

NH 9.10 Natural hazards' impact on natural and built heritage and infrastructure in urban and rural zones

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The All-Hazards River Basin Governance Risk Assessment Strategy Under Covid-19 Pandemic Impact: A Social-Economic Vulnerability Case Study of Da'an River Basin Area in Central Taiwan



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The All-Hazards River Basin Governance Risk Assessment Strategy Under Covid-19 Pandemic Impact: A Social-Economic Vulnerability Case Study of Da'an River Basin Area in Central Taiwan ²

- **Abstract**

- The existing literature on hazard risk cases and theories often neglects risk-oriented spatial planning and dialogue, resulting in a phenomenon known as "weakness policy." This study aims to address this gap by constructing an all-hazards river basin governance index system and using it as the research methodology to assess the disaster social-economic vulnerability and mitigation response on the case study site of Da'an River basin townships in central Taiwan. Analytical tools such as AHP and GIS overlays were employed. The study found that the COVID-19 pandemic reduced noise and environmental pollution caused by religious activities. The Central Government's "Stimulus Voucher" policy and tourists' "retaliatory consumption" had benefited the local tourism industry.

Keywords: all-hazards risk assessment, social-economic vulnerability, post pandemic era, disaster governance

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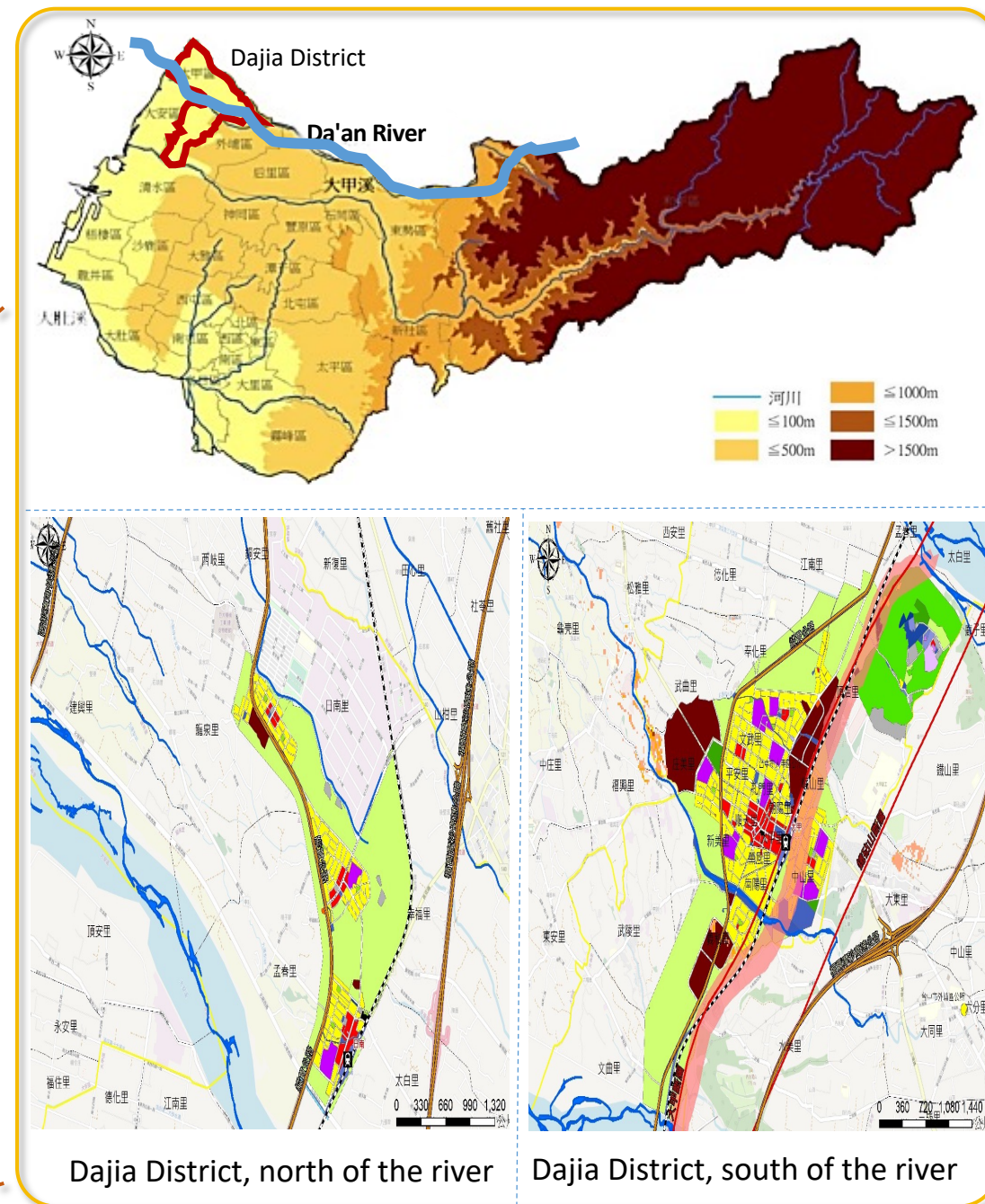
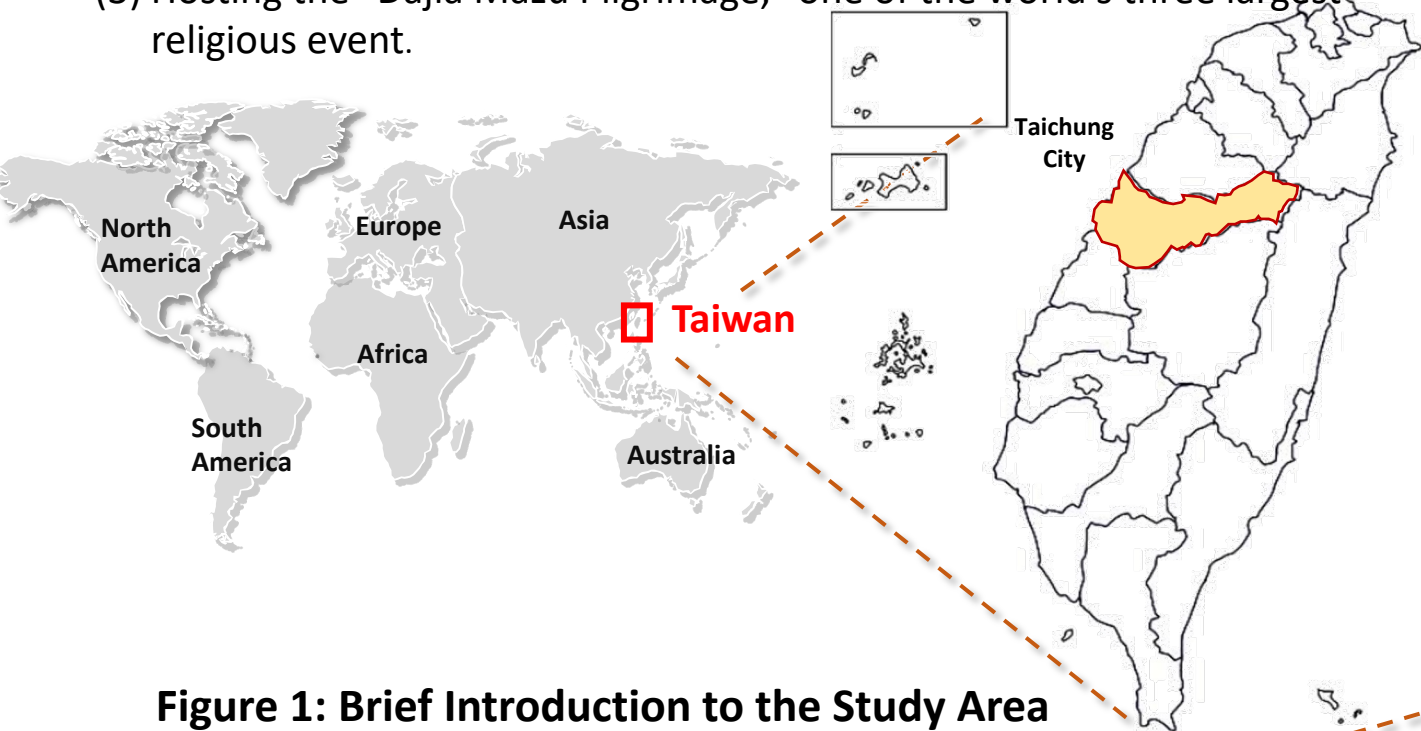
05 Research Findings

Introduction:

Background of the Study Area:

■ **Dajia District** lies between two rivers: Da'an River and Dajia River, on the alluvial plain, with the Da'an River demarcating the north and south regions (see Figure 1). It benefits from its geological advantage and is known for:

- (1) Being the second-largest vegetable and the largest rice production areas in Taichung city, Taiwan.
- (2) Serving as a hub for metal products, machinery equipment manufacturing, and the bicycle industry.
- (3) Hosting the "Dajia Mazu Pilgrimage," one of the world's three largest religious events.



1. Reasons for Choosing the Case Study Under the Impact of the Pandemic:

The COVID-19 pandemic and its variants have had a severe impact on the global economy, particularly on Taiwan's tourism industry between 2020 and 2022. Specific insights into the impact on Taiwan's tourism industry can be gained from the "Taiwan Centers for Disease Control" (refer to Table 1 and Figure 2).

(1). The reasons for not traveling: include concerns about infection (18% to 50.3%) and compliance with government pandemic prevention policies (11.9% to 47.1%).

(2). The reasons for traveling: include confidence in Taiwan's pandemic prevention measures (0.3% to 1.2%) and a shift from foreign to domestic travel (0.3% to 1.9%). These findings underscore the relationship between government pandemic prevention policies (and subsidies), psychological factors related to infection, and population mobility, gathering, and industry development.

Therefore, this study aims to approach the case study from the perspective of **socio-economic vulnerability**, supplement risk-oriented spatial planning, and initiate a dialogue on pandemic disasters.

Table 1: Survey on Reasons for Taiwan's Travel Activities during the Pandemic in 2020

| Impact of COVID-19 on Taiwan's Travel Industry In 2020 | | Q1 | Q2 | Q3 | Q4 | Total |
|--|--|-------------|-------------|-------------|-------------|-------------|
| Percentage | | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Reduced Frequency of Travel | | 59.0 | 41.5 | 20.4 | 27.8 | 37.0 |
| Reasons | Worries about infection | 50.3 | 35.7 | 16.4 | 18.0 | 22.4 |
| | Cancellation of travel plans by companions | 14.4 | 9.6 | 3.8 | 3.9 | 6.2 |
| | Compliance with government pandemic prevention policies | 47.1 | 31.8 | 11.9 | 13.1 | 19.0 |
| | Limitations of attractions due to pandemic measures | 15.0 | 11.3 | 4.9 | 5.2 | 7.1 |
| | Company/school regulations (prohibition) | 8.4 | 5.6 | 1.3 | 1.6 | 3.0 |
| | Decreased income | 9.0 | 5.4 | 2.5 | 2.0 | 3.3 |
| | Other | - | - | - | - | - |
| Increased Frequency of Travel | | 0.5 | 1.2 | 2.6 | 1.2 | 1.4 |
| Reasons | Confidence in Taiwan's pandemic prevention measures | 0.3 | 0.8 | 1.2 | 0.7 | 0.8 |
| | Less crowded attractions | 0.2 | 0.5 | 0.5 | 0.3 | 0.4 |
| | Business promotional activities | 0.1 | 0.2 | 0.4 | 0.3 | 0.2 |
| | Government relief and revitalization plans | - | 0.1 | 0.7 | 0.2 | 0.3 |
| | Encouragement of vacation by companies | - | 0.1 | 0.2 | 0.1 | 0.1 |
| | Shift from foreign to domestic travel | 0.3 | 0.7 | 1.9 | 0.8 | 0.9 |
| | Other | - | - | - | - | - |
| No Impact | | 40.5 | 57.3 | 77.0 | 71.0 | 61.7 |

2. Tourism Activities and the Impact of Pandemic on the Case Study Selection

- Reasons for choosing the case study:** The aging rate in Taiwan is the highest in the world, and it is expected to reach a super-aging society by 2025 (refer to Figure 2), with over 65-year-olds accounting for 20% of the total population. In the Dajia District of Taichung, the outflow of young population is severe, which is even more pronounced in the post-pandemic era. Notably, the annual Mazu Pilgrimage of the Jenn Lann Temple in Dajia District, a folk cultural and religious event, involves cross-border processions (refer to Figures 4-7) and environmental impact activities such as burning incense and firecrackers, which are significantly affected during the pandemic. This is the primary reason for selecting it as a case study for observation.

Taiwan

From old age to super old age

Fastest Aging Speed in the World



Source: Senior Workforce Development Service Center, Ministry of Labor

Note: An aging society is when 14% of the entire population consists of people aged 65 or above; when it's 20%, it is called "Super Aged-Society."

▲ Figure 2: Schematic diagram of Taiwan's transition from old age to super old age

retrieved from:

<https://autos.yahoo.com.tw/news/%E8%80%81%E5%8C%96%E9%80%9F%E5%BA%A6%E4%B8%96%E7%95%8C%E7%AC%AC-%E5%A4%A7%E9%BD%A1%E8%80%85%E4%BD%95%E5%8E%BB%E4%BD%95%E5%BE%9E-004000621.html> 2023/4/2

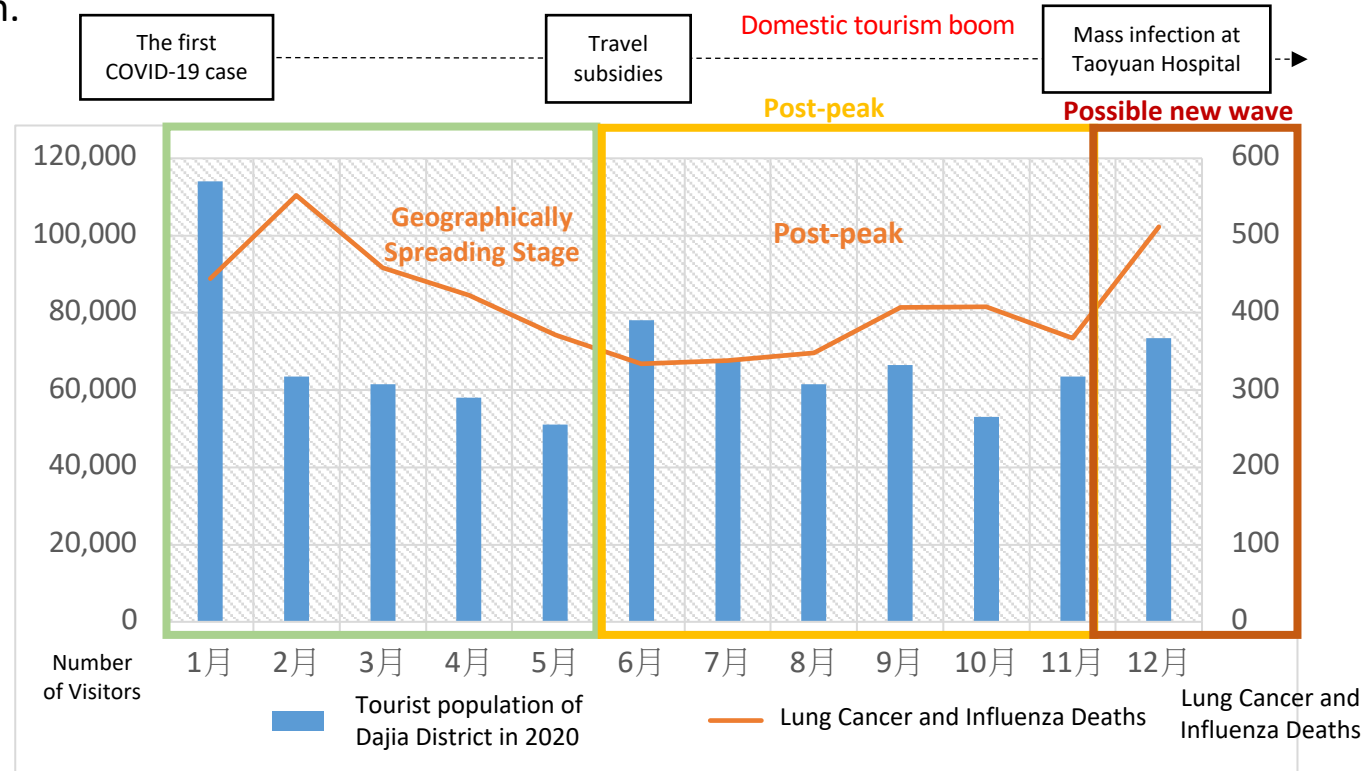


Figure 3: Schematic diagram of the relationship between tourist population and epidemic infection in the case area during the epidemic period

Introduction:

3. Tourism Activities and the Impact of Pandemic

Dajia Mazu Pilgrimage Route

【大甲鎮瀾宮媽祖遶境進香路線圖】①



Figure 4: Location of the main case, Da'an River



Figure 5: Situation of Dajia Jenn Lann Temple before the pandemic

retrieved from: <https://today.line.me/tw/v2/article/9wkG9K> 2023/4/2



Figure 6: Situation of Dajia Jenn Lann Temple during the pandemic

retrieved from:

(1). <https://news.ltn.com.tw/news/life/breakingnews/3194483> 2023/4/2;

(2). Photographed 12/04/2020



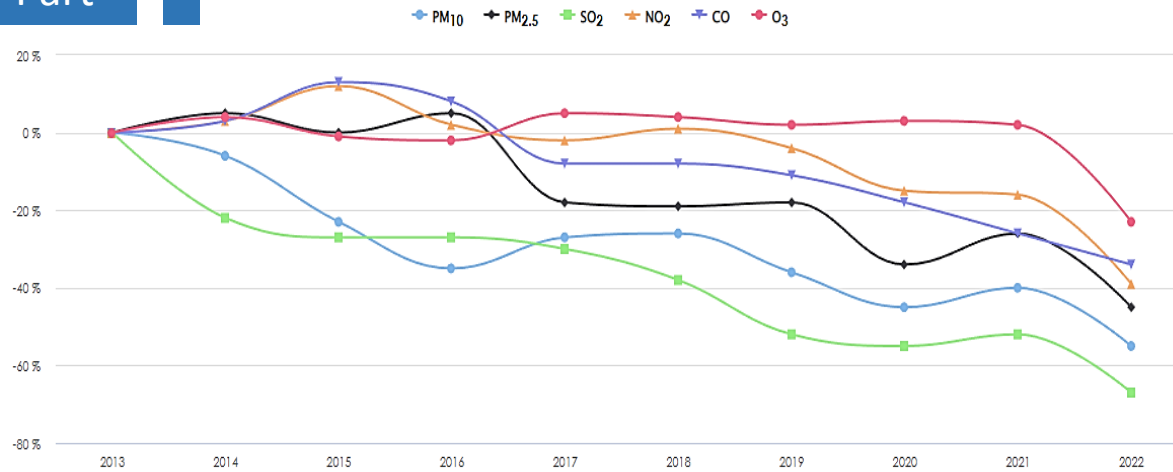
Figure 7: Situation of Dajia Jenn Lann Temple after the pandemic

retrieved from:

<https://city.gvm.com.tw/article/100670> 2023/4/2;
<https://www.mazubuybuy.com.tw/blog/posts/051106>
 2023/4/7

Introduction:

3. Tourism Activities and the Impact of Pandemic



- 1) Findings show that during the pandemic, there is a significant correlation between environmental pollution and its impact on the region (refer to Figure 8). Environmental monitoring values decreased in 2020, particularly in 2021-2022, and were attributed to the movement of populations and transportation (related to tourism).
- 2) However, the growth rate of factory registrations increased during this period (refer to Figure 9) due to the resilience of processing and transportation industries, which may be linked to industrial agglomeration in the area.
- 3) The impact of the pandemic affected accommodation and catering, as well as construction projects (from 2020 to 2021), but paradoxically, other service industries and retail industries increased (refer to Figure 10), which may be attributed to the rise of logistics services such as online shopping, Uber, and Foodpanda.

Figure 8: Changes in air pollution concentration at Taichung Fengyuan Station from 2013 to 2022

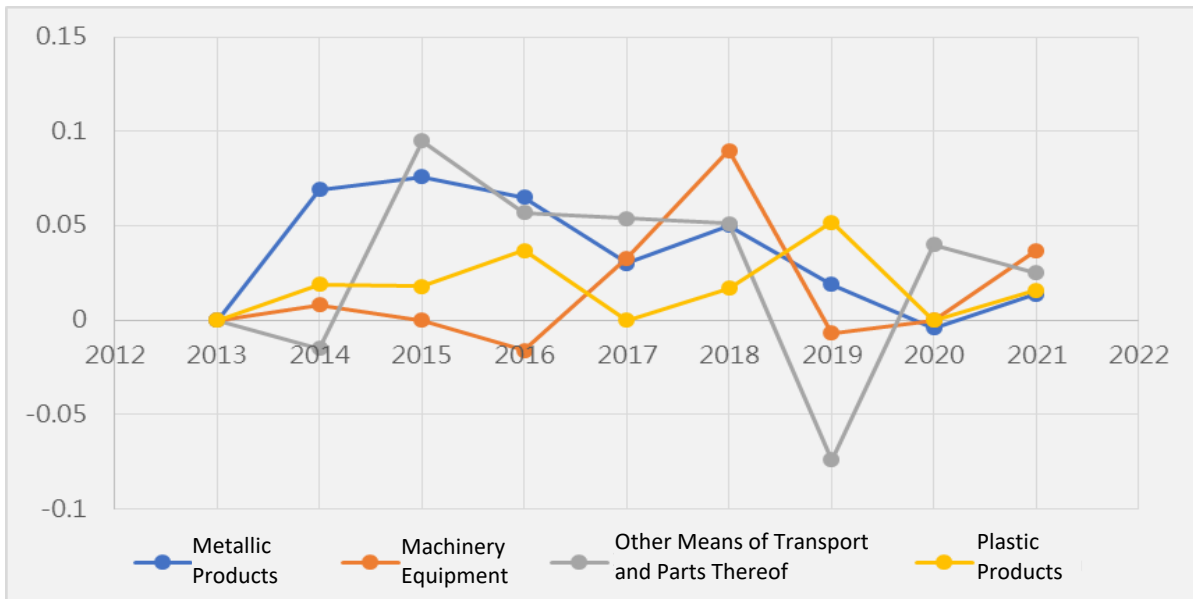


Figure 9: Changes in factory registration growth rate in Dajia District from 2013 to 2021

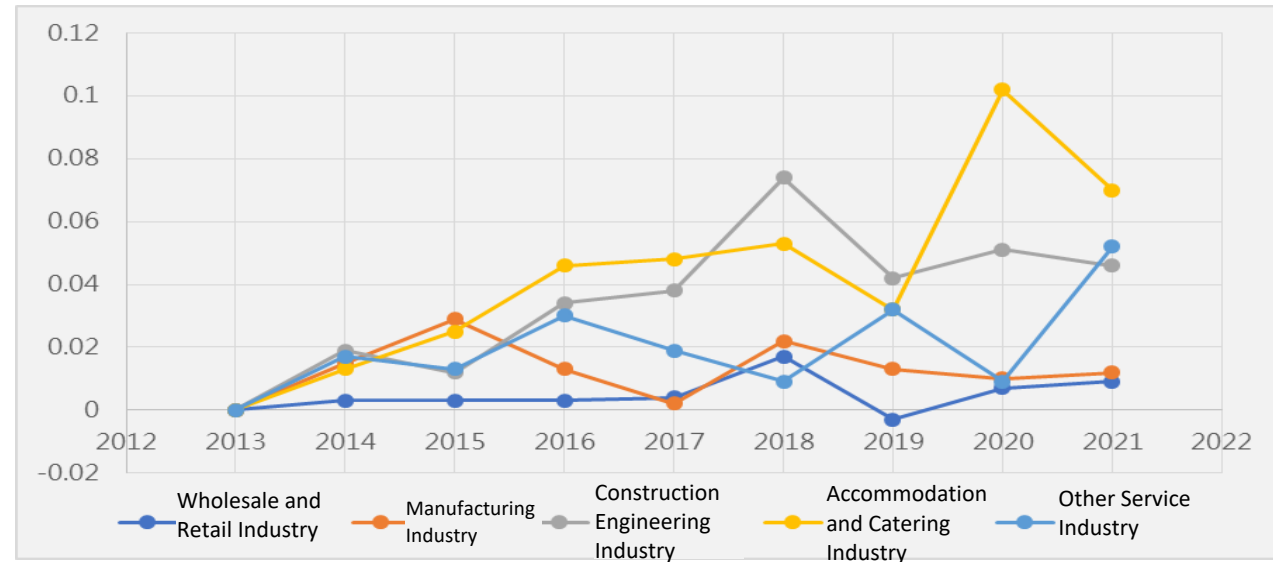


Figure 10: Changes in commercial registration growth rate in Dajia District from 2013 to 2021

3. Tourism Activities and the Impact of Pandemic

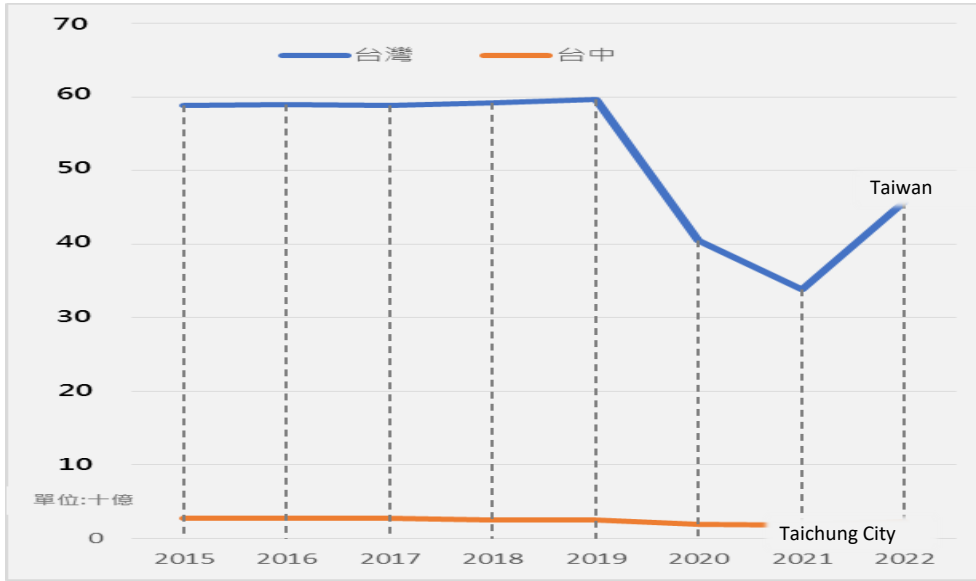


Figure 11. Total turnover of tourist hotels in 2015-2022

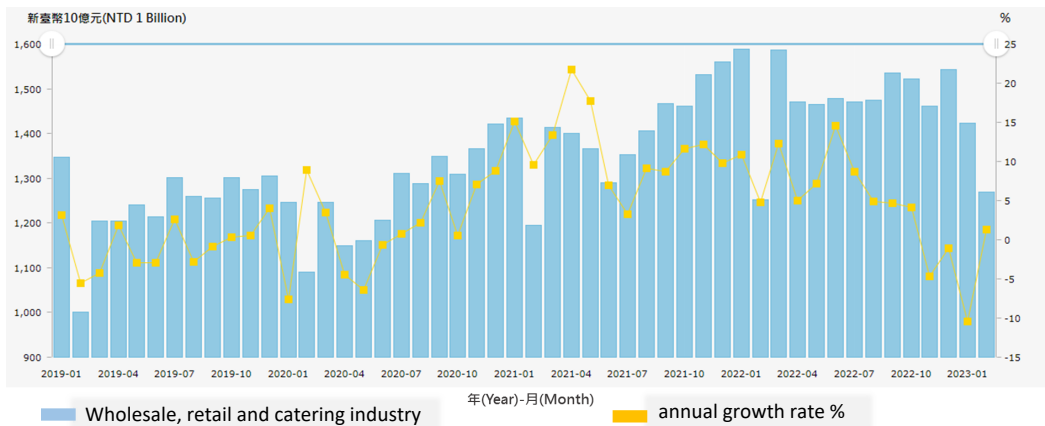


Figure 12. Output value and growth rate of Taiwan's wholesale, retail and catering industries from 2019 to 2023

- Figure 11 shows a decline in the total revenue of the tourism industry in Taichung, particularly in 2020-2021.
- While the value of the wholesale, retail, and food service industries increased during the pandemic (see Figure 12), the growth rate decreased annually, possibly due to the global inflation caused by the pandemic.
- Figure 13 shows fluctuations in Taiwan's economic growth rate during the pandemic, with the government's issuance of stimulus vouchers increasing consumer spending and prompting retaliatory consumption behaviors. However, with the implementation of stricter restrictions, the growth rate turned negative.

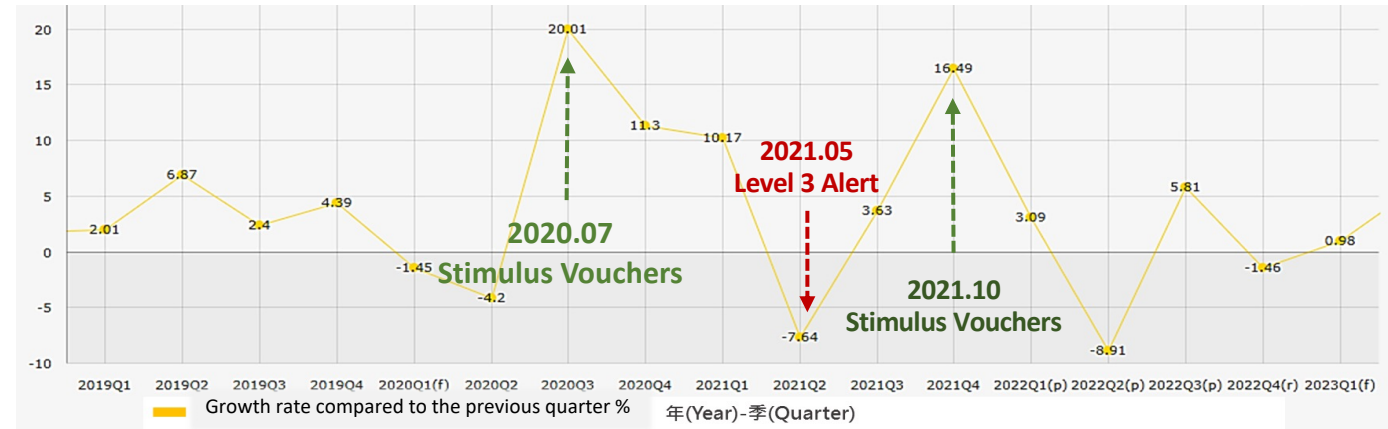


Figure 13. Taiwan's economic growth rate from 2019 to 2023

4. Research Objectives

1

The research aims **to investigate the spatial socio-economic vulnerability of the Da'an River Basin in the context of the overlapping of local disasters and the COVID-19 pandemic**. Specifically, the study focuses on the association between the tourism industry and land use in the city of Dajia, Taichung.

2

The research also aims **to establish an indicator framework for assessing the socio-economic vulnerability of large-scale tourism and cultural activities in the post-pandemic era**, using the Dajia Mazu pilgrimage as a case study.

3

The study examines **the effectiveness of government subsidies and retaliatory consumption benefits in the post-pandemic recovery** of the tourism industry in the study area, which has a rich cluster of agricultural and manufacturing industries.

1. Construction of All-Hazard Risk Assessment System

- ❑ **All-Hazard management or Disaster Common Management is a comprehensive concept:**

According to Canton (2013), "All-Hazard" does not mean "one plan fits all", but "All-Hazard planning" should be based on a risk-based approach.

Scenario-based Planning

It involves constructing scenario analyses of potential disasters or threats, and analyzing the corresponding response strategies.

Function-based Planning

It identifies the responsibilities and roles of relevant authorities in responding to the disaster threat.

Capabilities-based Planning

It assesses the capacities of relevant authorities and determines appropriate actions to be taken.

1. Construction of an all-disaster risk assessment system (2/2)

Table 2: Summary table of relevant research discussions on all-hazard risk assessment indicators

| Yohe and Tol (2002) | | Brooks, Adger and Kelly (2005) | | Polsky, Neff and Yarnal(2007) | |
|------------------------|--|--------------------------------|--|-------------------------------|---|
| Type | Index | Type | Index | Type | Index |
| Economy | GDP per capita ∙ GINI coefficient | System | Politics, citizenship, civil liberties, corruption, polity, economic freedom, government effectiveness, regulation, political rights and stability | Exposure | Disaster type, safe place, density, frequency, location, number of people |
| Health | Per capita health expenditure, public health expenditure, piecemeal average life expectancy | Religion | Buddhism, Christianity, Hinduism, Islam, Yoruba Religion, animal traits and spiritualism | Sensitivity | Infrastructure, age structure, income, water storage and rainfall correlation |
| Education | Education spending, literacy rate | Culture | Individualism, gender inequality, resilience to uncertainty, degree of inequality, trust | Adaptability | Advocacy Organizations, Education Level Emergency Programs, Wealth Revenue Sources, Conservation Programs |
| Infrastructure | Road density, safe drinking water rate, sewage treatment rate | Economy | GINI coefficient, poverty, per capita income | | |
| Governance | Size of refugees, corruption, government effectiveness, political stability, quality of governance, regulations, civil liberties, political rights | Education | Primary education, secondary education, tertiary education, literacy rate | | |
| Geography & Population | Coastline Length, Number of Coastal Residents Population Density | | | | |
| Agriculture | Ratio of agriculture, rural population, agricultural production indicators | | | | |
| Ecology | Percentage of protected areas, forest change, forest cover | | | | |
| Science & Technology | Investment in R&D, number of scientists and engineers per million people | | | | |






Table 3. Summary of all-hazard risk assessment indicators defined in this study

| Study Index | | Adger et al.(2004) Index |
|---------------|-------------------------------|--|
| Type | Index | Vulnerability and Adaptive Capacity Indicators |
| Economy | Regional human resources | Economic Welfare |
| | Degree of poverty | |
| | Job opportunity | |
| | Industrial diversity | |
| Social | Population loss | Geographic and Demographic Factors |
| | Land development | |
| | Land use failure | |
| | Emergency rescue capabilities | Social Capital |
| Environment | Degree of aging | Geographic and Demographic Factors |
| | Earthquake disaster | Natural Resources and Ecosystems |
| | Noise pollution | Health and Nutrition |
| | Traffic accident | |
| | Water pollution | |
| | Community messiness | |
| Air pollution | | |

Sources: (1). Xiao Dai-ji, Hong Hong-zhi and Yang Zhi-kai et al., 2018; (2). Adger, 2004; (3). Compilation of this study.

2. Epidemic Spatial Development Crisis and the Fragility of Cities and Towns

Table 4 History of Pandemics and Urban Adaptation Strategies

| Year | 1347 | 1817 | 2002 | 2012 | 2019 |
|---|---|--|---|---|--|
| Pandemic | Black death / Plague | Cholera | SARS | MERS | Covid-19 |
| Place of Origin |  West Asia – Iraq |  South Asia – India |  Asia-China |  West Asia – Saudi Arabia |  Asia-China |
| Death | 75 million | 50 million | 774 | 866 | 62.5 million (ongoing) |
| Government Coping Measures | Initiating Epidemic Prevention Policies and Public Health Institutes | Legislation of Public Health System | International Notification Mechanism of Information Sharing | Korea Enhancing Public Health Management, which Influences COVID-19 Disease Control | Isolation / Quarantine Policies Application of 5G Network, Smart Tech. Trace the Virus Spreading |
| Preliminary Land Use Changing / Adaptation Strategies | City-state Quarantine and Hospital for Treating Patients | Urban Sewage System Improvement | Enhancing Government-Civilian Cooperation by Regulatory Review and Organizational Adjustment | The Expansion of Korea Public Health Infrastructures (10 Detention Hospitals for Infectious Disease) | Pop. Density Is the Key; Expansion of Public Space; Revising the Street Planning. |

Source: Compilation of this study

3. Social culture and environmental pollution hazards of tourism industry and watershed environment

- According to Sharon Zukin (2009), the spread of globalization may lead to the homogenization of tourism's fragile cultures, and the commercialization of urban spaces can weaken regional resilience.
- Rural areas in remote parts of Taiwan heavily rely on tourism-related industries and chains, and their vulnerability is generally characterized by high exposure to the environment, combined with economic underdevelopment or a lack of other favorable conditions for economic development (Mbaiwa, 2003; Crotti and Misrahi, 2017; Calderwood and Soshkin, 2019).
- Researchers have used various indicators and survey methods to assess the impact of extreme weather on tourism in different geopolitical regions, countries, and cities (Gössling et al., 2012; Rosselló-Nadal, 2014; Ruddy et al., 2017).

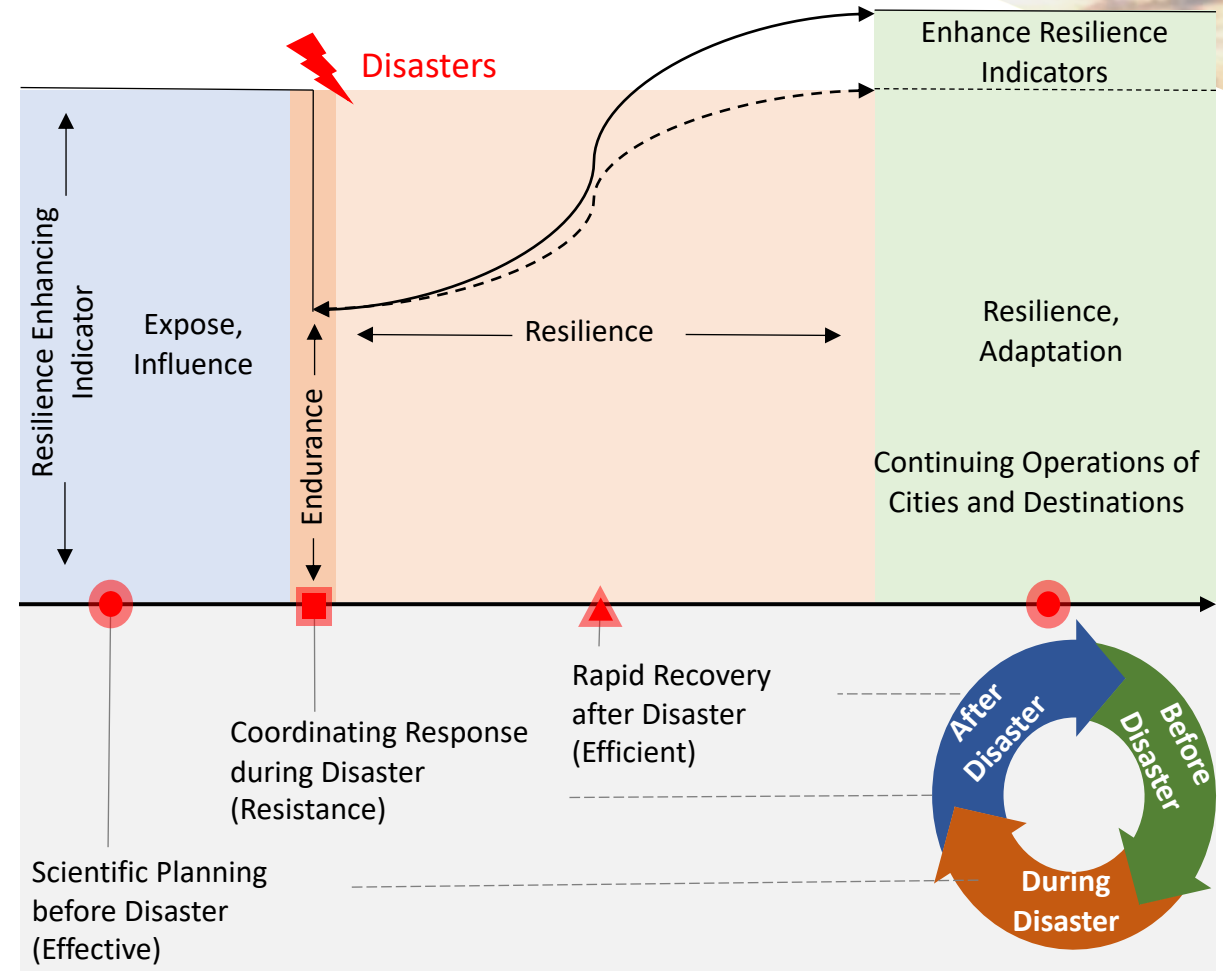


Figure 14: Concepts of Tourism Vulnerability and Resilience

Source: (1) Duro et al., 2022: 3 (2) Wang, 2022 (3) Compilation of this study

1. Research Methods

- (1) **Historical Literature Review:** Compilation of Disaster Vulnerability Theory, Relevant Indicators, Evaluation Factors, and Current Situation of Typhoon Disaster Management.
- (2) **Field Investigation and In-Depth Interviews:**
 - a) Two field visits conducted on 2020/12/04 and 2021/04/03-04 due to the impact of the epidemic
 - b) Two online interviews conducted on 2021/03/04 and 2021/08/27
 - c) Main interview subjects include north and south of the Da'an River in Dajia area, Dajia Jenn Lann Temple, and Youth Industrial Park.
- (3) **The Analytic Hierarchy Process, AHP:**

Relevant evaluation factors were obtained through the Delphi method and divided into three main dimensions - A. Society, B. Economy, and C. Environment. These dimensions were further divided into 15 topic indicators as the basis for designing the questionnaire.

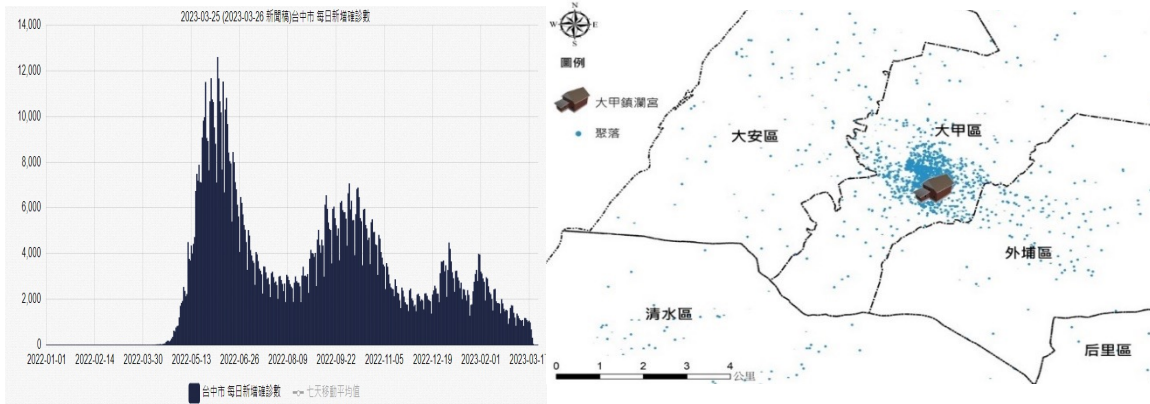


Figure 15: Number of Confirmed Cases of Respiratory Diseases and Their Distribution in Taichung.

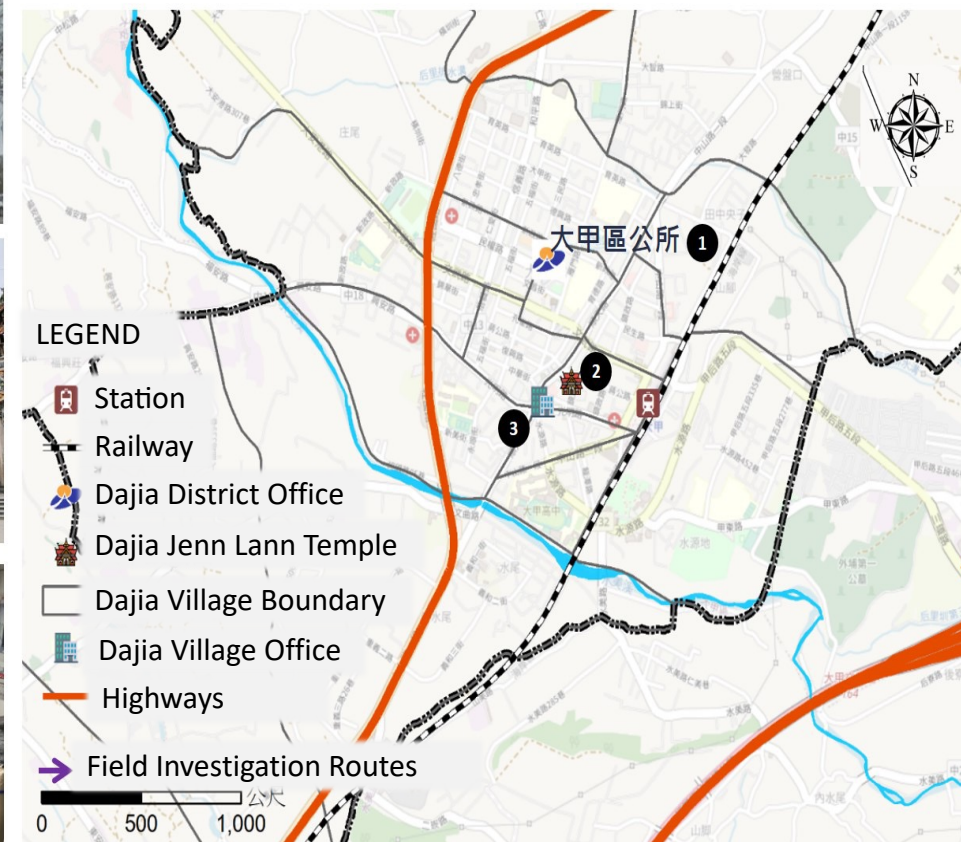
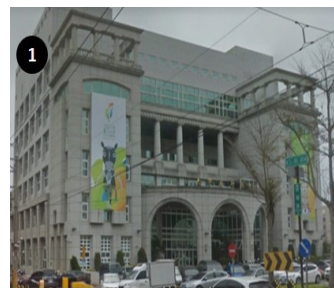
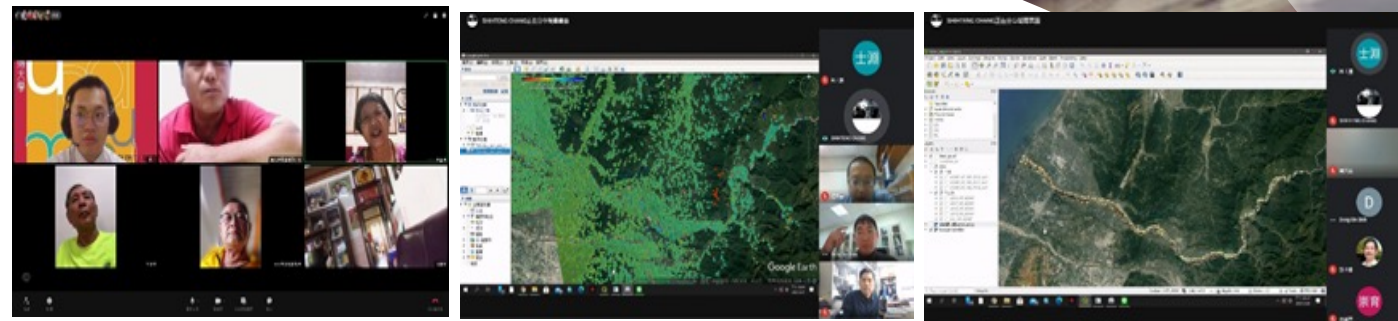
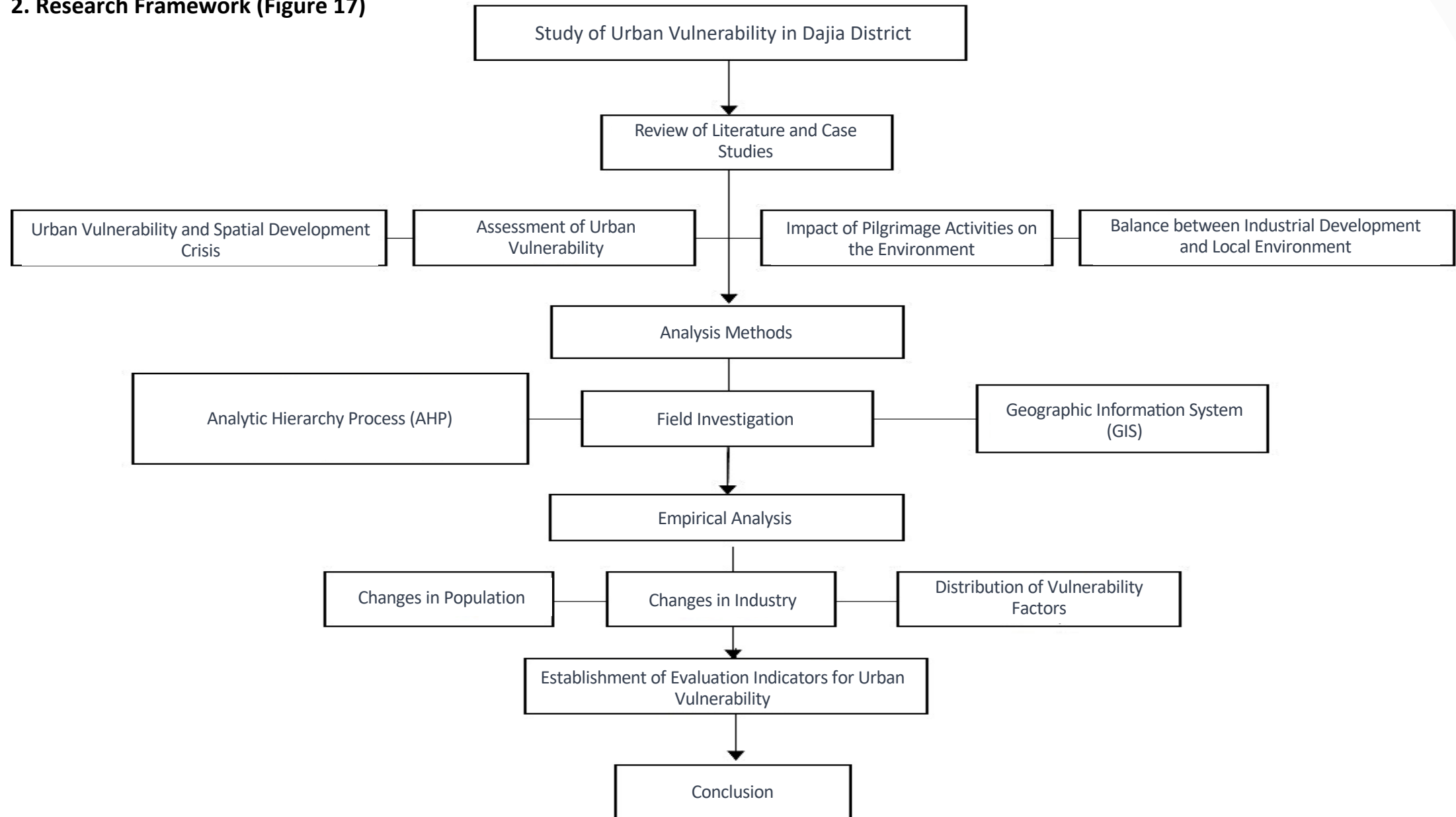


Figure 16: Interview Roadmap

2. Research Framework (Figure 17)



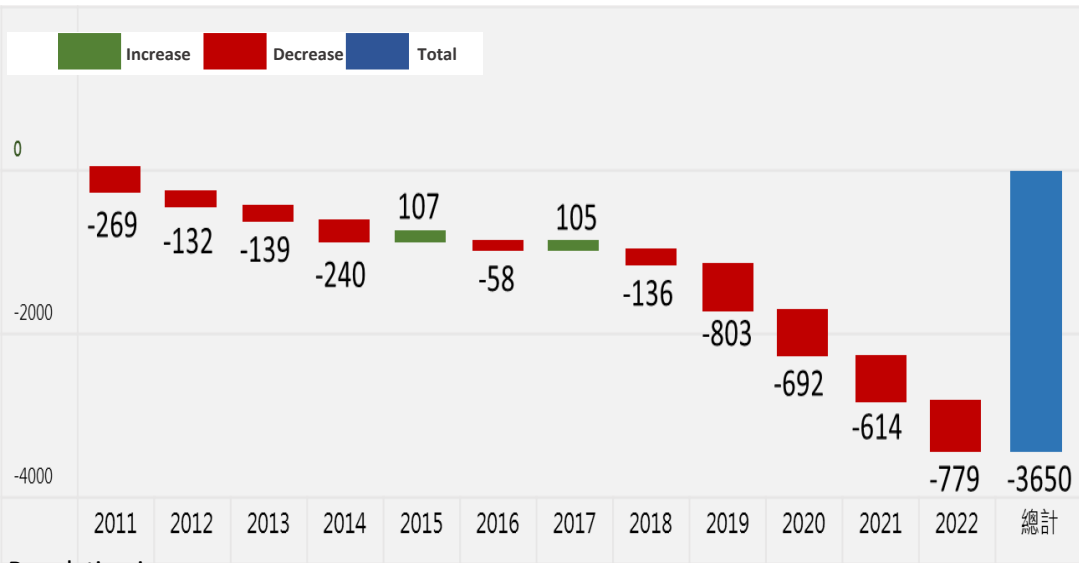
2. All-disaster Risk Assessment Index Structure

Table 5: Explanation table of the structure of vulnerability assessment indicators in this study

| Guideline | Elements | Heading | Calculation | Source |
|------------------|--|---------|---|---|
| A Economy | A1. Employed population (regional human resources) | - | 15 years of age or older engaged in paid work, or engaged in unpaid family workers for more than 15 hours | Social and economic information service platform, Dajia District population statistics annual report, Taichung City Government Civil Affairs Bureau population management statistics platform |
| | A2. Local Taxation (Poverty Level) | + | Local income (housing tax, land value tax) | Dajia District Annual Report |
| | A3. Number of industries (job opportunities) | - | Based on the number of industrial, commercial and manufacturing companies in each ri | Social and economic data service platform |
| | A4. Proportion of industry types (industry diversity) | - | Based on the ratio of the number of industrial, commercial and manufacturing companies in each ri | Social and economic data service platform |
| B Social | B1. Social increase rate (population loss) | + | Population immigration and emigration, calculated as immigration rate - emigration rate | Social and economic information service platform, Dajia District population statistics annual report, Taichung City Government Civil Affairs Bureau population management statistics platform |
| | B2. Area of urban planning area (land development) | + | Land area occupied by urban planning in each village | Compilation of Urban and Regional Development Statistics |
| | B3. Illegal factory area (land use failure) | + | Land area occupied by illegal factories in each village | Compilation of Urban and Regional Development Statistics |
| | B4. Infrastructure service area (rescue rescue capacity) | - | Land area occupied by infrastructure in each mile | Compilation of Urban and Regional Development Statistics |
| | B5. Aging index (degree of aging) | + | Population of the elderly over 65/population of the young and middle-aged | Social and economic information service platform, Dajia District population statistics annual report, Taichung City Government Civil Affairs Bureau population management statistics platform |
| C Environment | C1. Fault impact potential area (earthquake hazard) | + | Land area of each mile occupied by the area of 50 meters on both sides of the fault sensitive zone | National Disaster Prevention Technology Center |
| | C2. Noise pollution incidents (noise pollution) | + | Proportion of noise pollution incidents in each district | Executive Yuan Environmental Protection Agency |
| | C3. Traffic incident point (traffic accident) | + | Proportion of traffic incidents in each mile | Executive Yuan Environmental Protection Agency |
| | C4. Water pollution incidents (water pollution) | + | Proportion of water pollution incidents in each mile | Executive Yuan Environmental Protection Agency |
| | C5. Pollution incidents of waste accumulation (community is dirty) | + | Proportion of waste accumulation pollution incidents in each mile | Executive Yuan Environmental Protection Agency |
| | C6. Air pollution incidents (air pollution) | + | Proportion of vacant house pollution incidents in each mile | Executive Yuan Environmental Protection Agency |

1. Socio-economic characteristics- Cities and towns in Dajia District: population migration

- 1) Population decline is an ongoing concern in Dajia district, especially during the pandemic period. The population trend can be observed in Figure 18, which shows a continuous decrease. Furthermore, the net migration of population is mainly concentrated around the Nangong area of Dajia Town, as illustrated in Figure 19.



Population increase

Figure 18 Statistical map of population increase in Dajia District over the years

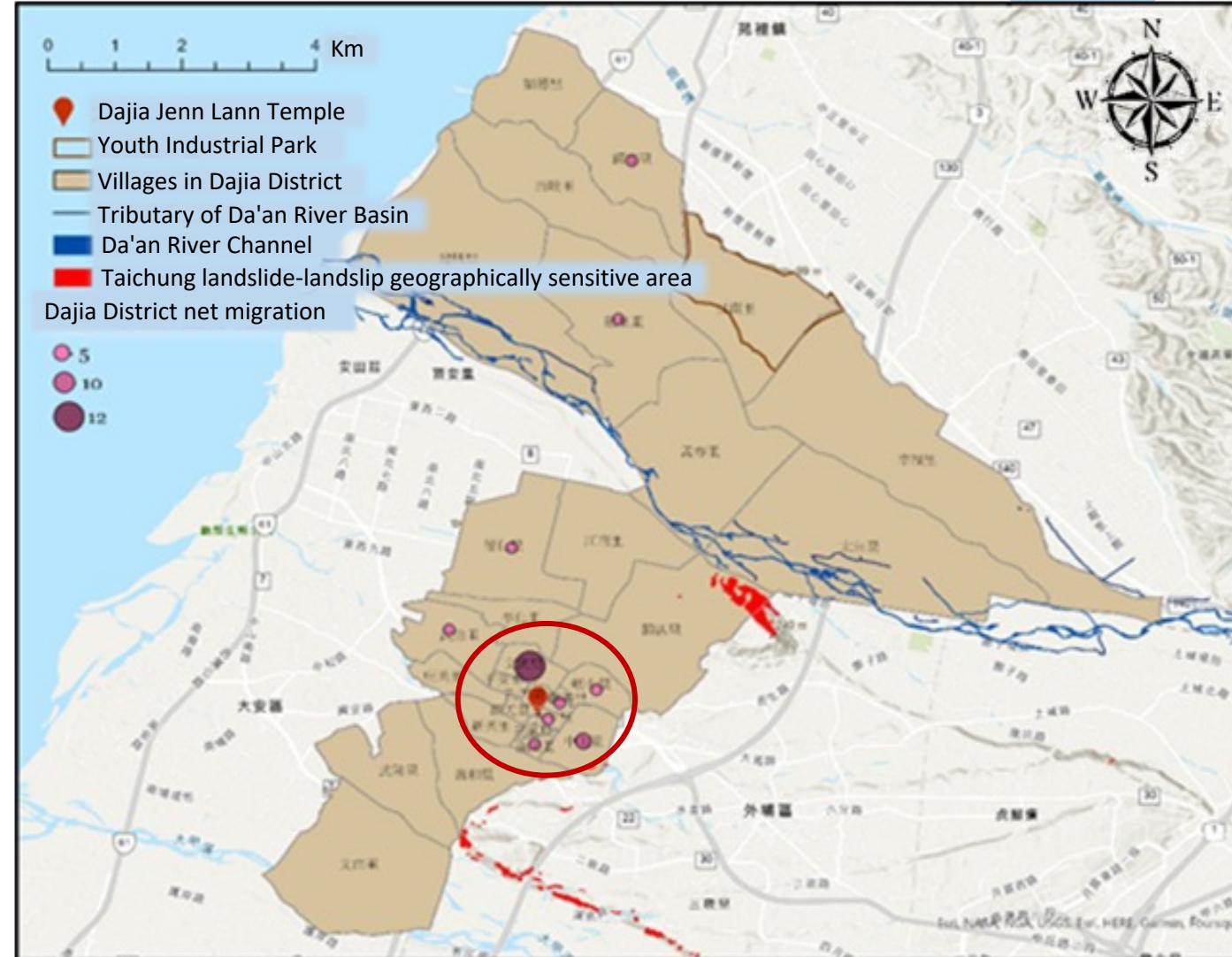
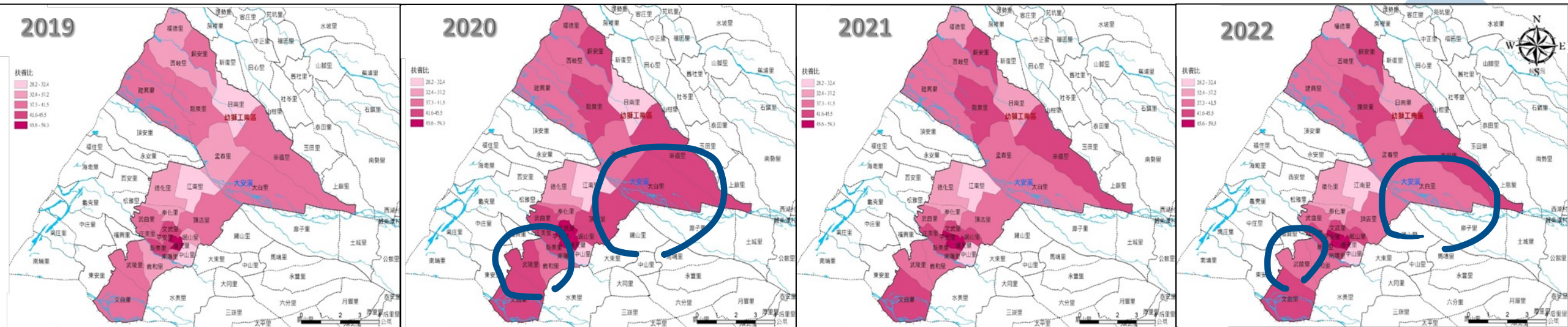


Figure 19 Distribution of Net Immigrants in Dajia District in 2022

1.Socio-economic characteristics- Cities and towns in Dajia District: Population Aging



(2) Based on the analysis of population data and interviews, this study identified that the decline in population in Dajia District is due to the lack of local development opportunities, resulting in the outflow of young and middle-aged population to other regions. This trend has led to an increase in the region's elderly population and a rise in the dependency ratio (as shown in Figure 20).

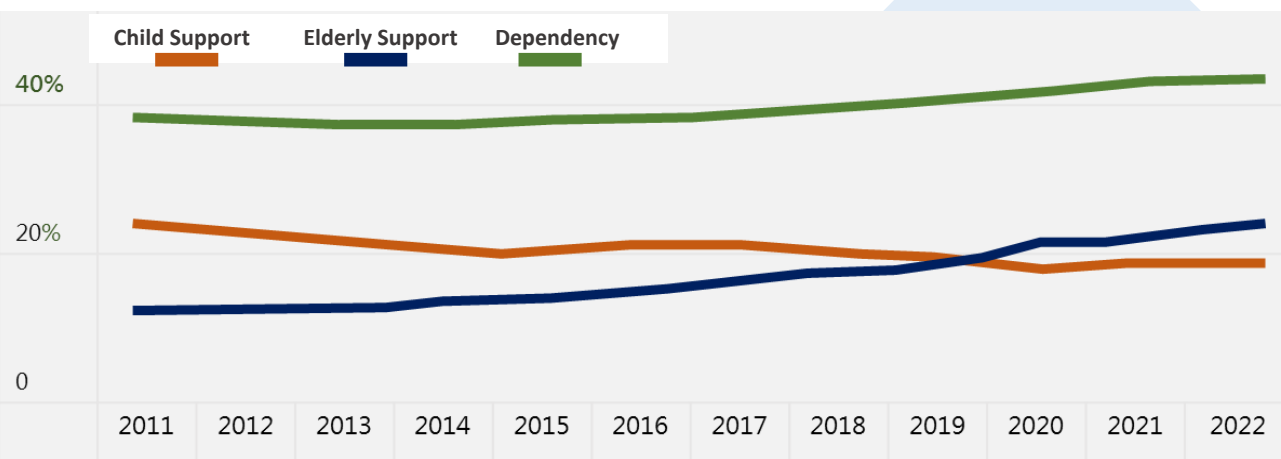
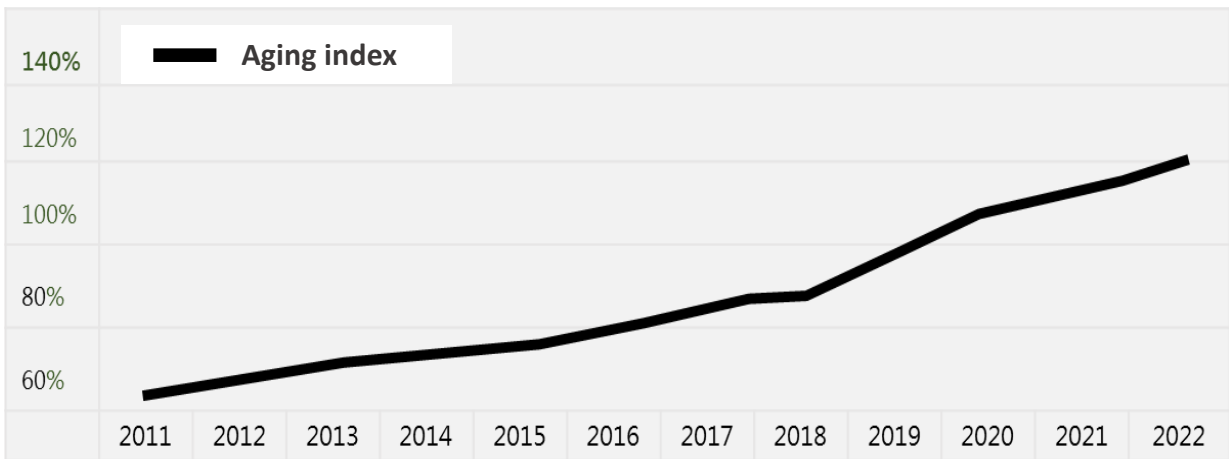


Figure 20 Changes in the Population Aging Index in Dajia District Over the Years

Sources: (1) Taichung City Government Civil Affairs Bureau Population Management Statistics Platform

<https://demographics.taichung.gov.tw/Demographic/index.html?s=16353386> (2) Drawn by this study.

1.Socio-economic characteristics- Cities and towns in Dajia District: industrial Changes

(3) This study found that the number of business and factory registrations in Dajia district during the epidemic period **still increased** (Figure 21, Figure 23);

a) **Business registration** includes wholesale and retail (53.76%) and manufacturing (15.16%) (Figure 22).

b) **Factory registration** is based on metal manufacturing (27.10%) and machinery manufacturing (17.19%) (Figure 24).

Source: (1) Taichung City Dajia District Office, 2022 (2) Drawn by this study.

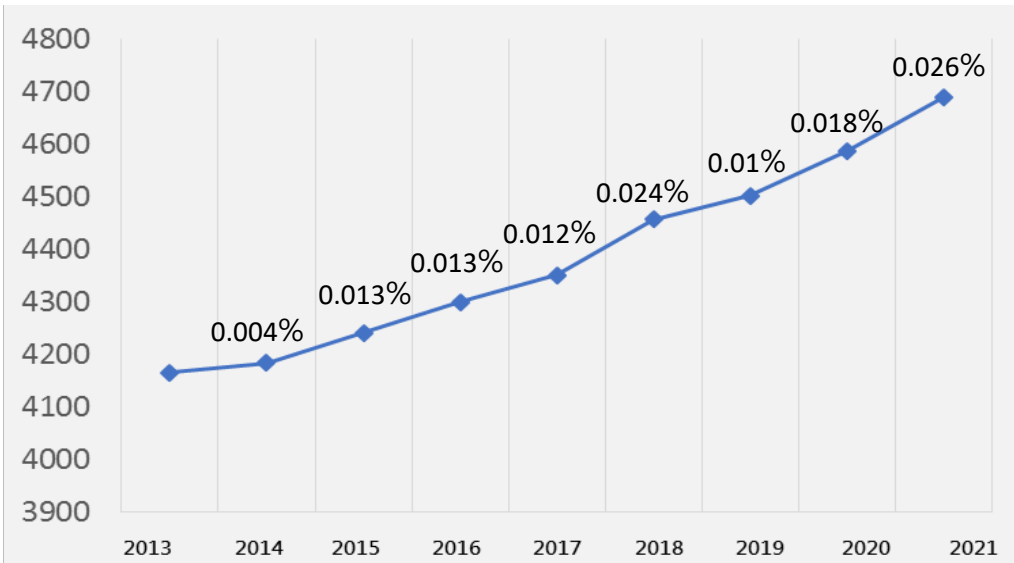


Figure 21: The number and growth rate of business registrations in Dajia District over the years

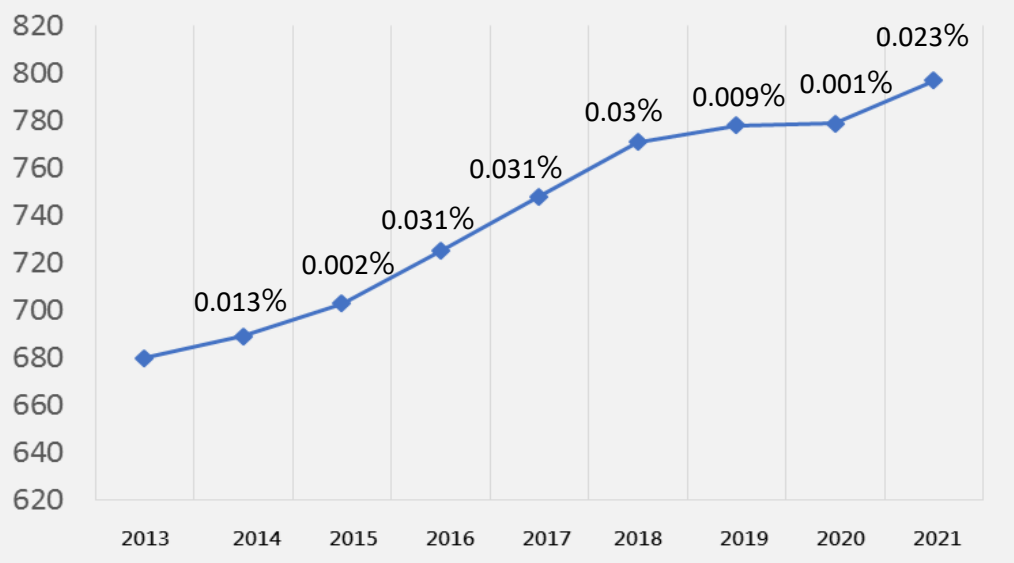


Figure 23: Number of factory registrations and growth rate in Dajia District over the years

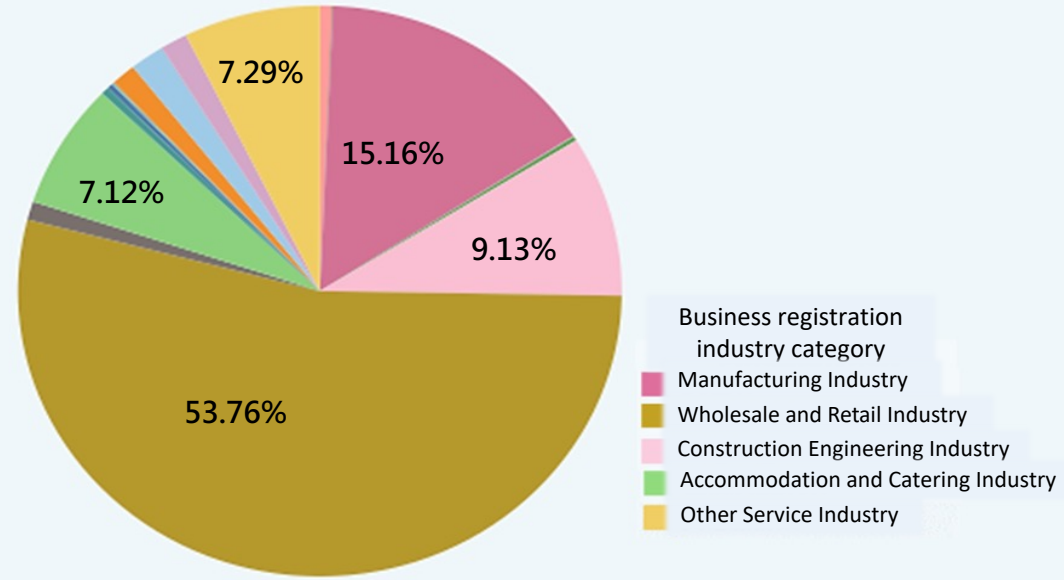


Figure 22: Schematic diagram of the proportion of business registration in Dajia District in 2021

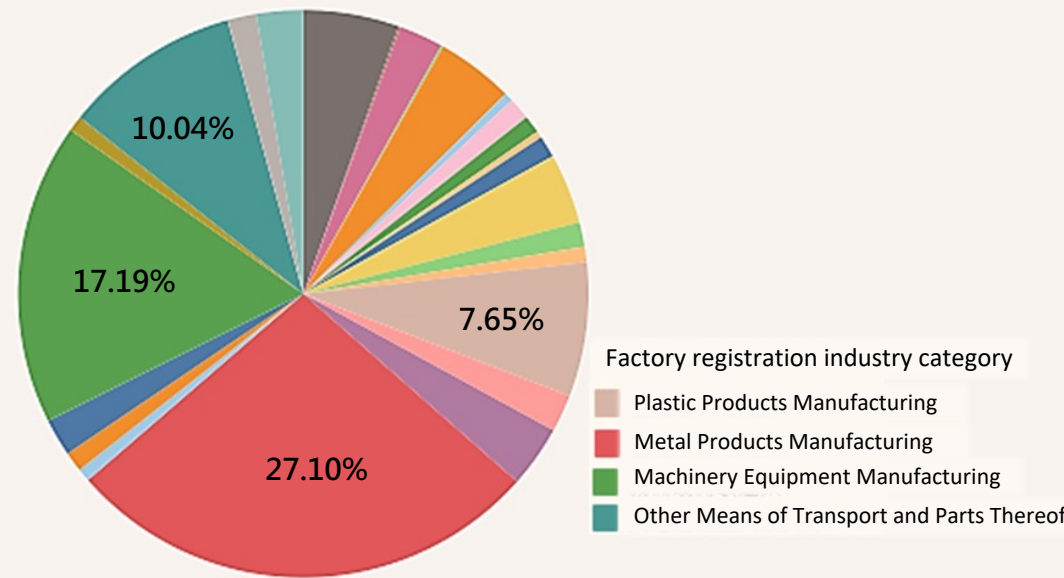


Figure 24: Schematic diagram of the ratio of factory registration in Dajia District in 2021

1.Socio-economic characteristics- Cities and towns in Dajia District: Land Use Status

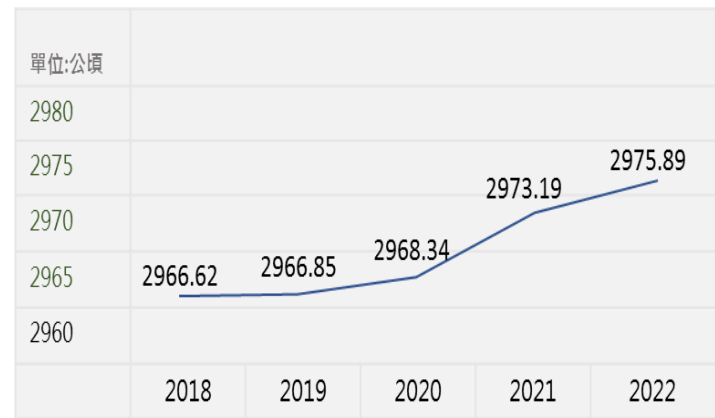
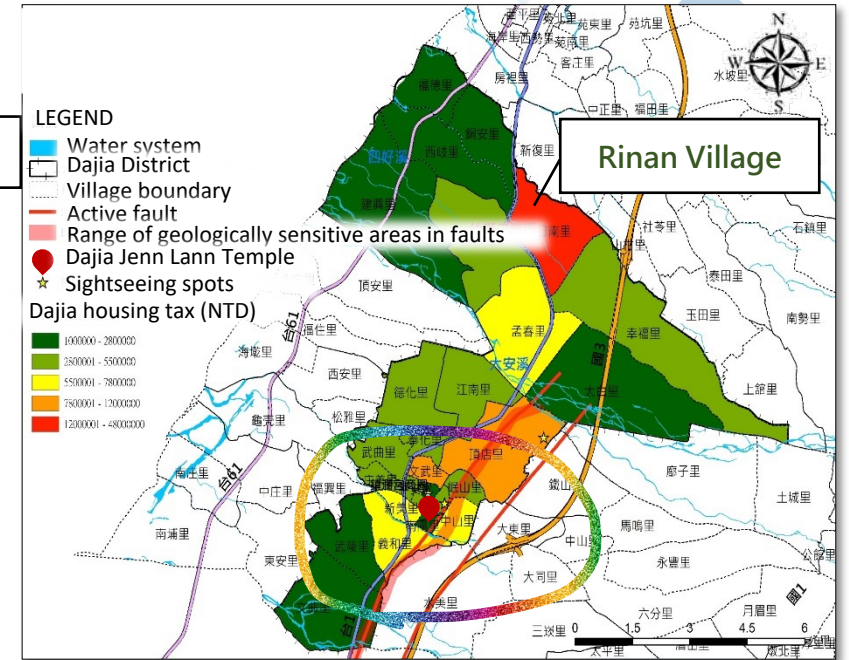
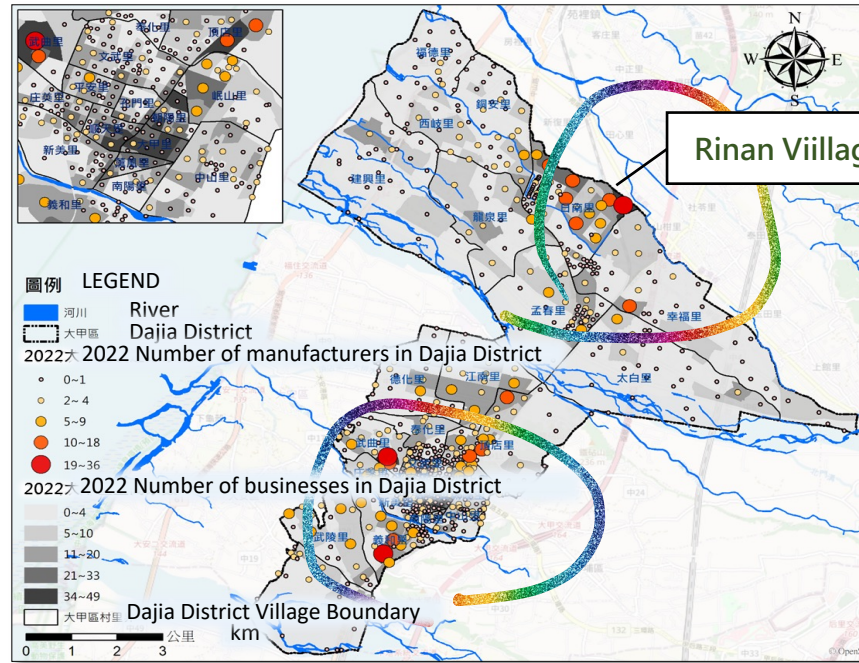


Figure 28: Changes in arable land area over the years in Dajia District

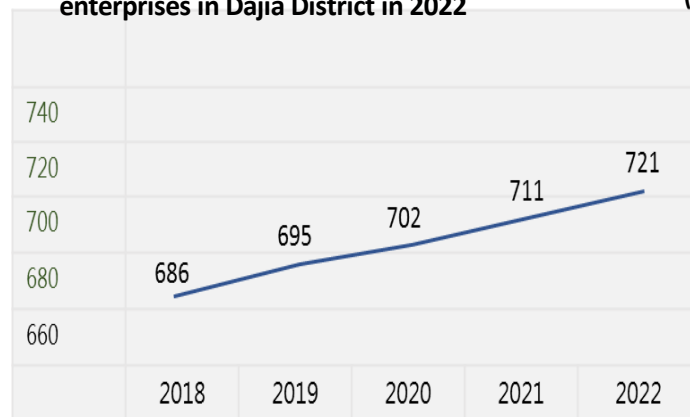


Figure 29: Changes in the number of manufacturing businesses in Dajia District over the years

(4) **The Xibei area** is mainly an agricultural area near the Da'an River (Figure 25). The Youth Industrial Park is an important manufacturing center in the Dajia area (Figure 26), while industrial and commercial factories are concentrated in the Rinan village area (Figure 26). All of the above areas showed a "growth" trend during the epidemic (Figure 28, Figure 29).

South of Xinan area: The tourism industry and agriculture around the Dajia Jenn Lann Temple are the main industries (Figure 26, Figure 27). The concentration of industries and population around the Dajia Jenn Lann Temple indirectly affects changes in real estate (Figure 27). The area with the highest housing tax is the **Ding Dian Village**.

2. The Impact of Pandemic and Subsidy Policies on Tourist Population Changes in Dajia District

- During the pandemic, government policies for preventing infections had a significant impact on the tourist population at Dajia District's main tourist attractions, such as Tiehanshan and Dajia Jenn Lann Temple . The following findings were observed:
 - The government's stimulus vouchers had a significant impact on tourism in July 2020 and October 2021, leading to retaliatory consumption behavior (see Figure 30).
 - When the pandemic alert level was raised to Level 3 in May 2021, the tourist population rapidly declined (see Figure 30). However, regardless of the alert level or stimulus vouchers, the tourist population increased during the Lunar New Year period.

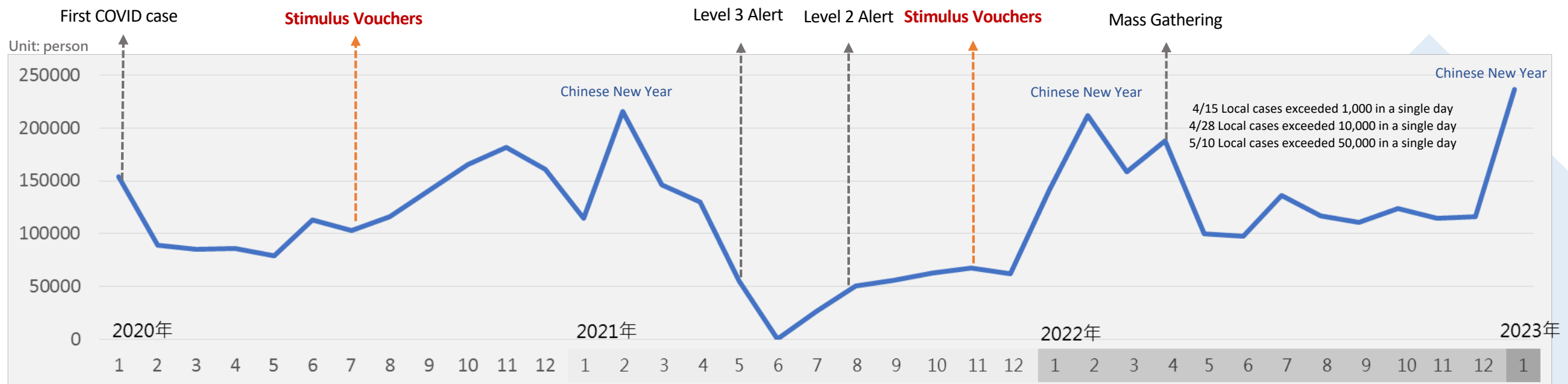


Figure 30 provides an analysis of the relationship between changes in the tourist population and government subsidies during the pandemic in Dajia District.

3. Disaster Potential and Regional Risk in Dajia District

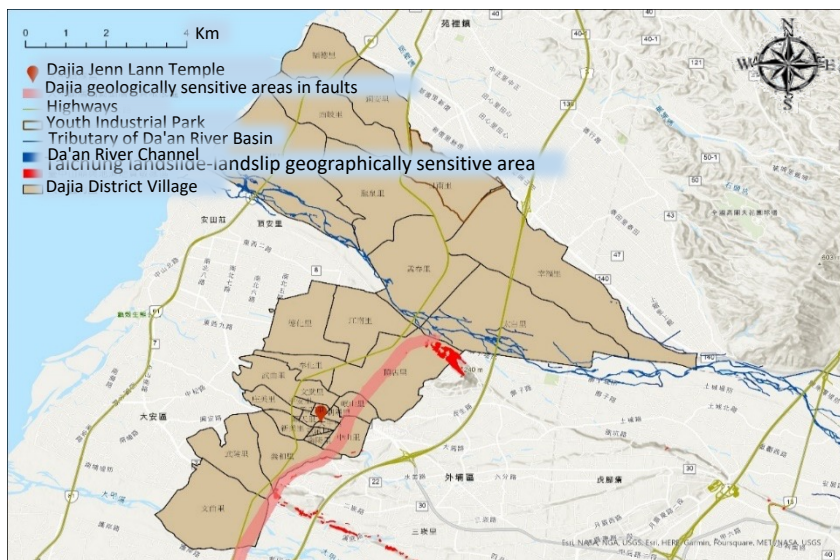


Figure 31: Landslide potential and sensitive areas for mountain collapse and landslide in Dajia District.

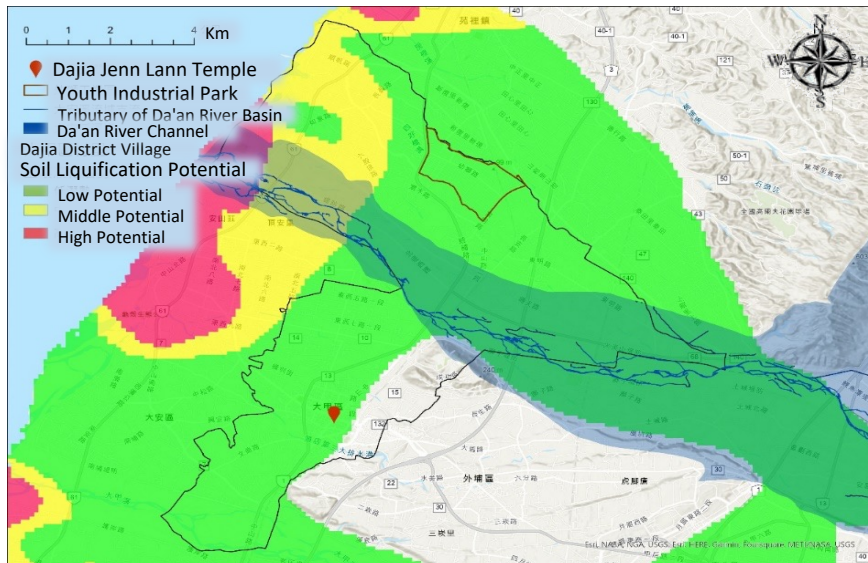


Figure 32: Soil liquefaction potential areas in Dajia District. Figure 34: Hazard classification map of wind and water disasters in each village in Dajia District.

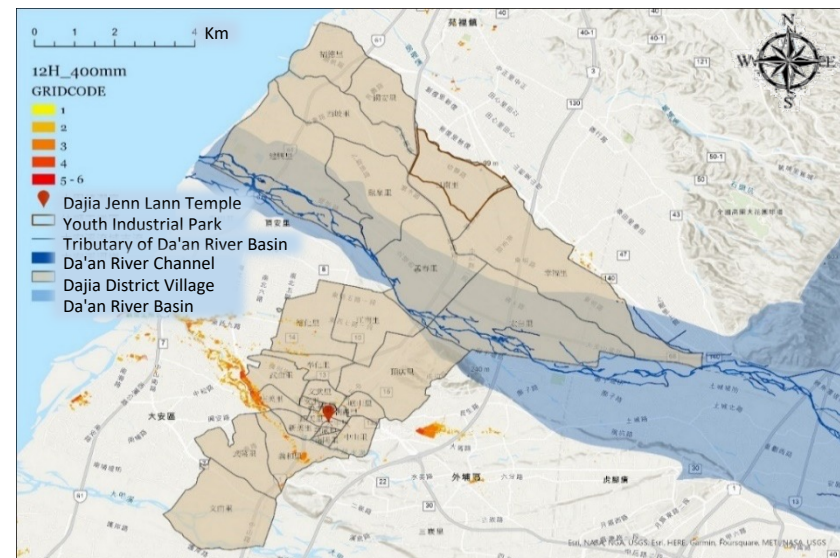


Figure 33: Simulation of flooding in Dajia District (continuous 12-hour rainfall of 400 mm.)

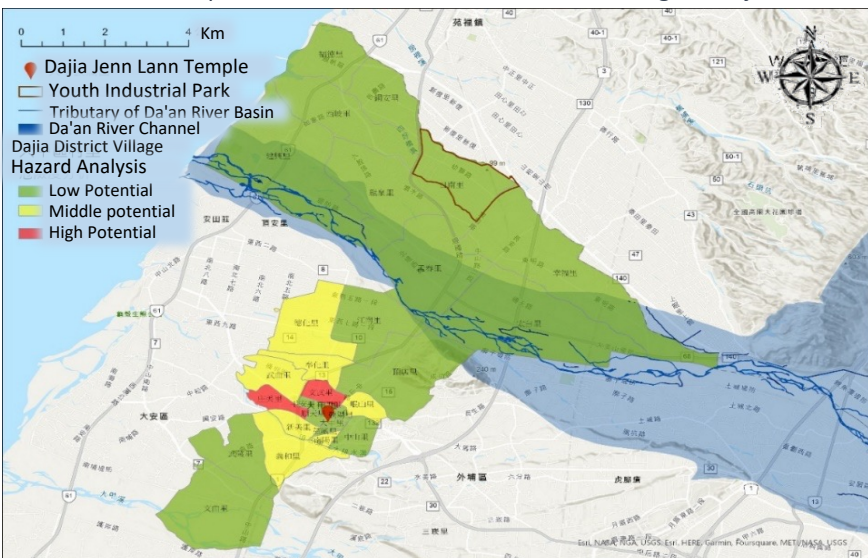


Figure 34: Hazard classification map of wind and water disasters in each village in Dajia District.

■ Due to time and budget constraints, this study has focused on earthquake and wind-water disasters, which are common and have a significant impact in Taiwan, as the framework for disaster risk analysis:

- (1) **Earthquake:** The south of the river area is adjacent to two active fault zones (Figure 31), and the Dajia Jenn Lann Temple commercial district is located within the sensitive area of the fault zone. According to Article 47 of the Building Act, "**Building is prohibited within 50 meters on either side of the fault line...**" However, it is inferred that the buildings were constructed before the regulation, leading to the current development phenomenon.
- (2) **Soil liquefaction:** It mainly occurs in coastal villages in the Xibei area (Figure 32) and has a relatively small impact on the case study area.
- (3) **Wind and water disasters:** Concentrated in the south of the river area (Figure 33, Figure 34), with a relatively small impact on the Dajia area.

4. Industrial environmental pollution and its disaster-causing factors in Dajia District

- (1) **Relatively more pollution cases:** In the case of Dajia District in Taichung City, compared with the pollution petition cases in other direct-controlled municipalities in Taiwan (Figure 35), it can be seen that the average number of cases in Taiwan in 2022 is about 119 cases, but **Taichung City has about 201 cases**, second only to Taipei City with 213 cases.
- (2) **Factors causing pollution disasters:** According to data from the Taichung City Environmental Protection Bureau in 2022, in Dajia District (Figure 36, Figure 37): **a) petition cases** account for 72.77%, **b) pollution** is mainly related to **environmental hygiene** (65%), followed by **waste** (17%) and **noise** (10%).
- (3) **The correlation between environmental hazard events and regional industries:** The metal processing and manufacturing industry and the Youth Industrial Park (Figure 21, Figure 26, Figure 27) are related to the industrial agglomeration in this area.

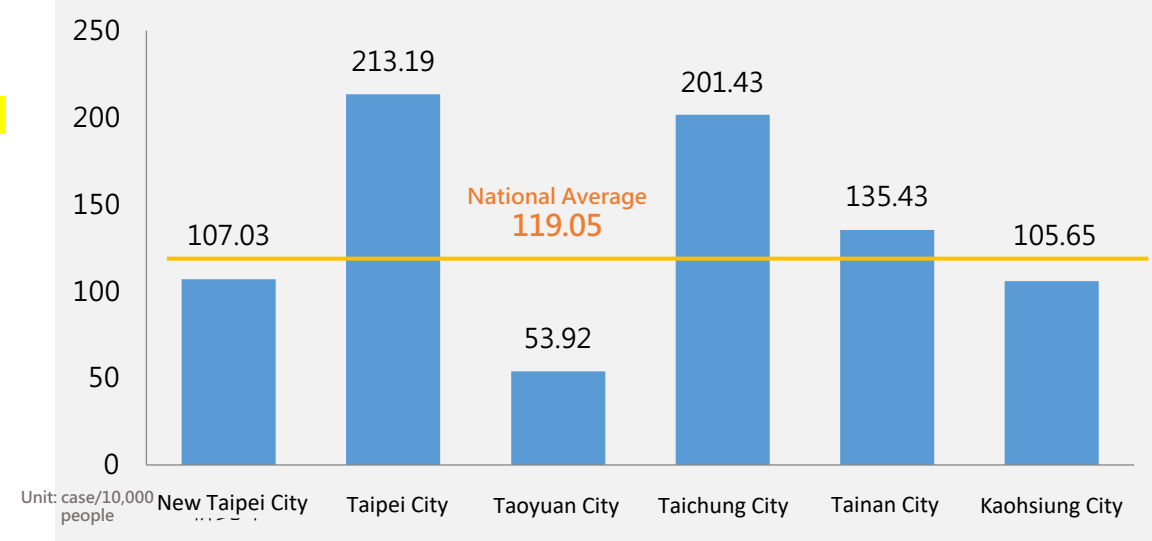


Figure 35: Comparison of pollution petition cases in the case study area and direct-controlled municipalities in Taiwan.

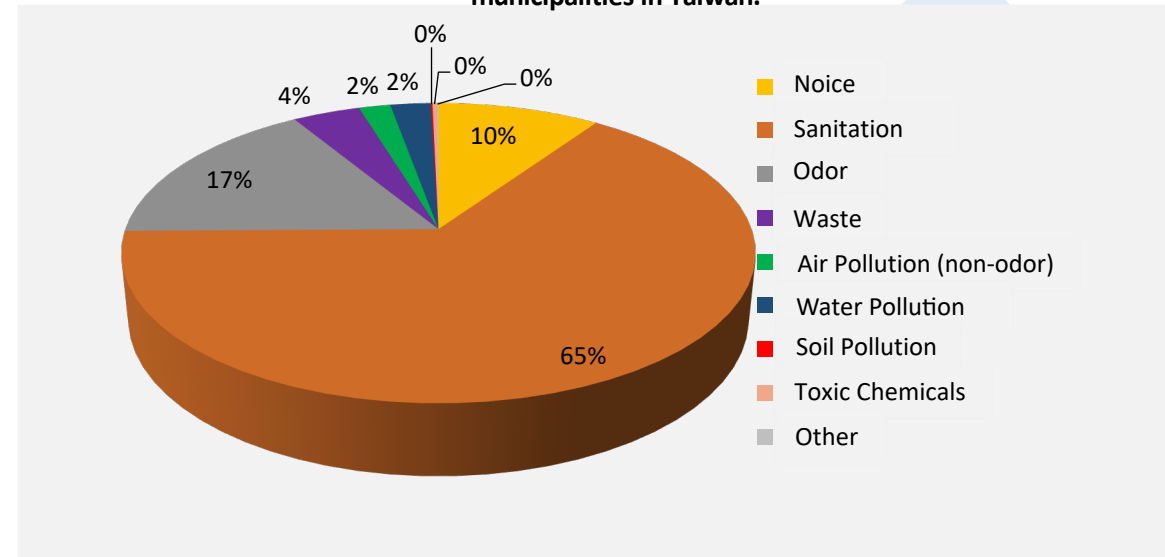


Figure 37: Analysis diagram of environmental pollution and disaster-causing factors in Dajia District in 2022.

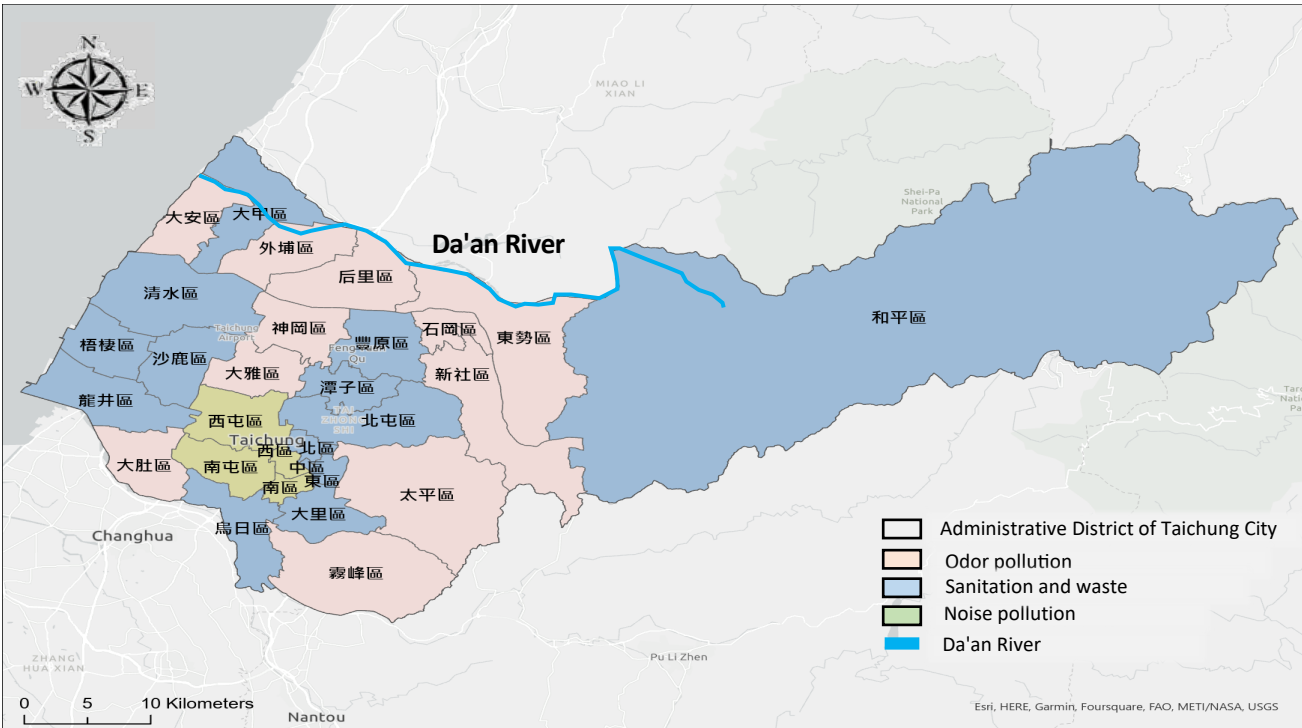


Figure 36: Spatial distribution diagram of pollution petition cases in Taichung City in the case study area

5. Vulnerability of the tourism and cultural industry and its spatial implications

(1). Environmental vulnerability of industrial clusters:

According to the 2020 statistics of pollution sites from the Environmental Protection Administration, **most of the pollution sites in the north of the river Region are located around the Youth Industrial Park** and extend to the surrounding areas (Figure 38). Environmental problems such as noise pollution, suspended particles, and wastewater discharge are common issues for factories in the area. According to the EPA's GE_01 data, "In the past two years (2018, 2019), a total of eight companies have discharged waste (sewage) into the Da'an River, including three metal surface treatment industries, two car washes, one hospital medical institution, one livestock farm, and one special sewage outlet system for a site" (Interviewed: 2020.12.18).

(2). Environmental vulnerability of the tourism and cultural industry:

The external impact of the south of the river Region is mainly from religious activities such as burning incense and firecrackers. Short-term heavy traffic flow from pilgrimage groups and the sound of car horns during the procession in the vicinity of the Dajia Jenn Lann Temple also affect the surrounding areas (Figure 39). According to a local shop owner (LS_05), "Our business is better when there is a pilgrimage or procession in Dajia Jenn Lann Temple, but it can be noisy and the smell of firecrackers is not pleasant..." (Interview date: 2020.12.04).

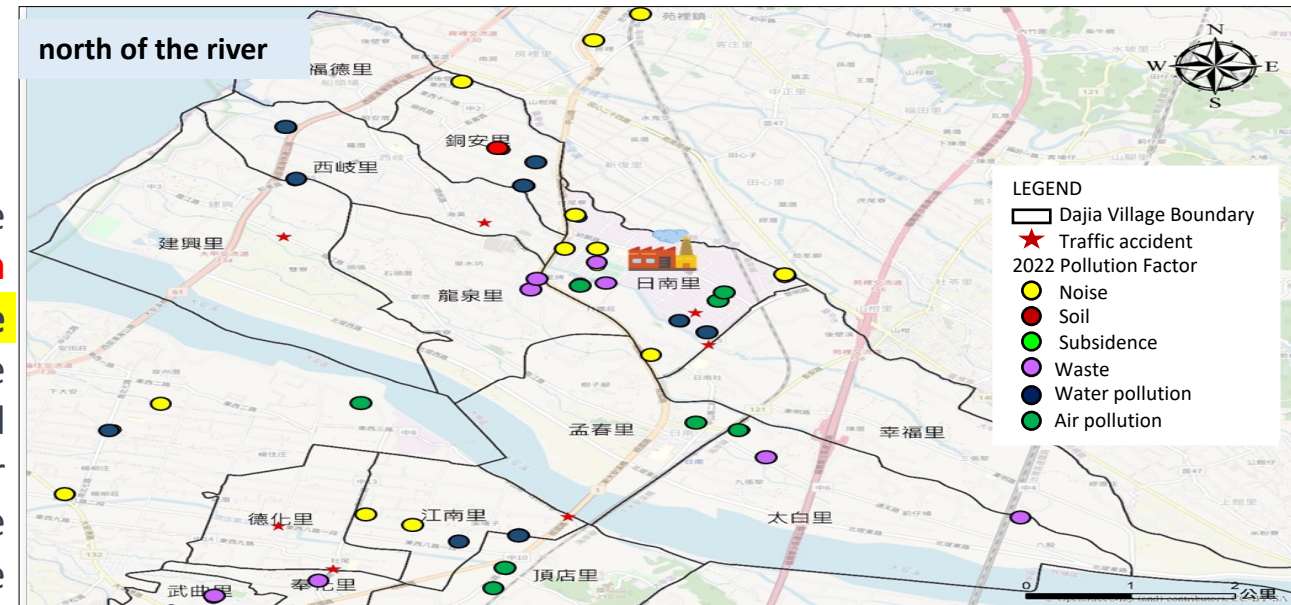


Figure 38: Spatial distribution of environmental vulnerability in the northern area of Dajia District.

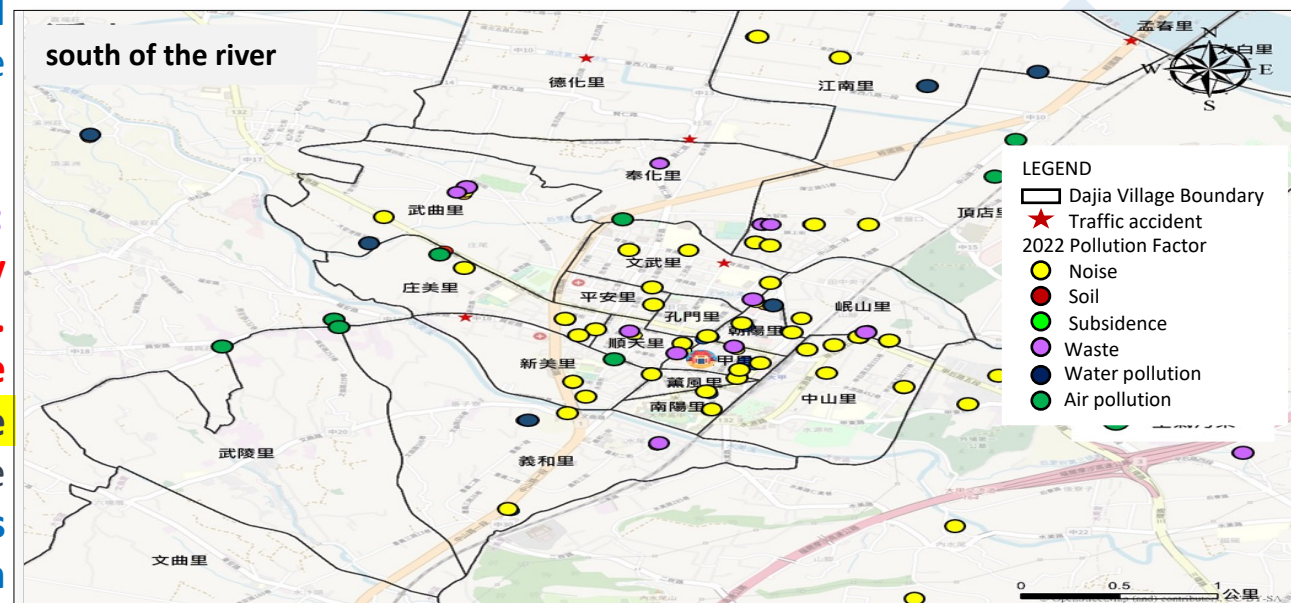


Figure 39: Spatial distribution of environmental vulnerability in the southern area of Dajia District.

1. An assessment framework for socio-economic vulnerability for all disaster types:

Based on secondary data and field survey results, a set of criteria for assessing vulnerability in Dajia district were developed. The criteria included economic, social, and environmental factors, which were then divided into 15 sub-factors. The weights of each factor were determined based on 12 survey responses, with **economic factors (employment, industry) and social factors (urban planning) given higher priority than environmental factors (earthquake, air pollution)**. The standardized and normalized values of each factor were determined using equal division methods. The overall vulnerability of Dajia District was then determined by combining the results of each factor (Table 6).

Table 6: List of criteria and weightings for assessing vulnerability in Dajia District

| Criteria | Criterion Weights | Factors | Overall Weights |
|--------------------|-------------------|---|-----------------|
| A Economic | 0.29 | A1. Employed population (regional human resources) | 0.081 |
| | | A2. Local Taxation (Poverty Level) | 0.071 |
| | | A3. Number of industries (job opportunities) | 0.073 |
| | | A4. Proportion of industry types (industry diversity) | 0.065 |
| B Social | 0.33 | B1. Social increase rate (population loss) | 0.052 |
| | | B2. Area of urban planning area (land development) | 0.064 |
| | | B3. Illegal factory area (land use failure) | 0.063 |
| | | B4. Infrastructure service area (rescue rescue capacity) | 0.051 |
| | | B5. Aging index (degree of aging) | 0.1 |
| C Environmental | 0.38 | C1. Fault impact potential area (earthquake hazard) | 0.072 |
| | | C2. Noise pollution incidents (noise pollution) | 0.062 |
| | | C3. Traffic incident point (traffic accident) | 0.051 |
| | | C4. Water pollution incidents (water pollution) | 0.057 |
| | | C5. Pollution incidents of waste accumulation (dirty community) | 0.07 |
| | | C6. Air pollution incidents (air pollution) | 0.068 |

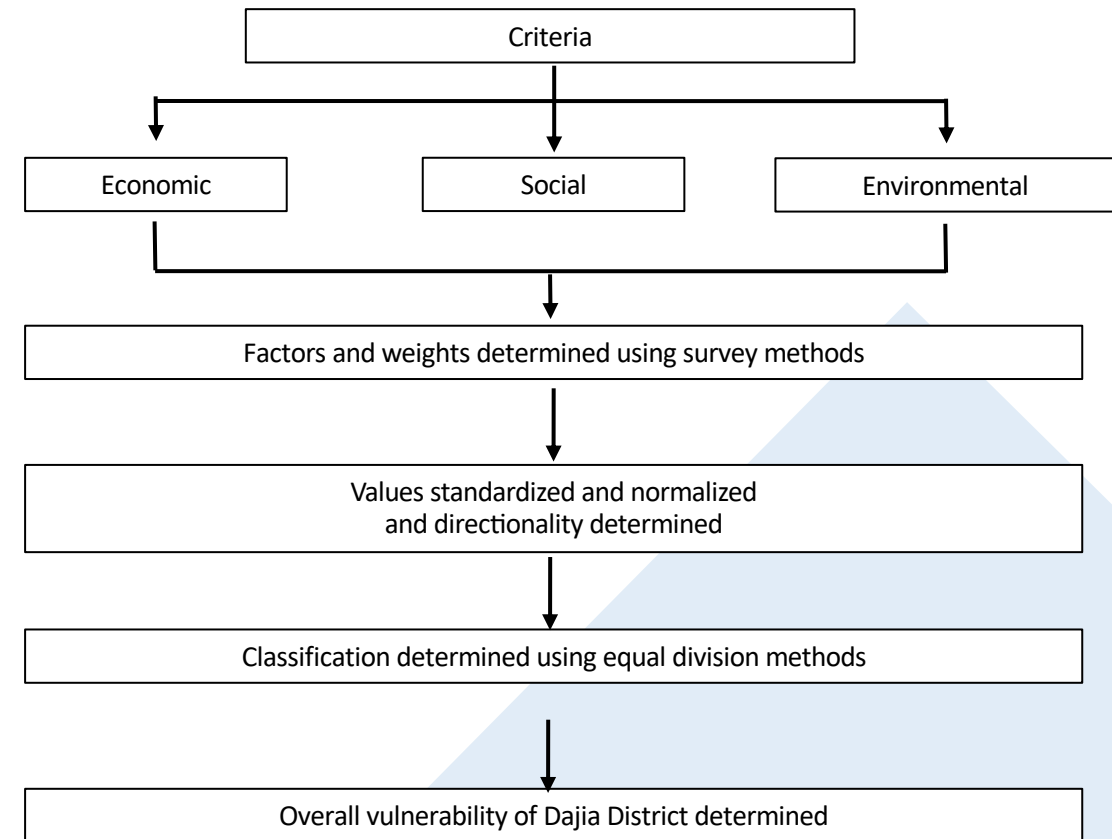


Figure 40: Flowchart of vulnerability analysis process

2. Natural Disaster Potential and Overlapping of Local Spatial Vulnerability Maps

- (1) **South of the River area** exhibits more natural disaster potential, such as earthquake fault hazards, and social vulnerability related to spatial socioeconomic factors like garbage, noise, and odor pollution. However, these factors are concentrated in areas with high population density, cultural beliefs, and real estate development (see Figure 41).
- (2) Due to the impact of the COVID-19 pandemic, **there has been a significant reduction in noise and environmental pollution in the cultural and religious townships in the study area** (see Figures 8-10).
- (3) **The government's stimulus vouchers and retaliatory consumption have benefited the local tourism industry during the pandemic** (see Figure 30).



LEGEND

- Water system
- Dajia District
- Village boundary
- Active fault
- Range of geologically sensitive areas in faults

Population Aging Index of Dajia District

| | |
|--|------------|
| | 60以下 |
| | 61 - 145 |
| | 145 - 284 |
| | 285 - 600 |
| | 601 - 1500 |

The main cause of pollution

- Noise
- Soil pollution
- Waste accumulation
- Water pollution
- Domestic garbage accumulation
- Odor Pollutants

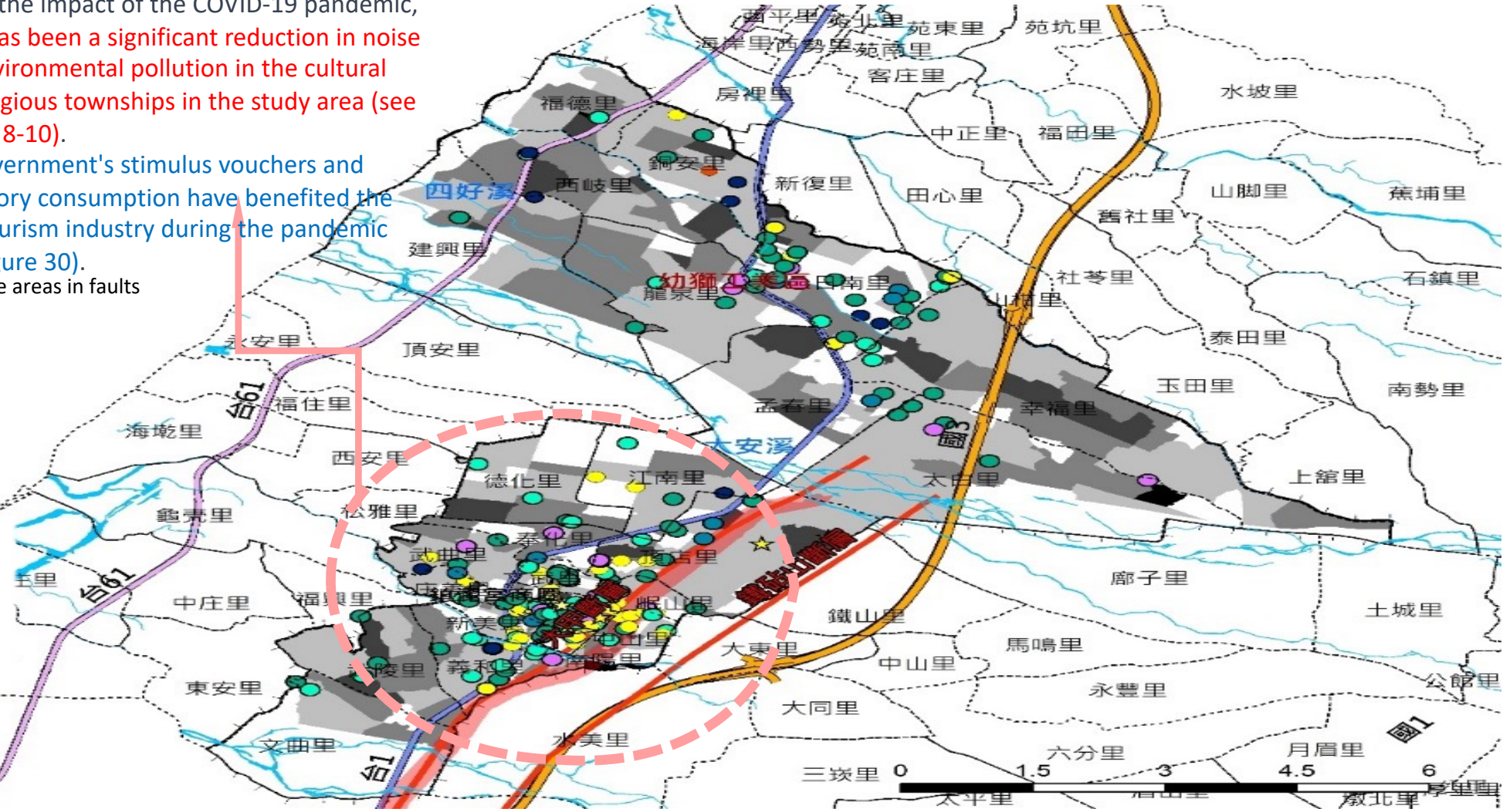


Figure 41 illustrates the overlapping spatial distribution of various environmental and socioeconomic vulnerability maps in the study area.

3. Assessment of Socioeconomic Vulnerability Risk:

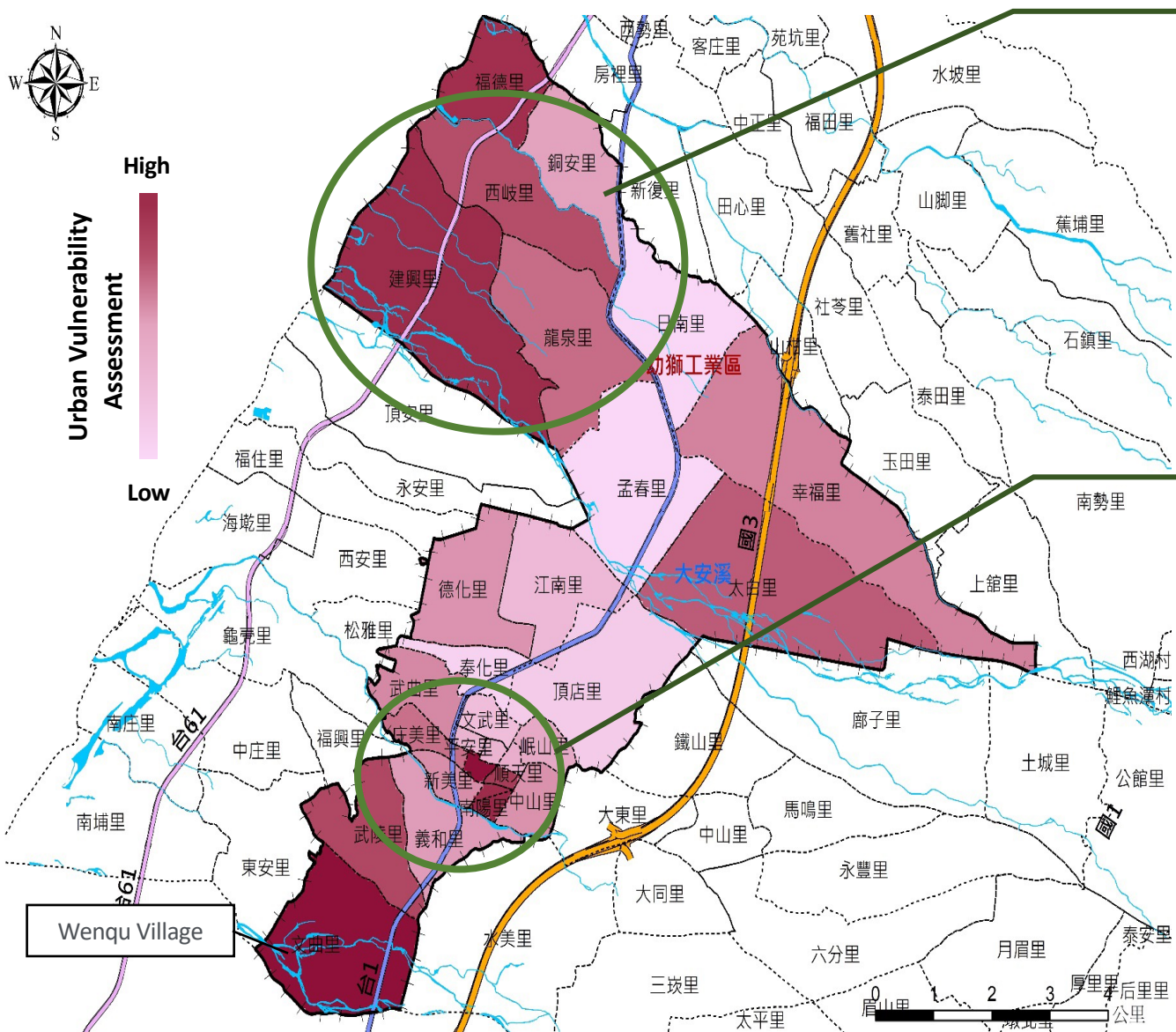


Figure 42: Schematic diagram of the spatial distribution of vulnerable areas in the urban town of Dajia.

❑ **The north of the river Region**, including Xiqi Village, Longquan Village, and Jianxing Village, is more vulnerable.

❑ **The Youth Industrial Park** has a complete pollution treatment mechanism, so it has a lower impact on the Jinan Village community. Instead, **agricultural land and residential areas surrounding the industrial zone are more affected by pollution and noise.**

❑ The densely populated areas of Da Jia Village, Shun Tian Village, and Zhong Shan Village, adjacent to **the Da Jia Fault and Jenn Lann Temple commercial district in the south of the river Region**, are at a higher risk of being impacted on old houses, historical buildings, and populations than other areas.

❑ **Wen Qu Village is a peripheral area of the urban town**, with a lower coverage of infrastructure and a lower local tax revenue, leading to a higher degree of vulnerability.

■ **Research has found that the critical factors for socioeconomic vulnerability in the watershed town are:**

(1) During the pandemic, there is a correlation between the movement and aggregation of tourists and the degree of environmental pollution: cultural and religious activities and scenic spots.

(2) The concentration and marginalization of real estate and industry increase the vulnerability of towns: the industrial concentration in the north and south of the river regions.

(3) South of the river Region is more vulnerable than north of the river Region: (a) Although there is a Youth Industrial Park in the north of the river Region, the complete public facilities in the area make it superior to the scattered processing industry outside the industrial zone; (b) The neighborhoods in peripheral areas lack critical infrastructure and related livelihood support, coupled with existing disaster potential, making them more vulnerable than the general neighborhoods.

Thanks for listening.



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