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VULNERABILITY ANALYSIS OF PESTICIDE POISONING IN FARMERS IN SIMPANG TANJUNG NAN IV VILLAGE, SOLOK REGENCY

Analisis Kerentanan Keracunan Pestisida pada Petani di Desa Simpang Tanjung Nan IV, Kabupaten Solok

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ABSTRAK

Desa Simpang Tanjung Nan IV, Kabupaten Solok merupakan daerah pertanian yang menghasilkan tanaman hortikultura. Petani bergantung pada penggunaan pestisida kimia untuk mengendalikan hama tanaman. Hasil observasi lapangan menunjukkan bahwa sekitar 82–88% petani menggunakan pestisida secara rutin, dengan frekuensi penyemprotan 2–3 kali per minggu selama musim tanam. Lebih dari 60% petani mencampur dua hingga tiga jenis pestisida berbeda untuk mendapatkan efek cepat, tanpa memperhatikan dosis dan petunjuk pada label kemasan. Letak permukiman masyarakat yang dekat (<100 m) dengan lahan pertanian membuat kondisi masyarakat rentan terhadap keracunan pestisida. Analisis kerentanan dilakukan untuk mengetahui tingkat kerentanan akibat penggunaan pestisida. Penelitian ini merupakan penelitian semi kuantitatif dengan menampilkan data secara deskriptif dan spasial. Sampel adalah kualitas air, tanah dan udara serta wawancara dengan wali nagari, jorong dan petugas puskesmas sebanyak 11 orang. Analisis kerentanan dilakukan dengan menggabungkan data sekunder dan kualitas lingkungan. di wilayah pertanian Desa Simpang Tanjung Nan IV, Kabupaten Solok pada bulan Januari sampai Desember 2022. Hasil indeks kerentanan sosial menunjukkan dua desa dengan indeks tinggi. Indeks kerentanan ekonomi dapat dilihat dari enam desa yang memiliki indeks tinggi. Indeks kerentanan lingkungan menunjukkan bahwa rata-rata desa memiliki indeks kerentanan lingkungan yang tinggi. Indeks kerentanan keracunan pestisida menunjukkan bahwa lima desa memiliki indeks kerentanan keracunan pestisida yang tinggi. Indeks kerentanan sosial, ekonomi, fisik/lingkungan dan keracunan pestisida di Desa Simpang Tanjung Nan IV cenderung tinggi. Oleh karena itu, pengendalian risiko kerentanan diarahkan pada intervensi perilaku petani, penguatan sistem pemantauan lingkungan, pengembangan dan promosi pestisida hayati untuk mengurangi ketergantungan terhadap pestisida kimia.

Kata kunci: *keracunan, kerentanan, pestisida*

ABSTRACT

Desa Simpang Tanjung Nan IV, located in Solok Regency, is an agricultural area that produces various horticultural crops. Farmers in this region largely depend on chemical pesticides for pest control. Field observations indicate that approximately 82–88% of farmers regularly use pesticides, applying them two to three times per week during the planting season. More than 60% of farmers mix two to three different types of pesticides to achieve faster effects, often disregarding dosage and label instructions. The proximity of residential areas to farmlands (less than 100 meters) increases the risk of pesticide poisoning among the community. This study aims to assess the level of vulnerability associated with pesticide use. A semi-quantitative method was employed, combining descriptive and spatial data analysis. Samples included water, soil, and air quality, complemented by interviews with 11 key informants consisting of village leaders, sub-village heads, and local health officers. The vulnerability analysis integrated secondary data and environmental quality parameters collected from January to December 2022.

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Results show that two villages exhibit high social vulnerability, six villages have high economic vulnerability, and most villages demonstrate high environmental vulnerability. Moreover, five villages display a high level of pesticide poisoning vulnerability. Overall, the social, economic, environmental, and pesticide-related vulnerability indices in Desa Simpang Tanjung Nan IV are relatively high. Therefore, vulnerability risk management should focus on behavioral interventions among farmers, strengthening environmental monitoring systems, and promoting the development and adoption of bio-pesticides to reduce dependence on chemical pesticides.

Keywords: pesticides, poisoning, vulnerability

INTRODUCTION

Agriculture is an activity that supports the economy, but it can also negatively affect the environment due to the use of pesticides. Pesticides are applied in many ways—like spraying, soaking, and sowing—to manage pests, diseases, and weeds. However, not all of this pesticide actually hits the target. In fact, only about 20 percent of the pesticide reaches its intended destination, while the other 80 percent falls to the ground and contaminates the groundwater.[1]

According to the national report on pesticide poisoning cases in Indonesia 2023, there were 946 reported pesticide poisoning incidents in Indonesia during 2023, with the highest cases occurring in the agricultural regions of Central Java, West Sumatra, and East Java. Of these**,** about 8% were classified as severe poisoning**,** and three resulted in fatalities.[2] The number of poisoning cases has shown an increasing trend compared to previous years due to poor pesticide handling. Globally, the World Health Organization 2023 estimates that more than 385 million cases of unintentional pesticide poisoning occur annually, of which 11,000–20,000 result in death, mostly in developing countries with intensive agricultural practices [3]

Pesticide poisoning causes an estimated 20,000 deaths globally each year, primarily among agricultural workers in developing countries. Moreover, WHO and the Food and Agriculture Organization (FAO) report that around 385 million cases of unintentional pesticide poisoning occur annually, of which 11,000 to 20,000 result in fatalities. Beyond acute toxicity, long-term exposure to pesticides has been linked to serious chronic health conditions, including cancer, neurological disorders, reproductive dysfunction, infertility, and hepatic diseases.[4,5]

Chronic poisoning from long-term pesticide exposure can manifest as severe neurological and behavioral disorders, which are neurotoxic in nature, or as mutagenic effects that alter genetic material. The chronic impacts extend to multiple organ systems, impairing the function of the nervous, hormonal, and immune systems and causing damage to the lungs, liver, stomach, and intestines. Individuals with prolonged exposure may exhibit respiratory symptoms such as a persistent cough or a sensation of chest tightness, which are manifestations of conditions like bronchitis or asthma; sustained lung damage can ultimately lead to lung cancer. [6,7]

Pesticides that enter the body will undergo a detoxification process by the liver. However, the liver itself is often damaged by pesticides when exposed over many years. This can cause diseases such as hepatitis, cirrhosis, and even cancer. [6]

Acute poisoning occurs when the poisoning effect of pesticides occurs directly at the time of application or immediately after application of pesticides. Acute poisoning effects are divided into local acute effects and systemic acute effects.[8] Acute pesticide poisoning manifests in two distinct forms: local and systemic effects. Acute local effects are confined to the areas of the body that have been in direct contact with the pesticide, typically presenting as

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irritation of the eyes, nose, throat, and skin. In contrast, systemic effects occur upon the pesticide's entry into the human body, where it interferes with physiological systems. The bloodstream then circulates the toxin to all parts of the body, inducing symptoms such as involuntary, unconscious muscle contractions (characterized by smooth or rough movements), excessive lacrimation (tearing) and salivation, and abnormal respiration that becomes either weak or rapid.[9]

The use of pesticides that cause poisoning for the community is a non-natural disaster caused by human behavior that threatens society due to interactions between non-natural factors and humans. Threats can become disasters if humans are in a vulnerable condition and do not have the ability to face threats or be vulnerable to disasters. Disasters that occur due to pesticide use have an impact on increasing community vulnerability. Vulnerability is influenced by complex factors (physical, socio-economic, and environmental processes), thereby increasing the risk of impact. The level of vulnerability is an important thing to know as one of the factors that influence disaster risk. If they can maintain or improve their capabilities and assets both now and in the future, the community will be able to cope with and recover from pressures and shocks.[10]

Simpang Tanjung Nan IV Village, Solok Regency, is an agricultural area that produces horticultural crops. Based on initial field observations conducted in 2023 and data from the Simpang Tanjung Nan IV Village Office, it was found that most farmers rely heavily on chemical pesticides for pest control. Pesticides are a solution used by farmers to increase agricultural yields. Excessive use of pesticides, including not complying with regulations and using their own concoctions of several types of pesticides, is common for farmers. The location of community settlements, which are close to agricultural land, makes the condition of the community vulnerable to pesticide poisoning. Therefore, it is necessary to analyze the vulnerability of pesticide poisoning in farmers in the agricultural area of Simpang Tanjung Nan IV Village, Solok Regency. Vulnerability analysis was carried out to determine the level of vulnerability resulting from the use of pesticides.

METHODS

This research was a semi-quantitative research by presenting data descriptively and spatially. The focus of this study was an analysis of the vulnerability of pesticide poisoning to farmers in the agricultural area of Simpang Tanjung Nan IV Village, Solok Regency, from January to December 2022.

The population in this study was all people who were in Simpang Tanjung Nan IV Village, Solok Regency. The demographic information used was secondary data, like sex, age, education, and population density, from the Simpang Tanjung Nan IV Village Office. The selection of the village was based on a purposive sampling method. The primary inclusion criterion required the village to be located near an agricultural area. To assess environmental quality, water, soil, and air samples were analyzed for pesticide residues using Gas Chromatography–Mass Spectrometry (GC–MS). This was supplemented by interviews with key informants: one village head, nine hamlet leaders, and one official from the public health center.

Measurements were carried out on all villages in the Tanjung Nan IV Intersection. Data collection was carried out by observing, interviewing, and measuring pesticides in the environment. Primary data sources were obtained by conducting structured interviews and measuring environmental quality. Data on pesticide levels were obtained from direct sampling and checked using the type of tool: GC-MS-QP2010 Ultra Brand Shimadzu. By

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column type: column: RTX-5MS 30m; 0.25 mmID; 0.2 µm df. Pesticide levels were measured in water, air, and soil. Secondary data is used to complement data obtained from local government offices, such as the Solok District Health Office, Simpang Tanjung Nan IV Health Center, Office of the Chief Simpang Tanjung Nan IV Village.

The analysis carried out in this study was a univariate analysis, which was used to describe variables by presenting frequency distribution tables. This research was conducted by applying BNPB's InaRisk calculations. [11] This research has passed ethical review. The ethical approval number is 177/KEPK.F1/ETIK/2022.

RESULT

Table 1. Frequency Distribution of Population Density Description

Village	N
Traditional Market	1775
Kapalo Danau Bawah	1174
Kapalo Danau Ateh	1221
Lurah Ingu	740
Aka Gadang	660
Rawang Gadang	1050
Gurun Data	806
Kinari Bay	592
Anjali Bay	899
Village	N
Total	8917

Based on Table 1, the frequency distribution table above, it can be seen that the most densely populated Village is in Pasar Village with a total of 1775 people, and the most sparsely populated Village is in Village Teluk Kinari

Table 2. Frequency Distribution of Agricultural Land Area

Village	Agricultural Land Area(m2)
Traditional Market	4.722
KDB	3.572
KDA	1.685
Lurah Ingu	4.346
Aka Gadang	6.428
Rawang Gadang	5.985
Gurun Data	3.553
Kinari Bay	4.346
Anjali Bay	7.549
Total	42,186

Based on table 2, the frequency distribution table for the description of agricultural land area above, it can be seen that the village with the most extensive agricultural land is in the VillageTeluk Anjali Bay with an area of 7,549 m2, and the narrowest Village is in the Village Kapalo Danau Ateh.

Table 3. Pesticide Concentration Frequency

Village	Pesticide Concentration (%)		
	Air	Water	Soil
Traditional Market Village	7,61	7,96	18,54
Kapalo Danau Bawah Village	28,69	24,49	22,58
Kapalo Danau Ateh Village	33,18	31,56	24,5
Lurah Ingu Village	27,18	24,6	22,34
Aka Gadang Village	26,96	21,21	45,76
Rawa Gadang Village	29,16	21,21	43,14
Gurun Data Village	8,29	19,25	18,54
Teluk Kinari Village	28,5	21,32	43,71
Teluk Anjalai Village	30,26	31,01	34,91

Distribution based on Table 3, the frequency distribution table depicting pesticide concentrations above, it can be seen that the Village with the highest pesticide content in the air is at Kapalo Danau Ateh Village, namely 33.18%, and the Village with the highest pesticide content in the water is at Kapalo Danau Ateh Village is 31.56%, and the Village with the highest pesticide content in the soil is Aka Gadang Village, which is 45.76%.

Based on Figure 1, the social village vulnerability index map at Simpang Tanjung Nan IV, it can be seen that there are two Villages with high social vulnerability indexes, namely Traditional Market Village and Kapalo

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Danau Diateh Village. Meanwhile, the other seven Villages have a moderate social vulnerability index. Therefore, there are no Villages at Kanagarian Simpang Tanjung Nan IV that have a low social vulnerability index.

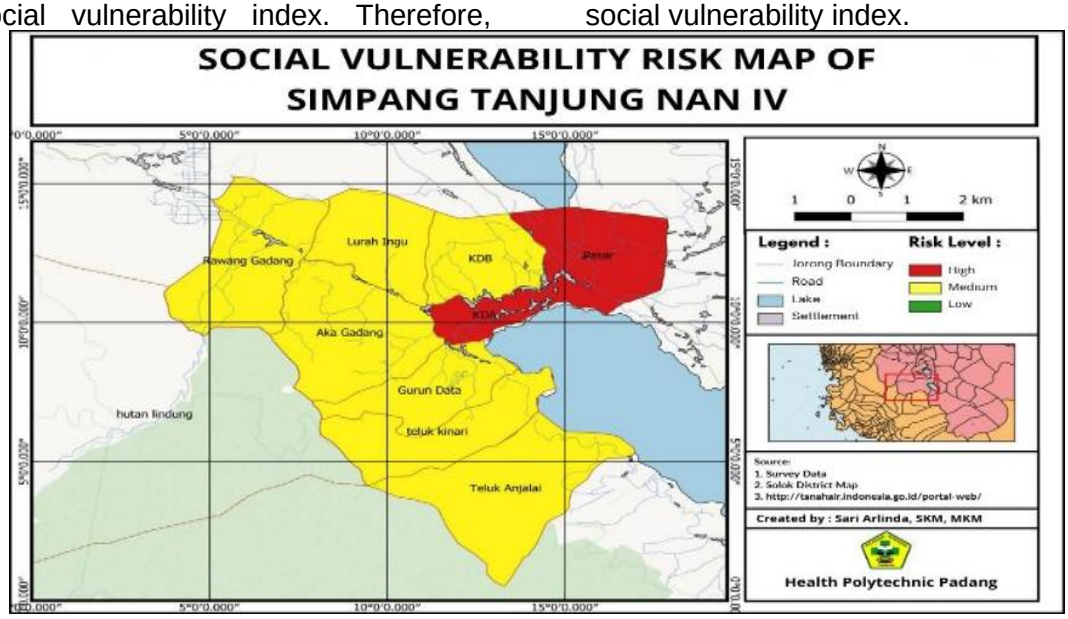

Figure 1. Social Vulnerability Index Map

Based on Figure 2, the economic vulnerability index map of Simpang Tanjung Nan IV Village, it can be seen that there are six Villages with a high economic vulnerability index, namely Kapalo Danau Di Bawah Village, Kapalo Danau Diateh Village, Aka Gadang Village, Gurun Data Village, Teluk Kinari Village and Teluk Anjalai Village. Meanwhile, the other three Villages, namely Pasar Village, Rawang Gadang Village and Lurah Ingu Village, have moderate economic vulnerability indexes.

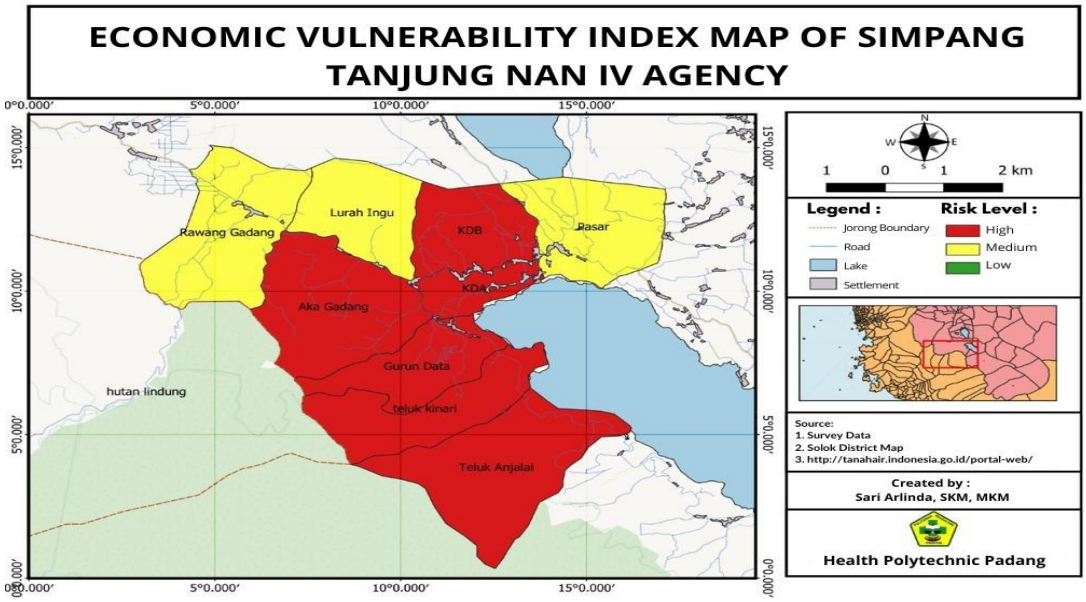

Figure 2. Economic Vulnerability Index Map

Based on Figure 3, the environmental vulnerability index map of Tanjung Nan IV Intersection, it can be seen that the average Village in Tanjung Nan IV Intersection has a high environmental vulnerability index. Only two Villages, namely Village Pasar and Village Gurun Data, received moderate environmental vulnerability indexes.

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Based on Figure 4, the pesticide poisoning vulnerability index map of Simpang Tanjung Nan IV Village, it can be seen that there are five Villages with a high pesticide poisoning vulnerability index, namely Village Kapalo Danau Di Bawah, Village Kapalo Danau Diateh, Village Aka Gadang, Village Teluk Kinari and Village Teluk Anjali. Meanwhile, the other four Villages, namely Village Rawang Gadang, Village Lurah Ingu, Village Gurun Data and Village Pasar, had moderate pesticide poisoning susceptibility indexes.

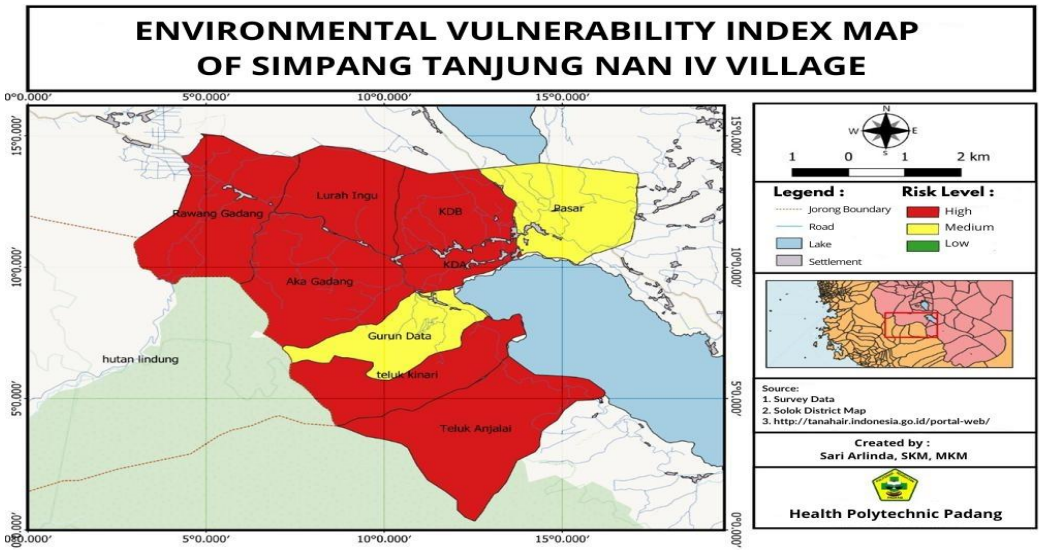

Figure 3. Physical/Environmental Vulnerability Index Map

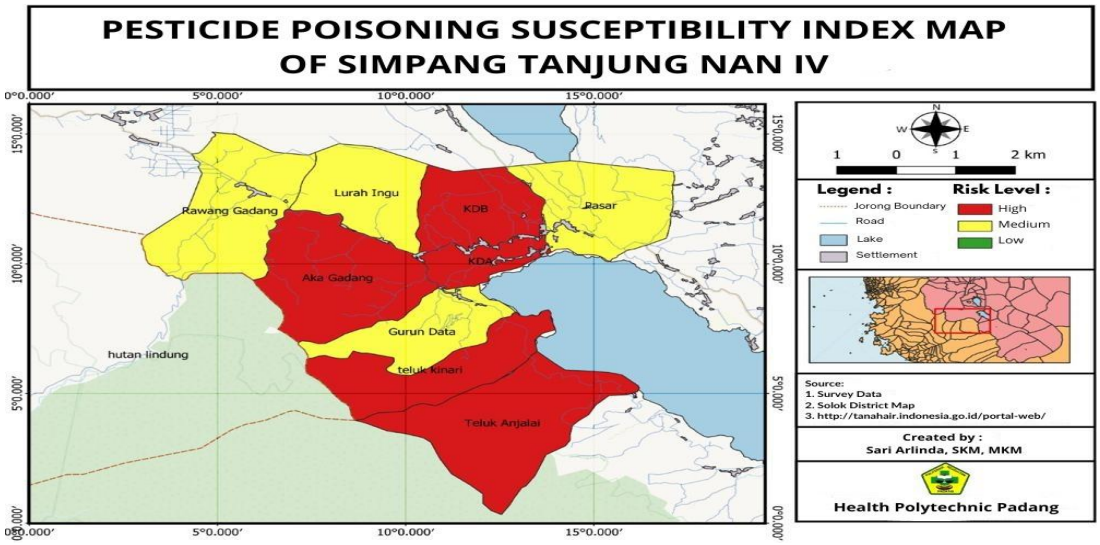

Figure 4. Pesticide Poisoning Susceptibility Index Map

DISCUSSION

Vulnerability describes the level of social fragility in facing a disaster. Social vulnerability, according to BNPB, includes parameters of population density and vulnerable groups. The research found that Pasar Village has the highest population density (1,775 people), while Teluk Kinari Village has the lowest (592). Villages with higher population densities tend to have greater social and environmental vulnerability to pesticide exposure. This is because densely populated areas are typically located closer to agricultural land (within 100 meters) where pesticide spraying occurs, increasing residents' risk of exposure to airborne pesticide residues.

A study by Lekei et al. and Putri & Rahman found that population density

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and settlement proximity to farmlands significantly increase chronic pesticide exposure. The limited availability of buffer zones and improper storage of pesticides near residential areas exacerbate environmental contamination and health risks.[7,12]

Anjali Bay Village has the most extensive agricultural land area (7,549 m^2), while Kapalo Danau Ateh Village has the smallest (1,685 m^2). The size of agricultural land directly influences the frequency and volume of pesticide application, which in turn affects environmental and human exposure levels. Villages with broader agricultural land, such as Anjali Bay and Aka Gadang, exhibit higher pesticide utilization rates due to greater pest control needs. Consequently, these areas experience increased pesticide residue accumulation in soil and water, contributing to higher environmental vulnerability indices. This relationship aligns with findings from Putri and Rahman in 2023, who reported that larger-scale horticultural farmers in West Sumatra applied pesticides more frequently (two to three times per week) and used multiple active ingredients simultaneously.[12]

The highest pesticide concentration in air (33.18%) and water (31.56%) was detected in Kapalo Danau Ateh Village, while the highest soil concentration was in Aka Gadang Village (45.76%). These findings indicate that areas with higher pesticide concentrations are directly associated with intensive farming activities and frequent pesticide application. Both Kapalo Danau Ateh Village and Aka Gadang Village have large horticultural plots with continuous pesticide spraying—typically two to three times per week during the planting season—which leads to residue accumulation. The elevated air concentration in Kapalo Danau Ateh can be attributed to aerial drift during spraying and the absence of natural barriers. Meanwhile, the high soil residue levels in Aka Gadang and Rawang Gadang Villages are likely due to the use of persistent active ingredients such as fipronil, deltamethrin, and paraquat, which are known for their long degradation periods.

Water samples showing high contamination in Kapalo Danau Ateh and Teluk Anjalai Villages suggest runoff from sloped farmlands during rainfall, transporting pesticide residues into nearby waterways. This pattern aligns with the findings of Putri & Rahman in 2023, who observed that pesticide residues in irrigation systems were strongly correlated with application frequency and land slope gradient. [12]

Prolonged environmental accumulation of these residues poses significant health risks, particularly for farmers and residents living near agricultural plots. Studies by Lekei et al. emphasize that chronic exposure, even at low concentrations, can lead to long-term health outcomes such as endocrine disruption, liver toxicity, and neurobehavioral disorders.[7]

Social Vulnerability Index

Vulnerable groups include sex ratio, poverty ratio, disability ratio, and age group ratio[13]. Based on the Social Vulnerability Risk Map of Simpang Tanjung Nan IV, two villages Pasar and Kapalo Danau Ateh (KDA), were classified as having high social vulnerability indexes, while the remaining seven villages showed moderate vulnerability. None of the villages were categorized as having low vulnerability levels.

The high social vulnerability in Pasar and KDA Villages can be explained by several demographic and socioeconomic factors. These areas have the highest population densities, reaching over 1,500 persons per km^2, with a population growth rate of approximately 1.8% per year[14]. In

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addition, a large proportion of the workforce (68–75%) in these villages is employed in agricultural and horticultural sectors, where the risk of pesticide exposure is particularly high.

In contrast, villages with moderate social vulnerability, like Aka Gadang, Gurun Data, and Teluk Anjalai, typically have smaller populations, diversified livelihoods, and greater access to non-farming income. These factors enhance adaptive capacity and reduce overall exposure risk.

The spatial pattern in Figure 1 illustrates a clear cause-and-effect relationship. High population density, agricultural dependency, and low education lead to higher social vulnerability. Conversely, lower density, diversified occupations, and better socioeconomic resources result in reduced vulnerability. These findings align with previous Indonesian studies, which identified demographic pressure, occupational homogeneity, and gender composition as strong determinants of social vulnerability in agricultural areas.[12,15]

Economic Vulnerability Index

According to Seth and Ragab, vulnerability has two constructs: microeconomic and macroeconomic. Microeconomic vulnerability involves shocks affecting individuals/households, primarily through income, which can lead to poverty. Macroeconomic vulnerability concerns shocks to broader economic growth, defined as a country's susceptibility to a financial crisis that impacts national outcomes.[13]

Parameters of economic vulnerability used in this study are types of work, livelihood diversification, agricultural land area, and economic means. Based on the economic vulnerability index map of Simpang Tanjung Nan IV Village, six Villages have a high economic vulnerability index: Village Kapalo Danau Di Bawah, Village Kapalo Danau Diateh, Village Aka Gadang, Village Gurun Data, Village Teluk Kinari, and Village Teluk Anjalai. The high index of economic vulnerability is influenced by the type of occupation, as the majority of the population are Farmers, Farm Laborers, Coolers, or the Unemployed.

Physical/Environmental Vulnerability Index

Environmental vulnerability indicators measured in this study were pesticide levels in water, air, and soil. The environmental vulnerability index map of Tanjung Nan IV Intersection shows that, on average, the Villages have a high environmental vulnerability index. Only two Villages, Village Pasar and Village Gurun Data, received moderate environmental vulnerability indexes. The high environmental vulnerability index is reflected by high pesticide levels: >25% in air, >20% in water, and >20% in soil. Therefore, controlling the risk of pesticide levels in water, air, and soil is necessary.

Pesticide levels in Simpang Tanjung Nan IV exceeded 25% in the air and 20% in water and soil, indicating widespread contamination. This accumulation results from interrelated factors, primarily the excessive and repeated application of pesticides (two to three times per week) during the planting season. Farmers often exceed the recommended dosage and mix different active ingredients, which promotes chemical persistence and volatilization, increasing airborne pesticide levels.[16]

The impacts of pesticide residue accumulation are twofold. Environmentally, residues in the soil and water disrupt microbial ecosystems, reduce soil fertility, and harm beneficial insects and aquatic organisms. For human health, chronic exposure to low concentrations of pesticide residues has been linked to neurological disorders, endocrine disruption, reproductive toxicity, and increased cancer risk.[17].

Pesticide Poisoning Susceptibility Index

The pesticide poisoning vulnerability index map for Simpang Tanjung Nan IV Village shows five Villages with a high

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pesticide poisoning vulnerability index: Village , Village Kapalo Danau Diateh, Village Aka Gadang, Village Teluk Kinari, and Village Teluk Anjali. Meanwhile, the other four Villages—namely Village Rawang Gadang, Village Lurah Ingu, Village Gurun Data, and Village Pasar—received moderate pesticide poisoning susceptibility indexes.

High susceptibility in these areas reflects the intensity of pesticide use, lack of personal protective equipment (PPE), and limited awareness of safe handling practices among farmers. Field observations and interviews revealed that most farmers apply pesticides two to three times per week during the planting season, often mixing multiple chemical formulations. Similar behavioral patterns have been reported in other Indonesian agricultural regions, particularly in Batu (East Java) and Brebes (Central Java), where over 80% of farmers regularly exceed the recommended pesticide dosage.[18]

The observed risk pattern in Simpang Tanjung Nan IV is consistent with broader trends of increasing pesticide poisoning prevalence in Indonesia. According to the Indonesian Ministry of Health, there were 972 reported cases of pesticide poisoning in 2023, a 22% increase from 2020. Approximately 68% of these occurred in horticultural regions, where farmers have high dependency on chemical pesticides. West Sumatra alone recorded over 50 cases of acute pesticide poisoning among horticultural workers, with two fatalities reported in 2022.[19,20]

The spatial concentration of high-risk areas in Simpang Tanjung Nan IV, particularly in Aka Gadang and Teluk Anjalai Villages, is linked to their large agricultural land areas and continuous pesticide application schedules. The proximity of residential areas (less than 100 meters from farmland) further amplifies exposure risks through airborne drift and groundwater contamination. These local findings support the national evidence that prolonged exposure and occupational proximity are dominant determinants of pesticide-related health impacts in Indonesia.[21]

The use of synthetic pesticides results in significant adverse consequences for both human health and the environment. Environmentally, they cause severe ecosystem disruption by killing the natural enemies of pests and beneficial organisms like bees, which are essential for pollination. This creates an ecological imbalance and fosters pest resistance. For human health, the primary negative impact arises from pesticide residues that are difficult to decompose, accumulate in the food chain, and lead to the ingestion of these pollutants.[22]

Numerous methods are employed to reduce pesticide residues in agricultural products to ensure food safety for human consumption, a worldwide concern for both the Indonesian and international communities. These mitigation efforts are categorized into pre-harvest and post-harvest treatments. The effectiveness of removing these residues depends on many variables, including the pesticide's chemical properties (its absorption, translocation, and decay), and the nature of the food commodity. Factors related to application and processing—such as the application method, contact duration, and all processing steps from planting to harvest—are crucial. Environmental processes in the field, like evaporation and hydrolysis, also influence final residue levels. It is also noted that treatments during cultivation can affect pesticide residues, though this relationship is complex and not always directly correlated with the pesticide's physico-chemical properties.[23]

Continuous consumption of well water contaminated with pesticides can severely compromise community health, potentially causing acute and chronic poisoning, digestive disorders,

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degenerative diseases, and mortality. The chronic effects of pesticide residue exposure are extensive and systemic. They can disrupt the endocrine system by interfering with steroid metabolism, damaging thyroid function, and affecting spermatogenesis, classifying them as Endocrine Disrupting Pesticides (EDs). Chronic poisoning can also lead to neurological and behavioral disorders (neurotoxicity) and genetic mutations (mutagenicity). Pesticides can inflict direct damage on vital organs (lungs, liver, stomach, intestines) and impair the nervous, hormonal, and immune systems. Respiratory damage may present as a persistent cough or chest tightness (symptomatic of bronchitis, asthma, or other lung diseases), with long-term damage potentially leading to lung cancer. While exposure increases the likelihood of cancer, it is not an inevitability; however, hundreds of pesticide compounds are recognized as carcinogens, with leukemia being the most commonly associated malignancy.[24].

Acute poisoning from pesticide use is characterized by the immediate onset of effects, occurring either during or directly following the application of the substance. These effects are classified into two categories: acute local effects and acute systemic effects. Acute local effects are confined to the specific body parts in direct contact with the pesticide, typically manifesting as irritation of the eyes, nose, throat, and skin. In contrast, systemic effects occur when the pesticide is absorbed into the body and interferes with internal systems. The pesticide is then circulated by the bloodstream, leading to symptoms such as involuntary muscle nerve activation (causing fine or coarse movements), excessive lacrimation (tearing) and salivation, and abnormal respiration (weak or rapid)[24]

General symptoms of pesticide poisoning, which can manifest individually or concurrently, affect various physiological systems. Systemic and dermal symptoms include excessive weakness, fatigue, skin irritation, a burning sensation, diaphoresis (excessive sweating), and skin discoloration. Ocular symptoms are characterized by irritation, burning, excessive lacrimation (tears), blurred vision, and changes in pupil size. The gastrointestinal tract can also be affected, with symptoms like a burning sensation in the mouth and throat, excessive salivation, nausea, vomiting, abdominal cramps, and diarrhea. Furthermore, pesticide poisoning may cause nervous system disturbances, presenting as respiratory distress with symptoms such as difficulty breathing, wheezing, coughing, and chest pain or stiffness.[6].

One key effort to prevent pesticide poisoning symptoms in farmers, especially considering age-related factors, is enhancing nutritional status. A superior nutritional status fortifies the immune system, improving its ability to resist toxins and infections. Furthermore, good nutrition avoids protein deficiency, ensuring that the body's enzymatic processes for metabolic and detoxification functions can operate normally and efficiently. This study's main contribution is identifying social, economic, and environmental factors as critical to pesticide poisoning vulnerability, making it a human-centric issue determined by risk and low adaptive capacity. Risk is amplified by poor education, poverty, adverse social conditions, and susceptible populations (elderly, children, pregnant women, disabled). Limitations include potential bias from secondary data and the topic's sensitivity, which may have caused participants to withhold information about non-compliant pesticide use. [25,26].

CONCLUSION

Based on research conducted at the Tanjung Nan IV Kenagarian Intersection, Solok Regency, regarding the vulnerability of pesticide poisoning among farmers, it can be concluded that:

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The social vulnerability index shows two Villages, Village Pasar and Village Kapalo Danau Diateh, have high social vulnerability indexes, while the other seven Villages have a moderate index. Six Villages show a high economic vulnerability index: Village Kapalo Danau Di Bawah, Village Kapalo Danau Diateh, Village Aka Gadang, Village Gurun Data, Village Teluk Kinari, and Village Teluk Anjalai. The other three Villages have moderate social vulnerability indexes. The environmental vulnerability index for the Tanjung Nan IV Intersection is, on average, high. Five Villages have a high pesticide poisoning vulnerability index: Village Kapalo Danau Dibawah, Village Kapalo Danau Diateh, Village Aka Gadang, Village Teluk Kinari, and Village Teluk Anjali. Meanwhile, the four other Villages have moderate pesticide poisoning susceptibility indexes.

Based on these findings, it is recommended to enhance vigilance and implement preventive measures in pesticide use. These efforts include regular health screenings, mandatory safety training for pesticide handling, and establishing buffer zones between agricultural and residential areas. Public education on the dangers and proper use of pesticides should be strengthened through health promotion campaigns, collaborating with community health centers (Puskesmas), agricultural extension workers, and local governments.

Furthermore, a transition from synthetic pesticides to bio-pesticides is strongly encouraged to minimize environmental contamination. Plant-based extracts such as papaya leaf (Carica papaya), soursop leaf (Annona muricata), ginger (Zingiber officinale), and lemongrass oil (Cymbopogon citratus) have demonstrated insecticidal and antifungal properties with minimal residue persistence. Studies in Indonesia have shown that substituting synthetic pesticides with bio-pesticides can significantly reduce pesticide residue levels in soil and water, supporting healthier, sustainable agricultural practices.

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