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Multilevel modelling of sustainable consumption for achieving carbon neutral production – case study of the urban in Thailand

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ABSTRACT

Purpose: The research aims to determine a living model that is eco-environmental and sustainable. Climate change and scarcity of resources have led world policymakers, along with the United Nations, to set guidelines in the form of 17 sustainable development goals (SDGs). Sustainable production consumption is one of the major issues that is considered worldwide, including the SDG mission of the University ranking under SDG_{12}.

Design/methodology/approach: The paper proposes a new model development for sustainable consumption production using multi-criteria decision-making of the Fuzzy Analytical Hierarchy Process (FAHP) under the 5P principle. The questionnaire was designed and distributed to sample populations in the community, and the analysis was done under the FAHP procedure. The research area focused on green space near Bangkok, Bang Kachao. It is one of six local governmental units (Tambon) in Phra Pradaeng district located in Samut Prakran province, Thailand.

Findings: It was found out that people concerned the most sustainable production consumption using natural local materials at 25.09%, followed by making community products by green industry at 12.42% and making local green products at 6.18%. From the development of the multi-modelling framework, the paper proposes a new model of the urban community

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in Thailand for sustainable production consumption to support SDG_{12} using FAHP for multi-decision making based on the 5P principle. There are people, porosity, planet, peace, and partnership.

Research limitations/implications: However, various factors influence production and consumption and impact the carbon footprint.

Practical implications: It was obviously found that people mostly use local materials to make green local products under the local policy of 3R waste management. Innovative design uses community wisdom, knowledge and know-how to make value-added products.

Originality/value: The strategic planning and control consist of green industry, zero waste management, zero carbon footprint and innovative product design. The expected outputs from the model are green and homemade products with cleaner production, clean energy, and gain carbon credit.

Keywords: Carbon neutral, CO_2, FAHP, SDG_{12}, Sustainable consumption production

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1. Introduction

The Sustainable Development Goals (SDGs) are the ultimate goal to achieve by 2030 for both developed and developing countries. It is designed based on the UN's principle that is consistent with the theory of leaving no one behind, along with gender equality and human rights. There are 17 main sustainable development goals (SDGs) that are international connections to support each other [1]. Indicators have been defined to monitor and evaluate development progress by grouping the SDGs according to factors linked in 5 dimensions (5P). They include (1) People development, which focuses on eradicating poverty and hunger and reducing societal inequality. (2) Prosperity, which promotes people's well-being and harmony with nature. (3) Planet places importance on protecting and preserving natural resources and climate for future generations of global citizens. (4) Peace is based on the principle of peaceful coexistence, and (5) Partnership is the creation of cooperation of all sectors to drive the agenda for sustainable development [2].

However, at present, it has been found that some of the main sustainable development goals have not yet been achieved, which is essential for driving the development process and requires cooperation between organizations at all levels. As well as educational organizations, there is a challenge in promoting and developing research for sustainability, especially SDG_{12}, ensuring sustainable production and consumption [3]. This is one of the development goals that many researchers have attempted to develop the processes based on economic growth that are primarily aware of social and environmental costs [4,5]. The issue will require integrating government agencies, society, and the private sector, which are applied from the policy level to the implementation in the area to drive sustainable production and consumption of the country [6]. In order to reduce losses and create pollution that can affect the environment and confront adversaries of human health.

Thailand has laid the foundation for development by developing the "Sustainable Production and Consumption Plan 2017-2037 (Revised Version)" [7]. To formulate a framework and policy for developing Thai society to lead to a society with efficient use of natural resources. It has led to Thailand's 20-year national strategic plan from 2018 to 2037 [7], which is "Thailand is stable, prosperous, and sustainable through development based on the sufficiency economy philosophy" [8,9]. The goal is to achieve sustainable management and efficient use of natural resources by 2030. For example, reducing food waste, preventing, reducing, reusing, and recycling are the things that are carried on in the present. In order to ensure that people everywhere are aware of and pay attention to sustainable development through a lifestyle in harmony with nature, Sustainable development in the field of sustainable tourism creates jobs and promotes local culture and products. It also reduced subsidies for inefficient fossil fuels and led to wasteful consumption.

Thailand has formulated a strategy for the development process to empower local communities through self-reliance. Holistic economic development and growth are based on an environmentally friendly quality of life. In other words, it is a guideline for development and sustainable growth by emphasising value creation for bio-resources in each locality in the bio-economy society. This aim also

focuses on planning for the efficient use of resources to create a circular economy society and developing a participation management system that reduces costs and minimises resource consumption for a low-carbon society, focusing on growth in the form of building a green economy. The approach increases the value of bio-resources based on the economy, which is in line with the competitive advantage strategy in Thailand [10].

To support the country's development goals concretely, the research team has set the target area for this research operation as a pilot area to determine criteria and sub-criteria. To find guidelines in the development process in accordance with Goal 12 and to be consistent with all contexts of the development goals. The area selected for this study is Bang Kachao Subdistrict, Phra Pradaeng District, Samut Prakan Province. It is an area that is surrounded by the Chao Phraya River, almost in a circular terrain, or resembling an island surrounded by rivers, hence the nickname "pig's maw" from the natural conditions surrounded by the Chao Phraya River. As a result, this area is influenced by the accumulation of sediments that are washed away with water. The abundance and biodiversity that occur naturally are suitable for agriculture and other ecological activities [11], but nowadays, due to the growth of various technologies, the area has been developed into an industrial area. Therefore, green space has been reduced accordingly [12].

The purpose of the research paper is to seek decision-making guidelines for the formulation and process of sustainable development to ensure the creation of sustainable production and consumption processes of SDG_{12}. Research was carried out in the Bang Kachao area while developing the given prototype model. The priority assessment criteria are set at two levels, focusing on the five development criteria per the SDGs. The research area is paving the way for further development by developing research processes from integrating knowledge in science, technology, and innovation in the future in order to promote and develop prototype areas to be concrete and truly protrusive [13]. Moreover, it can be applied in other nearby contexts. At the end of the research, suggestions were given on the process of further development of the research in the future.

2. Proposed methodology

The research design is divided into three steps. The first step is collecting data by using a questionnaire. The main content of the sustainable production and consumption processes of SDG_{12} consists of five criteria based on multilevel modelling. They use natural materials, the green industry, promote local production, reduce waste generation and publish and transfer knowledge in Figure 1. The collected data is organized by matrix and compared using the fuzzy AHP methodology.

Fig. 1. SDG_{12} and the 5P for decision-making

The analytic hierarchy process (AHP) and the fuzzy theory are combined in the article [14]. The fuzzy analytical hierarchy process (FAHP) is applied in the sustainable production and consumption processes of SDG_{12} on multilevel modelling in order to make decisions for planning production [15]. The method includes three layers in Figure 2, as follows:

1. Establish the main criteria and sub-criteria for the factor in the Bang Kachao area.
2. Define the weights of sustainable development goals (SDG_{12}).
3. Defuzzification values the priorities in a model of the Bang Kachao area.

The problem#based is converted into a hierarchical structure. It consists of sub-factors and alternative strategies to provide a state that can be measured by fuzzy logic, AHP, and fuzzy AHP to choose a method for ranking sustainable development goals (SDG_{12}). Figure 3 shows all main criteria and sub-criteria in a hierarchic view. A linguistic scale is used to create a pairwise comparison matrix, which is given in Table 1.

2.1. Analysis for finding the value of the Fuzzy Analytic Hierarchy Process (Fuzzy AHP)

The assessment divided the priority into five levels. They stood for the meanings from the value in the assessment form along the scale levels of pairwise comparison. After that, the data will be analysed based on the results from the priority by comparing the risk factors. The steps of result analysis from fuzzy AHP are shown in Figure 4. Then, the assessment results were changed into triangle fuzzy numbers, as shown in the form of triangle fuzzy numbers in Table 1.

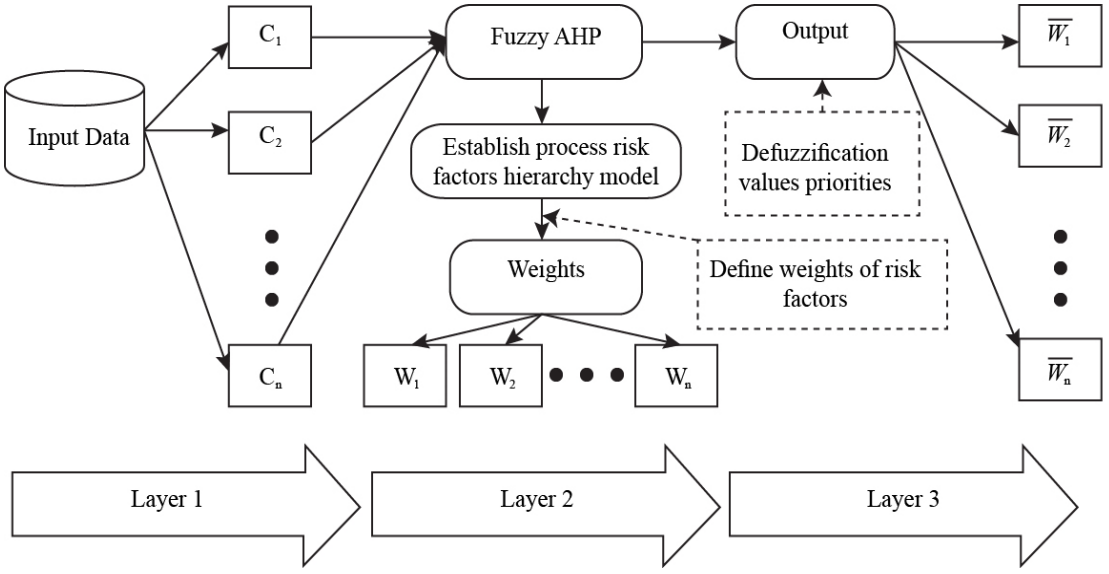

Fig. 2. The model of Multilevel Criteria Decision using Fuzzy AHP that modified from Butdee et al. (2019) [16]

Table 1.
Fuzzy AHP linguistic variables used for sustainable consumption production of the criteria

Linguistic variable	AHP	Membership function	Domain	Triangular fuzzy AHP	Definition
Equally important	1			(1,1,1)	Practical knowledge and experience imply that factor i is equally important compared to factor j.
Moderately important	3	$\mu_M(x) = (x-1)/(3-1)$ $\mu_M(x) = (5-x)/(5-3)$	$1 \le x \le 3$ $3 \le x \le 5$	(1,3,5)	Practical knowledge and experience imply that factor i is moderately more important when compared to factor j.
More important	5	$\mu_M(x) = (x-3)/(5-3)$ $\mu_M(x) = (7-x)/(7-5)$	$3 \le x \le 5$ $5 \le x \le 7$	(3,5,7)	Practical knowledge and experience imply that factor i is more important when compared to factor j.
Strongly important	7	$\mu_M(x) = (x-5)/(7-5)$ $\mu_M(x) = (9-x)/(9-7)$	$5 \le x \le 7$ $7 \le x \le 9$	(5,7,9)	Practical knowledge and experience imply that factor i is strongly important when compared to factor j.
Extremely important	9	$\mu_M(x) = (x-7)/(9-7)$ $\mu_M(x) = (10-x)/(10-9)$	$7 \le x \le 9$ $9 \le x \le 10$	(7,9,10)	Practical knowledge and experience imply that factor i is extremely important when compared to factor j and totally outweighs it.

The analysis of the priority assessment by comparing the risk factors from fuzzy AHP had three steps as follows [16]:

Step 1 To compare the priority of each pair. To put the calculated values in Matrix.

Step 2 To calculate the value of the normalized matrix or eigen vector of matrix A in each row. The normalized values were calculated from the average importance in each row.

Step 3 To find the priority in the next hierarchy, go back to Steps 1 and 2. Next, the calculated values of decision measures from the higher hierarchy at 1 level were multiplied by the normalized values of the 2nd rank, which were calculated. Finally, there would be the priority values in the lower ranks as the measure of any factors. Doing this until all of the factors are met. When the researcher converted the assessment results into the triangle fuzzy numbers, the matrix of pairwise comparison could be made from the equation (3) to the equation (6).

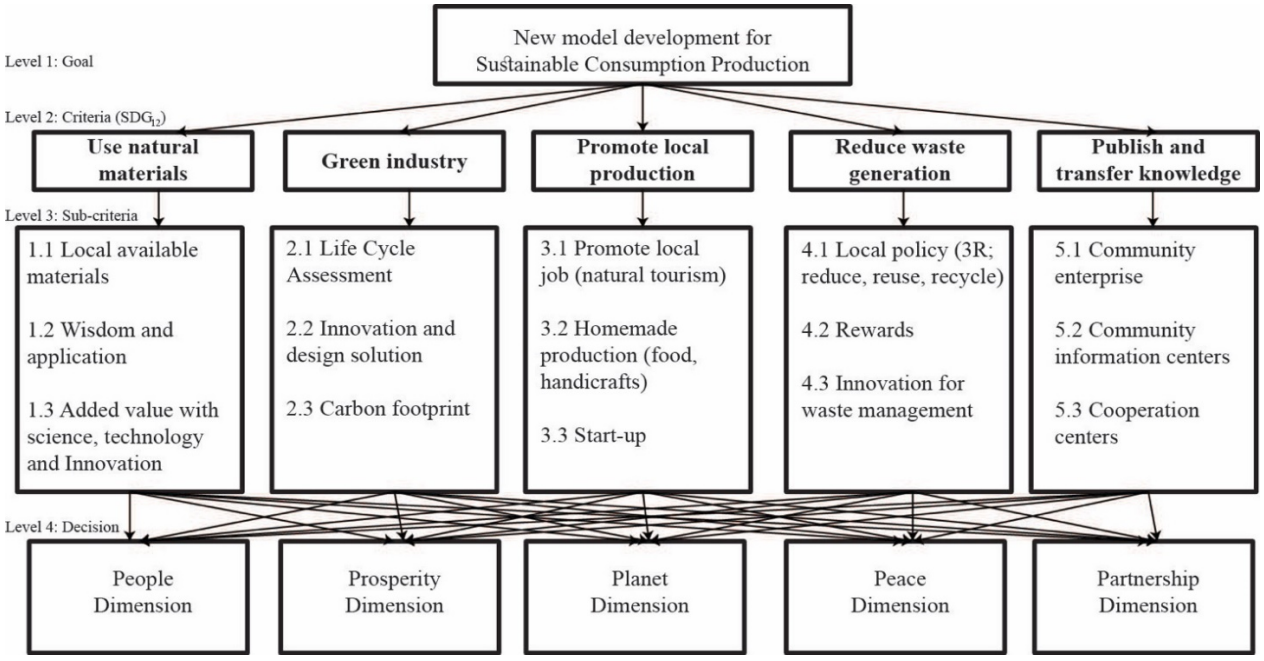

Fig. 3. The Structure of Multilevel Criteria Decision for the Development of sustainable consumption production

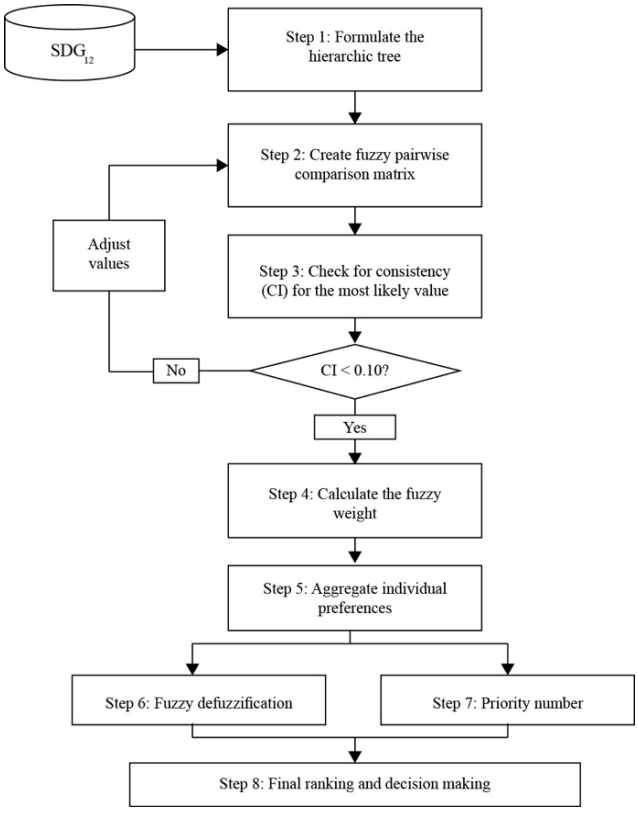

Fig. 4. The steps of priority assessment by comparing the risk factors from fuzzy AHP

2.2. Analysis to find Consistency Ratio (CR)

The assessment results were converted to triangle fuzzy numbers, and the reasons for giving the marks were examined before analysing the data from equation (1) to equation (2).

The highest eigenvalue must also be used in calculating the consistency index [17].

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{1}$$

where λ_{max} is the maximal eigenvalue and n is the dimension of the matrix.

If $CR \leq 10$ or 10, the evaluations of decision-making can be considered as having an acceptable consistency. Saaty, in 1977 [17], calculated the random indices given in Table 2.

$$CR = CI/RI \tag{2}$$

where CR is the consistency ratio, and CI is the random index.

Saaty, in 1977 [17], defined the consistency rates that could be accepted for the matrix tables with the different sizes as follows:

- the consistency rate at 0.05 for the matrix table with the size 3×3;
- the consistency rate at 0.08 for the matrix table with the size 4×4;
- the consistency rate at 0.10 for the matrix table with the size more than 4×4.

Table 2.
Random indices

n	3	4	5	6	7	8	9	10
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Thus, if the calculated consistency rates were the same as or lower than the acceptable consistency rates, it meant that the data was in accordance. On the contrary, if the calculated consistency rates were more than the acceptable consistency rates, it meant that the data had not in accordance with the matrix table. If the assessment results were not accepted, the analysis and the priority in the pairwise comparison had to be done again.

2.3. Analysis to find the values of importance by comparing fuzzy AHP

Step 1 To calculate the bound of the fuzzy synthesis. For the choice by Zadeh (1965) [18] as the equation (3) to the equation (6).

The positive reciprocal comparison matrix of criteria weights is given as [18-20]:

$$A \cdot p = \lambda_{max} \cdot p \tag{3}$$

where A is the comparison matrix, λ_{max} is the maximal eigenvalue, and p is the priorities vector.

Linguistic judgements are depicted in different levels of importance for different persons. Fuzzy logic is often used to capture this variation in the level of importance.

$$\mu_A(X) = \begin{cases} 0, & x < l \\ \dfrac{x-l}{m-l}, & l \le x \le m \\ \dfrac{u-x}{u-m}, & m \le x \le u \\ 0, & x > u \end{cases} \tag{4}$$

The geometric average method was applied for group integration [18]. The formula is presented as follows:

$$\widetilde{M}_{ij} = \left(\prod_{i=1,j=1}^{N} m_{ij}\right)^{\frac{1}{N}} i = 1,2,\dots,N \tag{5}$$

where $\widetilde{M}_{ij}$ is the triangular fuzzy number generated from group integration, $\widetilde{m}_{ij}^{N}$ is the expert N's pair comparison of indicator *i's* and *j's* importance, and N indicates the numbers of experts.

Then, the triangular fuzzy numbers were employed to obtain the fuzzy weight by constructing the fuzzy judgment matrix, which is shown as follows [18]:

$$M = [\widetilde{M}_{ij}], \widetilde{M}_{ij} = (l_{ij}, m_{ij}, u_{ij}), \widetilde{M}_{ij} = \frac{1}{\widetilde{M}_{ij}}, \forall_{i,j} = 1,2,\dots,n \tag{6}$$

where l_{ij} is the lower value in the triangular fuzzy membership function of the experts' opinions on the indicator *j* in managerial competencies aspect *i*, m_{ij} is the median value in the triangular fuzzy membership function of the experts' opinions on the indicator *j* in managerial competences aspect *i* and u_{ij} is the upper value in triangular fuzzy membership function of the experts' opinions on the indicator *j* in managerial competences aspect *i*.

Step 2 To calculate the importance vectors $\widetilde{w}_i$ by Buckley (1985) [19] as the equation (7) to the equation (8).

$$\tilde{z}_l = \left(\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \dots \tilde{a}_{ij}\right)^{1/j}, \forall_i \tag{7}$$

$$\widetilde{w}_i = \tilde{z}_l \otimes (\tilde{z}_1 \otimes \tilde{z}_2 \otimes \dots \otimes \tilde{z}_n)^{-1} \tag{8}$$

where $\tilde{z}_1$ is the geometric average of the triangular fuzzy number, $\tilde{a}_{ij}$is the triangular fuzzy number in row *i* and column *j* in the fuzzy judgment by substituting ordinal values#matrix and $\widetilde{w}_i$ is the fuzzy weight of the indicator *i*.

Step 3 To calculate the level conversion values of the triangle fuzzy by the normalization of the importance of $\overline{W}$ by Kaufmann and Gupta (1991) [21] as the equation (9).

$$\widetilde{w} = (a_1 + 2a_2 + a_3)/3 \tag{9}$$

The methods of analysis to find the values of the Fuzzy analytical decision process (Fuzzy AHP) as Figure 4 for eliminating the unclearness occurring from the assessor's decision for finding the values of important marks of each criteria by comparing the factors in solving the problems in the model development.

3. Results and discussion

The pairwise comparisons for the main criteria and sub-criteria under each main criterion are determined. The pair-wise comparisons are based on the triangular fuzzy numbers for the five main criteria and sub-criteria (The sub-criteria under the five main criteria). The final output of the sustainable development goals (SDG_{12}) model use category in this study based on multilevel modelling by fuzzy AHP technique. After computing the priority weights for each dataset (suitability criterion), each layer, representing each criterion, was multiplied by its fuzzy-AHP weight separately. The results are shown in Tables 3 to 12.

3.1. People dimension

The final score of the main criteria in the FAHP model, Table 3, the people dimension has the most use natural materials (U_1) (25.09%) because it has the highest priority weight, the green industry (G_2) has the next most people dimension (12.42%) the Promote local production (P_3) has the people dimension (6.18%).

Table 3 shows that the people concerned the most about using natural materials (U_1) (25.09%), followed by the green industry (G_2) (12.42%) and promoting local production (P_3) (6.18%). It can be inferred that the sampling populations focus on material as the upstream of sustainable consumption production.

The final score of sub-criteria in the FAHP model, Table 4, the people dimension has the most published and transfer knowledge (P_5) in community enterprise (47.71%) because it has the highest priority weight. However, natural material in the community is still a high concerns from the people dimension.

Table 3.
Overall ranking of main criteria of the people dimension

Criteria	Triangular fuzzy number			Local weights	Global weights	Rank
	l	*m*	*u*			
Use natural materials (U_1)	1.0000	2.4082	3.6239	0.3514	0.2509	1
Green industry (G_2)	0.7248	1.5518	2.6265	0.2505	0.1242	2
Promote local production (P_3)	0.5253	1.0000	1.9037	0.1788	0.0618	3
Reduce waste generation (R_4)	0.3807	0.6444	1.3797	0.1278	0.0309	4
Publish and transfer knowledge (P_5)	0.2759	0.4152	1.0000	0.0915	0.0155	5

Table 4.
Overall ranking of sub-criteria of the people dimension

Criteria	Sub-criteria	Triangular fuzzy number			Local weights	Global weights	Rank
		l	*m*	*u*			
Use natural materials (U_1)	1.1 Local available materials	1.0000	1.8171	2.7144	0.5062	0.4415	1
	1.2 Wisdom and application	0.6300	1.1447	1.7100	0.3189	0.1752	2
	1.3 Added value with science, technology and innovation	0.3420	0.4807	1.0000	0.1750	0.0495	3
Green industry (G_2)	2.1 Life Cycle Assessment	1.0000	1.4422	1.7100	0.4031	0.2437	1
	2.2 Innovation and design solution	1.0000	1.4422	1.7100	0.4031	0.2437	1
	2.3 Carbon footprint	0.3420	0.4807	1.0000	0.1938	0.0511	2
Promote local production (P_3)	3.1 Promote local jobs (natural tourism)	1.0000	1.4422	1.7100	0.4155	0.2551	1
	3.2 Homemade production (food, handicrafts)	1.0000	1.2599	1.5874	0.3787	0.2118	2
	3.3 Start-up	0.3684	0.5503	1.0000	0.2058	0.0581	3
Reduce waste generation (R_4)	4.1 Local policy (3R; reduce, reuse, recycle)	1.0000	1.5874	2.5198	0.4934	0.3990	1
	4.2 Rewards	0.6300	1.0000	1.5874	0.3108	0.1583	2
	4.3 Innovation for waste management	0.3969	0.6300	1.0000	0.1958	0.0628	3
Publish and transfer knowledge (P_5)	5.1 Community enterprise	1.0000	1.8171	2.7144	0.5641	0.4771	1
	5.2 Community information centres	0.5848	0.6934	1.0000	0.2131	0.0707	3
	5.3 Cooperation centres	0.6300	0.7937	1.0000	0.2228	0.0791	2

3.2. Prosperity dimension

Table 5 shows that in the prosperity dimension, the use natural materials (U_1) (25.31%) can deal with prosperity together with the operation of green industry (G_2) (12.52%) followed with promoting local production (P_3) (5.62%).

Table 6 shows that the prosperity dimension concerns the most in using natural materials (U_1) that available in the community (51.85%).

3.3. Planet dimension

Table 7 shows that the planet dimension concerns the use of natural materials (U_1) (25.09%), followed with the green industry (G_2) (12.42%) and the promotion of local production (P_3) (6.18%).

Table 8 shows that the planet dimension has the most concern on using natural materials (U_1) (51.85%) followed with promoting local environment and tourism, making policy of 3R (reduce, reuse, and recycle) waste management as well as promoting community enterprise.

Table 5.
Overall ranking of main criteria of the prosperity dimension

Criteria	Triangular fuzzy number			Local weights	Global weights	Rank
	l	*m*	*u*			
Use natural materials (U_1)	1.0000	2.4082	3.6239	0.3543	0.2531	1
Green industry (G_2)	0.7248	1.5518	2.6265	0.2524	0.1252	2
Promote local production (P_3)	0.5253	0.9221	1.8206	0.1716	0.0562	3
Reduce waste generation (R_4)	0.3807	0.6444	1.3797	0.1288	0.0311	4
Publish and transfer knowledge (P_5)	0.2885	0.4503	1.0000	0.0930	0.0161	5

Table 6.
Overall ranking of sub-criteria of the prosperity dimension

Criteria	Sub-criteria	Triangular fuzzy number			Local weights	Global weights	Rank
		l	*m*	*u*			
Use natural materials (U_1)	1.1 Local available materials	1.0000	2.0801	2.9240	0.5428	0.5185	1
	1.2 Wisdom and application	0.5848	0.8736	1.5874	0.2805	0.1325	2
	1.3 Added value with science, technology and innovation	0.3684	0.5503	1.0000	0.1767	0.0526	3
Green industry (G_2)	2.1 Life Cycle Assessment	1.0000	1.5874	2.5198	0.4934	0.3990	1
	2.2 Innovation and design solution	0.6300	1.0000	1.5874	0.3108	0.1583	2
	2.3 Carbon footprint	0.3969	0.6300	1.0000	0.1958	0.0628	3
Promote local production (P_3)	3.1 Promote local jobs (natural tourism)	1.0000	1.8171	2.7144	0.5178	0.4533	1
	3.2 Homemade production (food, handicrafts)	0.6300	1.0000	1.5874	0.2991	0.1503	2
	3.3 Start-up	0.3684	0.5503	1.0000	0.1831	0.0547	3
Reduce waste generation (R_4)	4.1 Local policy (3R; reduce, reuse, recycle)	1.0000	1.5874	2.5198	0.4934	0.3990	1
	4.2 Rewards	0.6300	1.0000	1.5874	0.3108	0.1583	2
	4.3 Innovation for waste management	0.3969	0.6300	1.0000	0.1958	0.0628	3
Publish and transfer knowledge (P_5)	5.1 Community enterprise	1.0000	1.8171	2.7144	0.5641	0.4771	1
	5.2 Community information centres	0.5848	0.6934	1.0000	0.2131	0.0707	3
	5.3 Cooperation centres	0.6300	0.7937	1.0000	0.2228	0.0791	2

3.4. Peace dimension

Table 9 shows that the peace dimension concerns the most with using natural materials (U_1) (24.21%), following with green industry (G_2) (14.47%) and promotion of local production (P_3) (4.18%).

Table 10 shows that the peace dimension is concerned mostly with reducing waste generation (R_4) with local policy (3R; reduce, reuse, recycle) (54.28%) together with promoting community enterprise (51.8%), by using local natural material (41.6%), under life cycle analysis on green industry (39.9%), as well as promote local product.

3.5. Partnership dimension

Table 11 shows that the partnership dimension is the most concern with using natural materials (U_1) (25.31%) together with (G_2) (12.52%) and promotion local production (P_3) (5.62%).

Table 12 shows that the partnership dimension concerns the most on reducing waste generation (R_4) in local policy using 3R; reduce, reuse, recycle (47.71%) together with using local material (41.6%), for making green industry with life cycle assessment (39.9%) as well as promoting community enterprise (39.9%).

Table 7.
Overall ranking of main criteria of the planet dimension

Criteria	Triangular fuzzy number			Local weights	Global weights	Rank
	l	*m*	*u*			
Use natural materials (U_1)	1.0000	2.4082	3.6239	0.3514	0.2509	1
Green industry (G_2)	0.7248	1.5518	2.6265	0.2505	0.1242	2
Promote local production (P_3)	0.5253	1.0000	1.9037	0.1788	0.0618	3
Reduce waste generation (R_4)	0.3807	0.6444	1.3797	0.1278	0.0309	4
Publish and transfer knowledge (P_5)	0.2759	0.4152	1.0000	0.0915	0.0155	5

Table 8.
Overall ranking of sub-criteria of the planet dimension

Criteria	Sub-criteria	Triangular fuzzy number			Local weights	Global weights	Rank
		l	*m*	*u*			
Use natural materials (U_1)	1.1 Local available materials	1.0000	2.0801	2.9240	0.5428	0.5185	1
	1.2 Wisdom and application	0.5848	0.8736	1.5874	0.2805	0.1325	2
	1.3 Added value with science, technology and innovation	0.3684	0.5503	1.0000	0.1767	0.0526	3
Green industry (G_2)	2.1 Life Cycle Assessment	1.0000	1.5874	2.5198	0.4934	0.3990	1
	2.2 Innovation and design solution	0.6300	1.0000	1.5874	0.3108	0.1583	2
	2.3 Carbon footprint	0.3969	0.6300	1.0000	0.1958	0.0628	3
Promote local production (P_3)	3.1 Promote local jobs (natural tourism)	1.0000	1.8171	2.7144	0.5178	0.4533	1
	3.2 Homemade production (food, handicrafts)	0.6300	1.0000	1.5874	0.2991	0.1503	2
	3.3 Start-up	0.3684	0.5503	1.0000	0.1831	0.0547	3
Reduce waste generation (R_4)	4.1 Local policy (3R; reduce, reuse, recycle)	1.0000	1.8171	2.7144	0.5641	0.4771	1
	4.2 Rewards	0.5848	0.6934	1.0000	0.2131	0.0707	3
	4.3 Innovation for waste management	0.6300	0.7937	1.0000	0.2228	0.0791	2
Publish and transfer knowledge (P_5)	5.1 Community enterprise	1.0000	1.8171	2.7144	0.5178	0.4533	1
	5.2 Community information centres	0.6300	1.0000	1.5874	0.2991	0.1503	2
	5.3 Cooperation centres	0.3684	0.5503	1.0000	0.1831	0.0547	3

3.6. Sustainable production consumption model

Figure 5 shows the model development of the urban community for sustainable production consumption. It consists of input, process and output. The input involves local material, knowledge, wisdom and know-how, and innovative added product value added. The process converts input to obtain results. They implement local production with natural materials for local enterprises and micro-enterprises, namely OTOP. Green and home products with cleaner production, clean energy and plain carbon credit expect the model results. The strategic plan contains a green industry, zero waste management (3R: Reduce, Reuse, Recycle), zero carbon footprint, and innovative product design. The model can be applied to other urban communities with the same characteristics as those in Thailand undertaking SDG_{12}, which is concerned with sufficient consumption under carbon neutrality.

Table 9.
Overall ranking of main criteria of the peace dimension

Criteria	Triangular fuzzy number			Local weights	Global weights	Rank
	l	*m*	*u*			
Use natural materials (U_1)	1.0000	2.4082	3.6239	0.3644	0.2421	1
Green industry (G_2)	1.1247	1.7411	2.8252	0.2812	0.1447	2
Promote local production (P_3)	0.5065	0.9441	1.5281	0.1519	0.0418	3
Reduce waste generation (R_4)	0.3671	0.5942	1.3195	0.1247	0.0263	4
Publish and transfer knowledge (P_5)	0.2782	0.4251	0.8027	0.0778	0.0107	5

Table 10.
Overall ranking of sub-criteria of the peace dimension

Criteria	Sub-criteria	Triangular fuzzy number			Local weights	Global weights	Rank
		l	*m*	*u*			
Use natural materials (U_1)	1.1 Local available materials	1.0000	1.5874	2.5198	0.5345	0.4162	1
	1.2 Wisdom and application	0.6300	0.7937	1.0000	0.2327	0.0839	2
	1.3 Added value with science, technology and innovation	0.6300	0.7937	1.0000	0.2327	0.0839	2
Green industry (G_2)	2.1 Life Cycle Assessment	1.0000	1.5874	2.5198	0.4934	0.3990	1
	2.2 Innovation and design solution	0.6300	1.0000	1.5874	0.3108	0.1583	2
	2.3 Carbon footprint	0.3969	0.6300	1.0000	0.1958	0.0628	3
Promote local production (P_3)	3.1 Promote local jobs (natural tourism)	1.0000	1.2599	1.5874	0.3899	0.2212	1
	3.2 Homemade production (food, handicrafts)	1.0000	1.2599	1.5874	0.3899	0.2212	1
	3.3 Start-up	0.3969	0.6300	1.0000	0.2202	0.0670	2
Reduce waste generation (R_4)	4.1 Local policy (3R; reduce, reuse, recycle)	1.0000	2.0801	2.9240	0.5920	0.5428	1
	4.2 Rewards	0.5848	0.6934	1.0000	0.2040	0.0666	2
	4.3 Innovation for waste management	0.5848	0.6934	1.0000	0.2040	0.0666	2
Publish and transfer knowledge (P_5)	5.1 Community enterprise	1.0000	2.0801	2.9240	0.5428	0.5185	1
	5.2 Community information centres	0.5848	0.8736	1.5874	0.2805	0.1325	2
	5.3 Cooperation centres	0.3684	0.5503	1.0000	0.1767	0.0526	3

Table 11.
Overall ranking of main criteria of the partnership dimension

Criteria	Triangular fuzzy number			Local weights	Global weights	Rank
	l	*m*	*u*			
Use natural materials (U_1)	1.0000	2.4082	3.6239	0.3543	0.2531	1
Green industry (G_2)	0.7248	1.5518	2.6265	0.2524	0.1252	2
Promote local production (P_3)	0.5253	0.9221	1.8206	0.1716	0.0562	3
Reduce waste generation (R_4)	0.3807	0.6444	1.3797	0.1288	0.0311	4
Publish and transfer knowledge (P_5)	0.2885	0.4503	1.0000	0.0930	0.0161	5

Table 12.
Overall ranking of sub-criteria of the partnership dimension

Criteria	Sub-criteria	Triangular fuzzy number			Local weights	Global weights	Rank
		l	*m*	*u*			
Use natural materials (U_1)	1.1 Local available materials	1.0000	1.5874	2.5198	0.5345	0.4162	1
	1.2 Wisdom and application	0.6300	0.7937	1.0000	0.2327	0.0839	2
	1.3 Added value with science, technology and innovation	0.6300	0.7937	1.0000	0.2327	0.0839	2
Green industry (G_2)	2.1 Life Cycle Assessment	1.0000	1.5874	2.5198	0.4934	0.3990	1
	2.2 Innovation and design solution	0.6300	1.0000	1.5874	0.3108	0.1583	2
	2.3 Carbon footprint	0.3969	0.6300	1.0000	0.1958	0.0628	3
Promote local production (P_3)	3.1 Promote local jobs (natural tourism)	1.0000	1.2599	1.5874	0.3787	0.2118	2
	3.2 Homemade production (food, handicrafts)	1.0000	1.4422	1.7100	0.4155	0.2551	1
	3.3 Start-up	0.3684	0.5503	1.0000	0.2058	0.0581	3
Reduce waste generation (R_4)	4.1 Local policy (3R; reduce, reuse, recycle)	1.0000	1.8171	2.7144	0.5641	0.4771	1
	4.2 Rewards	0.5848	0.6934	1.0000	0.2131	0.0707	3
	4.3 Innovation for waste management	0.6300	0.7937	1.0000	0.2228	0.0791	2
Publish and transfer knowledge (P_5)	5.1 Community enterprise	1.0000	1.5874	2.5198	0.4934	0.3990	1
	5.2 Community information centres	0.6300	1.0000	1.5874	0.3108	0.1583	2
	5.3 Cooperation centres	0.3969	0.6300	1.0000	0.1958	0.0628	3

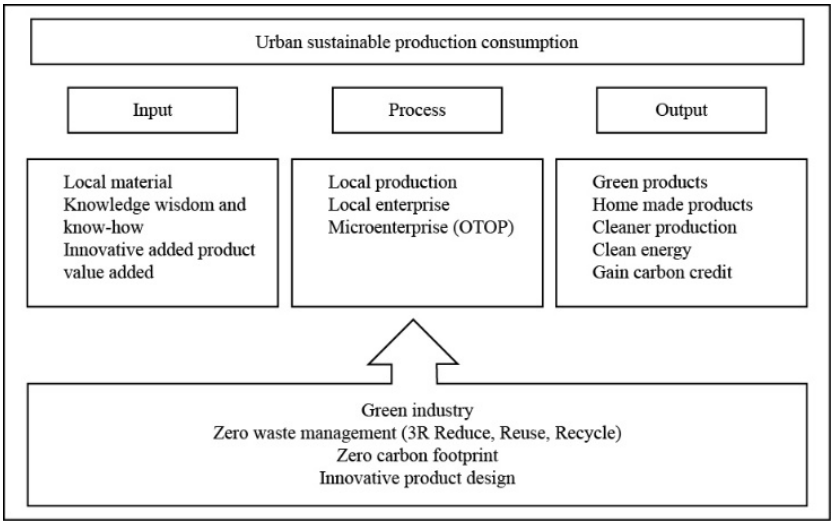

Fig. 5. Model development of the urban community for sustainable production consumption

4. Conclusions

The paper presents the decision-making process to develop the urban community model for sustainable production consumption in order to support SDG_{12} using FAHP for multi-decision-making based on the 5P principle. There are people, porosity, planet, peace, partnership. It was obviously found that people mostly use local materials to make green local products under the local policy of 3R waste management. Innovative design uses community wisdom, knowledge and know-how to make value-added products. The strategic planning and control consist of green industry,

zero waste management, zero carbon footprint and innovative product design. The expected outputs from the model are green and homemade products with cleaner production, clean energy, and gain carbon credit.

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Authors contribution

Suthep Butdee conceptualized ideas and wrote and edited them.

Phatchani Srikhumsuk wrote the manuscript, conceptualised the experiments, and collected data.

Puntiva Phuangsalee contributed to the analyses and wrote the manuscript.

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