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Analysis of the Practice of Dengue Prevention and Sustainable Control with Multi-attribute Decision-making

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Abstract

Dengue fever is one of the most common insect-borne diseases in the world, and epidemics mostly occur in tropical and subtropical regions. In the past, the grey multi-attribute decision-making method has been combined with the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method to predict which areas in southern Tainan may easily trigger dengue epidemics. As many studies have shown that the extent of human communication and active government is crucial in dengue prevention, this study aims to propose dengue prevention and control methods before and

after the occurrence of dengue cases. This study found that, when dengue fever cases begin to appear, the relevant county and city government departments must hire vector control companies to carry out regional indoor and outdoor spraying. Before the emergence of dengue cases, the green and sustainable-oriented remediation strategies, as promoted by the Environmental Protection Administration (EPA), can be adopted. Remediation of soil and groundwater pollution sites can reduce the source of vector mosquitoes, in order that the green environment can achieve sustainable development.

Keywords: Dengue Fever, Grey Multi-attribute Decision-making, Green and Sustainable Remediation, Environmental Protection Administration

Introduction

The most effective method is to improve the drainage gradient of roads and drains in the city, remove the waste tires and potted plants, large water tanks and fill the pool in the idle courtyard to reduce the occurrence of water accumulation, in order to completely isolate the mosquitoes and people. Life field. Infections most often occur in urban environments. In recent decades, due to the expansion of rural areas, towns and cities, dengue fever is common in these places, and the increase in mobility has increased the number of infectious diseases and epidemic viruses. Therefore, dengue fever, which was confined to infectious diseases in South Asia, has now spread to countries in southern China, the Pacific, and the Americas, and may also pose a threat to Europe [1-2]. In 2015, the dengue fever epidemic in Tainan City was more serious, with 40,000 confirmed cases and 214 deaths(<http://www.cdc.gov.tw/>). Dengue fever is a viral disease transmitted by mosquitoes, and its symptoms are most common in mild to moderate acute dengue fever, while about 5% of dengue cases develop into serious and life-threatening symptoms called severe dengue fever [3]. In the past five years, the incidences of dengue infection have

increased by 30 times, causing a global health disaster. It is estimated that dengue fever is prevalent in over 100 countries on an annual basis, endangering almost half of the world's population. According to the estimates of WHO, about 500-100 million people worldwide are infected with dengue fever every year [4]. Southeast Asian countries with an average temperature of 30 °C are prone to dengue fever, and the 2.5 billion people living in common areas of dengue, 70% are from Asia and the Pacific. If a person returning from a developing country has a fever, the first consideration is malaria, followed by dengue fever [4-5]. Late summer into early autumn is the peak period of dengue vector mosquitoes in Taiwan. There are dengue epidemics of different scales each year, which are mainly concentrated in the south, with the most serious damage in Tainan, Kaohsiung, and Pingtung areas [6]. A dengue fever epidemic hit southern Taiwan between 2014 and 2015, and in 2015, there were 43,419 notified cases, and 228 people died. It was the largest dengue epidemic in the history of Tainan City, and lasted for 32 weeks. A total of 22,775 cases were confirmed, which was an increase of 22.67 times, as compared with the total from 2011 to 2014, when 112 people died. The numbers of confirmed cases and deaths were highest over these years, and the dengue fever epidemic was out of control (Centers for Disease Control, Ministry of Health and Welfare). In 2015, Tainan reported and confirmed the first suspected dengue fever case of the summer, and the epidemic lasted for 6 months. As the municipal government failed to identify and remove the source of sputum, or conduct professional training on sprayers in a rapid manner, it could not promote proper chemical control measures at various stages, study individual cases, or separate chemistry and firewall area control operations, which resulted in an increasing density of vector mosquitoes, cluster infections, and spread of the fever(<https://data.tainan.gov.tw/>).

Due to the soaring global economy, Taiwan has built more and more plants for various industries. However, in Taiwan's past, the concept of sustainable development was not taken seriously, and enterprises only made great efforts in their pursuit of increased profits and reduced costs, but ignored environmental protection, such as the dumping of waste and the discharge of wastewater. The resulting massive environmental footprints highly increased the number of polluted sites in Taiwan. The environmental pollution of soil and groundwater is currently one of the major emerging pollution problems in Taiwan.

Environmental pollution accelerates global warming, causes more severe climate, and aggravates many diseases and epidemics. In addition, in the era of a global village, the scope of infection has spread to the whole world. In recent years, the dengue epidemic in Taiwan has been accompanied by environmental pollution, global trade, sightseeing, population growth, and rising temperatures, leading to an increased risk of dengue virus infection. According to the statistics of the Center for Disease Control, the northern part of Taiwan has witnessed growing dengue fever epidemics over the years; previously, dengue epidemics occurred frequently in the southern part of Taiwan (Center for Disease Control, Ministry of Health and Welfare).

Statistical analysis of historical data found that a dengue epidemic has appeared, on average, once every 4 years, and in the in-between years, efforts were made to heighten vigilance and strengthen the environment to reduce the incidences of dengue fever; however, reduced vigilance, accompanied by environmental pollution and the increased temperature of climate change in 2018, resulted in a dengue epidemic in northern and central Taiwan. As the dengue fever-prone areas in the past few years were south of Chiayi, people in the southern and central parts of Taiwan had little knowledge and understanding about dengue fever. Moreover, this area was short of medical resources for

dealing with dengue fever, and as a result, the dengue fever epidemic raged in the north 2018. In this regard, great attention must be paid to prevent future dengue epidemics in Taiwan due to various factors, such as environmental pollution, climate, environmental changes, and increasing tourism. In light of the more severe dengue fever epidemics in Taiwan, this study explores what kind of dengue fever prevention and treatment methods can be used to reduce the incidence and scale of dengue fever epidemics. Therefore, based on the confirmed cases of dengue fever in Tainan City, the infectious diseases statistics enquiry system of the Center for Disease Control, and the open data platform of Tainan City Government, this study collected the information of the dengue fever epidemic, as well as prevention and control data from 2012 to 2015, and adopted the grey system theory for analysis, in order to find a perfect solution for dengue fever epidemics (<https://data.tainan.gov.tw/>).

In most real-world decision-making problems, the clarity of information is often in the gray stage. This is the gray theory that provides a useful tool for decision-making problems under incomplete and uncertainties. Grey theory is an effective method to deal with uncertainty problems, especially it is a theory that can analyze and construct limited and incomplete information [7]. The factor weighting in the Grey multi-attribute decision-making is determined by using the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method. The TOPSIS method is a sequential selection technique for ideal target similarity, which is in multi-objective decision analysis. a very effective method [8]. The purpose of this study is to explore the ranking of factors affecting the dengue fever epidemic by GRA, and uses grey multi-attribute decision-making analysis and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) method to predict which areas of Tainan may become prevalent areas

for dengue fever. The findings can provide reference for the prevention and control of dengue fever to government departments, vector mosquito control operators, and environmental remediation workers, before and after the occurrence of dengue fever cases, in the hope of reducing the risk and scale of dengue fever through prevention and treatment measures [9-14].

Literature review

Once people are infected with the dengue virus, they become the main source and breeder of the virus, meaning they become a source of the virus for uninfected mosquitoes. The virus circulates in the blood of infected people for 2-7 days, which is about the same period as the human fever. Patients who have been infected with dengue virus may spread the virus through mosquitoes after the first symptom (4-5 days; up to 12 times) [15-16]. Preventive measures against dengue virus can improve the environment of families and communities, and make it difficult for mosquitoes to breed. Efforts should be made to educate the public through various channels, raise public awareness of the dangers of dengue fever, prevent them from being exposed to the disease, formulate public guidelines for controlling the environment and removing mosquito breeding grounds, promote the prevention of dengue fever and medical technology development, and establish effective medical and health workforces to provide effective treatment for patients with dengue fever [17].

In the context of scarce natural resources and growing environmental problems, such as global warming, the world has gradually paid attention to environmental remediation and introduced the concept of Green and Sustainable Remediation (GSR). Each country, as based on natural law and social demands, has introduced different definitions of GSR. The Interstate Technology & Regulatory Council (ITRC) defined GSR

as a strategy to remediate pollution sites, set standards for remediation techniques, procedures, or methods, and strike a balance among community goals, economic impacts, and overall environmental impact. GSR applies the principle of “sustainable development” to the management of pollution sites and lands, and sustainable development is defined as the principle of meeting current contemporary needs without compromising the ability of future generations to meet their needs [18]. GSR is often described as a combination of remedies, and its net benefits are maximized through the rational use of limited resources. GSR is a process- and goal-based implementation process that focuses on assessing the composition of remediation items in order to strike a balance and achieve sustainable remediation. That is, during the improvement process of pollution sites, relevant knowledge should be integrated into the green and sustainable remediation strategy by measuring the three indicators of environment, society, and economy – meaning a triple bottom line, thereby, reducing the secondary pollution caused by environmental remediation [19]. Green and sustainable remediation is not merely about improving polluted sites; instead, from the perspective of sustainable development and current and future environmental use, the “green and sustainable remediation” strategy states that the method most suitable for improving the polluted sites should be selected.

Regarding most real-world decision-making problems, the degree of information clarity is often in the grey stage. In this regard, the grey theory serves as a useful tool in decision-making under incomplete and uncertain scenarios [7], as it is an effective method to address uncertain problems. In addition, it can be used to analyze and construct limited and incomplete information [20].

Research method

This study used the open database of the Center for Disease Control, and Tainan

City Government as the main data source. Grey Relational Analysis (GRA) together with TOPSIS were employed to analyze various factors, such as dengue outbreaks and prevention measures. In addition, the dengue epidemic situations in various areas of Tainan City were analyzed by grey multi-attribute decision-making analysis [21-22].

Grey relational analysis

GRA is one of the extended theories of the grey system theory, which can address uncertain and nonlinear problems. Unlike statistical methods and the fuzzy theory, it does not require a large number of samples or distribution hypotheses, problems subjects are regarded as a whole, and the value of data is explored for analysis. These features make it suitable for data with complex structures and insignificant distributions [23].

GRA is a quantitative analysis method used to explore the similarities and differences among various factors in a system, by proposing dependence to measure the degree of correlation between factors: the higher the similarity, the more relevant the factors are. GRA uses grey relation to measure the degree of relationship among factors, and extracts and ranks the relevant parts of each factor to provide systematic and reliable information [24].

As GRA conducts analysis based on the development trend of each factor, it does not need a large amount of regularly distributed raw data. In addition, with a small calculation amount, it is less likely that the quantitative analysis result will be inconsistent with the qualitative analysis result. Relevance refers to the measure of the degree of correlation between factors that exist between systems in the context of time change or different objects. In the process of system development, if the degree of change between the two subsystems or factors is high, the degree of correlation between the two systems is considered to be high [8, 24].

The main procedure of GRA is to convert all data into comparable sequences, define the standard sequences, compare the sequences, and then, calculate the grey relation coefficient between all comparable sequences and the standard sequence. Finally, based on these grey relation coefficients, the grey relation degree between the standard sequence and each compared sequence is calculated [25]. GRA includes data normalization, definition reference sequence, grey relation coefficient, and grey relation degree calculation steps. The equation is written as follows:

Step 1: Standardize the data, as expressed in Eq. (1):

$$r_s(d) = \frac{x_s(d)}{\sum_{d=1}^y x_s(d)/y}, \quad a = 1, 2, 3, \dots, n, b = 1, 2, 3, \dots, n \quad (1)$$

Step 2: Define standard sequence r_0 and comparison sequence r_a , compare the absolute difference between the two sequences $r_0(b)$ and $r_a(b)$, and calculate the difference sequence $\Delta_{0i}(b)$, as expressed in Eq. (2):

$$\Delta_{0i}(b) = |r_0(b) - r_a(b)|, \quad a = 1, 2, 3, \dots, n, b = 1, 2, 3, \dots, n \quad (2)$$

Step 3: Obtain the maximum difference Δ_{max} and the minimum difference Δ_{min} between the two poles, as defined by Eq. (3) and Eq. (4):

$$\Delta_{max} = \underset{a,b}{Max} \Delta_{0a}(b) \quad (3)$$

$$\Delta_{min} = \underset{a,b}{Min} \Delta_{0a}(b) \quad (4)$$

Step 4: Calculate the grey relation coefficient. The relation coefficient is defined as $r_{0a}(b)$, where ζ is the grey relation coefficient (Distinguished Coefficient), which is used to control the value of the grey relation coefficient. It is usually recommended to fix it at 0.5, but it can also be adjusted according to operators' needs. As the value of ζ does not

affect the GRA results of this study, ζ is taken as 0.5, as expressed in Eq. (5):

$$\gamma_{0a}(b) = \frac{\Delta_{\min} + \zeta \Delta_{\max}}{\Delta_{0a}(b) + \zeta \Delta_{\max}}, \quad a = 1, 2, 3, \dots, n, b = 1, 2, 3, \dots, n \quad (5)$$

,

Step 5: Calculate the grey relation between each comparison sequence and the standard sequence. The definition of grey relation $\Gamma_{0i}(k)$ is Eq. (6):

$$\Gamma_{0a} = \sum_{b=1}^n \gamma_{0a}(b) / n, \quad a = 1, 2, 3, \dots, n, b = 1, 2, 3, \dots, n \quad (6)$$

Step 6: According to GRA, the grey relation degree of the operation results is ranked, where grey relation degree Γ_{0a} refers to the degree of association between standard sequence r_0 and comparison sequence r_a , wherein $0 < \Gamma_{0a} \leq 1$. When the Γ_{0a} value becomes closer to 1, it indicates that the degree of relation between the factor and the system is larger; when the Γ_{0a} value is closer to 0, it indicates that the factor is less related to the system, thus, the order of the relatively important factors affecting the development trend of the system are arranged according to the Γ_{0a} value.

Grey multi-attribute decision-making analysis

People encounter many multi-attribute decision-making problems in daily life, which are different from single attribute decision making. The purpose of multi-attribute decision-making is to consider multiple “attributes”, “targets”, or “evaluation standards”, in order to select the optimal solutions from various “options”, “policies”, “actions”, or “alternatives”. However, when considering various “attributes”, “targets”, or “standards”, it is usually easy to cause conflicts and contradictions; therefore, efforts should be made to strike a balance between these conflicting attributes. There are several commonly used methods for multi-attribute decision-making, such as simple weighted summation (SAW), TOPSIS, the analytic hierarchy process (AHP), and grey multi-attribute decision-making

[25].

Grey multi-attribute decision-making refers to a decision-making system composed of all possible uncertain or incomplete decision elements in the multi-attribute decision-making process. After obtaining the effect of the actual decision-making system by calculating the effect measure of the grey theory, the optimal solution may be selected according to the decision matrix [8].

The key point of grey multi-attribute decision-making is, “When event (A) occurs, strategy (B) is its countermeasure”, and the result is called a situation (S). Event A represents an event collection or a property set, and an element or attribute in the A collection is called $a_i, i = 1, 2, 3, \dots, n$. Strategy B is a collection of alternatives. B represents a set of countermeasures for event A, and an element in the set of countermeasures is called a solution $b_j, j = 1, 2, 3, \dots, m$. The result of each solution under the attribute is called a situation S, and the results can be established into a situation matrix (also known as the result matrix) $S_{ij} = (a_i, b_j)$ [8, 24].

The application of GRA to perform grey multi-attribute decision-making analysis process is, as follows:

Effect measure

In GRA, a sequence is defined as a standard sequence, and serves as the analysis target. Each comparable sequence is compared with the standard sequence to generate a difference sequence $\Delta_{oi}(k)$, and then, the grey relation coefficient $\gamma_{oi}(k)$ with the standard sequence is calculated. The effect measure of grey multi-attribute decision-making is divided into three types: upper limit effect measure, lower limit effect measure, and specific center effect measure. The following is an introduction of each effect measure [8].

Upper limit measure: Measure the extent to which the data deviates from the

maximum value, and the larger the expected target value the better, such as financial performance, quality, return on investment, etc. In this regard, when u_i^{max} is used to represent the maximum of all solutions under a certain sequence or certain attribute b_j , the upper limit effect measure is defined as Eq. (7):

$$r_{ij} = \frac{S_{ij}}{u_i^{max}}, \text{ where } u_i^{max} = \max_j S_{ij} \quad (7)$$

Lower limit effect measure: Measure the extent to which the data deviates from the minimum value, and the smaller the expected target value the better, such as production cost, environmental impact, personnel change, etc., In this regard, when u_i^{min} is used to represent the minimum of all solutions under a certain sequence or a certain attribute a_i , the lower limit effect measure is defined as Eq. (8):

$$r_{ij} = \frac{S_{ij}}{u_i^{min}}, \text{ where } u_i^{min} = \min_j S_{ij} \quad (8)$$

Specific center effect measure: Applicable to the expected target value within a specified interval, such as age, temperature, etc. Hence, u_i^* is used to represent a specific sequence value of all solutions under a certain sequence a_i or a certain attribute b_j . The definition of a specific central effect measure is shown in Eq. (9):

$$r_{ij} = \frac{\min\{S_{ij}, u_i^*\}}{\max\{S_{ij}, u_i^*\}} \quad (9)$$

Effect measure r_{ij} is the effect degree of attribute a_i and solution b_j . When the value of effect measure r_{ij} is greater than 0 and less than or equal to 1, that is $0 < r_{ij} \leq 1$. When r_{ij} is closer to 1, the better the effect of solution b_j under attribute a_i . When r_{ij} is closer to 0, the worse the effect of solution b_j under attribute a_i [8].

Multi-attribute decision-making matrix

Decision matrix D is established by effect measurer r_{ij} , where r_{ij} is an element in the

matrix, and a_i represents that the matrix has n attributes, namely $a_i, i = 1, 2, 3, \dots, n$; b_j represents that there are m solutions, namely $b_j, j = 1, 2, 3, \dots, m$. Then, the representation of decision matrix $D(n \times m)$ is shown in Eq. (10):

$$D = \begin{matrix} & \begin{matrix} b_1 & b_2 & \dots & b_m \end{matrix} \\ \begin{matrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{matrix} & \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1m} \\ r_{21} & r_{22} & \dots & r_{2m} \\ \vdots & \vdots & \dots & \vdots \\ r_{n1} & r_{n2} & \dots & r_{nm} \end{bmatrix} \end{matrix} \quad (10)$$

Decision standard

After decision matrix D is formed, the optimal solution can be selected according to the decision standard. The decision standard of grey multi-attribute decision-making analysis refers to the effect of selecting the optimal solution b_j under attribute a_i , as shown in Eq. (11). In short, it means that b_j is the most suitable decision under the consideration of attribute a_i . As the decision standard is to find the largest element value in each row, it can also be called a “row decision” [8].

$$r_{ij}^* = \max_j r_{ij} = \text{Max}\{r_{i1}, r_{i2}, \dots, r_{im}\} \quad (11)$$

To consider comprehensive result r_j of solution b_j under all attributes a_i , the corresponding weights w_i should be included. For each solution, the weighted average, as obtained by including the corresponding weights, is taken as the comprehensive score of the solution. The higher the comprehensive score, the more important the solution. The calculation of comprehensive result r_j is shown in Eq. (12):

$$r_j = \sum_{i=1}^n w_i r_{ij}, \sum_{i=1}^n w_i = 1 \quad (12)$$

Finally, the optimal solution shall be solution b_j with the largest value under the total comprehensive result r_j .

In the multi-attribute decision-making analysis method, the relative weight of the

attribute has considerable influence on the choice of the alternative, meaning different attribute weights may lead to different results. Attribute weights can be mainly divided into subjective weight method, compromise weight method, and objective weight method. The subjective weight method is based on the subjective consciousness or subjective preference of decision-makers themselves; the objective weight method is known through the results of the computing system; the compromise weight method is a combination of the subjective weight method and objective weight method. Common weighting methods include expert evaluation, weighted least square (WLS), AHP, and TOPSIS [8].

Technique for order preference by similarity to an ideal solution

Multi-attribute decision-making is designed to evaluate and select the most qualified solution, as based on the metrics of each attribute of each alternative. The multi-attribute decision-making method solves problems in many fields, and is widely used in engineering, economic, management, and social fields. There are two ways to analyze multi-attribute decision-making: (1) Methods that depend on human subjective preferences, such as the AHP and the Best Worst Method (BWM); (2) Mathematical methods that depend on mathematical operations, such as the TOPSIS method and the weighted sum method (SAW). The TOPSIS method is the most commonly used method in mathematics [8, 26].

The weight of the grey multi-attribute decision-making analysis method in this study is based on the TOPSIS method, as first proposed by Hwang and Yoon in 1981. The core concept is to define the positive ideal solution and negative ideal solution, in order to help decision-makers find the best alternative. In addition, the alternative must maintain the shortest distance from the “positive ideal solution” and the longest distance from the “negative ideal solution”. The positive ideal solution refers to the value with the largest benefit standard and the lowest cost standard; while the negative ideal solution is the value

with the largest cost standard and the smallest interest rate [8, 27]. The calculation process of TOPSIS is, as follows:

Step 1: Standardize the raw data, that is, r_{ij} is calculated by Eq. (13), where x_{ij} is expressed as the value of attribute i under solution j :

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^n x_{ij}^2}}, i = 1, 2, 3, \dots, n, j = 1, 2, 3, \dots, m \quad (13)$$

Step 2: Calculate the weighted standardized evaluation value, that is, v_{ij} is calculated by Eq. (14), where w_i is the weight value of the decision matrix:

$$v_{ij} = w_i \times r_{ij} \quad (14)$$

Step 3: Find the positive ideal solution (A^*) and the negative ideal solution (A^-), where J is the benefit standard and J' is the cost standard. The benefit standard means that the higher the target value, the higher the calculated value of the target; the cost standard means that the lower the target value, the higher the calculated value of the target. The positive ideal solution (A^*) and the negative ideal solution (A^-) are shown by Eqs. (15) and (16), respectively.

$$A^* = \{v_1^*, v_2^*, \dots, v_n^*\} = \left\{ \left(\max_i v_{ij} \mid j \in J \right), \left(\min_i v_{ij} \mid j \in J' \right) \mid i = 1, 2, 3, \dots, n \right\} \quad (15)$$

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\} = \left\{ \left(\min_i v_{ij} \mid j \in J \right), \left(\max_i v_{ij} \mid j \in J' \right) \mid i = 1, 2, 3, \dots, n \right\} \quad (16)$$

Step 4: Calculate the Euclidean distance between each alternative and its positive and negative ideal solutions, meaning the distance from the positive ideal solution (S_i^+) and the distance from the negative ideal solution (S_i^-), as shown in Eqs. (17) and (18), respectively.

$$S_i^+ = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^+)^2}, \quad i = 1, 2, 3, \dots, n \quad (17)$$

$$S_i^- = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^-)^2}, \quad i = 1, 2, 3, \dots, n \quad (18)$$

Step 5: Calculate the relative approximation of each alternative to the ideal solution, as in Eq. (19).

$$C_i^* = \frac{S_i^-}{(S_i^+ + S_i^-)} \quad (19)$$

here $0 \leq C_i^* \leq 1, i = 1, 2, 3, \dots, n$

Step 6: Prioritize the various alternatives, arrange them according to the C_i^* value, and judge the decision maker's preference for the alternatives.

Research method flow

This study used the government's open data platform to collect data on dengue epidemics, GRA to analyze the ranking of the factors affecting the Tainan dengue epidemic, applied grey multi-attribute decision-making analysis and TOPSIS to analyze which areas of Tainan may suffer dengue epidemics in the future, and provides conclusions and recommendations based on the results. The research process is shown in Figure 1.

Fig. 1. Flow Chart of Research Method

Case analysis

According to literature, while a total of 10 factors affecting the dengue fever epidemic have been listed, the number of households that tested positive, the number of containers that tested positive, the Brinell index, and the container index are used as the basis to analyze the situations in the 33 administrative districts of Tainan City. This study chose the number of positive households as an analysis indicator. The indicators are defined in Table 1, including annual average temperature, annual average rainfall, population density, number of containers surveyed, number of sprays, total number of sprayers, vector control operators, soil and underground pollution sites, environmental protection volunteers in attendance, and number of farms breeding over 2,000 waterfowl. Many abandoned, vacant

lots in the village, plus drainage ditch pollution, and a few septic tanks in the sunshine are uncovered, which may be the breeding ground for mosquitoes, leading to infectious diseases and dengue fever. Analysis of the data collected shows that the distribution of dengue cases is concentrated in annual rainfall of 1500 - 5000 mm. Comparing the relationship between climate and dengue, it was found that several historical outbreaks (such as 1852, 1856, 1903, 1943, 2001) coincided with the El Niño years. These annual climate characteristics include: drought in winter, reduced rainfall, and high temperatures in September. The increase in temperature increases the number of mosquitoes that lay eggs; the reduction in rainfall causes the original stream to become a pool of water, providing an environment for the breeding of vector mosquito larvae. In Taiwan, when the average monthly temperature is lower than 16 °C, no larvae of vector mosquitoes are found; when the monthly average temperature is higher than 21 °C, the density of vector larvae begins to appear in towns above 2; when the monthly average temperature is higher than 23 °C, the vector mosquitoes The density of larvae began to appear in towns and towns greater than grade 3. However, temperature is not the only environmental factor affecting the density of vector mosquito larvae. But, no mention of diurnal temperature range [3, 15-17, 28-35]. This study used the data concerning dengue epidemics on the Tainan City Government open data platform from 2012 to 2015 as the data source, and then, analyzed the data with GRA.

Table 1. Factor Selection

Code	Factor name	Definition
C_1	Annual average temperature	Average annual temperature of the administrative districts (°C)

C_2	Annual average rainfall	Average annual rainfall of the administrative districts (mm)
C_3	Population density	Total population of administrative districts by square km
C_4	Number of respondents	Total number of indoor and outdoor containers of respondents
C_5	Spray times	Total number of sprays in administrative districts
C_6	Total number of sprayers	Total number of sprayers in administrative districts
C_7	Number of vector control operators	Total number of vector control operators in administrative districts
C_8	Soil and groundwater pollution fields	Total soil and groundwater pollution fields in administrative districts
C_9	Environmental protection volunteers in attendance	Total number environmental protection volunteers in administrative districts
C_{10}	Farms breeding over 2,000 waterfowl	Total number of farms breeding over 2,000 waterfowl in administrative districts

References: [3, 15-17, 28-35]

Data analysis results of GRA

According to literature, a total of 10 factors affecting the dengue fever epidemic have been listed, with the number of positive households as the analysis basis, and the results are shown in Table 2, while the calculation process is shown in Appendix A~D. According

to the GRA results of Table 2, the factors that affect the number of positive households suffering dengue fevers are, as follows: Spray times, number of containers of respondents, number of vector control operators, number of sprayers, population density, soil and groundwater pollution fields, annual average rainfall (mm), annual average temperature (°C), environmental protection volunteers in attendance, and farms breeding over 2,000 waterfowl.

Table 2. GRA of Positive Households

Ranking	Factor	Γ_{0a}
1	Spray times	$\Gamma_{05}=0.923$
2	Number of containers of respondents	$\Gamma_{04}=0.922$
3	Number of vector control operators	$\Gamma_{07}=0.914$
4	Number of sprayers	$\Gamma_{06}=0.912$
5	Population density	$\Gamma_{03}=0.901$
6	Soil and groundwater pollution fields	$\Gamma_{08}=0.873$
7	Annual average rainfall (mm)	$\Gamma_{02}=0.862$
8	Annual average temperature (°C)	$\Gamma_{01}=0.858$
9	Environmental protection volunteers in attendance	$\Gamma_{09}=0.855$
10	Farms breeding over 2,000 waterfowl	$\Gamma_{10}=0.834$

According to the results of GRA (Table 2), the most significant factors affecting the number of households suffering dengue fever are spray times, number of containers, and number of vector control operators. The dengue fever vector density survey conducted by

the Ministry of Health and Welfare indicates that, an average of about 30% of breeding sources are found in indoor water containers. Therefore, the government should guide the public to reduce number of containers with standing water and clean indoor containers to reduce breeding sources. In case of any dengue fever cases, the relevant county and city departments should engage vector control operators to carry out regional spraying as soon as possible to avoid vector mosquitoes escaping to other areas [3, 15-17, 28-35]. Thus, a large number of vector control operators may conduct a wide range of pesticide spraying in a timely manner. The more the spraying times, the more vector mosquitoes can be extinguished to reduce the incidence and scale of dengue fever. Although the GRA results show that spray times, number of containers of respondents, and number of vector control operators are the most influential factors, these three have never been able to make Taiwan a dengue fever-free area. The more times the pesticide is sprayed, the stronger the resistance of mosquitoes, and the worse the future anti-epidemic effect on dengue. Moreover, the use of these environmental pesticide will result in poor environmental conditions, and expand the scale of the future dengue epidemic. Therefore, this study aims to reduce the incidences of mosquito-borne breeding and dengue fever through certain sustainable prevention and treatment measures before dengue fever cases occur.

Grey multi-attribute decision-making analysis

Through grey multi-attribute decision analysis, this study intends to understand which areas of Tainan may become dengue-prone areas in the future, discusses the factors that may affect a dengue fever epidemic in the future, provides a sustainable remediation method based on the influencing factors, and offers relevant suggestions for county and city government departments. Previous scholars have widely applied the TOPSIS method and grey theory in engineering, economics, management, agriculture, and other fields [36-37].

Grey multi-attribute decision-making analysis must include the impact factors after the effect measure into the corresponding weights to obtain the results. In assessing the corresponding weights of each impact factor, this study reviewed relevant research and literature on environmental sustainability and dengue fever in Taiwan, and defined and selected relevant indicators related to dengue prevention. In addition, this study employed data and recommendations obtained through interviews with 30 experts. The data were obtained through the simple average method, and the average was rounded to the third decimal place. The subjects of the expert interviews included: 1) academia: scholars who have studied environmental sustainability issues; 2) industry: personnel involved in dengue prevention and environmental remediation; 3) government: the first-line dengue prevention and control personnel of the Environmental Protection Administration and Bureau of Health. As senior professionals in dengue prevention and environmental sustainability, these respondents can provide ideas and practical experience regarding dengue prevention and environmental sustainability. Hence, this study has relative credibility in the corresponding weights of experts' impact factors.

In order to avoid deviations in the interview process and prevent important research topics from being missed during the interview process, the interview content was provided to respondents before the interview, in order that respondents could understand the research and participate in the interview at the stipulated time period. According to the recommendations of the experts and based on the number of positive households, this study employed the TOPSIS method to calculate the corresponding weight of each impact factor $C_i, i = 1, 2, 3, \dots, 10$, as described in Table 3.

Table 3. Corresponding Weights of Positive Household Factors

Ranking	Factor	C_i
1	Soil and groundwater pollution fields	$C_8=0.998$
2	Spray times	$C_5=0.894$
3	Number of containers of respondents	$C_4=0.891$
4	Number of sprayers	$C_6=0.879$
5	Number of vector control operators	$C_7=0.868$
6	Population density	$C_3=0.864$
7	Annual average rainfall (mm)	$C_2=0.799$
8	Annual average temperature (°C)	$C_1=0.794$
9	Environmental protection volunteers in attendance	$C_9=0.794$
10	Farms breeding over 2,000 waterfowl	$C_{10}=0.775$

Effect measure

This study employed grey multi-attribute decision-making analysis to determine which areas of Tainan City are prone to dengue fever. According to the factors in Table 1, this study adopted the suggestions of relevant experts and conducted corresponding measure of effect for each factor. The effect measure is divided into three types: upper limit effect measure, that is, the larger the target effect the better; lower limit effect measure, that is, the smaller the target effect the better; specific center effect measure, that is, the target effect is a specific target, as described in Tables 4~6, respectively.

Table 4. Factor of Upper Limit Effect Measure

Code	Factor name	Definition
C_2	Annual average rainfall	The greater the average annual rainfall, the more likely it is to cause mosquito breeding.
C_3	Population density	The higher the population density, the higher the risk of dengue infection
C_4	Number of containers of respondents	The more the number of containers of respondents, the easier it is to accumulate water and cause mosquito breeding.
C_8	Soil and groundwater pollution sites	The more the number of pollution sites in the area, the more likely it is to cause mosquito breeding.
C_{10}	Farms breeding over 2,000 waterfowl	The dirtier the farm environment, the more likely it is to cause mosquito breeding.

Table 5. Factor Table of Lower Limit Effect Measurement

Code	Factor name	Definition
C_5	Spray times	The fewer the spray times, the more likely it is to cause mosquito breeding.
C_9	Environmental protection volunteers in attendance	The fewer the volunteers in attendance, the smaller the cleaning scale, and the less possible to keep the environment clean.

Table 6. Factors of Specific Effect Measure

Code	Factor name	Specific expectant value	Definition
C_2	Annual average temperature (°C)	28.5	The temperature at which the dengue virus is most easily transmitted: 25~32 °C (take the average)
C_3	Total number of sprayers	1	This study supposes that there is at least one sprayer in each area of Tainan City.
C_4	Number of vector control operators	1	This study supposes that there is at least one vector control operator in each area of Tainan City.

Results of grey multi-attribute decision-making analysis

This study calculated the results of the corresponding weights of each factor according to Table 3. According to the effect measures in Table 6, and through No.7 and No.10 items, this study reached the calculation results shown in Table 7. The calculation process is shown in the appendix.

Table 7. Ranking after Grey Multi-attribute Decision-making Analysis

Ranking	Area (b_j)	r_j
1	East District	$r_{19}=3.26$
2	Nanxi District	$r_{28}=3.15$
3	North District	$r_{07}=3.15$

4	Madou District	$r_{25}=3.08$
5	West Central District	$r_{04}=3.05$
6	Zuozen District	$r_{08}=2.97$
7	Shanshang District	$r_{03}=2.96$
8	Anping District	$r_{12}=2.81$
9	Yongkang District	$r_{09}=2.69$
10	Yujing District	$r_{10}=2.67$
11	South District	$r_{21}=2.66$
12	Guantian District	$r_{17}=2.62$
13	Nanhua District	$r_{20}=2.60$
14	Xinshi District	$r_{27}=2.52$
15	Annan District	$r_{14}=2.39$
16	Guiren District	$r_{31}=2.36$
17	Xinhua District	$r_{26}=2.34$
18	Danei District	$r_{02}=2.17$
19	Longqi District	$r_{30}=2.15$
20	Rende District	$r_{05}=2.09$
21	Yanshuei District	$r_{33}=2.06$
22	Houbi District	$r_{22}=2.04$
23	Jiangjyun District	$r_{24}=1.85$
24	Xuejia District	$r_{29}=1.77$
25	Dongshan District	$r_{18}=1.69$
26	Lioujia District	$r_{06}=1.67$

27	Liouying District	$r_{23}=1.59$
28	Guanmiao District	$r_{32}=1.49$
29	Jiali District	$r_{16}=1.48$
30	Sigang District	$r_{15}=1.47$
31	Baihe District	$r_{11}=1.47$
32	Anding District	$r_{13}=1.41$
33	Cigu District	$r_{01}=1.29$

According to the results of grey multi-attribute decision-making analysis, it can be seen that the East District, Nanxi District, and North District in Tainan are prone to dengue fever, which is mainly due to the corresponding weights of positive household factors in Table 3. The ranking of the corresponding weights of positive households are, as follows: soil and groundwater pollution sites, spray times, number of containers of respondents, number of sprayers, number of vector control operators, population density, annual average temperature (°C), annual average rainfall (mm), environmental protection volunteers in attendance, and farms breeding over 2,000 waterfowl. Since the weight of soil and groundwater pollution sites is relatively high, its influence is relatively high, thus, to prevent dengue fever, it is necessary to improve the soil and groundwater pollution sites. This study proposes relevant suggestions based on the green and sustainable remediation strategy, as promoted by the Environmental Protection Administration, in order to reduce the incidences of vector mosquitoes, reduce the incidences of dengue fever, and improve environmental protection.

Discussion

This study analyzed the data of dengue epidemics and prevention methods, as

provided by the Tainan City Government open data platform from 2015 to 2016, according to the perspectives of annual average temperature ($^{\circ}\text{C}$), annual average rainfall (mm), population density, number of containers of respondents, spray times, number of sprayers, number of vector control operators, number of soil and groundwater pollution sites, number of environmental protection volunteers in attendance, and farms breeding over 2,000 waterfowl. Moreover, GRA was conducted through the grey system theory, and the results are listed in Table 2. The top three factors are spray times, number of containers of respondents, and number of vector control operators; in the second part, this study adopted the grey multi-attribute decision-making analysis of the grey system theory and the TOPSIS method for analysis. According to the results in Table 7, the top three areas that are prone to dengue fever epidemic in Tainan area are the East District, Nanxi District, and the North District [8, 17, 26].

When the epidemic slows down or there are no new cases, efforts should be made to block overseas immigration and encourage the public to adopt scientific behaviors to prevent dengue fever. The World Health Organization (WHO) also pointed out that dengue fever prevention must be carried out by relevant government departments and community members, and proper vector mosquito control strategies should be adopted. Since there is no effective vaccine or drug treatment for dengue fever, various government agencies should publicize the prevention and treatment measures of dengue fever to enhance people's self-prevention measures [15-16].

Before any dengue fever cases occur, county and city governments should carry out long-term cooperation with vector prevention and control operators, and pre-construct a dengue fever prevention system to spray environmental pesticides to eliminate vector mosquitoes and train sprayers, in order to facilitate operations in the event of an emergency; under the circumstance of any dengue fever case, the county and city

governments can carry out regional indoor and outdoor spraying according to the actual situation of the epidemic. In order to prevent vector mosquitoes from escaping to unsprayed areas during pesticide spraying, vector control operators should be of sufficient number, in order to expand the range of the spray and improve spraying speed. Dengue fever is an environmental and community infectious disease. According to the survey, an average of about 30% of breeding sources are found in containers with standing water per year. "Checking, pouring, clearing, and brushing" are the only ways to eliminate breeding sources and have a clean home environment, thus, county and city governments should publicize regular cleaning of water containers used in households, and try to reduce the number of containers. The government can also use garbage trucks, various news media, and dengue prevention lectures for the purpose of publicity. In addition, they should establish the concept of basic prevention and control among the public, and strive to improve people's self-protection and prevention awareness in a bid to effectively inhibit the rapid spread of dengue fever [9-10].

At present, the only way to prevent dengue fever in Taiwan, besides cleaning, is to spray pesticides; however, spraying pesticides has a negative impact on the human body, other living things, and the environment. Mosquito vectors will also develop pesticideresistance, thus, the next dose must increase the amount of pesticide in the next spraying. Under such a vicious circle, human health will be affected and the ecological environment will be destroyed. In the past, people had no concept of sustainable development or environmental protection, and farmers sprayed pesticides, and factories discharged waste water or dumped toxic wastes, which caused soil and groundwater to be polluted, destroyed the habitats of other creatures, and created serious ecological imbalances. As the natural enemies of mosquitoes are gradually disappearing, this study hopes to promote the development of green and environmental sustainability, achieve a

balance of the ecosystem in the future, and address dengue epidemics through the natural enemies of mosquitoes, rather than chemical prevention and control [3, 6].

Dengue fever is a kind of “community disease” and “environmental disease”. If there is a breeding source of mosquito vectors in a community environment, it will easily cause dengue fever. If a community has a high population density, it may cause a large-scale dengue fever outbreak, thus, to prevent dengue fever, efforts should be made to protect the environment and remove breeding sources. The East District has the second-highest population in the Tainan area, and if one person has been infected with dengue fever, the disease may easily spread, thus, the East District should make great efforts to avoid dengue fever sources. In addition to physical control methods, official units, such as the city government and the Environmental Protection Administration, should identify pollution sites and rectify them through GSR strategies [3, 6, 28].

Regarding the remediation strategy for soil and groundwater pollution sites, this study suggests that the government should regularly conduct surveys at these sites, including controlling pollution sites in the control area, selecting a suitable remediation strategy, and assessing a balance among environment, society, and economy. When the remediation plan is implemented, the government can also use its environmental carbon footprint to analyze or detect whether secondary pollutants have been produced, in order to understand the current situation of the remediation of polluted sites, timely adjust remediation strategies, and improve other strategies for remediation. Taiwan can also emulate foreign governments, strengthen exchanges with relevant international organizations and government departments, and regularly participate in international organization activities and seminars to learn the remediation strategies of international governments and organizations, and then, share such knowledge with pollution site remediation efforts. In addition, Taiwan can work with research units, environmental

groups, industry, etc., to establish a green and sustainable remediation platform to develop better tools and methods for the remediation of polluted sites. Relevant government departments may select a pollution site as a demonstration site, conduct remediation counseling, and evaluate the remediation results in a bid to attract other related enterprises through the demonstration site. Factories should cooperate with non-governmental organizations to promote the GSR strategy. In addition, government agencies must strengthen the environmental ban of enterprises and factories plants, impose corresponding punishments on illegal enterprises and factories, increase incentives, and encourage enterprises and factories to carry out environmental sustainability activities, as shown in Figure 2 (Taiwan Environmental Protection Administration)[3, 6, 9-10, 15-16, 38-39].

Fig. 2. Green and Sustainable Remediation Framework Planned by Taiwan Environmental

Conclusion and Suggestions

This study used GRA and grey multi-attribute decision-making to analyze the data. Based on the analysis results, this study provides dengue fever remediation strategies for relevant county and city government departments, and offers reference for follow-up research and environmental remediation.

Based on the results, this study provides methods and recommendations for government units, vector control operators, and environmental remediation companies for dengue prevention and control, and proposes references for the sustainable development of existing enterprises and factories. In the prevention and treatment of dengue fever, in the summer, autumn, and peak of mosquito vectors, the government should publicize the implementation of dengue prevention methods, reduce mosquito breeding sources, raise public awareness of dengue fever, communicate frequently with disease vector control operators, develop comprehensive dengue prevention strategies and processes, and improve existing environmental remediation pesticides to reduce the negative impacts on the environment and living things [3, 6].

Previously, there have been major soil and groundwater pollution incidents in Taiwan, which seriously endangered people's health and the environment. In addition to the existing pollution sites, government units should introduce green and environmentally sustainable remediation strategies, improve pollution sites, and remove the control. In addition to the secondary use of the original pollution sites, it is necessary to amend the laws and regulations to prevent unscrupulous enterprises from arbitrarily damaging the environment, thus, curbing soil and groundwater environmental pollution. In terms of

improving polluted sites, the government can cooperate with environmental remediation companies to jointly implement remediation strategies, continuously improve remediation technologies and management strategies, enhance remediation efficiency, and avoid shortcomings [9-10, 15].

Regarding the environmental prevention control methods of “soil and groundwater polluted sites”, this study believes that the government should publicize the importance of GSR to existing enterprises and factories, regulate the future establishment of enterprises and factories when planning and designing new projects, and integrate the related concepts of environmental sustainability. For companies and factories that are currently implementing environmental sustainability programs, the government should plan reward mechanisms to give relative incentives and encouragement, such as reducing taxation, providing free environmental sustainability coaching, and introducing the model enterprises to attract other companies. For example, the Taiwan Semiconductor Manufacturing Company promotes an environmental management system to implement pollution prevention, regularly conducts soil and groundwater pollution surveys, and set up anti-flood mechanisms for chemical storage tanks, in order to avoid soil and groundwater pollution caused by chemical leaks. In the prevention and control of dengue fever, government units are responsible for publicizing dengue fever prevention and control methods, and driving the people and industry to work together to reduce dengue fever epidemics in the future [10, 15-16, 28].

Due to limitations in the research process, this study discusses the research limitations, and offers reference and suggestions for follow-up researchers. The perfect dengue fever epidemic temperature is about 28-32 °C. Climate change and global warming, as well as the formation of the “one-day living circle” in Taiwan, meaning

people can move north and south in one day, may lead to the northward migration of dengue fever in the future. In terms of data, this study referred to the related data concerning the dengue epidemic in the Tainan area from 2012 to 2015, and does not include other data, thus, the results may be subject to change due to differences in the study area. Therefore, future research can include dengue-related data from the various regions of Taiwan, in order to understand the factors affecting the dengue fever epidemic in Taiwan, and to explore counties and cities other than Tainan, such as Taichung and Taipei,. The regional dengue prevention and control methods have made subsequent researches on the prevention and treatment of dengue fever perfect [10, 15-16, 28].

This study used the grey theory as the research method, and the TOPSIS method was applied as the weighting method. According to previous research, in addition to the TOPSIS method, the grey theory can be combined with multiple weighting methods, such as the AHP, weighted sum method (SAW), etc. It is suggested that future research can use the grey theory and multiple weighting methods to compare the results of various weighting methods, and further explore which weighting methods are more suitable for the analysis of dengue fever [8, 36].

Authors' contributions

MHL conceived the research idea, designed the study, and wrote the results, STW revised the manuscript, CCL assisted in the literature review and analysis, WCC wrote and proofread the manuscript, contributed to the discussion, and prepared the manuscript for submission. All authors read and approved the final manuscript.

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Availability of data and materials

This study of the dengue fever epidemic original data in Tainan City Government, Taiwan.

Ethics approval and consent to participate

No administrative permissions were required to access and use the mediation records described in our study.

Consent for publication
Not Applicable.

Competing interests
The authors declare that they have no competing interests.

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Appendices

Table A GRA Original Source

	<div>Area</div> <div>Factor</div>	Cigu District	Danei District	Shanshang District	West Central District	Rende District	Lioujia District	North District	Zuozhen District	Yongkang District	Yujing District	Baihe District	Anping District	Anding District	Annan District	Sigang District	Jiali District	Guantian District	Dongshan District	East District	Nanhua District	South District	Houbi District	Liouying District	Jiangiyun District	Madou District	Xinhua District	Xinshi District	Nanxi District	Xuejia District	Longqi District	Guiren District	Guanmiao District	Yanshuei District
Standard sequence	Positive households	7	2	6	438	195	2	91	199	12	1057	5	275	10	371	11	3	19	240	423	1	489	3	5	8	52	1	6	16	9	3	46	40	1
C ₁	Annual average temperature (°C)	24	24	24	23	23	24	24	23	24	23	23	24	24	24	24	24	24	23	23	23	24	24	24	24	24	24	24	23	24	24	24	24	24
C ₂	Annual average rainfall (mm)	1651	2200	2057	2194	2111	2011	2096	2269	2075	2387	2114	2096	1828	2019	1783	1998	1925	2102	2094	2613	2166	2049	1834	1616	1795	1948	1921	2484	1602	2229	2105	2071	1623
C ₃	Population density	210	142	264	12295	1470	332	19183	66	5765	187	228	5945	976	1784	736	1527	304	171	14790	52	4612	338	351	478	830	705	759	90	489	64	1222	645	495
C ₄	Number of containers of respondents	699	390	464	8162	2126	409	11748	559	14533	484	489	6059	365	8933	695	399	831	700	10283	437	7819	486	570	634	945	308	475	667	521	930	856	940	408
C ₅	Spray times	4	1	1	182	28	1	288	1	253	19	2	129	9	195	3	8	0	13	307	0	253	1	2	1	14	36	10	0	3	1	34	11	2
C ₆	Total number of sprayers	57	8	1	12558	593	15	13389	1	8109	543	11	3269	99	6970	9	129	0	381	14619	0	13030	7	9	2	140	686	199	0	34	8	709	177	11
C ₇	Number of vector control operators	0	0	0	6	6	0	6	0	12	0	0	4	0	9	0	0	0	0	12	0	6	0	0	0	1	1	0	0	0	1	0	0	0
C ₈	Soil and groundwater pollution sites	1	0	2	0	9	0	0	0	6	0	0	1	2	1	1	0	1	0	0	0	38	1	0	0	2	1	1	0	0	0	2	1	0
C ₉	Environmental protection volunteers in attendance	4332	219	205	1319	1547	505	3563	301	4601	619	3506	385	2437	3570	2152	3300	787	1465	783	652	3470	3011	1273	912	2011	1589	2124	192	1179	240	3302	2388	340
C ₁₀	Farms breeding over 2,000 waterfowl	1	0	0	0	12	0	0	1	9	0	0	0	3	0	1	4	14	1	0	0	0	37	7	2	54	5	18	0	28	0	0	0	23

Table B GRA Formula 1

	<div>Area</div> <div>Factor</div>	Cigu District	Danei District	Shanshang District	West Central District	Rende District	Lioujia District	North District	Zuozhen District	Yongkang District	Yujing District	Baihe District	Anping District	Anding District	Annan District	Sigang District	Jiali District	Guantian District	Dongshan District	East District	Nanhua District	South District	Houbi District	Liouying District	Jiangiyun District	Madou District	Xinhua District	Xinshi District	Nanxi District	Xuejia District	Longqi District	Guiren District	Guanmiao District	Yanshuei District
Standard	Positive households	0.06	0.02	0.05	3.57	1.59	0.02	0.74	1.62	0.10	8.62	0.04	2.24	0.08	3.03	0.09	0.02	0.15	1.96	3.45	0.01	3.99	0.02	0.04	0.07	0.42	0.01	0.05	0.13	0.07	0.02	0.38	0.33	0.01

C_4	Number of containers of respondents	0.2165	0.1363	0.1326	0.3782	0.7585	0.1437	3.8553	1.4043	5.5896	8.4317	0.1506	0.1282	0.0613	0.4700	0.1823	0.1317	0.1702	1.6835	0.5742	0.1629	0.9284	0.1657	0.1823	0.1829	0.0543	0.1124	0.1370	0.1305	0.1305	0.3395	0.0402	0.0416	0.1515
C_5	Spray times	0.0158	0.0019	0.0307	0.2578	1.0805	0.0019	4.5028	1.6049	4.5097	8.2751	0.0044	0.1064	0.0823	0.5254	0.0351	0.1212	0.1550	1.7207	2.1410	0.0082	0.6192	0.0063	0.0044	0.0470	0.1692	0.6475	0.1332	0.1305	0.0188	0.0063	0.2440	0.1259	0.0283
C_6	Total number of sprayers	0.0323	0.0128	0.0485	1.8967	1.3322	0.0098	5.0888	1.6226	3.4337	8.3846	0.0360	0.8193	0.0384	0.0096	0.0858	0.0317	0.1550	1.7916	2.9167	0.0082	1.6863	0.0214	0.0369	0.0644	0.3632	0.2906	0.0377	0.1305	0.0586	0.0210	0.0664	0.2492	0.0034
C_7	Number of vector control operators	0.0571	0.0163	0.0489	0.5263	1.4557	0.0163	2.3039	1.6231	5.9944	8.6211	0.0408	0.2122	0.0816	1.5433	0.0897	0.0245	0.1550	1.9575	2.6422	0.0082	0.9422	0.0245	0.0408	0.0652	0.0836	0.4995	0.4588	0.1305	0.0734	0.0245	0.1325	0.3262	0.0082
C_8	Soil and groundwater pollution sites	0.4143	0.0163	0.8939	3.5724	2.6524	0.0163	0.7422	1.6231	2.7307	8.6211	0.0408	1.7715	0.8613	2.5545	0.3817	0.0245	0.3165	1.9575	3.4501	0.0082	13.9259	0.4470	0.0408	0.0652	0.5187	0.4633	0.4225	0.1305	0.0734	0.0245	0.5677	0.1452	0.0082
C_9	Environmental protection volunteers in attendance	2.3959	0.1077	0.0671	2.8255	0.7145	0.2696	1.2753	1.4526	2.5074	8.2706	1.9445	2.0250	1.2984	1.0045	1.1288	1.8441	0.2907	1.1279	3.0067	0.3610	2.0235	1.6805	0.6800	0.4512	0.7146	0.8916	1.1538	0.0218	0.5942	0.1114	1.4945	1.0259	0.1844
C_{10}	Farms breeding over 2,000 waterfowl	0.0929	0.0163	0.0489	3.5724	0.2095	0.0163	0.7422	1.4731	1.2521	8.6211	0.0408	2.2430	0.3684	3.0260	0.0603	0.5755	1.9450	1.8075	3.4501	0.0082	3.9884	5.5255	1.0092	0.2348	7.6759	0.7418	2.6511	0.1305	4.1266	0.0245	0.3752	0.3262	3.4418

Table D GRA Formula 4~6

Grey correl ation	Ran king	Area Factor		Cigu	Danci	Shanshang	West Central District	Rende	Lioujia	North	Zuozhen	Yongkang	Yujing	Baihe	Anping	Anding	Annan	Sigang	Jiali Distric t	Guantian	Dongshan	East Distric t	Nanhua	South	Houbi	Liouying	Jiangjyun	Madou	Xinhua	Xinshi	Nanxi	Xuejia	Longqi	Guiren	Guanmiao	Yanshuei
				District	District	District		District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District	District
0.858	8	C_1	Annual average temperature (°C)	0.8802	0.8762	0.8793	0.7300	0.9203	0.8766	0.9648	0.9174	0.8853	0.4774	0.8798	0.8486	0.8829	0.7750	0.8839	0.8766	0.8917	0.8787	0.7395	0.8771	0.7004	0.8771	0.8793	0.8816	0.9230	0.8748	0.8793	0.8909	0.8825	0.8771	0.9181	0.9112	0.8757
0.862	7	C_2	Annual average rainfall (mm)	0.9024	0.8674	0.8787	0.7366	0.9268	0.8776	0.9604	0.9324	0.8832	0.4834	0.8747	0.8520	0.8951	0.7743	0.8986	0.8792	0.8981	0.8832	0.7423	0.8452	0.7045	0.8764	0.8901	0.9054	0.9384	0.8801	0.8862	0.8647	0.9071	0.8668	0.9136	0.9098	0.8983
0.901	5	C_3	Population density	0.9956	0.9940	0.9912	0.8075	0.8786	0.9826	0.4841	0.8139	0.7473	0.4492	0.9923	0.9605	0.9545	0.7546	0.9691	0.9178	0.9966	0.7872	0.7100	0.9983	0.7749	0.9834	0.9849	0.9808	0.9902	0.9600	0.9624	0.9872	0.9813	0.9999	0.9799	0.9929	0.9720
0.922	2	C_4	Number of containers of respondents	0.9701	0.9811	0.9816	0.9487	0.9020	0.9800	0.6438	0.8324	0.5549	0.4524	0.9791	0.9822	0.9915	0.9370	0.9748	0.9817	0.9764	0.8055	0.9241	0.9774	0.8826	0.9770	0.9748	0.9747	0.9925	0.9844	0.9810	0.9819	0.9819	0.9538	0.9945	0.9943	0.9790
0.923	1	C_5	Spray times	0.9980	1.0000	0.9959	0.9646	0.8659	1.0000	0.6074	0.8129	0.6071	0.4571	0.9996	0.9852	0.9886	0.9301	0.9953	0.9832	0.9785	0.8021	0.7650	0.9991	0.9186	0.9994	0.9996	0.9936	0.9765	0.9152	0.9815	0.9819	0.9976	0.9994	0.9664	0.9825	0.9962
0.912	4	C_6	Total number of sprayers	0.9957	0.9984	0.9934	0.7861	0.8396	0.9989	0.5779	0.8112	0.6699	0.4538	0.9951	0.8950	0.9948	0.9989	0.9881	0.9957	0.9785	0.7956	0.7050	0.9991	0.8053	0.9972	0.9950	0.9911	0.9507	0.9602	0.9949	0.9819	0.9919	0.9973	0.9908	0.9657	0.9998
0.914	3	C_7	Number of vector control operators	0.9921	0.9979	0.9933	0.9300	0.8273	0.9979	0.7516	0.8112	0.5375	0.4469	0.9944	0.9707	0.9887	0.8188	0.9875	0.9968	0.9785	0.7808	0.7251	0.9991	0.8810	0.9968	0.9944	0.9910	0.9884	0.9333	0.9384	0.9819	0.9898	0.9968	0.9816	0.9555	0.9991
0.873	6	C_8	Soil and groundwater pollution sites	0.9441	0.9979	0.8865	0.6611	0.7243	0.9979	0.9039	0.8112	0.7185	0.4469	0.9944	0.7974	0.8902	0.7318	0.9483	0.9968	0.9568	0.7808	0.6689	0.9991	0.3334	0.9399	0.9944	0.9910	0.9309	0.9379	0.9431	0.9819	0.9898	0.9968	0.9249	0.9798	0.9991
0.855	9	C_9	Environmental protection volunteers in attendance	0.7442	0.9850	0.9907	0.7115	0.9072	0.9630	0.8454	0.8276	0.7354	0.4572	0.7819	0.7749	0.8431	0.8742	0.8607	0.7908	0.9602	0.8608	0.6986	0.9510	0.7750	0.8058	0.9113	0.9394	0.9072	0.8867	0.8581	0.9972	0.9216	0.9845	0.8235	0.8718	0.9745
0.834	10	C_{10}	Farms breeding over 2,000 waterfowl	0.9871	0.9979	0.9933	0.6611	0.9711	0.9979	0.9039	0.8256	0.8478	0.4469	0.9944	0.7566	0.9500	0.6973	0.9917	0.9239	0.7819	0.7941	0.6689	0.9991	0.6360	0.5577	0.8736	0.9676	0.4758	0.9040	0.7244	0.9819	0.6281	0.9968	0.9491	0.9555	0.6694

Table E Corresponding Weights of Each Impact Factor in Grey Multi-attribute Decision-making Analysis Original Data

	<div>Area</div> <div>Factor</div>	Cigu District	Danei District	Shanshang District	West Central District	Rende District	Lioujia District	North District	Zuozhen District	Yongkang District	Yujing District	Baihe District	Anping District	Anding District	Annan District	Sigang District	Jiali District	Guantian District	Dongshan District	East District	Nanhua District	South District	Houbi District	Liouying District	Jiangjiyun District	Madou District	Xinhua District	Xinshi District	Nanxi District	Xuejia District	Longqi District	Guiren District	Guanmiao District	Yanshui District
Standard sequence	Positive households	7	2	6	438	195	2	91	199	12	1057	5	275	10	371	11	3	19	240	423	1	489	3	5	8	52	1	6	16	9	3	46	40	1
C ₁	Annual average temperature (°C)	24	24	24	23	23	24	24	23	24	23	23	24	24	24	24	24	24	23	23	23	24	24	24	24	24	24	24	23	24	24	24	24	24
C ₂	Annual average rainfall (mm)	1651	2200	2057	2194	2111	2011	2096	2269	2075	2387	2114	2096	1828	2019	1783	1998	1925	2102	2094	2613	2166	2049	1834	1616	1795	1948	1921	2484	1602	2229	2105	2071	1623
C ₃	Population density	210	142	264	12295	1470	332	19183	66	5765	187	228	5945	976	1784	736	1527	304	171	14790	52	4612	338	351	478	830	705	759	90	489	64	1222	645	495
C ₄	Number of containers of respondents	699	390	464	8162	2126	409	11748	559	14533	484	489	6059	365	8933	695	399	831	700	10283	437	7819	486	570	634	945	308	475	667	521	930	856	940	408
C ₅	Spray times	5	2	2	183	29	2	289	2	254	20	3	130	10	196	4	9	1	14	308	1	254	2	3	2	15	37	11	1	4	2	35	12	3
C ₆	Total number of sprayers	58	9	2	12559	594	16	13390	2	8110	544	12	3270	100	6971	10	130	1	382	14620	1	13031	8	10	3	141	687	200	1	35	9	710	178	12
C ₇	Number of vector control operators	1	1	1	7	7	1	7	1	13	1	1	5	1	10	1	1	1	1	13	1	7	1	1	1	2	2	2	1	1	1	2	1	1
C ₈	Soil and groundwater pollution sites	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C ₉	Environmental protection volunteers in attendance	4332	219	205	1319	1547	505	3563	301	4601	619	3506	385	2437	3570	2152	3300	787	1465	783	652	3470	3011	1273	912	2011	1589	2124	192	1179	240	3302	2388	340
C ₁₀	Farms breeding over 2,000 waterfowl	1	0	0	0	12	0	0	1	9	0	0	0	3	0	1	4	14	1	0	0	0	37	7	2	54	5	18	0	28	0	0	0	23

Table A Corresponding Weights of Each Impact Factor of Grey Multi-attribute Decision-making Analysis Formula 13

	<div>Area</div> <div>Factor</div>	Cigu District	Danei District	Shanshang District	West Central District	Rende District	Lioujia District	North District	Zuozhen District	Yongkang District	Yujing District	Baihe District	Anping District	Anding District	Annan District	Sigang District	Jiali District	Guantian District	Dongshan District	East District	Nanhua District	South District	Houbi District	Liouying District	Jiangjiyun District	Madou District	Xinhua District	Xinshi District	Nanxi District	Xuejia District	Longqi District	Guiren District	Guanmiao District	Yanshui District
Standard	Positive households	0.06	0.02	0.05	3.57	1.59	0.02	0.74	1.62	0.10	8.62	0.04	2.24	0.08	3.03	0.09	0.02	0.15	1.96	3.45	0.01	3.99	0.02	0.04	0.07	0.42	0.01	0.05	0.13	0.07	0.02	0.38	0.33	0.01

sequ ence																																				
C ₁	Annual average temperature (°C)	1.01	1.00	1.01	0.99	0.99	1.00	1.00	0.99	1.00	0.99	1.00	1.01	1.00	1.01	1.01	1.00	0.99	0.99	0.99	1.01	1.00	1.00	1.00	1.01	1.01	1.01	0.99	1.00	1.00	1.00	1.01	1.00	1.00	1.00	
C ₂	Annual average rainfall (mm)	0.81	1.08	1.01	1.08	1.04	0.99	1.03	1.12	1.02	1.17	1.04	1.03	0.90	0.99	0.88	0.98	0.95	1.03	1.03	1.29	1.07	1.01	0.90	0.80	0.88	0.96	0.95	1.22	0.79	1.10	1.04	1.02	0.80		
C ₃	Population density	0.09	0.06	0.11	5.24	0.63	0.14	8.17	0.03	2.45	0.08	0.10	2.53	0.42	0.76	0.31	0.65	0.13	0.07	6.30	0.02	1.96	0.14	0.15	0.20	0.35	0.30	0.32	0.04	0.21	0.03	0.52	0.27	0.21		
C ₄	Number of containers of respondents	0.27	0.15	0.18	3.19	0.83	0.16	4.60	0.22	5.69	0.19	0.19	2.37	0.14	3.50	0.27	0.16	0.33	0.27	4.02	0.17	3.06	0.19	0.22	0.25	0.37	0.12	0.19	0.26	0.20	0.36	0.33	0.37	0.16		
C ₅	Spray times	0.09	0.04	0.04	3.27	0.52	0.04	5.17	0.04	4.54	0.36	0.05	2.33	0.18	3.51	0.07	0.16	0.02	0.25	5.51	0.02	4.54	0.04	0.05	0.04	0.27	0.66	0.20	0.02	0.07	0.04	0.63	0.21	0.05		
C ₆	Total number of sprayers	0.03	0.00	0.00	5.47	0.26	0.01	5.83	0.00	3.53	0.24	0.01	1.42	0.04	3.03	0.00	0.06	0.00	0.17	6.36	0.00	5.67	0.00	0.00	0.00	0.06	0.30	0.09	0.00	0.02	0.00	0.31	0.08	0.01		
C ₇	Number of vector control operators	0.34	0.34	0.34	2.36	2.36	0.34	2.36	0.34	4.38	0.34	0.34	1.68	0.34	3.37	0.34	0.34	0.34	0.34	4.38	0.34	2.36	0.34	0.34	0.34	0.67	0.67	0.67	0.34	0.34	0.34	0.67	0.34	0.34		
C ₈	Soil and groundwater pollution sites	0.06	0.02	0.05	3.57	1.59	0.02	0.74	1.62	0.10	8.62	0.04	2.24	0.08	3.03	0.09	0.02	0.15	1.96	3.45	0.01	3.99	0.02	0.04	0.07	0.42	0.01	0.05	0.13	0.07	0.02	0.38	0.33	0.01		
C ₉	Environmental protection volunteers in attendance	2.45	0.12	0.12	0.75	0.88	0.29	2.02	0.17	2.61	0.35	1.99	0.22	1.38	2.02	1.22	1.87	0.45	0.83	0.44	0.37	1.96	1.70	0.72	0.52	1.14	0.90	1.20	0.11	0.67	0.14	1.87	1.35	0.19		
C ₁₀	Farms breeding over 2,000 waterfowl	0.15	0.00	0.00	0.00	1.80	0.00	0.00	0.15	1.35	0.00	0.00	0.45	0.00	0.15	0.60	2.10	0.15	0.00	0.00	0.00	5.55	1.05	0.30	8.10	0.75	2.70	0.00	4.20	0.00	0.00	0.00	3.45			

	Area Factor	Cigu District	Danei District	Shanshang District	West Central District	Rende District	Lioujia District	North District	Zuozhen District	Yongkang District	Yujing District	Baihe District	Anping District	Anding District	Annan District	Sigang District	Jiali District	Guantian District	Dongshan District	East District	Nanhua District	South District	Houbi District	Liouying District	Jiangjiyun District	Madou District	Xinhua District	Xinshi District	Nanxi District	Xuejia District	Longqi District	Guiren District	Guanmiao District	Yanshuei District
Standard sequence	Positive households	0.0571	0.0163	0.0489	3.5724	1.5905	0.0163	0.7422	1.6231	0.0979	8.6211	0.0408	2.2430	0.0816	3.0260	0.0897	0.0245	0.1550	1.9575	3.4501	0.0082	3.9884	0.0245	0.0408	0.0652	0.4241	0.0082	0.0489	0.1305	0.0734	0.0245	0.3752	0.3262	0.0082
C ₁	Annual average temperature (°C)	0.9497	0.9863	0.9579	2.5783	0.6049	0.9820	0.2561	0.6290	0.9047	7.6270	0.9533	1.2446	0.9253	2.0234	0.9171	0.9824	0.8476	0.9634	2.4560	0.9774	2.9816	0.9781	0.9575	0.9373	0.5827	0.9987	0.9579	0.8551	0.9292	0.9781	0.6231	0.6806	0.9902
C ₂	Annual average rainfall (mm)	0.7553	1.0662	0.9632	2.4929	0.5517	0.9732	0.2891	0.5066	0.9231	7.4466	0.9994	1.2116	0.8179	2.0325	0.7876	0.9587	0.7922	0.9232	2.4197	1.2776	2.9226	0.9837	0.8616	0.7299	0.4591	0.9504	0.8963	1.0918	0.7149	1.0723	0.6606	0.6928	0.7904
C ₃	Population density	0.0325	0.0440	0.0635	1.6626	0.9645	0.1249	7.4256	1.5948	2.3567	8.5415	0.0563	0.2884	0.3339	2.2665	0.2239	0.6257	0.0255	1.8849	2.8473	0.0138	0.2047	0.1194	0.1087	0.1381	0.0706	0.2918	0.2741	0.0920	0.1346	0.0028	0.1451	0.0516	0.2027
C ₄	Number of containers of respondents	0.2165	0.1363	0.1326	0.3782	0.7585	0.1437	3.8553	1.4043	5.5896	8.4317	0.1506	0.1282	0.0613	0.4700	0.1823	0.1317	0.1702	1.6835	0.5742	0.1629	0.9284	0.1657	0.1823	0.1829	0.0543	0.1124	0.1370	0.1305	0.1305	0.3395	0.0402	0.0416	0.1515

C_5	Spray times	0.0323	0.0195	0.0132	0.2992	1.0718	0.0195	4.4269	1.5873	4.4452	8.2634	0.0129	0.0822	0.0973	0.4797	0.0182	0.1365	0.1371	1.7071	2.0589	0.0097	0.5547	0.0113	0.0129	0.0295	0.1558	0.6536	0.1478	0.1126	0.0019	0.0113	0.2508	0.1116	0.0455
C_6	Total number of sprayers	0.0318	0.0124	0.0481	1.8948	1.3319	0.0093	5.0867	1.6222	3.4326	8.3843	0.0356	0.8195	0.0380	0.0087	0.0854	0.0321	0.1545	1.7912	2.9143	0.0077	1.6843	0.0210	0.0364	0.0639	0.3627	0.2909	0.0381	0.1301	0.0582	0.0206	0.0661	0.2488	0.0029
C_7	Number of vector control operators	0.2796	0.3204	0.2878	1.2153	0.7667	0.3204	1.6149	1.2863	4.2797	8.2844	0.2960	0.5593	0.2552	0.3414	0.2470	0.3123	0.1818	1.6208	0.9275	0.3286	1.6312	0.3123	0.2960	0.2715	0.2493	0.6653	0.6245	0.2062	0.2633	0.3123	0.2983	0.0105	0.3286
C_8	Soil and groundwater pollution sites	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
C_9	Environmental protection volunteers in attendance	2.3959	0.1077	0.0671	2.8255	0.7145	0.2696	1.2753	1.4526	2.5074	8.2706	1.9445	2.0250	1.2984	1.0045	1.1288	1.8441	0.2907	1.1279	3.0067	0.3610	2.0235	1.6805	0.6800	0.4512	0.7146	0.8916	1.1538	0.0218	0.5942	0.1114	1.4945	1.0259	0.1844
C_{10}	Farms breeding over 2,000 waterfowl	0.0929	0.0163	0.0489	3.5724	0.2095	0.0163	0.7422	1.4731	1.2521	8.6211	0.0408	2.2430	0.3684	3.0260	0.0603	0.5755	1.9450	1.8075	3.4501	0.0082	3.9884	5.5255	1.0092	0.2348	7.6759	0.7418	2.6511	0.1305	4.1266	0.0245	0.3752	0.3262	3.4418

Table H Corresponding Weights of Each Impact Factor of Grey Multi-attribute Decision-making Analysis Formula 17~19

Grey correl ation coeffi cient	Ran king	Area Factor	Cigu District	Danci District	Shanshang District	West Central District	Rende District	Licoujia District	North District	Zuozhen District	Yongkang District	Yujing District	Baihe District	Anping District	Anding District	Annan District	Sigang District	Jiali Distric t	Guantian District	Dongshan District	East Distric t	Nanhua District	South District	Houbi District	Liouying District	Jiangiyun District	Madou District	Xinhua District	Xinshi District	Nanxi District	Xuejia District	Longqi District	Guiren District	Guanmiao District	Yanshuai District
0.794	8	C_1 Annual average temperature (°C)	0.8195	0.8138	0.8182	0.6257	0.8769	0.8145	0.9439	0.8727	0.8265	0.3611	0.8189	0.7760	0.8233	0.6805	0.8246	0.8144	0.8357	0.8173	0.6370	0.8152	0.5911	0.8151	0.8182	0.8214	0.8809	0.8119	0.8182	0.8345	0.8227	0.8151	0.8737	0.8636	0.8132
0.799	7	C_2 Annual average rainfall (mm)	0.8509	0.8017	0.8174	0.6336	0.8865	0.8158	0.9371	0.8948	0.8236	0.3666	0.8118	0.7806	0.8405	0.6796	0.8455	0.8181	0.8447	0.8236	0.6405	0.7714	0.5959	0.8142	0.8334	0.8552	0.9037	0.8194	0.8279	0.7979	0.8578	0.8008	0.8671	0.8615	0.8450
0.864	6	C_3 Population density	0.9925	0.9899	0.9855	0.7216	0.8172	0.9718	0.3673	0.7299	0.6465	0.3354	0.9871	0.9373	0.9281	0.6554	0.9506	0.8732	0.9941	0.6958	0.6022	0.9968	0.6804	0.9730	0.9754	0.9690	0.9839	0.9366	0.9402	0.9791	0.9697	0.9993	0.9674	0.9882	0.9551
0.891	3	C_4 Number of containers of respondents	0.9522	0.9693	0.9701	0.9193	0.8504	0.9677	0.5279	0.7543	0.4354	0.3383	0.9662	0.9711	0.9860	0.9017	0.9594	0.9704	0.9620	0.7191	0.8825	0.9636	0.8228	0.9630	0.9594	0.9593	0.9876	0.9746	0.9692	0.9706	0.9706	0.9270	0.9908	0.9904	0.9660
0.894	2	C_5 Spray times	0.9926	0.9955	0.9970	0.9351	0.8009	0.9955	0.4933	0.7309	0.4923	0.3428	0.9970	0.9813	0.9779	0.8999	0.9958	0.9693	0.9692	0.7163	0.6768	0.9977	0.8860	0.9974	0.9970	0.9932	0.9651	0.8683	0.9668	0.9745	0.9996	0.9974	0.9450	0.9748	0.9896
0.879	4	C_6 Total number of sprayers	0.9927	0.9971	0.9890	0.6947	0.7640	0.9978	0.4587	0.7266	0.5567	0.3396	0.9918	0.8403	0.9913	0.9980	0.9806	0.9926	0.9654	0.7064	0.5966	0.9982	0.7190	0.9952	0.9916	0.9854	0.9224	0.9368	0.9912	0.9707	0.9867	0.9953	0.9849	0.9454	0.9993
0.868	5	C_7 Number of vector control operators	0.9391	0.9308	0.9374	0.7801	0.8490	0.9308	0.7275	0.7702	0.5018	0.3422	0.9358	0.8852	0.9441	0.9266	0.9458	0.9325	0.9595	0.7267	0.8229	0.9292	0.7255	0.9325	0.9358	0.9408	0.9453	0.8663	0.8735	0.9543	0.9424	0.9325	0.9353	0.9976	0.9292
0.998	1	C_8 Soil and groundwater pollution sites	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.794	9	C_9 Environmental protection volunteers in attendance	0.6428	0.9756	0.9847	0.6040	0.8578	0.9411	0.7717	0.7479	0.6322	0.3426	0.6891	0.6804	0.7685	0.8110	0.7925	0.7004	0.9368	0.7926	0.5891	0.9227	0.6805	0.7195	0.8637	0.9053	0.8578	0.8286	0.7889	0.9950	0.8789	0.9748	0.7425	0.8078	0.9590
0.775	10	C_{10} Farms breeding over 2,000 waterfowl	0.9789	0.9962	0.9888	0.5468	0.9536	0.9962	0.8531	0.7453	0.7749	0.3333	0.9906	0.6577	0.9213	0.5875	0.9862	0.8822	0.6891	0.7046	0.5554	0.9981	0.5194	0.4382	0.8103	0.9484	0.3596	0.8532	0.6192	0.9706	0.5109	0.9944	0.9199	0.9296	0.5560

Table I Grey Multi-attribute Decision-making Formula 7~12

			Result (r_j)		1.29	2.17	2.96	3.05	2.09	1.67	3.15	2.97	2.69	2.67	1.47	2.81	1.41	2.39	1.47	1.48	2.62	1.69	3.26	2.60	2.66	2.04	1.59	1.85	3.08	2.34	2.52	3.15	1.77	2.15	2.36	1.49	2.06			
Corresponding weight of impact factor (w_i)	Effect measure	Factor	Area	Cigu District	Danei District	Shanshan District	West Central District	Rendeh District	Lioujia District	North District	Zuozhe District	Yongkan District	Yujing District	Baihe District	Anping District	Anding District	Annan District	Sigang District	Jiali District	Guantian District	Dongshan District	East District	Nanhu District	South District	Houbi District	Liouying District	Jiangyuan District	Madoxa District	Xinhu District	Xinshi District	Nanxi District	Xuejia District	Longqi District	Guiren District	Guanmiao District	Yanshuei District				
				0.794	C	C_1	Annual average temperature (°C)	0.83	0.83	0.83	0.82	0.81	0.82	0.82	0.83	0.82	0.82	0.82	0.83	0.83	0.83	0.83	0.83	0.82	0.82	0.81	0.83	0.83	0.82	0.83	0.83	0.83	0.81	0.83	0.83	0.82	0.83	0.82		
				0.799	A	C_2	Annual average rainfall (mm)	0.63	0.84	0.79	0.84	0.81	0.77	0.80	0.87	0.79	0.91	0.81	0.80	0.70	0.77	0.68	0.76	0.74	0.80	0.80	1.00	0.83	0.78	0.70	0.62	0.69	0.75	0.74	0.95	0.61	0.85	0.81	0.79	0.62
				0.864	A	C_3	Population density	0.01	0.01	0.01	0.64	0.08	0.02	1.00	0.00	0.30	0.01	0.01	0.31	0.05	0.09	0.04	0.08	0.02	0.01	0.77	0.00	0.24	0.02	0.02	0.02	0.04	0.04	0.04	0.00	0.03	0.00	0.06	0.03	0.03
				0.891	A	C_4	Number of containers of respondents	0.05	0.03	0.03	0.56	0.15	0.03	0.81	0.04	1.00	0.03	0.03	0.42	0.03	0.61	0.05	0.03	0.06	0.05	0.71	0.03	0.54	0.03	0.04	0.04	0.07	0.02	0.03	0.05	0.04	0.06	0.06	0.06	0.03
				0.894	B	C_5	Spray times	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				0.879	C	C_6	Total number of sprayers	0.02	0.13	1.00	0.00	0.00	0.07	0.00	1.00	0.00	0.00	0.09	0.00	0.01	0.00	0.11	0.01	0.00	0.00	0.00	0.00	0.14	0.11	0.50	0.01	0.00	0.01	0.00	0.03	0.13	0.00	0.01	0.09	
				0.868	C	C_7	Number of vector control operators	0.00	0.00	0.00	0.17	0.17	0.00	0.17	0.00	0.08	0.00	0.00	0.25	0.00	0.11	0.00	0.00	0.00	0.08	0.00	0.17	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
				1.000	A	C_8	Soil and groundwater pollution sites	0.01	0.00	0.01	0.41	0.18	0.00	0.09	0.19	0.01	1.00	0.00	0.26	0.01	0.35	0.01	0.00	0.02	0.23	0.40	0.00	0.46	0.00	0.00	0.01	0.05	0.00	0.01	0.02	0.01	0.00	0.04	0.04	0.00
				0.794	B	C_9	Environmental protection volunteers in attendance	0.04	0.88	0.94	0.15	0.12	0.38	0.05	0.64	0.04	0.31	0.05	0.50	0.08	0.05	0.09	0.06	0.24	0.13	0.25	0.29	0.06	0.06	0.15	0.21	0.10	0.12	0.09	1.00	0.16	0.80	0.06	0.08	0.56
				0.775	A	C_{10}	Farms breeding over 2,000 waterfowl	0.02	0.00	0.00	0.00	0.22	0.00	0.00	0.02	0.17	0.00	0.00	0.00	0.06	0.00	0.02	0.07	0.26	0.02	0.00	0.00	0.00	0.69	0.13	0.04	1.00	0.09	0.33	0.00	0.52	0.00	0.00	0.00	0.43

Note: A=upper limit effect measure B=lower limit effect measure C=specific effect measure

Figures

Figure 1

Flow Chart of Research Method

Figure 2

Green and Sustainable Remediation Framework Planned by Taiwan Environmental