A Study of the Evaluation Model for Sustainable Community Industrial Development Using Dynamic Programming Method

Kuei-Yang Wu
Department of Architecture, National United University
No. 1 Lien-Da, Kung-Ching Li, Miaoli 36003, Taiwan, ROC
kyw@nuu.edu.tw

Abstract: - Nowadays, towns and villages usually try to get funds for community constructions by following empirical rules. It is not possible to predict the effectiveness. And in the previous researches related to community development, there is no decision support model built using mathematical planning for fund allocation. This study obtains index weights for community industrial development by applying FAHP and develops a supporting system through dynamic programming models and results from the interviews with experts, combining hierarchy structure of community industrial development. "The Golden Town" in Gongguan Township, Miaoli County is chosen for empirical analysis. The result of dynamic programming analysis shows that the best decision is to first create sense of community and develop proper local environmental and spatial characteristics. Then the structure of resources for community development should be constructed to further form the key value of community industrial development. After that, local natural environment, humanities resources, and industrial cultures should be integrated to concretely create sense of community and construct the concept of "life community".

Key-Words: - FAHP, Dynamic programming, Community industrial development, Sustainable development.

1 Introduction

Community industrial development has been promoted and the ideal has become "being bottom-up, building community autonomy, having residents participate, and managing sustainably" today. A new area of tasks for development of communities has begun. The reason of community industrial development is that the development of business and economics has caused the difference in populations in urban and rural areas, which leads to larger distances between people in urban and rural areas. To solve this problem, the key lies in developing local economics with community characteristics, improving community industrial development [1].

The goal of community industrial development are the existence and sense of community. Through active involvement of government and community residents in public affairs and reaching common consensuses, unique cultural characteristics can be created for communities and industrial planning can be done, with community residents' ability to make decisions for themselves and the ideal of complete community industrial development. And community residents can be joined and in charge of culturalization of industries, industrialization of cultures, and operation of community organizations, in order to increase community industrial potentials and community income [2]. With enthusiastic participation of government, community autonomy associations, and the people, community environment, living quality of the people, and economic development can all be greatly improved. And planning and management of sustainable community industrial development can be fully conducted. This shows that overall development of community cultures, living environments, and local industries can not be done without participation of government, community autonomy associations, and the people.

However, the factors to be considered for sustainable community industrial development are very complex due to decision making and allocation of limited funds. Traditionally, decisions are made based on personal knowledge, experiences, and judgments. But there are vagueness and uncertainty in human thoughts. Therefore, methods are limited. Thus, FAHP was applied in this study to the empirical survey and analysis of sustainable community industrial development [3].

In the existing literature related to community development, allocation of funds has never been done through decision support models built with mathematical planning models. The advantage of building a decision support model is that the system can change with the environment, and through the development of mathematical models and programs, an efficient community system can be created for schedule planning and providing decision makers the best way to allocate limited funds in order to obtain the highest performance within the budget [4]. Besides, a decision support system can be applied to several different community development projects according to their conditions. It can assess the status of multiple community development and planning and conduct comparative analyses in a short time. This study obtained the weights of the indexes for community industrial development using FAHP. And a decision support system was constructed using dynamic programming models and results from interviews with experts, combining hierarchy structure of community industrial development. Also on-site investigations were conducted to find out the current statuses of communities in order to understand what can be improved for community residents, to plan and manage sustainable community industrial development.

2 Sustainable Communities and Industrial Development

This study analyzed the influences of community health and welfare on sustainable development with FAHP, as illustrated as follows.

The purpose of sustainable community industrial development is to solve current problems with community resources, in order to assure that there will be enough resources left for future generations without taking away their rights to use resources. Therefore, the functions of community industries are to satisfy the needs for living and then to enrich community residents' lives. By applying sustainable management method, small amount of resources will never be never used-up. Local government and residents propose their ideas internally to include characteristics of local social, economic, and cultural systems. Local existing resources are used with the belief of appropriate design to conform to local resources and technical conditions, so that government departments and community residents can fully consider the roles played by organizations in their community and the relations between them, and planning and management of sustainable community industrial development can be implemented efficiently.

Community industrial development should not be considered as an issue related to economics only, but to diversified planning and management of sustainable development. We can expect an ideal community, as an integration of families as units. Some of the families make traditional crafts, some are in the agriculture, forestry, fishery or husbandry industry, and some are responsible to maintain environments. This type of sustainable community industrial development is usually guided by a team composed of regional, communal, and local organizations. In other words, based on local mixed atmosphere, attraction of consumption can be created with integration of traditions, creativity, and personality. The keys include community characteristic industrial planning and quantity of output of agricultural products.

In the White Rice Community case, it can be found that, to make perfect community industrial development, local features of the community must be included to develop unique industries inside the community, and make sure the factors such as society, culture, economics, and environment, are balanced for sustainable development [5]. Complete planning for community characteristic industries must include complete planning for industry transformation, so that facilities with local characteristics can be built to preserve community cultures and local properties. And marketing channels can be expanded by creating community internet resources [6] [7]. However, when developing agricultural products with local community characteristics, it is also important to create a local biology database to maintain the balance of community ecology and offer people from urban areas a way to be close to the nature to improve the development of community tourism and other industries [8]. When developing community industries, government departments must work with communities in software and hardware infrastructure. The most important is to build community drinking water systems and sewage systems [9] [10], in order to implement prevention of community contaminants and improve convenience of access to water and electricity. This way, everyone can access and enjoy safe drinking water.

The purpose of this study is to develop an evaluation model for sustainable community industrial development in Taiwan. First, by referencing the literature [11] [12] [13] [14] [15] [16] [17] [18] [19] [20], and results of interviews with experts, with the purpose of sustainable community industrial development, 14 importance indexes were constructed for sustainable community industrial development, as shown in Table 1.

After the fuzzy relative index weights are obtained by applying FAHP, dynamic programming method is applied to construct a decision support system. The index weights obtained by applying FAHP are used as input data. The influences of project decisions from the expert evaluation system on different indexes are integrated to calculate the influence of project decisions on overall weighted performance related to the goal. Finally, a model is built using dynamic programming method and a solution is obtained through computer programming. This way, the most appropriate multi-year project implantation process for the community and the result of fund allocation are obtained as references for decision makers [21]. Reviews are conducted and improvement measures are proposed to increase the sustainability of town/village-level industrial development. The analysis process is as below:

1. Setting up the community industrial sustainable development indexes and performing cluster analysis.
2. Constructing the FAHP structure and clearly setting up the research goal for community industrial sustainable development, the evaluation aspects, and the criteria.
3. Completing the FAHP questionnaire for this study and inviting 6 experts and scholars to participate in the questionnaire survey of community industrial sustainable development for this study.
4. Analyzing the data obtained from the FAHP questionnaires and exploring the weights of different evaluation aspects and different criteria.
5. Constructing a decision support system for community industrial sustainable development using the weights obtained using FAHP and the results of interviews with the experts, applying this system to the Golden Town in Gongguan Township, Miaoli County (Fig. 1), performing dynamic programming analysis according to the actual survey result, and exploring the most appropriate project implantation process for community development and the result of overall fund allocation. Conducting reviews and proposing measures to improve the current status of community industrial sustainable developmen to increase the sustainability of town/village-level industrial development.

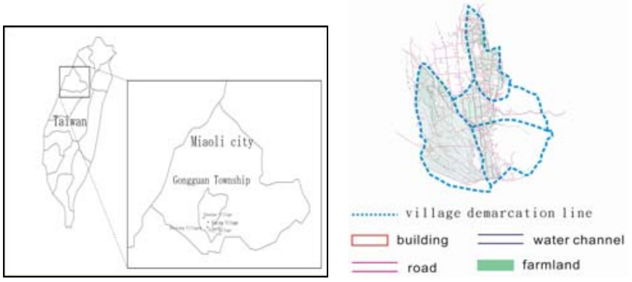

Fig 1. The locations of the Golden Town Community in Gongguan, Miaoli County, Taiwan

Table1. The hierarchy structure of community industrial development

First-level criterion	Second -level criterion	Third-level criterion
Community industrial development	community characteristic industry planning (B1)	quantity of output of characteristic agricultural products (C1) facilities with local characteristics (C2) building a local biology database (C3) maintenance of cultural and local properties (C4) complete plan for industry transformation (C5) industry development and job opportunities (C6) creating community internet resources (C7)
	community infrastructure (B2)	convenience of water access (C8) convenience of electricity access (C9)
	community drinking water and sewage systems (B3)	construction of community sewer system (C10) access to safe drinking water (C11)
	community leisure facilities (B4)	convenience of sports facilities (C12) construction of permeable pavements (C13) planning for bikeways (C14)

3 The Golden Town

According to the principles such as definition of sustainable community management, research purpose, research duration, manpower, and material resources, the Golden Town in Gongguan Township, Miaoli County was selected as the real example base (Fig. 1). The Golden Town Community in Miaoli County covers four villages, including Guannan, Fuji, Fuxing, and Shiqiang. The Golden Town was established in 2003. The plan was to include these four villages. And the main purposes of the community include creating high-quality living environment and sense of community and promoting the community by focusing on internet marketing. In the recent years, lots of projects of sustainable development and community industry development have been set into action. A lot of software and hardware infrastructure has been constructed, and management measures of greening and beautifying environment have been adopted. This community has great potential to stride forward to the goal of sustainable community industrial development in the future.

4 FAHP Analysis

This study uses the 14 key indexes for community industrial sustainable development to create questions for the questionnaire and, based on the result of cluster analysis, determines the hierarchy structure of community industrial development. 6 community development experts and scholars are invited to fill in the questionnaire (Fig. 2).

4.1 Fuzzy Sets Theory

The fuzzy sets theory was first proposed by professor Zadeh of University of California, Berkeley [22]. The theory is similar to human thoughts, inference, and perception of surroundings. Its nature is quite fuzzy. Therefore, it is necessary to describe things in life using fuzzy logic concept to avoid the disadvantage of traditional sets theories describing things using Boolean logic [23]. Accordingly, the fuzzy sets theory uses a mathematical method to clearly divide all kinds of fuzzy, uncertain, and vague things in real life, featuring representing fuzzy sets with membership functions. [24] The important calculations and analysis content of the fuzzy sets theory are as below:

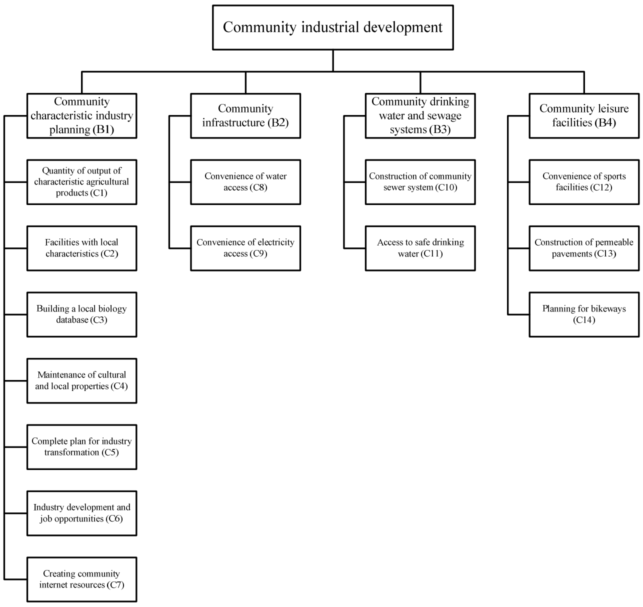

Fig. 2 The hierarchy structure of community industrial development

4.1.1 Fuzzy Number

The fuzzy numbers used in this study are the triangular fuzzy numbers (TFN). Fuzzy numbers can express linguistic uncertainty. They can retain more complete information and uncertainty of information in life compared with actual numbers. Therefore they are more flexible.

The definition of the membership function of a fuzzy number $\tilde{A}$ is:

$$\mu_{\tilde{A}}(x)=\begin{cases}(x-L)/(M-L), & L\le x\le M\\ (U-x)/(U-M), & M\le x\le U\\ 0, & otherwise\end{cases}$$

Where L and U are the upper and lower bounds of the fuzzy number, and M is the median. The relationship can be expressed as shown in Fig. 3.

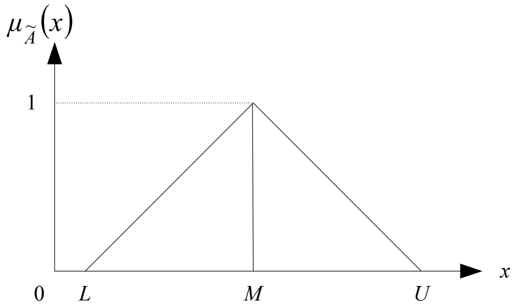

Fig. 3 The membership of triangular fuzzy number

A triangular fuzzy number can be expressed as $\tilde{A}=(L,M,U)$. Given two triangular fuzzy numbers, $\tilde{A}_1=(L_1,M_1,U_1)$ and $\tilde{A}_2=(L_2,M_2,U_2)$, the operations of fuzzy numbers are listed below:

Addition of fuzzy numbers：

$$\tilde{A}_1\oplus\tilde{A}_2=(L_1,M_1,U_1)\oplus(L_2,M_2,U_2)=(L_1+L_2,M_1+M_2,U_1+U_2)$$

Multiplication of fuzzy numbers

$$\tilde{A}_1\otimes\tilde{A}_2=(L_1,M_1,U_1)\otimes(L_2,M_2,U_2)=(L_1L_2,M_1M_2,U_1U_2)\ for\ L_i>0,M_i>0,U_i>0$$

Subtraction of fuzzy numbers

$$\tilde{A}_1\Theta\tilde{A}_2=(L_1,M_1,U_1)\Theta(L_2,M_2,U_2)=(L_1\text{-}U_2,M_1\text{-}M_2,U_1\text{-}L_2)$$

Division of fuzzy numbers

$$\tilde{A}_1\phi\tilde{A}_2=(L_1,M_1,U_1)\phi(L_2,M_2,U_2)=(L_1/U_2,M_1/M_2,U_1/L_2)\ for\ L_i>0,M_i>0,U_i>0$$

Inverse of a fuzzy number

$$\tilde{A}_1^{-1}=(L_1,M_1,U_1)^{-1}$$

4.1.2 Fuzzy Scales for Linguistic Variables

According to Zadeh (1975), the traditional methods of quantification can hardly handle complex situations and situations which are hard to define. Therefore, the concept of fuzzy scales for linguistic variables seems to be a feasible solution. The traditional methods of quantification, on the one hand, use specific scales to represent vague meanings of wordings, transforming value statuses and concepts into specific numbers, and on the other hand, under the premise that interval scales are equal-spaced, ignore differences and vagueness of linguistic expressions. These methods may easily cause errors of meaning transformation. The application of fuzzy scales can solve the issues of complexity, subjectiveness, and uncertainty. The criteria for solution evaluation in this study can be considered as linguistic variables. Thus, the criterion scores of the solutions should be given by the evaluators using fuzzy meaning scales, so that the fuzzy meanings contained can be completed retained.

4.1.3 Fuzzy Analytic Hierarchy Process

By applying FAHP, the fuzzy numbers of the evaluation criterion weight for the system can be obtained. How FAHP can be applied is shown below:

Step 1: Establishing the paired comparison matrix $\tilde{A}$ for the evaluation criteria according to the hierarchical structure. All the paired comparison results in the matrix are fuzzy numbers.

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1 \end{bmatrix}$$

Where the scale of a_{ij} are $\{\tilde{1},\tilde{3},\tilde{5},\tilde{7},\tilde{9}\}$, representing the relative importance, while $\{\tilde{1}^{-1},\tilde{3}^{-1},\tilde{5}^{-1},\tilde{7}^{-1},\tilde{9}^{-1}\}$ represents the relative unimportance. The fuzzy number mapping is shown in Table 2.

Step 2: Using geometric averages to calculate the fuzzy weights of the evaluation criteria.

$$\tilde{r}_i = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i1} \otimes \cdots \otimes \tilde{a}_{in}\right)^{1/n}$$

$$\tilde{w}_i = \tilde{r}_i \otimes \left(\tilde{r}_1 \oplus \cdots \oplus \tilde{r}_n\right)^{-1}$$

Where $\tilde{a}_{in}$ is the fuzzy value of the comparison value of evaluation criteria i and n, $\tilde{r}_i$ is the geometric average of the fuzzy comparison values of criterion i and all the other criteria, and $\tilde{w}_i$ is the fuzzy weight of criterion i, which can be expressed in the form of a triangular fuzzy number $\tilde{w}_i = \left(Lw_i, Mw_i, Uw_i\right)$, with Lw_i, Mw_i, and Uw_i representing the lower bound, median, and upper bound of the fuzzy weight, respectively.

Table2. The fuzzy number mapping

Fuzzy number	Verbal judgments of preferences	Scale of fuzzy number
$\tilde{1}$	Equal importance	(1,1,3)
$\tilde{3}$	Little importance	(1,3,5)
$\tilde{5}$	Common importance	(3,5,7)
$\tilde{7}$	Certain importance	(5,7,9)
$\tilde{9}$	Absolute importance	(7,9,9)

4.2 Fuzzy Multiple Criteria Decision Making

When using the fuzzy weights to evaluate the projects (candidates), in the beginning the interviews with experts must be conducted to obtain the fuzzy impact values of the projects on the system. The experts or evaluators evaluate the influences after the projects are implemented through previous experiences. These values can also be expressed in fuzzy numbers. $\tilde{E}_{ij}$ represents the influence of project i on the system using evaluation criterion j. $\tilde{E}_{ij} = \left(LE_{ij}, ME_{ij}, UE_{ij}\right)$.

After interviewing the experts, the impact value $\tilde{E}_{ij}$ of each project and the evaluation criterion fuzzy weight $\tilde{w}_i$ calculated by applying FAHP are obtained. Then the overall influence of the project on the system, $\tilde{R}_i = \left(LR_i, MR_i, UR_i\right)$, can be calculated using the following equations:

$$LRi = \sum_{j=1}^{n} LE_{ij} \times Lw_j$$

$$MRi = \sum_{j=1}^{n} ME_{ij} \times Mw_j$$

$$URi = \sum_{j=1}^{n} UE_{ij} \times Uw_j$$

The result of every evaluated criterion is a fuzzy number, no matter its a fuzzy performance value or a fuzzy weight. As for the priority of the projects, the fuzzy numbers must be handled with a non-fuzzy scale of crisp numbers. In other words, the purpose of defuzzification is to obtain the best non-fuzzy performance value (BNP value). In the past, many scholars had proposed fuzzy methods, including the mean of maximal (MOM) method, the center of area (COA) method, and the α-cut method [25] [26]. Among them, the COA method is easier and more practical with no need to consider evaluators' preferences. Therefore this method is adopted by this study. By applying the COA method, the fuzzy weights and the BNP of the fuzzy performance values can be obtained through the following equation:

$$BNP_i = [(UR_i - LR_i) + (MR_i - LR_i)]/3 + LR_i, \forall i$$

The overall impact values of the projects (candidates) on the system can be obtained through the evaluation method above for impact on the system.

First of all, there are 4 goals of community development (please reference the FAHP structure in Fig. 2):

Community characteristic industrial planning (o=1);

Community infrastructure (o=2);

Community drinking water and sewage systems (o=3);

Community leisure facilities (o=3);

For each goal, there are several characteristics of paired comparison (fuzzy numbers). For a goal o with a characteristic $a(o) \in A(o)$, where $A(o)$ is the characteristic set of the goal o, the cumulative impact (CI_o) of the character of the goal is the sum of the multiplication of the expert score $E_{a(o)}$ and the relative weight $w_{a(o)}$ of each character. The equation is shown below:

$$CI_o = \sum_{a(o) \in A(o)} w_{a(o)} E_{a(o)}$$

Where the weight $w_{a(o)}$ of the character $a(o)$ can be obtained by calculating the eigenvectors of the paired comparison matrix by FAHP.

4.3 Empirical analysis

Table 3 shows the FAHP analysis results of the sustainable community industrial development in this study. According to the FAHP analysis results, among all the aspects for evaluation, the one with the highest weight was community characteristic industry planning (B1), whose weight was 0.4608. This means that the experts all agreed the most important evaluation aspect which influences sustainable community industrial development was community characteristic industry planning (B1). Therefore, its local weight was much higher than other aspects'. In the evaluation aspect of community characteristic industry planning, there were seven criteria for evaluation, including quantity of output of characteristic agricultural products (C1), facilities with local characteristics (C2), building a local biology database (C3), maintenance of cultural and local properties (C4), complete plan for industry transformation (C5), industry development and job opportunities (C6), and creating community internet resources (C7). The corresponding local weights obtained by analysis were 0.1287, 0.3333, 0.1335, 0.1358, 0.1094, 0.1156, and 0.0437. The analysis results showed that the highest weight is the weight of facilities with local characteristics (C2). In other words, the experts agreed putting emphasis on facilities with local characteristics may largely improve and facilitate planning for community characteristic industries. In addition, the experts also agreed that in the evaluation aspect of community characteristic industry planning, the criteria, including maintenance of cultural and local properties (C4), building a local biology database (C3), quantity of output of characteristic agricultural products (C1), industry development and job opportunities (C6), and complete plan for industry transformation (C5), were implementation methods which can fully show the community's characteristics under the principle of balanced economics, environment, and society of community industries. Therefore, the local weights obtained by the analysis were between 0.11~0.14. Creating community internet resources (C7) was the criterion the experts all considered with less influence on community characteristic industry planning (B1), the local weight obtained by the analysis was 0.0437.

Table3. The factors which influence the decisions for sustainable community industrial development

First-level criterion	Second -level criterion	Local weights	Important level	Third-level criterion	Local weights	Importantance level	Global weights	Important level
Community industrial development	community characteristic industry planning (B1)	0.4608	1	quantity of output of characteristic agricultural products (C1)	0.1287	4	0.0593	7
				facilities with local characteristics (C2)	0.3333	1	0.1536	2
				building a local biology database (C3)	0.1335	3	0.0615	6
				maintenance of cultural and local properties (C4)	0.1358	2	0.0626	5
				complete plan for industry transformation (C5)	0.1094	6	0.0504	9
				industry development and job opportunities (C6)	0.1156	5	0.0533	8
				creating community internet resources (C7)	0.0437	7	0.0201	14
	community infrastructure (B2)	0.2161	3	convenience of water access (C8)	0.8241	1	0.1781	1
				convenience of electricity access (C9)	0.1759	2	0.0380	11
	community drinking water and sewage systems (B3)	0.2212	2	construction of community sewer system (C10)	0.4935	2	0.1091	4
				access to safe drinking water (C11)	0.5065	1	0.1120	3
	community leisure facilities (B4)	0.1019	4	convenience of sports facilities (C12)	0.2524	3	0.0257	13
				construction of permeable pavements (C13)	0.4838	1	0.0493	10
				planning for bikeways (C14)	0.2638	2	0.0269	12

And community drinking water and sewage systems (B3) was the second important evaluation aspect of sustainable community industrial development. The weight obtained by analysis was 0.2212. Table 4 shows that, in the evaluation aspect of community drinking water and sewage systems (B3), there were two criteria for evaluation, including construction of community sewer system (C10) and access to safe drinking water (C11). The corresponding local weights obtained by analysis were 0.4935 and 0.5065. This means the experts agreed that, in the evaluation aspect of community drinking water and sewage systems (B3), although the control of community sewage disposal was important, the quality of drinking water for the community was an even more important factor which influences community residents' lives. Thus, the analysis result showed that the criterion access to safe drinking water (C11) was important.

Furthermore, according to Table 3, community infrastructure (B2) was the third important evaluation aspect of sustainable community industrial development. The weight obtained by analysis was 0.2161. In the evaluation aspect of community infrastructure (B2), the important evaluation criteria included convenience of water access (C8) with the local weight being 0.8241 and convenience of electricity access (C9) with the local weight being 0.1759. It is obvious that the access to water resources and convenience of it were important to community residents. Lastly, according to Table 3, “community leisure facilities” (B4) was the fourth important evaluation aspect of sustainable community industrial development. The weight obtained by analysis was 0.1019. According to the result, although the weight of community leisure facilities was rather low in the decision evaluation for sustainable community industrial development, the planning for community leisure facilities was still necessary for the mental and physical health of community residents, improvement of living comfort and quality, and improvement of leisure spaces. In the evaluation aspect of community leisure facilities, the local weight obtained by the analysis for construction of permeable pavements (C13) was 0.4838, followed by that of planning for bikeways (C14), 0.2638, and that of convenience of sports facilities (C12), 0.2524. Convenience of sports facilities and planning for bikeways can be considered for community leisure facilities in order to improve places for activities for residents to spend their leisure time and provide them physical and mental relaxation. Also, detailed planning for and construction of permeable pavements may improve the greening of the community and the comfort of the environment in the community other than providing community residents entertainments and leisure activities. Nowadays, the structures of community characteristic industry are diversified with different types of developments. However, with the innovation of production techniques and business markets, consumers have paid more attention to product quality, design, choices of functions, and appeals of environmental protection. In order to follow the continuous changes of market conditions and consumers' consumption patters, "community characteristic industry planning" should be considered as the most important item. When decision makers or managers implement the "community characteristic industry planning", they must make overall considerations and efficiently retrieve the information of the market, environmental loads, consumption demands, product market channels, and promotional campaigns in order to market their products and improve community industrial development.

Finally, in the evaluation aspect of overall weights for sustainable community industrial development, the most important criterion was convenience of water access (C8). The global weight obtained by analysis was 0.a781. The second important criterion was facilities with local characteristics (C2), with the global weight obtained by analysis being 0.1536. And the third and fourth important criteria were access to safe drinking water (C11) and construction of community sewer system (C10), with the global weights obtained by analysis being 0.1120 and 0.1091. It can be found that good quality of water resources and the convenience to access them are necessary in people's livelihood. To improve sustainable community industrial development, the focus must be put in the planning and management of water resources. In order to improve the economics and quality of environments and livelihood for the residents, measures for improvement such as facilities with local characteristics (C2) and construction of community sewer system (C10) should be implemented, so that contaminants can be prevented to improve the community environment. And with the establishment of, planning for, and management of facilities with local characteristics (C2), a beautified and greened community environment with low pollution can be created to increase people's willingness to pay visits to this community and spend leisure time and money in the community, to improve sustainable community industrial development. Moreover, according to global weights obtained by analysis and shown in Table 3, the global weights of maintenance of cultural and local properties (C4), building a local biology database (C3), quantity of output of characteristic agricultural products (C1), industry development and job opportunities (C6), and complete plan for industry transformation (C5) were 0.0626, 0.0615, 0.0593, 0.0533, and 0.0504, respectively. According to the result of the analysis, industrial competitiveness must be improved before the sustainable management of community industrial development is implemented, in order to improve people's livelihood in the community, the employment opportunities, and the preservation of community characteristic cultures and ecological environment. Thus, maintenance of cultural and local properties (C4), building a local biology database (C3), quantity of output of characteristic agricultural products (C1), industry development and job opportunities (C6), and complete plan for industry transformation (C5) are the keys to improve economics, environment, society, and cultures in the community. More attention should be paid to them. Among the FAHP evaluation criteria for sustainable community industrial development, the global weights of construction of permeable pavements (C13), convenience of electricity access (C9), planning for bikeways (C14), convenience of sports facilities (C12), and creating community internet resources (C7) were 0.0493, 0.0380, 0.0269, 0.0257, and 0.0201, which were rather low. Although the global weights of these 5 criteria obtained by analysis were rather low, if evaluated from the overall aspect of sustainable community industrial development, these 5 criteria still needed attention. It can be seen that to make an overall evaluation on sustainable community industrial development, the above criteria obtained by analysis must be considered as well, and it is also important to know the niche where competitive conditions lie. Then the pre-set supporting strategies and implementation methods can meet managers' demands, in order to reach the goal of a community with sustainable community industrial development, which is completely balanced in the aspects of environment, economics, society, and culture.

Table 4. Table of the best path analysis for A~B1 during 2003~2005 in the Golden Town Community in Gongguan, Miaoli County, Taiwan

A-B1	μ(x)	ω(x)	Performance Value/ Attributes	Performance Value/ Objectives	Composite Utility Value
NO.2					
community characteristic industry planning (B1)		0.4608		1.1542[a]	2.0114[b]
community infrastructure (B2)		0.2161		0.4322	
community drinking water and sewage systems (B3)		0.2212		0.2212	
community leisure facilities (B4)		0.1019		0.2038	
NO.3					
quantity of output of characteristic agricultural products (C1)	1	0.1287	0.1287		
facilities with local characteristics (C2)	3	0.3333	0.9999		
building a local biology database (C3)	4	0.1335	0.5340		
maintenance of cultural and local properties (C4)	1	0.1358	0.1358		
complete plan for industry transformation (C5)	5	0.1094	0.5470		
industry development and job opportunities (C6)	1	0.1156	0.1156		
creating community internet resources (C7)	1	0.0437	0.0437		
convenience of water access (C8)	1	0.8241	0.8241		
convenience of electricity access (C9)	1	0.1759	0.1759		
construction of community sewer system (C10)	1	0.4935	0.4935		
access to safe drinking water (C11)	1	0.5065	0.5065		
convenience of sports facilities (C12)	2	0.2524	0.5048		
construction of permeable pavements (C13)	2	0.4838	0.9676		
planning for bikeways (C14)	2	0.2638	0.5276		

a.1.1542=1*0.1287+3*0.3333+4*0.1335+1*0.1358+5*0.1094+1*0.1156+1*0.0437
b.2.0114=0.4608*1.1542+0.2161*0.4322+0.2212*0.2212+0.1019*0.2038

5 A Case Study of the Decision Support System

Among the decision support models proposed by this study, the project planning model uses the dynamic programming method to select a multi-year community development project and allocate funds. The dynamic planning method is to deconstruct a problem into a series of multi-phase sub-problems. Then the solution of a sub-problem is used to obtain the solution of another sub-problem. In each phase, the performance values of all possible decisions are cumulated. The best partial decision for that phase is picked and used in the next phase. The same procedure repeats until all sub-problems are solved. Then the best project (decision) combination for the system is obtained.

By solving the dynamic programming model, the implementation solution and priority of community planning for each term are obtained, to achieve the best overall performance of the community system. The decision support model includes the following factors: year term, system state, project decision, transfer function, and system performance impact evaluation. They will be illustrated respectively below.

5.1 Year Term

In this study, the scheduled overall period of the community system can be divided into several year terms, which are identified with the time vector t (t=0,…, N) of the system program. In every year term, a decision maker can implement one or several projects to improve the performance of community system development. By applying the dynamic programming method, multi-year projects can be selected and their priority can be determined, so that the system can be optimized to reach the goal of the best performance. And the year terms used for dynamic programming are the stages of the community system.

5.2 System State

The system state variables are variables used to describe the state of the community system, including several criteria and evaluation of community development. They are summarized to a performance value. In the year term t, the system state, represented by $x(t, j)$, may vary. $x(t, j)$ is composed of the parameters or properties in the system, assuming that the system contains r parameter indexes $s_1, s_2, \ldots, s_r$.

The system parameters mentioned above are set values if the related information is specific. On the contrary, they can be represented by fuzzy numbers if the related information contains uncertainty or differences. There are fuzzy sets and membership functions corresponding to the system parameters with fuzzy property.

Assuming that, in any year term, the system state is a finite and discrete set, with all the fuzzy and non-fuzzy system parameters, the system states in the n[th] year term can be defined as $x(t, j) = x(t, s_1, s_2, \ldots, s_r) \in X(t)$, where j is defined by parameters $s_1, s_2, \ldots, s_r$ and $X(t)$ is the set of all possible states in the t[th] year.

In this study, in order to reduce the complexity, the system state is defined as the remaining system budget of that year term. The goal of the decision support system is to maximize the performance of community development. To reach this goal, the decision makers must make the best use of their limited resources and arrange the most appropriate projects for every year term, in order to improve the performance of the community system after the projects are implemented.

5.3 Project Decisions and Transfer Functions

The community system administrator can influence the state of the system $x(t, j)$ through decision process. In a decision process, an administrator decides whether a project related to community development will be implemented or put on hold to change the state of the system according to project decision variables $d(k, x(t, j))$, $k=1,2,\ldots,K$. Project decisions, technologies, funds, and manpower are all related to this issue.

Therefore, in every year term, the decisions of implementation for projects are a limited set: $D(x(t, j))$. Given a system state $x(t, j)$ and year term t, then decisions $d(k, x(t, j)) \in D(x(t, j)), k = 1,2,..., K$ are mutually exclusive.

Given the current year term t, when a manager makes a decision $d(k, x(t, j))$, the system will be influenced by that decision and its current state $x(t, j)$ will be transferred to a new state $x(t+1, j)$ in the next year term. The corresponding influence can be expressed as:

$$x(t+1, j) = v(x(t, j), d(k, x(t, j)))$$

The v in the equation above is called system transfer function, representing the influence of decision $d(k, x(t, j))$, causing system state to transfer from $x(t, j)$ to $x(t+1, j)$.

Assuming that the best project decision in phase $t+1$ is $d(x(t+1, j^*))$, which is known, when the system state is reversely transferred from $x(t+1, j^*)$ to $x(t, j)$, the increased system performance value can be defined as:

$$f(x(t, j), x(t+1, j^*), d(k, x(t, j^*)))$$

If the cumulative increased performance value is $u(x(t, j))$ when the system state is reversely transferred from the final state $x(N, j^*)$ to the state $x(t, j)$, the community system performance value can be derived according to the following definition:

$$u(x(t, j)) = \max_d \begin{pmatrix} u(x(t+1, j^*)) + \\ f(x(t, j), x(t+1, j^*), d(k, x(t, j^*))) \end{pmatrix}$$

$$t = N-1, N-2, ..., 0$$

Using the above-mentioned dynamic programming model, the best project combination and priority for the multi-year community system can be obtained.

5.4 Case Study

Based on the weights for the criteria obtained by FAHP in the previous section, empirical analyses are demonstrated by using the decision support system constructed for this study. This system's dynamic programming model was coded and compiled by the C++ programming language.

This case is a three-year plan for a single community. The total budget was 8 million dollars. The executable projects for the community were known. The states of the system were defined as the remaining budget which could be used for the community. The performance values of the projects were calculated with FAHP fuzzy weights and the dynamic programming model and are listed below: In 2003, the performance value was 2.0114 for the reconstruction project for rural irrigation life, 1.4444 for the innovation and training for Hakka affairs, and 1.8434 for the combination of both projects. In 2004, the performance value was 1.6248 for the joy ride in the Golden Town for taros in Guannan, 2.2290 for the blue-collar clothes artistry and craft hall, 2.8409 for the project for demonstration of creating urban and rural landscapes in Taiwan, and 2.9514 for the combination of all three projects. In 2005, the performance value was 2.6539 for the community project for demonstration of urban and rural landscapes, 1.9467 for the construction project for healthy environment and space, and 2.7725 for the combination of both projects.

After the solution is found via dynamic programming, the best overall performance value for the system is 7.5062. And the best process to implement the projects is: reconstruction project for rural irrigation life (B1 performance value: 2.0114) -> Project for demonstration of creating urban and rural landscapes in Taiwan (C3a performance value: 2.8409) -> Community project for demonstration of urban and rural landscapes ((D1e performance value: 2.6539)). According to the result of the system programming, this solution makes the best use of the system resources, so that the budget for community development is almost used up. The best project combination is shown in Fig. 4 represented by the thick line.

The network system represented in this study is based on the case study of dynamic programming in 2003, 2004, and 2005 for the Golden Town in Guannan, Miaoli County, Taiwan. 7 projects had been implemented for the Golden Town in these 3 years, including the reconstruction project for rural irrigation life ($5,000,000), the innovation and training for Hakka affairs ($600,000), the joy ride in the Golden Town for taros in Guannan ($300,000), the blue-collar clothes artistry and craft hall ($4,000,000), the project for demonstration of creating urban and rural landscapes in Taiwan($2,000,000), the community project for demonstration of urban and rural landscapes ($1,000,000), and the construction project for healthy environment and space ($1,500,000). The result of this study showed that, under the circumstance when the sustainable community industrial development of the Golden Town was restricted by the $8,000,000 from the practical planning and development for communities in Miaoli County fund, according to the result of the dynamic programming analysis (shown in Fig. 4), the best schedule was in the following sequence:

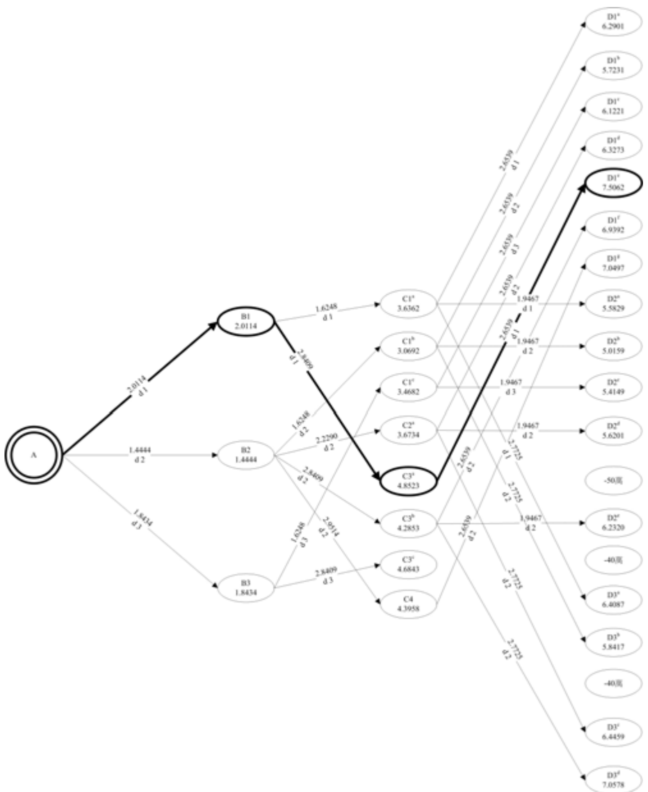

Fig.4 The dynamic programming analysis graph for the Golden Town Community in Gongguan, Miaoli County, Taiwan

Reconstruction project for rural irrigation life → Project for demonstration of creating urban and rural landscapes in Taiwan → Community project for demonstration of urban and rural landscapes. The main reason was because the purposes of the reconstruction project for rural irrigation life were to remind residents to care about and take part in public affairs, to create new interpersonal relationships in the society and new cultural life, and to develop proper local environmental and spatial characteristics, in order to enhance the unity and collaboration of community industrial development. The purposes of the project for demonstration of creating urban and rural landscapes in Taiwan were to well use local characteristics and social resources to construct resource structures for community development, to cultivate all kinds of talents, and to integrate usable resources from related units of the government and non-government sources. The purposes of the community project for demonstration of urban and rural landscapes were to combine local natural environment, humanities resources, and industrial cultures, to build community awareness, and to create the concept of "sense of community", in order to drive the overall development of the area.

6 Conclusion

In the previous studies, the influences of the good and the bad of community industrial development on the community's environment, economics, and social sustainability had not been taken into consideration. And currently, there is no decision support system developed for community development. Therefore, this study applies Fuzzy Analytic Hierarchy Process (FAHP) to construct the evaluation indexes with the fuzzy property of human languages and develop an objective and fast decision support system using dynamic programming and the results of the interviews with the experts. Then the "Golden Town" in Gongguan Township, Miaoli County is chosen for empirical analysis and evaluation. The result of the analysis can be used to develop complete overall management strategies for sustainable community industrial development. After being analyzed using the FAHP method, it is found that, among all the evaluation aspects, "community characteristic industry planning" is the most impotent one, followed by "community drinking water and sewage systems", "community infrastructure", and "community leisure facilities".

The result of the study shows that dynamic programming helps to come up with the best process for the community's direction of development and visions. This method can not only optimize the community's fund allocation, but also avoid waste while using the funds meaningfully. Developing the sustainable community industrial development model can not only transform the abstract concept of sustainability into something specific, but also objectively quantify weights through a mathematical method. Integrating diversified information and transforming it objectively into specific instructions through a mathematical method helps residents of the community and government agencies to clearly understand current state. And the analysis of advantages and disadvantages can provide the management and decision-makers references to make their decisions.

The inspiration this case gives this study is that, when proceeding sustainable community industrial development, the first thing to do should be creating the sense of community, building new social interpersonal relationships while members dynamically participate, and creating environment space characteristics which are suitable for local areas. Then the structure of resources for community development should be constructed in order to cultivate talents in all kinds of community constructions and further form key values for community industrial development. After that, a demo site has to be constructed, so that local and natural environments, humanities resources, and industrial cultures can be integrated to concretely create sense of community and construct the concept of “life community”.

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