water sources coupled with improper drinking water treatment can lead to an increased risk of stunting in children [25]. Sarnili et al. (2024) revealed that the physical condition of water, microbiological quality of water, drinking water source, and drinking water treatment are associated with the incidence of stunting in children under five years old. Cloudy and colored water, combined with dirt and chemical contamination, can lead to various health issues in children, including diarrhea. This can increase a child's risk of stunting [26]. For this reason, to ensure the quality of drinking water, the government sets drinking water quality standards as described in the Regulation of the Minister of Health of the Republic of Indonesia Number 2 of 2023 concerning the Implementation Regulation of Government Regulation Number 66 of 2014 concerning Environmental Health [27].

Furthermore, the habit of washing hands with soap is also associated with the incidence of stunting in children. Susanti, Amaliyah, and Suharno (2021) revealed that in addition to sanitation, the habit of

washing hands with soap is closely related to the incidence of stunting in toddlers. This is because the habit of washing hands with soap can prevent the entry of pathogenic microorganisms into the child's body, thus preventing children from experiencing infections and other health problems. With this, children do not experience impaired absorption of child nutrition and are protected from stunting [28]. Not only in children, but also in mothers, the habit of washing hands is a factor that affects the incidence of stunting in toddlers. Mothers who are accustomed to washing their hands are a protective factor against stunting in toddlers (OR = 0.12) [29]. The results of this study show that Ogan Komering Ilir District has 0% of families with HWWS habits. This may be because it has not been reported; therefore, it should be identified to assess how the HWWS health promotion program is implemented.

Finally, based on the results of stunting vulnerability mapping in South Sumatra Province in 2023, two out of 17 districts/cities are included in the very high priority category, and five districts/cities are categorized as having high priority. Empat Lawang District and Ogan Komering Ilir District are high-priority areas because both have a high prevalence of stunting; however, access to proper sanitation, utilization of clean water, sanitation, and hygiene habits in these areas tends to be low. The combination of WASH (water, sanitation, and hygiene) factors is an indirect factor that needs to be considered in preventing and reducing the prevalence of stunting in children under five years old. Artharini, Bumi, and Noveyani (2022) revealed that WASH, which encompasses access to drinking water sources, access to latrines, waste disposal, sewerage, and maternal hand washing habits, is associated with the incidence of stunting in toddlers [30]. Another study revealed that inadequate WASH together increased the risk of stunting by 2.7 times [31].

This research provides an overview of stunting vulnerability among under-fives, based on WASH components and the prevalence of stunting among this population. Visualization of the research results in the form of maps makes it easy for readers to interpret precisely and quickly the areas with the highest priority. However, as this study uses aggregate data, its limitations lie in the availability of data and the limitations of analyzing it at the individual unit level.

## CONCLUSION

Based on the results of vulnerability mapping, it was found that Empat Lawang District and South Ogan Komering Ulu District are high-priority districts for

immediate stunting prevention and reduction management in South Sumatra. On the other hand, there are four districts/cities with high priority, three areas with medium priority, five areas with low priority, and three areas with very low priority. By mapping stunting vulnerability based on WASH indicators, local governments can determine the areas and focus of stunting prevention and reduction interventions in South Sumatra. For this reason, the government, especially the South Sumatra Provincial Health Office, is expected to accelerate this intervention, particularly in areas of very high and high priority, by continuing to increase community involvement and empowerment.

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