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A HYBRID METHOD FOR OCCUPATIONS SELECTION IN THE BIO-CIRCULAR-GREEN ECONOMY PROJECT OF THE NATIONAL HOUSING AUTHORITY IN THAILAND

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Abstract: *The National Housing Authority (NHA) in Thailand has developed a new project with the aim of sustainable development based on the Bio-Circular-Green (BCG) economy for improving the quality of life of people in the country. It not only provides houses to live in but also promotes income generation by choosing and promoting the appropriate occupations for the people. Choosing appropriate occupations within the BCG economy is a complex decision-making process, as there are likely to be many factors to consider for each community. To, address this challenge, a novel hybrid approach combining the Fuzzy Logarithmic Full Consistency Method (FUCOM-LF) and the Combined Compromise Solution (CoCoSo) is introduced. This hybrid method effectively evaluates the sustainability of different occupations and identifies appropriate occupations for the community by ensuring full consistency in weighing the relevant criteria and high-resolution discrimination of alternatives. The proposed comprehensive BCG occupation selection framework serves as a general framework for NHA that can be applied to any community. Additionally, this research provides a compilation of support guidelines for each occupation. Through a case study community, the practicality and effectiveness of the hybrid method and the proposed framework in selecting the appropriate occupations are demonstrated.*

Key words: *Fuzzy Logarithmic Full Consistency Method, Combined Compromise Solution, Bio-Circular-Green Economy, Multi-Criteria Decision Making, Sustainable Development, Sustainability.*

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1. Introduction

Originally, the purpose of the National Housing Authority (NHA) housing in Thailand was building residences for improving the quality of life of people in the country (National Housing Authority, 2022). However, in the long run when the economy in the country was not good and people had insufficient income, many consequences arose, such as crime, depredation, or quarrels with neighbors due to stressful family situations. As a result, the government of Thailand realized that the quality of life of underprivileged people should be improved. Currently, NHA has instigated a new project with the aim of developing sustainability (National Housing Authority, 2022). Besides providing housing, generating income is also necessary. Creating jobs for disabled people, low-income people, and uneducated people based on the policy of national administration should be initiated. Bio-Circular-Green (BCG) principle (NSTDA, 2021) was used as a guideline in choosing occupations for these people in the NHA projects. BCG economy is an economic system that focuses on efficiently using resources, maximizing resource recovery, and minimizing the negative environmental impact.

The motivation for this research came from the NHA's need. The objective for the selection of the best occupation for the BCG project is to provide people in the community with a place to live and have a livelihood with long-term sustainable household income. Based on the problem mentioned above, the solution is to promote occupations that are critical to the BCG economy for the community, as choosing the wrong occupation is a waste of time and money. Selecting the right occupations for the people in the community requires several elements to be considered simultaneously. So, the tools for prioritizing and selecting should be employed.

In this research, the Multi-Criteria Decision Making (MCDM) method was utilized to prioritize essential criteria and select a promoted career in the BCG project. Critical criteria related to the BCG project were gathered from existing literature. The International Labor Organization has divided the occupations of the population in Thailand into 10 groups ("Thailand: A Labor Market Profile," 2013): 1. legislators, senior officials and managers 2. professionals 3. technicians and associate professionals 4. clerks 5. service workers, shop and market sales workers 6. skilled agricultural and fishery workers 7. craftsmen and related trade workers 8. plant and machine operators and assemblers 9. elementary occupations, and 10. workers, or not classifiable occupation. NHA has selected six suitable occupations for the BCG project: 1. organic farming 2. livestock 3. service career 4. flea market and parking 5. small industry 6. mini-mall, distribution, and warehouse (Keha Sukpracha, 2022). It is difficult to identify specifically which occupations are appropriate for the people in the selected community because they depend on the people and environment of the community.

Existing applications of MCDM are qualified personnel selection problems using the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for employee promotion selection (Akmaludin et al., 2022). Fuzzy Delphi method, Analytic Hierarchy Process (AHP); and TOPSIS assisted the managers of shopping websites in selecting live streamers (Lim et al., 2021). Nowadays, the Full Consistency Method (FUCOM) and Fuzzy Full Consistency Method (FUCOM-F) are prevalent with computational advantage (Panjavongroj & Phruksaphanrat, 2022). There have been several applications of FUCOM, for example, choosing the most suitable manufacturing method (Sofuoğlu, 2019), assessment of alternative fuel vehicles (Pamucar et al., 2021), and determining the weights of the main and sub-criteria of sustainable urban mobility plan (Demir et al., 2022). The FUCOM method outperforms the AHP and Best

Worst Methods (BWM) (Pamucar et al., 2018; Pamucar & Ecer, 2020) because they eliminate the drawback of a large number of comparisons and define a deviation from full consistency (DFC).

In the actual world, there is uncertainty of information about situations. So, decision-makers (DMs) prefer to evaluate characteristics using linguistic variables because of ambiguous, inaccurate, or incomplete information. The fuzzy set theory is one of the strategies successfully used to portray this imperfect information. MCDM problems with inaccurate data have been effectively modeled using fuzzy set theory since their inception (Pamucar & Ecer, 2020). However, the existing FUCOM-F method's efficiency is insufficient (Panjavongroj & Phruksaphanrat, 2022), resulting in the development of a new approach known as the Fuzzy Logarithmic Full Consistency Method (FUCOM-LF). Combined Compromise Solution (CoCoSo) has been widely applied in risk evaluation and prioritization of occupational hazards (Chen et al., 2022), selecting the most appropriate container seaport (Pamucar & Faruk Görçün, 2022), and assessing the ranking of the best choice for sustainable material (Dwivedi & Sharma, 2022). CoCoSo is the preferred method for selecting a suitable alternative because it can increase the exactitude of decision-making and has a greater resolution in identifying the evaluated alternatives.

This research aimed to present a hybrid approach called FUCOM-LF with CoCoSo in selecting an occupation for a community within the BCG economy criteria. Initially, the criteria that affect the BCG economy were considered in the BCG project selection. Then, the main criteria from related literature were summarized, such as innovation and knowledge, emission, collaboration, sustainable management, value, etc. FUCOM-LF was applied in the first phase, obtaining weights criteria that affect the BCG economy. Next, the appropriate occupation group for the community was identified based on the critical criteria of the BCG project by the proposed MCDM method. Then, a recommendation for investment and formulation of policies was proposed to boost the occupation. CoCoSo was adopted in the second phase for an alternative selection. To the best of our knowledge, there is no previous research about occupation selection for the BCG economy by FUCOM-LF and CoCoSo methods.

The contributions of this research were divided into educational and social benefits. For educational benefit, the critical criteria when considering the BCG economy of a community were gathered from existing research works. They could be used as a guideline for further consideration of a BCG economy project for case studies. Additionally, the new prominent integrated approach of MCDM was presented in this research. It uses fewer comparative pairs than existing methods to obtain effective criteria and the best alternative, and it has high resolution in identifying the alternatives. For social benefit, appropriate occupations for the BCG project were selected to be promoted. It could help people in the community to gain income and improve their quality of life. Additionally, a guide for investment and formulation of policies for each occupation based on the BCG economy for other projects was also suggested.

The research is structured as follows: Literature reviews of the related articles are presented in the second section. Section 3 shows the details of the FUCOM-LF and CoCoSo methods. Section 4 discusses a case study of an occupation selection in the BCG project, concerning the essential criteria for the BCG economy. The last section summarizes the findings of this research and future research.

2. Literature Reviews

This section provides a quick review of a handful of research work related to this study. The critical research papers published in reputable journals have been reviewed to produce a suitable comprehensive concept and to develop an appropriate relationship with the primary idea of the study.

2.1. Bio-Circular-Green economy

The concept of BCG economy has 3 components: bio-economy, circular economy, and green economy as shown in Figure 1.

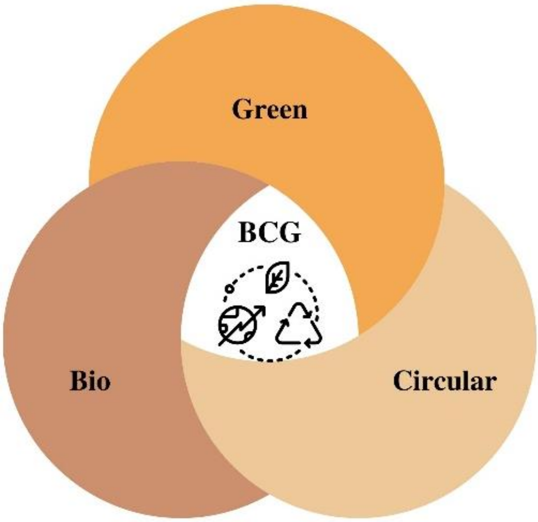

Figure 1. Relations among bio-economy, circular economy, and green economy.

2.1.1. Bio-economy

The bio-economy is a type of economy that deals with biomass, biological processes (Bröring et al., 2020; Pfau et al., 2014), renewable biological resources, biotechnology businesses, and energy industries (Bugge et al., 2016; Wesseler & Von Braun, 2017). The bio-economy is driven by social and economic developments, with a focus on long-term growth.

2.1.2. Circular economy

The circular economy emphasizes resource optimization, manufacturing that utilizes fewer resources, allowing the value of goods, materials, and resources to endure as long as possible, recycling, and reduction of waste (Carus & Dammer, 2018; Corvellec et al., 2022; Kardung et al., 2021; Marsh et al., 2022; Stegmann et al., 2020; Wesseler & Von Braun, 2017) by employing scientific processes or semi-science principles (Corvellec et al., 2022).

2.1.3. Green economy

The green economy is the most effective technique for reducing negative environmental and ecological impacts. This strategy necessitates the utilization of restricted resources. As a result, essential metrics must be established to address the problem of excessive resource use. Indicators to measure the amount of waste emissions are also required (Chen et al., 2011). The green economy has the potential to help achieve the Sustainable Development Goals (SDGs) and accelerate the transition to low-carbon, resource-efficient, and comprehensive economies (Khoshnava et al., 2019).

2.2. Overview of criteria and occupations for the BCG project

Many criteria about the concept of the BCG economy have been presented in the literature. These criteria could be grouped into 5 main criteria, the specifics of which are provided in Table 1.

Six occupations were selected and evaluated based on the BCG criteria for the BCG project of NHA: A_1, Organic farming; A_2, Livestock; A_3, Service career; A_4, Flea market and parking; A_5, Small industry; and A_6, Mini-mall, distribution, and warehouse. These occupations are the potential occupations for the community in the BCG project. They can provide a sustainable livelihood for people in the long run. They may be particularly well-suited for the BCG economy, which emphasizes resource efficiency and sustainability. Specific characteristics of these occupations and how they contribute to the goals of the BCG project are as follows:

Organic farming (A_1) is a type of agriculture that uses natural pest control systems and bio-fertilizers made from plants and animals rather than chemical pesticides and synthetic fertilizers. This approach can prevent environmental harm and reduce soil erosion that benefits the ecosystem.

Livestock (A_2) can be raised using organic feeding practices and regular inspections to produce products verified as organic on the market. In addition, waste products from livestock, such as excreta can be used as fertilizers and pesticides.

Service career (A_3) within the community involves training professionals, such as barbers, electricians, and technicians, to provide services to people both within and outside the community. These professional careers may be selected based on their previous work and customer satisfaction. The service career could also include roles such as driver and security guard.

Flea market and parking (A_4). A flea market is a market that primarily sells products within the community, helping to distribute products and generate revenue for people in the community. By designating appropriate waste disposal points and separating waste for efficient recycling, the market can promote sustainability by reducing the environmental impact of waste. Providing parking for sellers and buyers inside and outside the community can also help to facilitate access to the market and potentially reduce traffic congestion.

Table 1. Literature review about BCG criteria

Criteria	Details	References
C_1: Innovation and knowledge	Innovation capacity and knowledge integration International collaboration among educators is needed to determine the knowledge, skills, and necessary abilities. Technological innovation policies and BCG policy model. Using information and technological innovation helps to improve competitiveness and environmental friendliness. Research and development: innovative products.	(Bröring et al., 2020; Dietz et al., 2018; Khoshnava et al., 2019; Seesung, 2021)
C_2: Emissions	Utilizing organic waste streams. Reduction of greenhouse gas (GHG) emissions. The change rate of the volume of waste emissions.	(Kardung et al., 2021; Pfau et al., 2014; Vukovic et al., 2019)
C_3: Collaboration	Collaborations between public and private organizations and governments. To encourage worldwide partnerships, research, and development. Assistance programs.	(El-Chichakli et al., 2016; Palapleevalya et al., 2017)
C_4: Sustainable management	Minimizing waste. Renewable energy investment and green economy development / Recycling / Reduction of material / Reuse and remanufacturing / Replacing non-renewables with biological resources / Renewable resources. Evaluation and control of occupation risks and consequences. Sustainable society / Sustainable energy / Sustainable biomass production / Sustainable production chains. Regulation: sustainability standards for resources	(Bröring et al., 2020; Kardung et al., 2021; Marsh et al., 2022; Seesung, 2021)
C_5: Value	Value optimization. Maintaining the value of materials, products, and resources. Value chain-related challenges / Resource-efficient value chains. Value added.	(Bröring et al., 2020; Kardung et al., 2021; Seesung, 2021; Stegmann et al., 2020)

Small industry (A_5) is a processing industry that uses some of raw materials from the community to add value to the product or extend its shelf life. For example, marinated or preserved mangoes, and pork or chicken could be transformed into Chinese sausage, grated pork, or grated chicken. By using modern technology to maximize productivity, minimize waste or pollution, and design compostable or reusable packaging, the industry could contribute to the BCG economy's goals, emphasizing resource efficiency and sustainability.

Mini-mall, distribution, and warehouse (A_6) is a larger-scale operation than a flea market and likely involves a relatively large number of people. Proper waste management practices can help to promote sustainability. Warehouses serve as an essential part of the supply chain, providing storage and consolidation of products before distribution to retailers and consumers.

2.3. Literature review of FUCOM and CoCoSo methods

MCDM methods for weighting criteria and selecting alternatives can be roughly classified into two groups. The first group is pairwise comparison-based methods such as AHP, Analytic Network Process (ANP), and Decision Making Trial and Evaluation Laboratory (DEMATEL). The second group is outranking or compromise criteria methods such as Weighted Sum Approach (WSA), TOPSIS, Vlse Kriterijumska Optimizacija Kompromisno Resenje (VIKOR), Complex Proportional Assessment (COPRAS), Elimination Et Choix Traduisant la Realite (ELECTRE), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) (Franek & Kashi, 2014). Currently, the ranking is used instead of pairwise comparison because the number of comparisons is lower than pairwise comparison. However, for a large number of criteria or alternatives, it may be difficult for DM to rank. Recently developed methods, FUCOM and CoCoSo are in the second group. Based on Table 2 and Table 3, FUCOM and CoCoSo are currently very popular methods applied to many fields of study.

The FUCOM method employs crisp numbers to prioritize alternatives, whereas FUCOM-F utilizes triangular fuzzy numbers (TFN). For the case study, the decision-making was quite complex and the decision data were not so complete, so it was not appropriate to use crisp numbers. Therefore, fuzzy data were used. However, the existing FUCOM-F was not effective enough (Panjavongroj & Phruksaphanrat, 2022). Therefore, a new method was proposed for calculating the relevant weights of criteria for the BCG economy. The calculation for occupation selection in the BCG project was based on the CoCoSo method, as recommended by Yazdani et al. (2019), to provide the most suitable solution, because it promotes the accuracy of decision-making systems and has a higher resolution in discriminating the considered options. In the CoCoSo method, numerous applications with diverse databases encounter situations where traditional crisp number normal estimation (Kumar et al., 2022; Popović, 2021), fuzzy z number (Haseli et al., 2023; Zafaranlouei et al., 2023), and fuzzy set estimation (Bonab et al., 2023; Ghoushchi et al., 2022; Lai et al., 2022) were employed. In this study, the utilization of a crisp number of CoCoSo is considered sufficient for evaluating efficiency.

The current literature review reveals a gap in the examination of the combined utilization of FUCOM-LF and CoCoSo for occupation selection in the BCG project. This study introduce the FUCOM-LF as a new method that integrated the LFPP into the the FUCOM, effectively reducing the number of required pairwise comparisons and ensuring full consistency. In parallel, the CoCoSo approach enhances accuracy and provides a high resolution in distinguishing among various alternatives. Notably, this method offers flexibility in adding or removing considered options and alternatives, without impacting the outcome. By combining the strengths of different approaches, this method excels in achieving high performance in multicriteria decision-making scenarios.

Table 2. Applications of FUCOM group in different fields

Authors	Field of applications
FUCOM	
Erceg et al. (2019)	Determination of the significance of parameters for stock management in the storage system
Fazlollahtabar (2019)	Selection of forklift in a warehouse
Sofuoğlu (2019)	Choosing the most suitable manufacturing method
Badi and Kridish (2020)	Selection of landfill site in Libya
Durmić et al. (2020)	Sustainable supplier selection
Akbari et al. (2021)	Identification of the groundwater potential recharge zones
Feizi et al. (2021)	Assigning weights to the spatial proxies
Ocampo (2022)	Evaluating the sustainability of farm tourism sites
FUCOM-F	
Pamucar et al. (2020)	Selection and prioritization of appropriate transportation demand management measures
Pamucar et al. (2021)	Assessment of alternative fuel vehicles for sustainable road transportation in the United States
Demir et al. (2022)	Selection decision of final measures and policies to be carried out to achieve sustainable urban mobility plans and workspace goals
Khan et al. (2022)	Evaluating strategies to enhance the resilience of the healthcare sector to combat the COVID-19 pandemic
Khosravi et al. (2022)	Prioritization and selection of the most suitable organizational structure

Table 3. Applications of CoCoSo in different fields

Authors	Field of applications
Ecer and Pamucar (2020)	Sustainable supplier selection
Peng et al. (2020)	Considering the 5G industry evaluation
Khan and Haleem (2021)	Evaluation of the circular economy practices
Popović (2021)	Selection of the best candidate
Chen et al. (2022)	Evaluation of the most serious work-related hazards for corrective actions.
Dwivedi and Sharma (2022)	Selection of the most appropriate engineering sustainability components
Kumar et al. (2022)	Selection of a spray-painting robot suitable
Lai et al. (2022)	Selection of blockchain platform
Narang et al. (2022)	Stock portfolio selection
Pamucar and Faruk Görçün (2022)	Selecting the most appropriate European container seaport
Qiyas et al. (2022)	Choosing the optimal antiviral medicine to manage COVID-19s
Ghoushchi et al. (2022)	Evaluation of wind turbine failure modes
Bonab et al. (2023)	Selection of sustainable resilient supplier
Haseli et al. (2023)	Selection of sustainable resilient recycling partner

Authors	Field of applications
Zafaranlouei et al. (2023)	Assessment of sustainable waste management alternatives

3. Methodologies

The methodology of this research has two stages, which are to estimate the weights of the criteria relevant to the BCG economy and to find the most appropriate occupation in the BCG project. In the first part, the weights of the criteria are calculated by FUCOM-LF technique. After the weight of each criterion has been computed, CoCoSo calculation technique is applied to find the appropriate occupation alternative in the BCG project in this research.

3.1. Logarithmic Fuzzy Full Consistency Method (FUCOM-LF)

In this section, two novel approaches, LFPP (Wang & Chin, 2011) and FUCOM techniques (Pamucar et al., 2018), are combined to take advantage of both methods in the new hybrid method. It is beneficial for analyzing using small numbers of comparisons; it is also a way to achieve complete consistency of assessment. The computing technique is illustrated below.

Step 1: Evaluate the decision criteria.

The first stage in multi-criteria models is to define a set of assessment criteria. Assuming that there are n (j=1, 2,...,n) assessment criteria represented by a set of criteria, $C = \{C_1, C_2,..., C_n\}$.

Step 2: Sort the selection criteria in order of significance. Criteria are rated by DMs based on their preferences regarding the relevancy of the criteria. The criterion with the significant weight coefficient is ordered in the top rank. The criterion with the lowest predicted value of the weight coefficient is assigned to the last position. As a result, each criterion is prioritized based on the DMs expected effect on decision-making.

$$C_{j(1)} > C_{j(2)} >...> C_{j(k)} \tag{1}$$

Step 3: Compare the criteria using triangular fuzzy numbers (TFN) as shown in Table 4. The comparison is carried out with the top-ranked (most important) criterion in mind for each criterion ranked in Step 2. The following criteria must be compared n times. Then, the fuzzy judgment significance ($\varpi C_{j(k)}$) can be obtained. The fuzzy comparable significance $\varphi_{k/(k+1)}$ is derived using Eq. (2) depending on the relevance of the criteria.

Table 4. TFN scale

Linguistic	Membership function
Equally important	(1, 1, 1)
Weakly important	(2/3, 1, 3/2)
Fairly important	(3/2, 2, 5/2)
Very important	(5/2, 3, 7/2)
Absolutely important	(7/2, 4, 9/2)

$$\varphi_{\frac{k}{k+1}} = \varpi C_{j(k+1)} / \varpi C_{j(k)} = \left(\varpi^{l}_{j(k+1)}, \varpi^{m}_{j(k+1)}, \varpi^{u}_{j(k+1)}\right) / \left(\varpi^{l}_{j(k)}, \varpi^{m}_{j(k)}, \varpi^{u}_{j(k)}\right) \tag{2}$$

Eq. (3) illustrates a fuzzy vector of the comparative significance of the evaluation criteria.

$$\Phi = (\varphi_{1/2}, \varphi_{2/3}, \dots, \varphi_{k/(k+1)}) \quad (3)$$

where $\varphi_{k/(k+1)}$ indicates the $C_{j(k)}$ criterion's significance with respect to the $C_{j(k+1)}$.

Step 4: Choose the appropriate fuzzy weights. The final results of the fuzzy weight criteria coefficients $(w_1, w_2, \dots, w_n)^T$ are computed. The final weight coefficient values must meet two conditions:

Condition 1

$$w_k / w_{k+1} = \varphi_{k/(k+1)} \quad (4)$$

Condition 2

$$w_k / w_{k+2} = \varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)} \quad (5)$$

Step 5: The final estimated weight values of the problem threshold can be calculated from the model as follows:

Model: FUCOM-LF

$$Minimize\ J = (1-\lambda)^2 + M \cdot (\sum_{k=1}^{n} \delta_{k/k+1}^2 + \eta_{k/k+1}^2)$$

$$S.t. \begin{cases} x_k - x_{(k+1)} - \lambda\, ln\left(\varphi_{k/(k+1)}^m / \varphi_{k/(k+1)}^l\right) + \delta_{k/(k+1)} \geq ln\, \varphi_{k/(k+1)}^l \\ -x_k + x_{(k+1)} - \lambda\, ln\left(\varphi_{k/(k+1)}^u / \varphi_{k/(k+1)}^m\right) + \eta_{k/(k+1)} \geq -ln \varphi_{k/(k+1)}^u \\ \lambda, x_k, x_{(k+1)} \geq 0 \\ \delta_{k/(k+1)}, \eta_{k/(k+1)} \geq 0 \\ k = 1, \dots, n. \end{cases} \quad (6)$$

Let k denote the criterion's rank,

$\varphi_{k/(k+1)} = (\varphi^l_{k/(k+1)}, \varphi^m_{k/(k+1)}, \varphi^u_{k/(k+1)})$,

$x_k = ln\ w_k$ for $k = 1, \dots, n$,

$w_k = (w^l_k, w^m_k, w^u_k)$,

x_k^* is an optimum solution,

M is a large constant value, 10^3,

λ is a membership degree,

$\delta_{k/(k+1)}, \eta_{k/(k+1)}$ are nonnegative deviation variables for $k = 1, \dots, n$.

Eq. (7) is used to normalize the value of x_k^* and sort fuzzy pairwise comparison matrices.

$$w_k^* = exp\, x_k^* / \sum_{j=1}^{n} exp(x_k^*)\ , k = 1, \dots, n. \quad (7)$$

where exp ( ) is the function of exponential for which the computation is $exp(x_k^*) = e^{x_k^*}$ for $k = 1, \dots, n$. w_k^* is the weight of each criteria from $k = 1, \dots, n$.

Step 6: A consistency test is performed. If an inconsistency is detected, it must be assessed until the consistency test satisfies the condition listed below.

In general, a positive optimum value is desired. If it is discovered that its ideal value is $\lambda^* = 0$, there is a significant inconsistency between the fuzzy judgments unless $\sum_{k=1}^{n} (\delta_{k/k+1}^2 + \eta_{k/k+1}^2) = 0$. The bigger the value of δ^*, the more inconsistent the fuzzy judgments. As a result, the value of δ^* in fuzzy pairwise comparison matrices might be seen as a measure of inconsistency.

3.2. Combined Compromise Solution (CoCoSo)

The following stages are used to demonstrate the CoCoSo method's calculation approach (Yazdani et al., 2019):

Step 1: Preparing the initial decision matrix.

Step 2: Criteria values are normalized.

Benefit criterion

$$r_{ij} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}};\ i = 1, 2, \dots, m;\ j = 1, 2, \dots, n. \quad (8)$$

Non-benefit criterion

$$r_{ij} = \frac{\max_i x_{ij} - x_{ij}}{\max_i x_{ij} - \min_i x_{ij}};\ i = 1, 2, \dots, m;\ j = 1, 2, \dots, n. \quad (9)$$

where r_{ij} is a normalized rating of the relative alternative between *i* and *j*, and x_{ij} signifies the rating of the relative alternative between *i* and *j*.

Step 3: The CoCoSo approach is based on the integrations of simple additive weighting (SAW) and the exponentially weighted product model illustrated as follows:

$$S_i = \sum_{j=1}^{n} (w_j r_{ij}) \quad (10)$$

$$P_i = \sum_{j=1}^{n} (r_{ij})^{w_j} \quad (11)$$

S_i is the sum of the weighted comparability sequence for each alternative.

P_i is the sum of the power weight of comparability sequences for each alternative.

Step 4: Rank the alternatives that have been evaluated. The CoCoSo approach employs a relative performance score k_i for ranking purposes, which is computed using three appraisal score strategies k_{ia}, k_{ib}, and k_{ic}. DMs select λ (usually $\lambda = 0.5$) for evaluation.

$$k_i = \frac{1}{3}(k_{ia} + k_{ib} + k_{ic}) + (k_{ia} k_{ib} k_{ic})^{\frac{1}{3}} \quad (12)$$

with:

$$k_{ia} = \frac{S_i + P_i}{\sum_{i=1}^{m}(S_i + P_i)} \quad (13)$$

$$k_{ib} = \frac{S_i}{\min_i S_i} + \frac{P_i}{\min_i P_i} \quad (14)$$

$$k_{ic} = \frac{\lambda S_i + (1 - \lambda) P_i}{\lambda \max_i S_i + (1 - \lambda) \max_i P_i} \quad (15)$$

4. A case study

The framework for selecting the BCG economics project was developed as illustrated in Figure 2. This research aimed to identify the best occupation to be promoted for the BCG project of NHA in Thailand. It began by rating the significance of five BCG economy-related criteria. The weights gained from the FUCOM-LF were then used to compute the selection of alternatives from the six alternative occupations of the BCG project selection by CoCoSo.

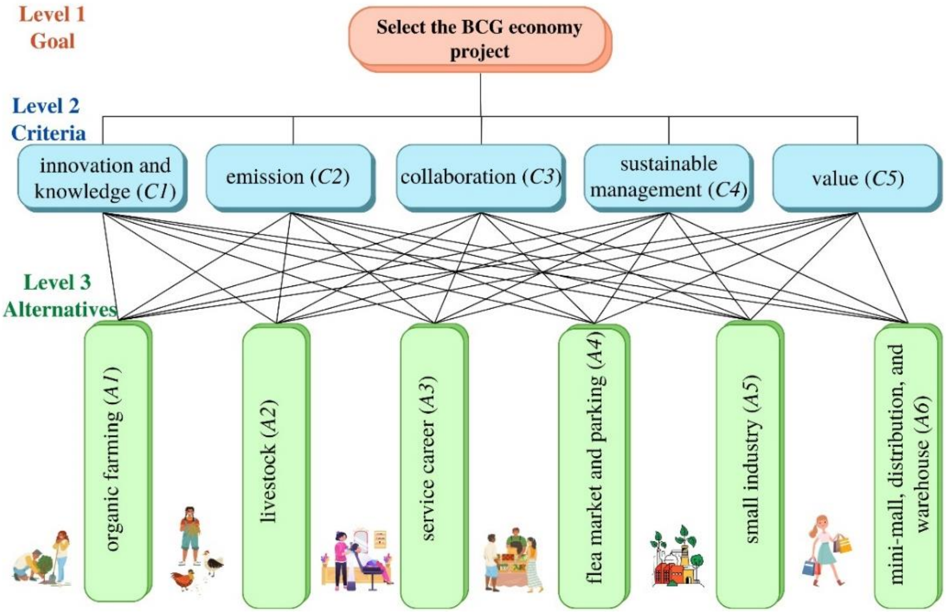

Figure 2. Framework of BCG economy project selection.

The preference matrix was evaluated by experts who were involved in the project implementation. Table 5 depicts the evaluation of the five criteria. C_4 is the most important criterion followed by C_1, C_3, C_5, and C_2, respectively.

Table 5. The priorities of criteria

Criteria	C_4	C_1	C_3	C_5	C_2
TFN	(1, 1, 1)	(2/3, 1, 3/2)	(2/3, 1, 3/2)	(3/2, 2, 5/2)	(5/2, 3, 7/2)

Calculate the comparative significance of each criterion according to Eq. (2) as follows:

$$\varphi_{4/1} = \varpi C_4 / \varpi C_1 = (2/3, 1, 3/2) / (1, 1, 1) = (0.6667, 1, 1.5)$$

$$\varphi_{1/3} = \varpi C_1 / \varpi C_3 = (2/3, 1, 3/2) / (2/3, 1, 3/2) = (0.4444, 1, 2.25)$$

$$\varphi_{3/5} = \varpi C_3 / \varpi C_5 = (3/2, 2, 5/2) / (2/3, 1, 3/2) = (1, 2, 3.75)$$

$$\varphi_{5/2} = \varpi C_5 / \varpi C_2 = (5/2, 3, 7/2) / (3/2, 2, 5/2) = (1, 1.5, 2.3333)$$

As a result, a vector of relative significance was defined as follows:

$$\Phi = ((0.6667, 1, 1.5), (0.4444, 1, 2.25), (1, 2, 3.75), (1, 1.5, 2.3333))$$

From Eq. (5), the conditions were derived from four restrictions, imposed by the transitive requirements as shown in the following.

$$w_4 / w_3 = (0.6667, 1, 1.5) \otimes (0.4444, 1, 2.25) = (0.2963, 1, 3.375)$$

$$w_1 / w_5 = (0.4444, 1, 2.25) \otimes (1, 2, 3.75) = (0.4444, 2, 8.4375)$$

$$w_3 / w_2 = (1, 2, 3.75) \otimes (1, 1.5, 2.3333) = (1, 3, 8.75)$$

Criteria weight values were solved with Lingo 17.0 with the model shown in Eq. (6); the result was $w_1 = w_3 = w_4$ (0.2609) > w_5 (0.1304) > w_2 (0.0870), and λ was equal to 1 (positive), which means that the matrix was consistent.

The weight results indicate that sustainable management (C_4), innovation and knowledge (C_1), and collaboration (C_3) are the main criteria selected for the BCG project. Sustainable management such as waste management, selection of materials for recycling or reuse, and community-based biomass power generation, is critical for supporting the promoted occupation in the BCG project. Knowledge includes smart operations, information technology, and innovative technology which are crucial points for sustainable careers and are in line with the BCG project. Cooperation between organizations from both the public and private sectors can efficiently support a sustainable occupation. Value and emission criteria have lower consideration in the BCG project for occupation selection.

Next, the resulting weights were calculated with the CoCoSo method to select the most suitable occupations for the community. The optimal criteria for beneficial factors are set to maximize the desired outcomes, while non-beneficial criteria are aimed at minimizing their values to achieve the best results. The evaluation outcomes are presented in Table 6.

Table 6. The evaluation result of the BCG project selection

	Criteria	C_1	C_2	C_3	C_4	C_5
	Weights	0.2609	0.0870	0.2609	0.2609	0.1304
	Optimal value	max	min	max	max	max
Alternatives	A_1	10	4	9	9	10
	A_2	10	4	9	9	10
	A_3	5	4	10	6	8
	A_4	5	5	9	6	8
	A_5	7	10	8	9	10
	A_6	6	9	7	7	5
	sum	43	36	52	46	51

The values from Table 6 are normalized and presented in Table 7.

Table 7. The normalized decision-making matrix

	Criteria	C_1	C_2	C_3	C_4	C_5
Alternatives	A_1	0.2326	0.1111	0.1731	0.1957	0.1961
	A_2	0.2326	0.1111	0.1731	0.1957	0.1961
	A_3	0.1163	0.1111	0.1923	0.1304	0.1569
	A_4	0.1163	0.1389	0.1731	0.1304	0.1569
	A_5	0.1628	0.2778	0.1538	0.1957	0.1961
	A_6	0.1395	0.2500	0.1346	0.1522	0.0980

Then, after considering benefit / non-benefit criteria by applying Eq. (8) and Eq. (9), the result was the matrix shown in Table 8.

Table 8. Comparability sequence measures

Criteria		C_1	C_2	C_3	C_4	C_5
Alternatives	A_1	1	1	0.6667	1	1
	A_2	1	1	0.6667	1	1
	A_3	0	1	1	0	0.6000
	A_4	0	0.8333	0.6667	0	0.6000
	A_5	0.4	0	0.3333	1	1
	A_6	0.2	0.1667	0.0000	0.3333	0

The CoCoSo method utilizes the SAW approach, and the exponentially weighted product model was computed by Eqs. (10)-(15). The corresponding results are presented in Tables 9 - 11.

Table 9. Weighted comparability sequence and S_i

Criteria		C_1	C_2	C_3	C_4	C_5	S_i
Alternatives	A_1	0.2609	0.0870	0.1739	0.2609	0.1304	0.9130
	A_2	0.2609	0.0870	0.1739	0.2609	0.1304	0.9130
	A_3	0	0.0870	0.2609	0	0.0783	0.4261
	A_4	0	0.0725	0.1739	0	0.0783	0.3246
	A_5	0.1043	0	0.0870	0.2609	0.1304	0.5826
	A_6	0.0522	0.0145	0	0.0870	0	0.1536

Table 10. Exponentially weighted comparability sequence and P_i

Criteria		C_1	C_2	C_3	C_4	C_5	P_i
Alternatives	A_1	1	1	0.8996	1	1	4.8996
	A_2	1	1	0.8996	1	1	4.8996
	A_3	0	1	1	0	0.9355	2.9355
	A_4	0	0.9843	0.8996	0	0.9355	2.8194
	A_5	0.7874	0	0.7508	1	1	3.5382
	A_6	0.6571	0.8557	0	0.7508	0	2.2637

Table 11. Final aggregation and CoCoSo ranking of the alternatives

		k_a	Ranks	k_b	Ranks	k_c	Ranks	k	Final ranks
Alternatives	A_1	0.2356	1,2	8.1078	1,2	1	1,2	4.3553	1,2
	A_2	0.2356	1,2	8.1078	1,2	1	1,2	4.3553	1,2
	A_3	0.1363	4	4.0704	4	0.5783	4	2.2795	4
	A_4	0.1274	5	3.3587	5	0.5409	5	1.9564	5
	A_5	0.1670	3	5.3555	3	0.7089	3	2.9363	3
	A_6	0.0980	6	2	6	0.4159	6	1.2715	6

The results of the assessment were as follows: $A_1 = A_2 > A_5 > A_3 > A_4 > A_6$. Based on the result of the study, two occupations were suggested, organic farming and livestock. The case study community was an underprivileged community in the capital city of Thailand. However, most people there have a low level of education. Both occupations are necessary for a living that can help them survive and be self-reliant. However, sustainable management, innovation and knowledge, and collaboration should be prepared for the community to achieve successful implementation. The next priorities were the small industry, service career, flea market, and mini-mall, respectively. The details of the action plans for the selected occupations were suggested as follows:

Organic farming uses techniques that rely on natural processes rather than synthetic inputs like chemical pesticides and fertilizers. Training in organic farming practices, such as pest control, bio-fertilization, and product processing, can help farmers improve their skills and increase the sustainability and efficiency of their operations. Drying vegetables and fruits can be an excellent way to extend their shelf life and create value-added products. It could be helpful to work with government agencies or universities to access training and expert guidance on organic farming practices. Using renewable energy sources like solar cells would also be a way to reduce the environmental impact of farming and make it more sustainable.

Raising livestock using organic and natural methods can be a sustainable way to produce food and have a lower environmental impact than intensive methods of animal agriculture. Providing a varied diet for the animals using supplementary plant-based feed can help reduce costs and improve the health of the animals. It is important to choose a breed of animal that is well-suited to the local environment and easy to care for and to work with local experts to ensure that the animals are being raised sustainably and responsibly. Using organic methods, such as recycling chicken manure as fertilizer for vegetables, can help close the nutrient loop and minimize the environmental impact of the farming operation.

It is essential to consider each community's specific needs and characteristics when implementing a project. Different communities may have different knowledge bases, sizes, and environmental conditions that will affect the project's success. It may be necessary to adapt the project to fit each community's needs and consider the relative importance of different criteria and alternatives based on the specific context of the community. It is helpful to consult with local experts and community members to ensure that the project meets the needs and goals of the community.

The possible contributions of the other BCG project of occupation selection are shown in Table 12:

Table 12. Possible contributions from the BCG project's occupation selection

Criteria	Detail
Organic farming (A_1)	
Innovation and knowledge (C_1)	• Select vigorous, productive, and weather-resistant fruits and vegetables. • Inform the community promptly of customer trends. • Gain knowledge of growing fruits and vegetables that are in demand in the market.
Emission (C_2)	• Using renewable energy in processing and transporting to reduce GHG emissions.

Criteria	Detail
Collaboration (C_3)	• Gain support from the public and private sectors for the development and recommendation of appropriate plant species.
Sustainable management (C_4)	• Employ organic fertilizers instead of chemical fertilizers. • Use agricultural waste for biomass production. • Utilize herbs or plants in organic farming.
Value (C_5)	• Produce value-added products using processes, such as drying, pickling, and freezing.
Livestock (A_2)	
Innovation and knowledge (C_1)	• Acquire knowledge and assistance in selecting species and breeds for small-scale farming. • Inform the community about consumer trends on time. • Use innovative technologies for farming for the community.
Emission (C_2)	• Modifying diets to increase productivity and reduce GHG emissions.
Collaboration (C_3)	• Acquire support from the public and private sectors in developing and introducing suitable animal breeds.
Sustainable management (C_4)	• Replace animal feed with a blend of vegetables that can be grown locally. • Making the most of waste utilization.
Value (C_5)	• Create new value-added products that are made from farmed meat and extend consumption life, such as grated chicken and dried sweet pork.
Service career (A_3)	
Innovation and knowledge (C_1)	• Transfer occupational techniques from experienced people to disseminate knowledge to people in the community. • Create a group in social media applications or webpage of the community to be easy to contact, notify or make an appointment for services of the community.
Emission (C_2)	• Decide the delivery or service route to reduce energy consumption and emissions.
Collaboration (C_3)	• Cooperate with experts within the community. If anyone has experience in new service careers or has new techniques, they should be shared so that people in the same line of work can further develop themselves.
Sustainable management (C_4)	• Use sustainable materials or equipment with a long lifetime. Reduce frequent repair of equipment or tools to save money and be more cost-efficient.
Value (C_5)	• Do an online satisfaction survey to evaluate services. In addition to ensuring the quality of services, it also gives customers more confidence in receiving technical services in the community.
Flea market and parking (A_4)	
Innovation and knowledge (C_1)	• Use online communication (Line/Facebook applications) to book, order, and deliver products within the community and neighboring communities.
Emission (C_2)	• Properly dispose of waste. • Use a campaign to reduce waste burning.

Criteria	Detail
	• Use a campaign to put up a parking sign to turn off the engine when parked. • Allocating the parking area to be well-ventilated and not cause pollution to traders in the market and nearby residences. • Use renewable energy instead of traditional electricity.
Collaboration (C_3)	• Collaborate among people in the community to separate waste properly to make it easier to recycle or reuse. • Share information about sold products without overlapping and undercutting each other in the community marketplace. • If raw materials such as meat, vegetables, and fruits are not sold out, and there is a large amount left, agree to cooperate with a small industry in the community to convert them into other products.
Sustainable management (C_4)	• Proper waste sorting will result in the most effective disposal or utilization. • Install a solar cell system for use in the market. • Install a wastewater treatment system. • Campaign to reduce the use of plastic packages in the community. • Promote biodegradable packaging and natural products.
Value (C_5)	• Selecting good and high-quality products, focusing on selling organic products to create a market that targets environmentally friendly consumers.
Small industry (A_5)	
Innovation and knowledge (C_1)	• Organize training from external organizations or companies to educate community members in a small industry about production planning and operations, and train them to use modern machines or tools to improve output quality.
Emission (C_2)	• Using renewable energy sources in the production process is an important way to reduce GHG emissions and combat climate change. • Biodegradable packaging materials are designed to break down into natural materials over time. Communities can use them to reduce the environmental impact.
Collaboration (C_3)	• Cooperation within a community can help to ensure that the developed products and services meet consumers' needs. • necessitates research and development of technology that produces the least waste and pollution with universities or government services.
Sustainable management (C_4)	• Using renewable energy sources or biomass in the manufacturing process. • Biodegradable packaging materials are typically made from renewable resources, such as plant-based materials like paper, cardboard, and cornstarch, which can be easily broken down by natural processes.
Value (C_5)	• The transformation of originally obtained products to new products with value-added and consumer demand, such as alternative Thai herbal extracts for treating diseases.

Criteria	Detail
Mini-mall, distribution, and warehouse (A_6)	
Innovation and knowledge (C_1)	• Introduce basic calculation methods for operations such as inventory control to prevent an overstock problem. • Use a simple POS (point of sales) system to control sales. • Give knowledge about shelf space management, shelf space marketing, and layout management.
Emission (C_2)	• Choosing vehicles that use renewable energy, such as electric vehicles (EVs) to reduce GHG emissions and contribute to a more sustainable future. • Use appropriate route management for distribution. • Use renewable energy in the community.
Collaboration (C_3)	• Collaborate among communities to find efficient transportation routes or share vehicles. • Collaboration can also help build relationships and trust among the different parties involved, which can facilitate ongoing cooperation and coordination.
Sustainable management (C_4)	• Choose vehicles that use renewable energy, such as EVs. • Arrange suitable transportation routes to reduce transport distance.
Value (C_5)	• Distribution planning can involve both carrying and returning goods to reduce backhaul to improve the efficiency and sustainability of transportation operations.

5. Conclusion

Although NHA has built residences for improving the quality of life of underprivileged people in Thailand, generating income for them is also significant for sustainable development. The BCG project of selecting occupations and supporting a community by NHA was raised. In this research, the new hybrid method of FUCOM-LF and CoCoSo was presented to find the appropriate occupations based on the BCG concept of NHA. The framework of occupation selection based on the BCG project was introduced in this research so that it could be employed in any community in Thailand. The 5 main criteria are innovation and knowledge (C_1), emission (C_2), collaboration (C_3), sustainable management (C_4), and Value (C_5). Six occupations: organic farming, livestock, service career, flea market and parking, small industry, mini-mall, distribution, and warehouse, were considered. The FUCOM-LF approach was utilized in the research to weigh the significant criteria for the BCG economy. The critical criteria for this BCG project were sustainable management, innovation and knowledge, and collaboration. Value and emission criteria were of less concern in the BCG project for occupation selection. Organic farming and livestock were selected by the CoCoSo method to be the best occupations that should be promoted as viable vocations for such model communities to create long-term sustainable income based on sustainable management. Sustainable management for both organic farming and livestock should be well-prepared for the community such as the utilization of organic fertilizers, using agricultural waste, utilizing herbs or plants, or producing value-added products. Training to improve research and development expertise to foster innovation within the professional group should be provided to the community. Selecting productive and weather-resistant vegetables and fruits that have a high demand for the community. Furthermore, collaborations between the public and commercial sectors are also essential to enhance the ability of people in the community to make a living through promoted professions such as consulting, knowledge, market, and demand.

The implementation of the FUCOM-LF technique outperforms the existing approaches by a lower number of comparisons than pairwise comparison and full consistency. CoCoSo's approach promotes accuracy and high resolution in discriminating between different options. The method allows flexibility in adding or eliminating the number of considered options and alternatives without affecting the final outcome. By combining the advantages of both methods, the hybrid approach for prioritization problems is both effective and flexible. The FUCOM-LF and CoCoSo hybrid approach can be applied to a wide range of problems in MCDMs due to its convenient assessment and the perfect assessment consistency. The contribution of other occupations is also presented in the research to be a guideline for other practices.

The framework proposed in this study has certain limitations regarding its applicability to diverse climatic countries, as well as variations in lifestyles, actions, and occupations among different populations. The occupation profiles of each country differ, potentially leading to changes in the occupation's selection structure, such as the addition or reduction of specific occupation options. Consequently, a re-evaluation is necessary for Phase 2, which involves occupation selection using the CoCoSo method. However, if the majority of options remain unchanged, it is unlikely to significantly impact the previous calculations. Moreover, the CoCoSo method offers flexibility by allowing the addition and removal of alternatives as needed.

Future research may explore the selection of key performance indicators (KPI) for action after occupation promotion in the community to measure the effectiveness of the outcomes based on the BCG economy. Furthermore, an additional research suggestion for this study is to explore the conventional utilization of CoCoSo. Other researchers who are interested in this area can delve further into the application of CoCoSo in conjunction with fuzzy z numbers and fuzzy sets, as this can potentially lead to a more dependable assessment and enhance research efficiency in alternative ways.

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