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Extracting Evaluation Factors of Social Resilience in Water Resource Protection Areas Using the Fuzzy Delphi Method

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Abstract: Development in water resource protection areas frequently grapples with balancing environmental sustainability and local economic growth. Consequently, a nuanced assessment of social resilience becomes imperative. This research presented a case study of the Water Resource Protection Area in Taipei, gauging its social resilience across five dimensions: "social support function", "inclusive governance", "economic allocation", "built environment", and "resources for sustainability". From these, 49 influential factors that could impact the social resilience of the water resource protection area were discerned. Through the engagement of 21 experts via questionnaires and subsequent analysis using the Fuzzy Delphi method, this study identified 23 core factors. Notably, influential factors pertaining to the "social support function" significantly impacted the water resource protection area. The findings aim to streamline the evaluation of social resilience in water resource protection areas, potentially guiding future research utilizing the multi-criteria decision-making (MCDM) method and steering industrial developments in these areas.

Keywords: social resilience; evaluation factor; water resource protection area; fuzzy Delphi method; multi-criteria decision-making

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1. Introduction

Social resilience refers to building resilient communities so that they can resist and recover in the event of a disaster or change. The five key directions for building social resilience include sustainable human resources, community governance, equitable distribution of economic resources, the construction environment and facilities, and natural resources [1]. Sustainable operation includes not only resilience but also basic sustainability. It refers to the ability to maintain human, environmental, and social balance in future resources, economic planning and investment, and industrial, technological, and institutional development while meeting basic human needs such as food, housing, and resource use. That is, the higher the social resilience, the more flexible the community will be in terms of recovery and development, while the lower the social resilience, the more limited the development and the worse the speed and condition of recovery from disaster will be [2]. The United Nations Ocean Sustainable Development Plan points out that in order to create an ideal blueprint for the future, sustainable ocean management based on science, data, and services is necessary to achieve social and economic prosperity in order to truly implement environmental conservation and achieve sustainability. It is clear from this that in order to achieve sustainability, the areas to focus on include the economy, technological development, public education, social balance, etc. Only when these conditions are met can we achieve sustainability in the living environment, natural environment, social development, and economic development of human society [3].

Only with sustainability can the industry continue to develop with stability. In terms of maintaining sustainability, in addition to consolidating infrastructures such as transportation in rural areas, discovering the characteristics of agricultural industries and marketing them by focusing on their strengths, such as local specialties, cultural assets, tourist attractions, cultural history, etc., have helped to open up more possibilities for rural development [4]. Through the development or combination of different agricultural industries in rural areas, different-oriented results can be achieved, such as the combination of a production factory with a processing plant and tourism, which result in a new model of business that, at the right time and location, may promote economic development. For example, in small and medium-sized cities in Egypt, new tourism development models can be used to increase income and maintain a balance with nature [5].

The Taipei Water Resource Protection Area supplies clean drinking water for downstream cities, including the Peishih River and its tributaries upstream of the Taipei Feitsui Reservoir, which are responsible for supplying drinking water to a population of 6 million people in the Taipei Metro Area. In the particular context of the Water Resource Protection Area, constraints will put them in an unequal position for development, given that water source management is the primary concern for the areas [6]. Cities within the governance of water quality and resources, coupled with the restrictions on development due to the water resource protection areas, will need to adopt a different business model for development [7]. Especially in rural areas where the agricultural industry is the only source of development, it is necessary to obtain the maximum benefits through the comprehensive and sustainable development of the industry. Regardless of the level of integration of agricultural industries, it will be influenced by flexibility, resilience to disasters, and post-disaster recovery capabilities. For example, a rural area will develop through tourism. If the area has mudslides or soil problems, it can easily damage the ecology and cause more problems [8]. Therefore, after the environment in different regions is affected by disasters, other restoration methods should be set according to the region's characteristics, such as using or changing to locally appropriate methods for restoration based on climate, population age, etc. [9].

In terms of social resilience, the community's awareness is also likely to impact industrial transformation and public-sector cooperation. For example, if the community or local public sector has allocated an adequate budget, it becomes easier to implement the policy if there is also a consensus among local residents. In addition, the rationality of the public sector's budgeting also impacts the agricultural industry [10]. In summary, the issue of sustainability in agriculture is influenced by social resilience, not only by the coordination of different levels of agricultural industries to generate maximum benefits, but also by the sustainability of such operations [11].

There are some limitations in water resource protection areas, especially those with heavy dependence on the agricultural industry, due to the conservation of the environment. However, the restrictions on developing other industries will reduce job opportunities, resulting in population loss [6], leading to the aging or migration of the population, specifically those young and middle-aged residents. Local development also stagnates [12]. To achieve sustainable development, it is necessary to solve population problems while allowing the environment, technology, and human habitation to coexist and prosper. It is also a requirement and standard for local development in the modern era [13]. At the same time, industrial development can be integrated with local characteristics to maximize and further enhance the marketing of special agricultural industries, allowing local development to progress [14]. Therefore, the social structure is important for the development process and direction of the agricultural industry, and if local marketing is continued, it will lead to sustainability and demonstrate the resilience of the local community to overcome different problems, that is, social resilience [15].

In the case of the water resource protection area, although there are regulatory restrictions that prevent the comprehensive development of secondary and tertiary industries, in terms of ecological issues, the restrictions on development have preserved large areas of primitive forests in the area, making the environment less susceptible to pollution and damage. Therefore, this is positive and good for biodiversity [6,7]. The perfection of biodiversity also indicates good ecological resilience, and at the same time, when a region suffers disaster or change, its social adaptability is relatively higher [16]. In the social aspect, it also affects the agricultural industry. In terms of social resilience, it may benefit the water resource protection area by giving it sustainability, structural transformation, recovery from disaster, etc. Thus, social resilience is an important and worthwhile topic for a region.

This study involves a water resource protection area in the Pinglin District of Taipei. The Fuzzy Delphi method was used to evaluate the important criteria for developing its social resilience, for which we would then screen out the essential principles from the core factors for further analysis. The purpose of this study is three-fold: (1) to use social resilience evaluation as an important component in constructing the assessment criteria for water resource protection areas; (2) to construct a series of evaluation framework models and validate them through real-world cases; and (3) to establish this study as a reference for future development strategies of social resilience in water resource protection areas.

2. Materials and Methods

Some possible factors influence the decision-making process in social resilience, such as social composition, economic development, natural resources, etc. Therefore, before constructing and exploring the development of a specific area with social resilience, it is necessary to collect all possible influencing factors and objectively select the crucial ones to evaluate as the criteria for decision-making. Since many factors and evaluation criteria affect the decision-making process, the selection method for the development plan must conform to the characteristics and features of the MCDM method, including the characteristics of screen composition and evaluation calculation. Therefore, this study adopts the Fuzzy Delphi method of MCDM as the methodology, and the overall research framework is shown in Figure 1.

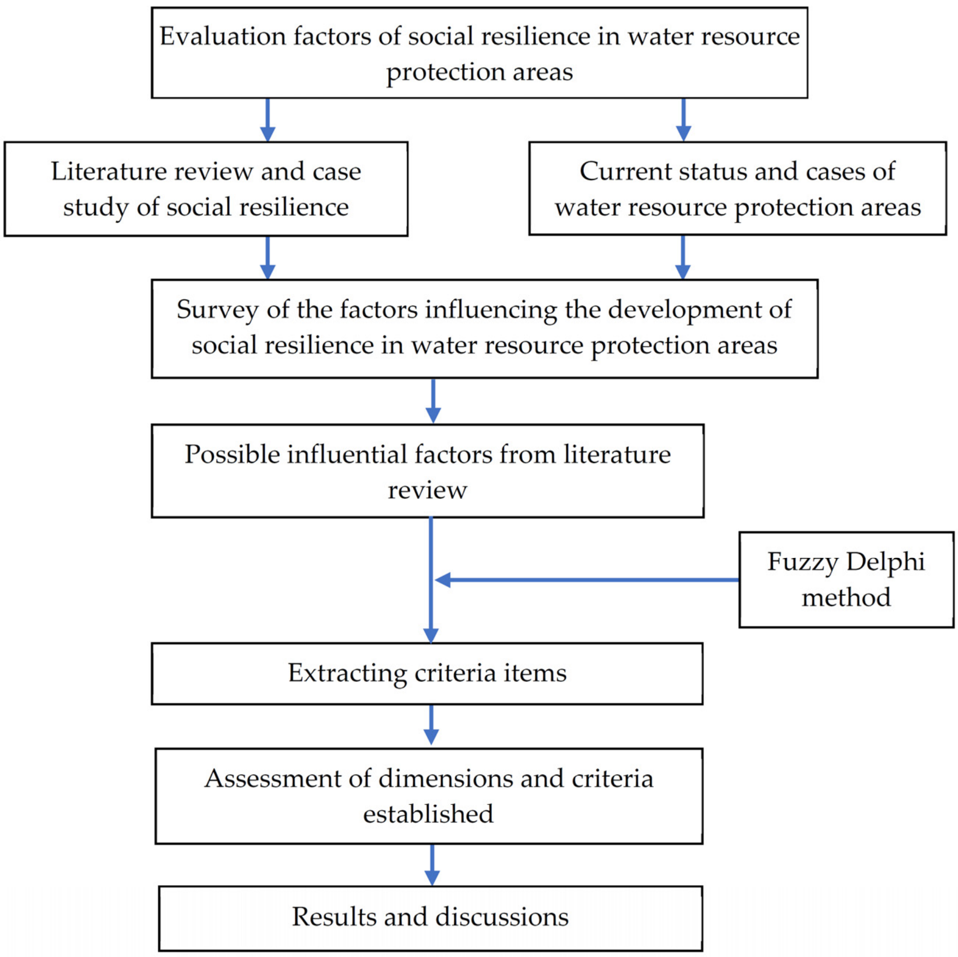

Figure 1. Research framework.

2.1. MCDM

MCDM is a method that uses an off-the-shelf approach to help people make decisions based on their preferences in situations where multiple conflicting criteria exist. MCDM is used to re-examine the smaller elements and influential factors, which can end up with a precise or fuzzy result, where the impact results are time intervals [17]. Decision-making requires multiple considerations, with a wide range of factors to be evaluated and not solely determined by a single criterion. Therefore, if we need to make determinations with limited resources, we must select the best scheme by means of data analysis. Accordingly, the decision-maker can analyze the problem to find the most appropriate direction and decision and proceed with it [18].

Experience has shown that MCDM can integrate information and technology and make stakeholder value visible so that decision-makers can more easily consider the interests of multiple parties, for which a single influential factor is integrated into an overall index that allows the decision level to be revealed in a ranked order [19]. Therefore, MCDM is a method of deciding on the best choice in complex situations. MCDM theory mainly considers factors and implementation contents. In the case where many criteria already exist, MCDM can be used to analyze the scope of different criteria further and, within this scope, find the most suitable choice [20]. We identified five dimensions and 49 influential factors through literature reviews, as shown in Tables 1 and 2.

Table 1. Dimensions and explanations.

Dimension	Explanation
Social support function	Support of the social system, such as gender, age, education, regional culture, public security, and population. The social support function is integration, communication, and inheritance.
Inclusive governance	Social resilience requires governance to support the agricultural industry, including identifying multiple stakeholders. It also involves inclusive and innovative management models, multicultural symbiosis, and access to public services.
Economic allocation	In addition to meeting residents' basic needs and gradually increasing wages, land utilization, medical care, resource information, social welfare, and technological development of the agricultural industry should also be allocated.
Built environment	It needs suitable facilities to become a viable place for agricultural product sales and public gatherings.
Resources for sustainability	The agricultural industries and resources must be sustainable to have strong resilience, for they may quickly recover from significant change or disaster.

Through a literature analysis, MCDM can be carried out in six steps: (1) formulate the problem; (2) determine requirements; (3) set goals; (4) determine various alternative solutions; (5) develop standards; and (6) determine and apply alternative selection techniques. The above were passed through function calculations to find the most appropriate choice based on the nature of the problem and the complexity of the decision-making process. Based on the characteristics of MCDM and the structural aspects of the research objectives, structure, and evaluation criteria, the framework of the model of MCDM for this study was developed, as shown in Figure 2.

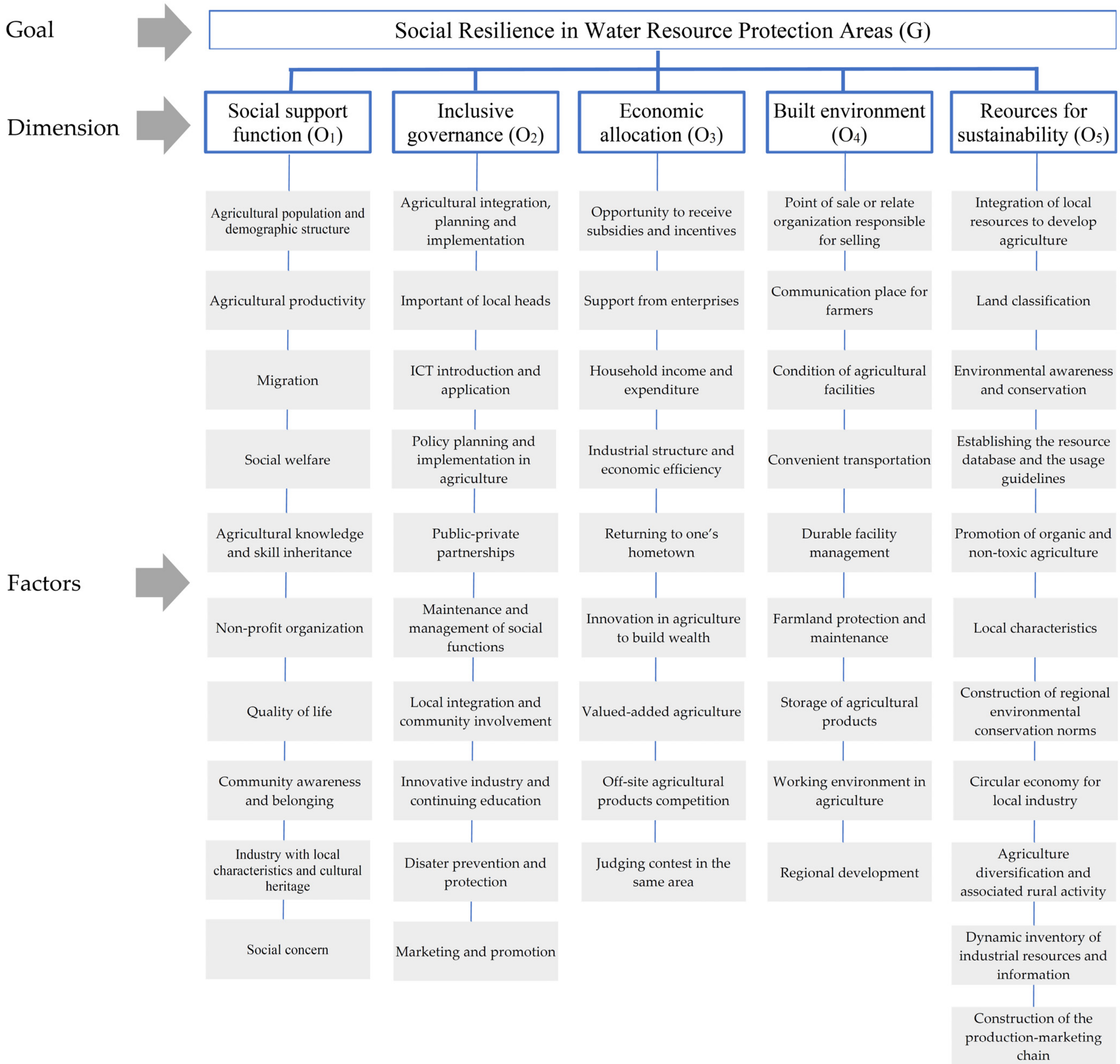

Figure 2. Possible influential factors.

Possible influencing factors have been collected based on relevant research literature, guidance methods, and reports from academic and research institutions. The criteria of impact factors extracted are based on relevant research reports such as competitive advantages, critical impact (success) factors, future development trends and prospects from the basic theory of resources. This study ultimately captured the key influencing factors of social resilience in developing water resource protection areas. It summarized 49 possible influencing factors that scholars and experts believed relevant.

Table 2. Dimensions, factors, and explanations.

Dimension	Factor (F)	Explanation	Reference
Social support function	Agricultural population and demographic structure	People in the agricultural industry and their demographic information from observing the density of land utilization to see if they are moving toward urbanization or ruralization.	[21,22]
	Agricultural productivity	Distribution of population to assess agricultural productivity.	[21,22]
	Migration	Observing the in-migration and out-migration of a place.	[22,23]
	Social welfare	Residents receiving subsidies or supports	[24,25]
	Agricultural knowledge and skill inheritance	The next generation acquiring agricultural knowledge and learning techniques.	[22,26]
	Non-profit organization	Playing the role of advocate will help social development.	[27]
	Quality of life	Health, employment, wealth, and education.	[23,28]
	Community awareness and belonging	Self-identity in a community may affect the amount of participation.	[23,28]
	Industry with local characteristics and cultural heritage	Industry with local characteristics and cultural heritage can help bring together a coherent development.	[28]
	Social concern	Caring for ethnic groups requires achieving ethnic harmony and providing social justice for all in the spirit of egoism and altruism.	[21,28]
Inclusive governance	Agricultural integration, planning, and implementation	Planning the development and following through on the steps for the community to grow.	[29,30]
	Importance of local heads	Determining the style of leadership, the vision, and policy implementation.	[29,31]
	ICT introduction and application	Smart agriculture can increase the quality and quantity of crops.	[32,33]
	Policy planning and implementation in agriculture	Appropriate policies in line with local conditions will encourage implementation to achieve the vision.	[27–29]
	Public–private partnerships	The cooperation between local organizations and the public sector is more realistic than the actual operating conditions.	[27,29]
	Maintenance and management of social functions	Laws mandate taxes, military service, and compulsory education.	[29,31]
	Local integration and community involvement	Participating in public affairs as part of human rights and needs.	[27,29,31]
	Innovative industry and continuing education	Implementation of a new system, process, or product.	[27]
	Disaster prevention and protection	Hardware and software for social resilience refer to infrastructure and community support, respectively.	[34]
	Marketing and promotion	Marketing and promotion help develop local industries and may become an example for other rural areas.	[23,29]
Economic allocation	Opportunity to receive subsidies and incentives	Providing subsidies or incentives to help residents in need and local development.	[21,29]
	Support from enterprises	A socially responsible enterprise will try to maximize profit and benefit society and the environment.	[29,30]
	Household income and expenditure	The average income reflects local development and the standard of living.	[28,29]
	Industrial structure and economic efficiency	Concluding the stability of an industry by observing its economic efficiency.	[30,35]
	Returning to one's hometown	Residents may choose to return to their hometown to open a store or pursue a career.	[30,35]
	Innovation in agriculture to build wealth	Agricultural innovation will generate profit by integrating industries or new technologies.	[35]
	Value-added agriculture	Differentiating types of processes from the original raw commodity.	[30]
	Off-site agricultural products competition	Comparing the strengths and weaknesses of agricultural products from different regions.	[23,28]
	Judging contests in the same area	Determining any peer cooperation or market competition through monopolizing the market will help check if the industry is healthy.	[28,30]
Built environment	Point of sale or related organization responsible for selling	Introducing products and helping people engage in social interaction.	[28]
	Communication place for farmers	A place for sharing ideas in the industry.	[31,35]
	Condition of agricultural facilities	Facilities in good condition can help improve the overall quality of a community.	[32,36]
	Convenient transportation	Transport is the key to efficient agricultural marketing.	[35]
	Durable facility management	The industrial environment must be well maintained and have good durability.	[30,37]
	Farmland protection and maintenance	Farmland protection and maintenance make the agri-related industry more sustainable.	[30]
	Storage of agricultural products	Available space for storing agricultural products.	[28]
	Working environment in agriculture	Creating a better working environment and minimizing occupational hazards.	[31,35]
	Regional development	Status of the development of secondary and tertiary industries in the region.	[35]

Table 2. *Cont.*

Dimension	Factor (F)	Explanation	Reference
Resources for sustainability	Integration of local resources to develop agriculture	The proportion of self-sufficiency and checking if the condition is proper.	[27,33]
	Land classification	Investigating the ratio of untapped green lands to lands for construction and cultivation.	[23,38]
	Environmental awareness and conservation	Awareness of natural ecological conservation to increase local sustainability.	[23,38]
	Establishing the resource database and the usage guidelines	Digitization of records and listing for protecting resources.	[21,23,38]
	Promotion of organic and non-toxic agriculture	Protecting soil and water resources and the ecological environment, and promoting eco-friendly agriculture.	[23,38]
	Local characteristics	Developing the uniqueness of the place by using local resources.	[36]
	Construction of regional environmental conservation norms	Stipulating relevant laws to protect the environment for better sustainability.	[33,39]
	Circular economy for local industry	Involves sharing, reusing, repairing, and recycling materials to achieve sustainability.	[29,40]
	Agriculture diversification and associated rural activity	Shifting traditional agriculture to other associated rural activities, such as recreational agriculture.	[21,30,41]
	Dynamic inventory of industrial resources and information	Agricultural and other industrial information in inventory to improve efficiency.	[42,43]
	Construction of the production-marketing chain	Creating a stable chain of production and marketing.	[30,44]

2.2. Fuzzy Delphi Method

The Fuzzy Delphi method starts with the Delphi method. The Delphi method identifies consensus and filters out the conclusions from the influences that may be relevant to the study through a group of experts, group communication, and objective questionnaires. This is a structured communication to construct conclusive opinions and a consensus anonymously for future planning. The RAND Corporation developed the Delphi method around the 1950s to solve national defense problems. It was successively used in government departments, industry and commerce, education, medical care, etc., or as a research method in various fields, such as evaluation, budgeting, selection methodology for planning, etc., from which a well-founded consensus can be found. This method has also become a survey method for many research units [45].

The basic assumptions of the Delphi survey method are as follows: (1) generally, group judgment is superior to individual judgment; (2) based on expert professional knowledge and experience to judge and predict future trends; (3) expert experience is more accurate and complete than the information of the general public; (4) maintaining the accuracy and impartiality of information through anonymous means; and (5) multiple questionnaires enhance the completeness of the questions. The traditional Delphi method also has the following six shortcomings: (1) the median and median values as the basis for selection, and selection can only be used as the direction and reference for determining strategies; (2) when aggregating expert opinions, preconceptions may filter out real experts' opinions, reducing or suppressing certain opinions; (3) the need for repeated questionnaires increases costs and decreases questionnaire effectiveness; (4) excellent experts may not necessarily participate; (5) it takes too long, and the progress is difficult to control; and (6) the questionnaire has limitations such as improper execution, limited feedback, and limited value [46].

Fuzzy theory is based on fuzzy sets, takes uncertain things as research targets, and accepts the fact that there are fuzzy phenomena. It is an extended concept of traditional set theory. The set in mathematics is a crisp set. However, fuzzy concepts exist in many situations. The nature and relationship of things are often vague. There are many fuzzy linguistic terms, but people tend to simplify and incorporate their own understanding of things in fuzzy situations. This ambiguity is distinctly different from an explicit set of dichotomies. However, fuzzy theory can still make correct judgments through approximate reasoning [47].

The Fuzzy Delphi method is a research method that was developed by Murry et al. in 1985 to incorporate fuzzy theory into the traditional Delphi method. The FDM has the characteristics of the traditional Delphi method and is suitable for collective decision-making, which can be used to assess the degree of consensus on fuzzy issues through expert opinions. The Fuzzy Delphi method can reduce the number of questionnaires, the original meaning of experts can also be clearly expressed, and the semantics of prediction can also be clearly expressed, considering the unavoidable ambiguity. A more precise selection conforms to experts' opinions and reaches a consensus [48].

The Fuzzy Delphi method has two important parts: (1) The process of triangular fuzzy numbers and defuzzification. After obtaining the data, the analysis obtains triangular fuzzy numbers by arranging the values of Li, Mi, and Ui for each factor. Li is the minimum value, Mi is the reasonable value, and Ui is the maximum. (2) Triangular fuzzy numbers are used to make a fuzzy scale (similar to the Likert scale), and variables are converted into fuzzy numbers. The selection value of the fuzzy scale uses an odd number. The process of defuzzification (solution value) is also the process of data analysis in the Fuzzy Delphi method; it is the process of determining the position or rank of each item or determining the position of each factor. Researchers can obtain the solution value in this process according to the formula A = 1/3 * (m1 + m2 + m3) [43]. The operation mode and steps of the Fuzzy Delphi method are explained as follows:

Step 1. Refer to the literature and compile the possible influencing factors (ui) (i is the number of factor items), and based on the expert questionnaire, obtain the evaluation values of the possible influencing factors.

Step 2. Collect experts' ratings (0~10) for each possible impact factor ui by means of a questionnaire.

Step 3. Establish the triangular fuzzy number (TFN) Fi (Li, Mi, Ui).

$$\text{Li} = \min(\text{Xij}) \text{ (minimum value), (j represents the jth expert; j = 1,2,...,n).} \quad (1)$$

$$\text{Mi} = \left(\sqrt[n]{\prod_{j=1}^{n} Xij} \right), \text{(intuitive values are taken as geometric means)} \quad (2)$$

$$\text{Ui} = \max(\text{Xij}), \text{ (maximum value), (j represents the jth expert; j = 1,2,...,n)} \quad (3)$$

Step 4. Solve the triangular fuzzy number Fi by the center of gravity method and convert (defuzzify) each triangular fuzzy number Fi into a single explicit evaluation value.

$$\text{Di: Di} = (\text{Li} + \text{Mi} + \text{Ui})/3 \quad (4)$$

Step 5. Set the threshold value (Si), which is generally the mean value. In this study, the mean value higher than the fuzzy value was used as the extracting threshold value, and those larger than the threshold value (Di > Si) were selected as the result criterion for the study, i.e., those with a possible influence factor.

$$\text{Di} < \text{Si were discarded} \quad (5)$$

2.3. Study Field

This study took the water resource protection area as the research background and field and discussed the ones in Pinglin District of New Taipei City for developing its social resilience.

The Taipei Water Resource Protection Area is located in the southeast corner of the Taipei Metropolitan Area, covering an area of 717 square kilometers. The administrative area includes 5 districts, namely Pinglin, Wulai, and part of Shiding, Shuangxi, and Xindian districts in New Taipei City. The water catchment area at the Feitsui Reservoir is 303 square kilometers, and the main water supply is for the whole of Taipei City and parts of Xindian District, Yonghe District, Zhonghe District, Sanchong District, and Xizhi District in New Taipei City. Among these areas, Pinglin and Wulai are classified as water resource protection areas, of which Pinglin is mostly agricultural and limited for other developments. This highlights the dilemma of such an area compared to others. Therefore, this paper will case study the water resource protection area in Pinglin. The administrative area of Pinglin District covers 171 square kilometers, with 80% of the land area being primitive forests, mainly composed of mountainous terrain. Numerous streams originate from this area, which has a natural environment and water resources. It is also the catchment area of the Feitsui Reservoir, which provides water for the six million people in northern Taiwan. The location is shown in Figure 3. Its importance is its designation as a water resource protection area since 1980, with the aim of protecting water quality, quantity, and the natural environment. Regulations, measures, and institutions have been established, but there are also restrictions on protecting the natural environment. To prevent local pollution, industry and development are prohibited, affecting the development of secondary and tertiary industries. More than 80% of the residents are engaged in tea-related industries. The population of Pinglin is currently around 7000. In recent years, the population structure has been dominated by the elderly, and there has been a serious population exodus due to the restriction of industries and limited job opportunities in Pinglin. With the aging population structure, the industry has the problem of succession. Although some young farmers have returned to their hometowns, the extent to which the population problem can be improved is still limited. In addition to the population structure, its living quality is also affected. For example, development cannot be carried out due to the restrictions on water source-specific areas, and the tap water penetration rate in the whole area is low. Most of the water sources residents use are mountain spring water and rainwater, and the water stability is insufficient. The district office built simple taps to solve the problem of unstable water sources for residents.

Therefore, in the context of limited field conditions, it is necessary to provide opportunities for the development of the region. In recent years, community tourism has become an opportunity to improve the area's economic conditions while promoting ecological tourism and organic agriculture and strengthening education for the public, communities, and stakeholders to maintain environmental resources such as water sources, soil, and water. There has also been a combination of industries, such as tea sugar, which combines the tea and processing industries. The tea industry combines service-oriented leisure agriculture with tea garden sightseeing, etc. The combination of the above industries, such as the combination of the primary and tertiary industries of the agricultural industry and tourism, has become the sixth level of the agricultural industry, which can also enhance social resilience. In summary, this study will explore the selection scheme of key influencing factors of social resilience in water resource protection areas and further compare and analyze them in the field.

This study chose Pinglin, a water resource protection area, as the study site because it is in the upper reaches of the reservoir and environmental conservation has become an important issue in local governance [6]. At present, the development of Pinglin is mainly focused on agricultural industries. Due to the legal restrictions for water resource protection areas, the area cannot even develop the secondary and tertiary industries, let alone the primary industry, because they will also produce pollution. Secondary industries are completely prohibited on the site. Under this limited background, the disadvantage of this site is that there can only be agriculture, such as crop cultivation, and animal husbandry cannot develop here because of animal excretion. Moreover, the cultivation of crops and the use of pesticides are limited. Although in today's social context the relationship between pesticide spraying and the environment has become a topic of concern, moving towards organic and friendly usage will inevitably increase insect pests and lead to less yield, making it impossible to develop large-scale agriculture [49]. In this context, there are issues of water resource protection and environmental conservation [7]. Despite the restrictions, Pinglin has the advantage of a unique natural environment that is pure without any contamination by crops or the spraying of pesticides. Strict law enforcement is the guarantee for any agricultural consumer product [50].

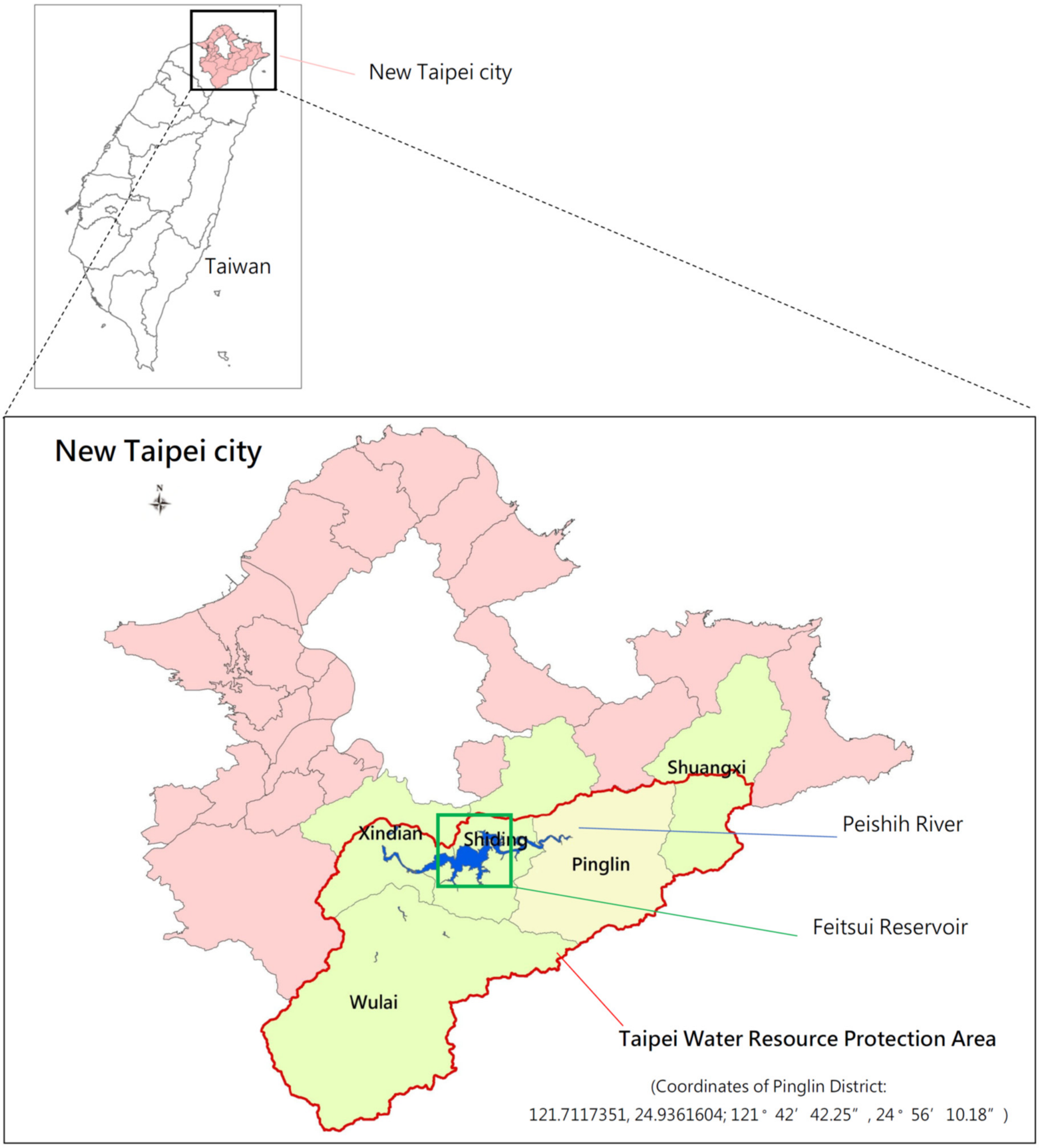

Figure 3. Location of the Taipei Water Resource Protection Area.

2.4. Evaluation Modeling (A Generalization of Possible Influencing Factors)

Continuing the above research methods, the MCDM model was used to construct this research based on the "Fuzzy Delphi method to explore the social resilience evaluation factors of water resource protection areas". The MCDM model was divided into three layers: objectives, dimensions, and selection criteria. First, the relevant literature was referred to, and the possible influential factors related to the research were summarized. Then, different dimensions of this issue were compiled according to the attributes of each factor. The dimensions of this construction model have mutual influence relationships, and there is interdependence among possible influencing factors under each dimension. As the dimensions already reflect the relationship between each other, the possible influencing factors under each dimension can be regarded as mutually independent in the group, which can simplify the complexity of the research problem, increase the operability of this model, and serve as a selection model for subsequent empirical case studies.

To explore the key influencing factors of social resilience on the development of water resource protection areas, five different dimensions were constructed through literature analysis, namely "social support function", "inclusive governance", "economic allocation", "built environment", and "resources for sustainability", in order to screen the possible influencing factors of social resilience on water resource protection areas.

3. Results

In order to screen out the influencing factors of social resilience in water resource protection areas by using the Fuzzy Delphi method, this research committee invited 21 experts in relevant work fields in water resource protection areas, who are individuals from the public sector, academic fields, local, and water source-specific areas and have shown great achievements in various fields, to fill out a Fuzzy Delphi questionnaire. The questionnaires were targeted at officials (government departments), industry (practical industries), and scholars (academic research), with questionnaires for each. Twenty-one questionnaires were distributed, and 21 valid questionnaires were collected. The questionnaire adopted three evaluations: intuitive value, acceptable maximum value, and minimum value. The evaluation value is an integer score of 0–10, with higher scores indicating greater importance. After summarizing the feedback from various experts, establish triangular fuzzy numbers for each possible influencing factor according to the equation. Then, by continuing with Equation (2), the triangular fuzzy number is converted into a clear evaluation value (level of importance). Afterwards, based on the actual situation and research needs, the threshold values (Sk = 6.12) for all dimensions would be uniformly set for extraction.

Through the above extraction operation, the 49 factors affecting social resilience and industrial development in water resource protection areas, originally categorized under the five major classification dimensions, were now reduced to 23 key influencing factors (marked as C). The results are summarized as follows: Under the social support function (O_1), four key influencing factors were selected from ten possible influencing factors, including agricultural productivity (C_1), agricultural knowledge and skill inheritance (C_2), quality of life (C_3), and industry with local characteristics and cultural heritage (C_4). For inclusive governance (O_2), the 10 possible influencing factors were reduced to five key ones, including the level of attention given by the importance of local heads (C_5), public–private partnership (C_6), local integration and community involvement (C_7), innovative industry and continuing education (C_8), and marketing and promotion (C_9). Under the economic allocation (O_3), four important key factors were selected from nine possible influencing factors, including strengthening the value of returning to one's hometown (C_{10}), innovation in agriculture to build wealth (C_{11}), value-added agriculture (C_{12}), and off-site agricultural product competition (C_{13}). From nine factors for the built environment (O_4), five key influencing factors were selected, including the point of sale or related organization responsible for selling (C_{14}), convenient transportation (C_{15}), farmland protection and maintenance (C_{16}), working environment in agriculture (C_{17}), and regional development (C_{18}). For the resources for sustainability (O_5), five key factors were selected out of eleven, including environmental awareness and conservation (C_{19}), construction of regional environmental conservation norms (C_{20}), circular economy for local industry (C_{21}), agriculture diversification and associated rural activity (C_{22}), and construction of the production-marketing chain (C_{23}). The results of the 23 key influencing factors obtained in total were compiled as the basis for subsequent research and evaluation of the development of social resilience in water resource protection areas. The remaining analysis results can be found in Table 3, and the bold font in the gray background represents the extraction results under this dimension.

Table 3. Evaluation and extracting results for each dimension.

Dimension	Influencing Factors	Minimum	Geometric Mean	Maximum	Triangular Fuzzy Number	Priority
Social support function (O_1)	Agricultural population and demographic structure	2	6.02	10	(2,6.02,10)	6.01
	Agricultural productivity	3	6.41	10	(3,6.41,10)	6.47
	Migration	1	5.84	10	(1,5.84,10)	5.61
	Social welfare	2	5.70	10	(2,5.70,10)	5.90
	Agricultural knowledge and skill inheritance	3	7.07	10	(3,7.07,10)	6.69
	Non-profit organization	1	5.56	10	(1,5.56,10)	5.52
	Quality of life	3	6.83	10	(3,6.83,10)	6.61
	Community awareness and belonging	2	5.97	10	(2,5.97,10)	5.99
	Industry with local characteristics and cultural heritage	3	6.69	10	(3,6.69,10)	6.56
	Social concern	2	6.16	10	(2,6.16,10)	6.05
Inclusive governance (O_2)	Agriculture integration planning and implementation	2	6.21	10	(2,6.21,10)	6.07
	Importance of local heads	2	6.67	10	(2,6.67,10)	6.22
	ICT (information and communications technology) introduction and application	1	6.26	10	(1,6.26,10)	5.75
	Policy planning and implementation in agriculture	1	6.60	10	(1,6.60,10)	5.87
	Public–private partnerships	2	6.70	10	(2,6.70,10)	6.23
	Maintenance and management of social functions	1	5.94	10	(1,5.94,10)	5.65
	Local integration and community involvement	2	6.96	10	(2,6.96,10)	6.32
	Innovative industry and continuing education	2	6.89	10	(2,6.89,10)	6.30
	Disaster prevention and protection	1	6.51	10	(1,6.51,10)	5.84
	Marketing and promotion	2	6.75	10	(2,6.75,10)	6.25
Economic allocation (O_3)	Opportunity to receive subsidies and incentives	2	5.51	10	(2,5.51,10)	5.84
	Support from enterprises	2	6.20	10	(2,6.20,10)	6.07
	Household income and expenditure	2	6.31	10	(2,6.31,10)	6.10
	Industrial structure and economic efficiency	1	6.67	10	(1,6.67,10)	5.89
	Returning to one's hometown	2	6.68	10	(2,6.68,10)	6.23
	Innovation in agriculture to build wealth	2	6.98	10	(2,6.98,10)	6.33
	Value-added agriculture	2	6.75	10	(2,6.75,10)	6.25
	Off-site agricultural product competition	2	6.58	10	(2,6.58,10)	6.19
	Judging contests in the same area	2	6.31	10	(2,6.31,10)	6.10
Built environment (O_4)	Points of sale or related organizations responsible for selling	2	6.70	10	(2,6.70,10)	6.23
	Communication place for farmers	2	6.21	10	(2,6.21,10)	6.07
	Condition of agriculture facilities	2	6.06	10	(2,6.06,10)	6.02
	Convenient transportation	2	6.73	10	(2,6.73,10)	6.24
	Durable facility management	2	6.29	10	(2,6.29,10)	6.10
	Farmland protection and maintenance	2	6.47	10	(2,6.47,10)	6.16
	Storage of agricultural products	1	6.31	10	(1,6.31,10)	5.77
	Working environment in agriculture	2	6.92	10	(2,6.92,10)	6.31
	Regional development	2	6.56	10	(2,6.56,10)	6.19
Resources for sustainability (O_5)	Integration of local resources to develop agriculture	2	6.31	10	(2,6.31,10)	6.10
	Land classification	1	6.80	10	(1,6.80,10)	5.93
	Environmental awareness and conservation	2	6.88	10	(2,6.88,10)	6.29
	Establishing the resource database and the usage guidelines	2	6.31	10	(2,6.31,10)	6.10
	Promotion of organic and non-toxic agriculture	2	6.33	10	(2,6.33,10)	6.11
	Local characteristics	2	6.29	10	(2,6.29,10)	6.10
	Construction of regional environmental conservation norms	2	7.12	10	(2,7.12,10)	6.37
	Circular economy for local industry	2	7.21	10	(2,7.21,10)	6.40
	Agriculture diversification and associated rural activity	2	6.78	10	(2,6.78,10)	6.26
	Dynamic inventory of industrial resources and information	2	6.34	10	(2,6.34,10)	6.11
	Construction of the production-marketing chain	2	6.99	10	(2,6.99,10)	6.33

Note: Threshold = 6.12 (the shaded area indicates the selected key influencing factors).

In this study, experts and scholars filled out questionnaires, and the Fuzzy Delphi method was used to explore the evaluation factors of social resilience in water resource protection areas. A total of 23 evaluation factors were screened out of 49, of which 26 were not selected. The key factors for whether they were selected might be the direct correlation between these areas and their industrial development or the extent of the coverage of factors. The more comprehensive the coverage, the more influential it will be and the easier it will be to select. For example, the scope involved in mastering productivity assets C_1 covered the population structure and the manpower available for production, which were closely related to industrial development and had a direct and widespread impact. The relative migration issue of the population only focused on the inflow and the outflow, and although its scope and agricultural development had mutual influence, it was not directly selected. The selected evaluation factors and their values are shown in Figure 4.

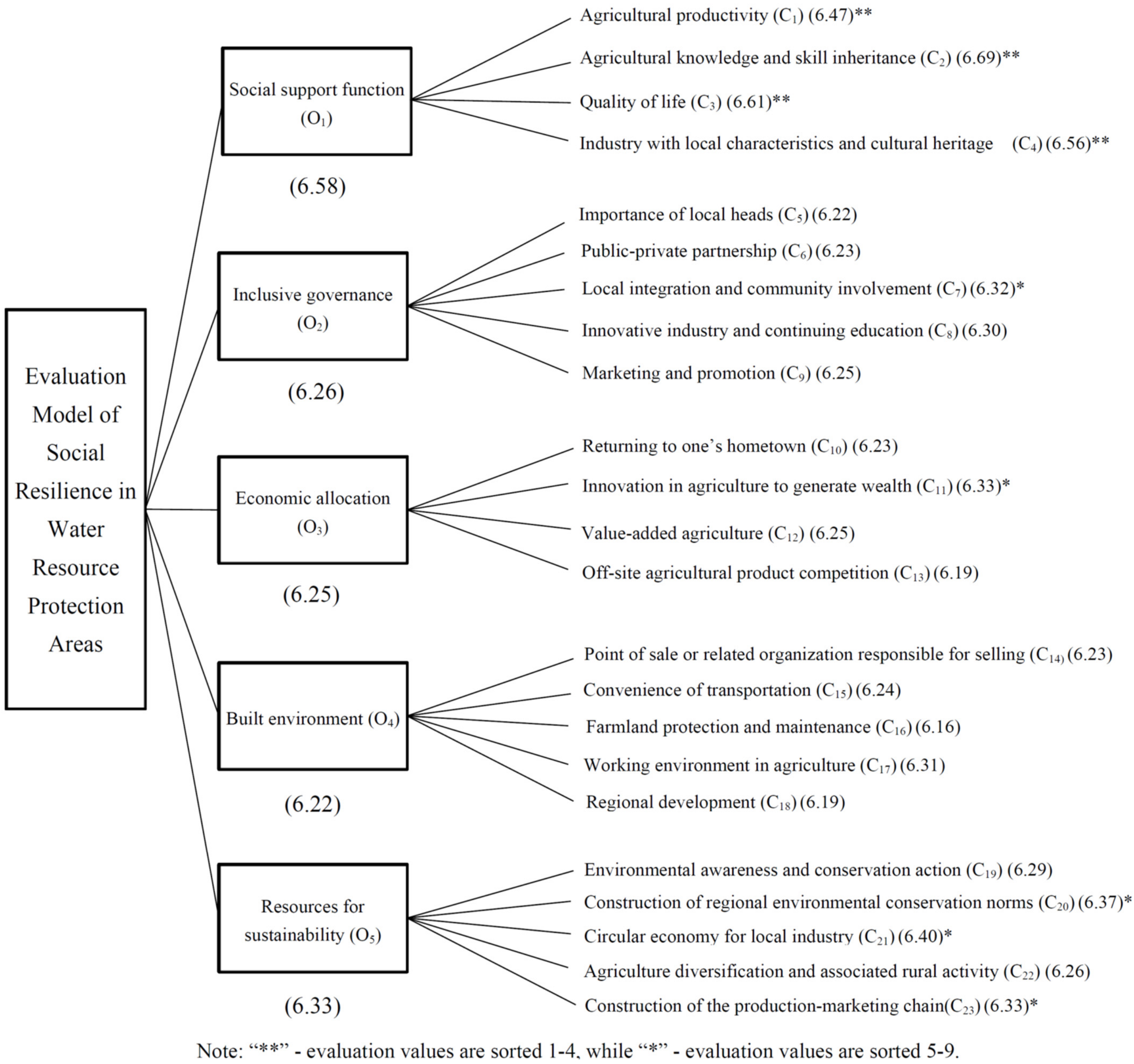

Figure 4. Distribution of evaluation values for selected dimensions and criteria.

4. Discussion

Based on the 23 criteria selected from the research results and comparison with the actual sites, this section will present various dimensions and the top nine evaluation performance schemes. The analysis was as follows:

4.1. Analysis of Each Dimension

In terms of each dimension, the social support function O_1 (6.58) had the highest average value, followed by the resources of sustainability O_5 (6.33), inclusive governance O_2 (6.26), economic allocation O_3 (6.25), and built environment O_4 (6.22). The main reason was that it was based on a water resource protection area with only the agricultural industry. The most important aspect of the agricultural industry is productivity, which includes human resources, agricultural technology, etc., to ensure the stable operation of agriculture in a region. However, based on statistical data from the Taipei Feitsui Reservoir Management Authority, the total water inflow in 2022 was 136,087.15 ten thousand cubic meters. The combined water usage for various purposes amounted to 18,223.26 ten thousand cubic meters, equivalent to domestic water consumption. Agricultural and industrial water usage were both zero. These data align with the emphasis and importance that experts place on social support functions. Therefore, the average evaluation of the social support function in this study was the highest in value. From the perspective of the social resilience of a water resource protection area, whether a region is sustainable or not determines if it can operate continuously. Hence, sustainability is also very important, which ranked the factor of sustainable utilization of resources second. As for the development of water resource protection areas, the type of governance and strategic direction, as well as the level of local participation, all had a certain influence on the development; hence, they were ranked third. Whether it was achieved or not, the rational distribution of wealth was always affected by social aspects, governance strategy, and sustainability, and it was ranked fourth. However, the actual site environment ranked last, probably because of the well-conserved condition of the area surveyed or the goal of sustainability being achievable when paid attention to.

4.2. Analysis of Each Criterion

A total of 23 items were selected by the criteria through the Fuzzy Delphi method, which can be used as important factors for influencing developmental strategy. Here, the first nine factors were selected as the focus of the analysis. The ranking of the first nine factors was C_2 (6.69) for the agricultural knowledge and skill inheritance, C_3 (6.61) for quality of life, C_4 (6.56) for the unique characteristics and cultural heritage of the local industry, C_1 (6.47) for the agricultural productivity, C_{21} (6.40) for the circular economy for local industry, C_{20} (6.37) for the construction of regional environmental conservation norms, C_{11} (6.33) for innovation in agriculture to build wealth, C_{23} (6.33) for the construction of the production-marketing chain, and C_7 (6.32) for the local integration and community involvement. Based on the results, this study then analyzed the following points:

- Agricultural knowledge and skill inheritance C_2 (6.69): Due to the leaving and aging of the population, many agricultural knowledge and skills are facing the problem of being lost. If sixth industrialization is necessary for agriculture, this knowledge and skill will be an important factor in continuing the agricultural operation in rural areas.
- Quality of life C_3 (6.61): On the site of producing agricultural products, safety and health are important indicators, as is quality of life, which will all affect the personnel and the products.
- Industry with local characteristics and cultural heritage C_4 (6.56): Because agriculture is the main industry in a water resource protection area, manpower will have a decisive influence and become a factor. By inheriting and protecting the local culture, it becomes a cohesive force to strengthen the return of personnel, which is important to development.

- Agricultural productivity C_1 (6.47): The water resource protection area depends on the agricultural industry, and tier-one production capacity is its basis. Without it, the development of the area will become relatively challenging.
- Circular economy for local industry C_{21} (6.40): By being an industry with local characteristics and a cultural heritage concept of circulation and ecological chain, the agricultural industry can connect with other sectors in a joint effort to protect the environment for sustainability.
- Construction of regional environmental conservation norms C_{20} (6.37): Relevant laws and regulations on environmental conservation and the promotion of local sustainability will partially limit local development, but they are positive in helping to achieve sustainability and social resilience in the water resource protection area.
- Innovation in agriculture to build wealth C_{11} (6.33): Introducing new technologies, combining different industries, etc., and given the advancement of these innovations, they help to increase agricultural profit and are an important source for the water resource protection area.
- The construction of the production-marketing chain C_{23} (6.33): By completing the chain of production and marketing for the site and the industry, it helps to develop a system of a certain scale to provide stability in production and marketing in the water resource protection area.
- Local integration and community involvement C_7 (6.32): Residents participate in public affairs, strive for their own needs, and respond to social values through social participation, including participating in activities such as social politics and natural and industrial development.

4.3. Comprehensive Suggestions

All five dimensions influence the social resilience of water resource protection because the area could only develop an agricultural industry. Related knowledge and skills became important assets for local development [26]. Social resilience refers to the interdependence of the capacities of social recovery and community recovery [16]; thus, social function and productivity are important. The importance of sustainability comes from the fact that it covers a wide range of sectors, and to achieve sustainable operation in a regional livelihood [51], it is necessary to consider the environment, biodiversity, productivity, resources, etc. For an actual case of local development, we could refer to the developmental model in the Satoyama Initiative [52]. The social support function and resources for sustainability ranked prior in terms of dimensions and factors, and while inclusive governance, economic allocation, and built environment all influenced the social resilience of the water resource protection areas, they could be regarded as ways and means of influence rather than being the purpose of social function, social resilience, and sustainability.

Looking at the selection criteria and the evaluation of each component, it was found that the criteria for the actual environment of the site were not in the first nine factors, probably because of its well-controlled conditions, while the rest had their own criteria. It was presumed that the top four criteria for the social support function were because the agricultural industry and development still dominated the water resource protection area. In addition, due to the restrictions imposed by regulations or the availability of social conditions, such as human resources and agricultural knowledge and skills, they were all determining factors and, thus, received more attention from the experts. Despite its good environmental condition, whether it could continue the operation for sustainability was also an important factor and criterion. The rest, such as inclusive governance, rational distribution of wealth, and the site's actual environment, still significantly impact the area because they are the reasons the area continues to function and operate.

The actual situation and development needs were examined during the operation process, and relevant possible influencing factors were classified and summarized based on the characteristics of social resilience. In practice, 49 possible influencing factors of social resilience were summarized and appropriately allocated to the five major dimensions of social support function, inclusive governance, economic allocation, built environment, and resources for sustainability. At the same time, through the objective Fuzzy Delphi method to process and screen, we effectively resolved the issues of ambiguity and biased human judgment in the evaluation. We reduced the number to five dimensions of social resilience and 23 key influencing factors for the water resource protection area. This analysis effectively integrated and transformed these qualitative and perceptual problems in MCDM research into quantitative data for objective analysis.

This study proposes four practical suggestions: (1) In the future, when discussing or formulating policies for developing water resource protection areas, try to focus on the five dimensions of social resilience to help strengthen the development of such resilience in the community. (2) It is possible to enhance the relevant development of 23 key factors, such as the population's demographics in agriculture, the learning of agricultural knowledge and skills, and the level of attention given by local leaders. (3) The development of a water resource protection area can strengthen the social resilience of a community, focus on sustainability, disaster prevention, resilience, biodiversity, etc., or construct other development models through the strategy of sixth industrialization of the industry or the Satoyama Initiative. (4) This study used Pinglin as the study site because it has a water resource protection area, which imposes restrictions on its development, especially the secondary industries, to satisfy environmental awareness. Thus, in developing social resilience for the water resource protection area, it is still necessary to evaluate the actual environment.

Suggestions for the public sector of Pinglin are as follows: (1) when developing the water resource protection areas and improving an industry's sustainability, try to focus on the factors in those five dimensions; (2) it may benefit the community by increasing public awareness of developing social resilience; and (3) this study could serve as a reference and research basis for formulating industrial development or related industry issues in the water resource protection area.

5. Conclusions

In this study, the Fuzzy Delphi method was used to explore the evaluation factors for social resilience in water resource protection areas, as well as the characteristics, actual conditions, needs, and future development of such resilience in the areas, which were investigated by literature reviews to collect possible influencing factors.

The study found that the value of the social support function is higher than the other four dimensions. Based on this, highlighting the factors of this dimension is necessary, such as the improvement of agricultural productivity or acquiring agricultural knowledge and learning about the local culture, to increase the return of the young population, as town governance could either improve the quality of life, strengthen the social support function, or formulate policies. The results also reference developing water resource protection areas and social resilience. They could serve as a basis for future research and application and suggest a direction to focus on for the future development of water resource protection areas. Following this study on social resilience, which summarized the important factors of local resilience at various levels, future studies could continue to focus on topics such as water source protection areas and Pinglin, particularly on which events in the past occurred in localities that specifically affected local development and whether these events were related to the influencing factors of social resilience.

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