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Economic Benefits for the Application of Standards of Sustainability in Construction Projects

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ABSTRACT

In this research, that been focused on the most important economic benefits expected when applying the three standards of sustainability in construction projects (economic, environmental and social). Fuzzy AHP, a multi-decision decision-making technique for evaluating construction projects. Which when used we get the speed and accuracy in the results. Using this technique will reduce uncertainties decisions significantly (fuzzy environment), that found in most projects .The results of the data analysis showed that the economic standards take the greatest relative importance (60%) among the three sustainability standards. Therefore, the implementation of any standards need a cost so the economic benefit of any project is ranked first, before implementing any sustainable project.

Key words: economic benefits, fuzzy AHP, sustainability.

الفوائد الاقتصادية لتطبيق معايير الاستدامة في المشاريع الانشائية

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الخلاصة

في هذا البحث تم التركيز على اهم المنافع الاقتصادية المتوقعة عند الالتزام بتطبيق معايير الاستدامة الثلاثة في المشاريع الانشائية (الاقتصادية ،البيئية، الاجتماعية).حيث تم تطبيق تقنية التحليل الهرمي الضبابي (Fuzzy AHP) وهي احدى تقنيات اتخاذ القرار المتعدد المعايير لتقييم المعايير الخاصة بالمشاريع الانشائية والتي عند استخدامها نحصل على السرعة والدقة في النتائج. وعند استخدام هذه التقنية سوف تقلل بشكل كبير قرارات عدم التأكد(البيئة الضبابية) الموجودة في اغلب المشاريع .وتشير نتائج تحليل البيانات ان معايير الاقتصادية تأخذ الاهمية النسبية الاكبر (60 %) بين معايير الاستدامة الثلاثة ولذلك لان تنفيذ اي معايير من المعايير يحتاج كلفة لذلك تكون الفائدة الاقتصادية لأي مشروع بالمرتبة الاولى قبل تنفيذ اي مشروع مستدام.

الكلمات الرئيسية: الفوائد الاقتصادية ، عملية التحليل الهرمي الضبابي ،الاستدامة.

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1. INTRODUCTION

Construction due to its nature differs from other sectors, because the construction sector has a large extent of variables and contradictions. In general the world today objective of attaining an equilibrium in the activities to keep up a healthy stable environment and take into account the conservation of the rights of future generations.Thus the need arises to attain a equilibrium in the construction projects sector inputs through the application of the concepts of sustainable (environment, economic and social aspects, **Salih, 2013**. Sustainable development are tasks of convention growing human requirements for natural resources as energy, nutrition, transport, housing, and waste management while keeping environmental quality necessary for future life. This concept identifies that keeping long-term human requirements will be uncontrollable unless we also conserve the earth's natural physical and biological systems.

2. DEFINITIONS OF SUSTAINABILITY

Sustainability is the "long-term, cultural, economic and environmental health and vitality" with emphasis on long-term, "together with the importance of linking our social, financial, and environmental well-being", **Salih, 2013**.

Sustainability is the establishment of an equilibrium between the economic, environmental, social aspects, with a specific end objective to make more decent and beneficial communities, **Rasoolimanesh, et al., 2011**.

Sustainability is the relationship between the social, economic and environmental specialists in the community to realize sustainable development, **Li-Yin Shen, et al., 2011.**

"Sustainability is essentially a personal investment towards a level of performance throughout an indefinite period of time. Not only can buildings affect the environment, social and economic impacts are also made. Buildings have an effect on the course of developments well as life of the structure". **Lisa, 2009**.

Sustainability is the essential that can compete with the concept of continued exponential material development." **Ernest, 1992**.

Sustainability requires a minimum a constant stock of capital, **David, 1987**.

3. THE THREE SUSTAINABILITY STANDARDS

The Interaction of three basic pillars of sustainability concepts are, **Hasan, 2016**:

1. Economic: it means establishment of new markets chances for sales growth, cost decrease through effectiveness improvements and decrease energy and raw material inputs.
2. Environmental: it means reducing waste, radiations to environment, diminution to effect on human health, and removal of toxic substances.
3. Social: it means employee health and safety, Impacts on societies, goodness of life. As showed in **Table.1**.

4. BENEFITS OF APPLYING SUSTAINABILITY TO PROJECTS

Certain potential benefits:

A. Energy and raw materials provision as changing many single use products with one reusable one which decreases the number that to be manufactured.
B. Decreased disposal needs and costs.
C. Renewal can bring developed, sustainable, well-paid jobs to undeveloped economies.
D. Cost provision for business and users as a recyclable product is often low-cost than the many single use products.

5- SUSTAINABLE CONSTRUCTION

Sustainable Construction is the use of sustainable development in the construction. It denotes to process that is resource-active during a building's life-cycle that includes location design, construction, operation, maintenance and destruction. That increases and balances building design concerns according to economy, usefulness, toughness, and comfort, **U.S. Environmental, 2009**.Though new technologies are continuously developing to accompaniment existing current in making green buildings, the common goal is that greener structures are designed to diminish the total effect by:

A. Efficient using energy, water.
B. Protecting inhabitant health and improving worker output.
C. Decreasing waste, contamination and ecological dilapidation.

Sustainable construction is establishment and in charge of managing of a healthy structure established on resource effective and basics environment. Sustainably designed buildings objective to reduce their effect on surrounding from energy and resource efficiency. It involves the principles, **U.S. Environmental, 2009**:

A. Reducing non- renewable resource exhaustion.
B. Protecting the natural environment.
C. Diminishing the usage of toxins.

6. PUBLIC CAPITAL

The part of which a society obtains benefits and on relies for continued presence. The term 'capital' is usually referred to money while, in the sustainability; communities have some different kinds of capital that natural, human, social, and built capital. These kinds are referred to as public capital. All kinds of capital are essential of societies **U.S. Environmental, 2009**:

6.1 Natural Capital

There are three types: natural resources, ecology services, and aesthetics. Resources are that we take out of nature: water, plants, animals, and minerals. Used either as raw material or as part of a construction process.

Ecology services are natural processes.

Aesthetics is important to tourism, which form the basis of societies' economy.

6.2 Social and Human Capital

That two types -- individuals and connections:

Human capital is each individual's personal skills and capabilities, and psychological health. Social capital is the connections in a community -- the methods in which people react and communicate to each other. The capability of people to form governments to solve problems, and capability of people to form businesses for making goods and services to the requirements of the societies.

6.3 Built Capital

Involves roads, equipment, factorys, houses, all buildings, food, clothing, cars, telephones and computers.

A sustainable community makes care of all its capital, natural, human, social and built capital, in order to continually improve the life. To invest capital, so that the capital be responsible for benefits now and in the future. When you invest monetary capital, will get interest so the value of that capital grows when you invest in social capital.

7. FUZZY AHP TECHNIQUE STEPS

The Fuzzy Analytic Hierarchy process technique (Fuzzy AHP) is to develop AHP technique was developed by **Thomas, 1980**. Hierarchical structure for FAHP.

The steps are, **Kahramana, et al., 2004**:

Decision Maker compares the standards via linguistic terms shown in **Table 2** and **Table1 3**.

Where gi is the goal set (i= 1,2,3,4,……,n) and M_{gi}^{j} (j=1,2,3,4,……,m), all are Triangular Fuzzy number , as shown in **Fig.1** .

1. The value of fuzzy synthetic extent with respect to the ith object is defined as:

$$S_i = \sum_{j=1}^{m} M_{g_i}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} \quad (1)$$

To obtain $\sum_{j=1}^{m} M_{g_i}^{j}$ from Eq(3).

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j\right) \quad (2)$$

and to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1}$, where M_{gi}^{j} (j=1 ,2,3,4,…..,m) such that:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i , \sum_{i=1}^{n} m_i , \sum_{i=1}^{n} u_i\right) \quad (3)$$

And then calculate the inverse of the vector in Eq. (3) such that

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i-1}^{n} u_i}, \frac{1}{\sum_{i-1}^{n} m_i}, \frac{1}{\sum_{i-1}^{n} l_i}\right) \quad (4)$$

2. $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ are two TFNS, the degree of possibility of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ and can be equivalently expressed as follows: $V(M_2 \geq M_1)$

$$= \begin{cases} 1 , & if\ m_2 \geq m_1. \\ 0 , & if\ l_1 \geq u_1 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & , otherwise \end{cases} \quad (5)$$

Where d is the ordinate of the highest intersection point D between M_1 and M_2.To compare M_1 and M_2; we need both the

Values of V ($M_1 \geq M_2$) and V ($M_2 \geq M_1$).

3. The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers Mi (I=1, 2, 3, 4... K) can be defined by:

$V(M \geq M_1, M_2, M_3, M_4, \ldots, M_K) = V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ and } \ldots \text{ and } (M \geq M_K)] = \min V(M \geq M_i)$, i= 1,2,3,4,…..,k. (6)

Assume that $d'(C_i) = \min V(S_i \geq S_k)$ for k= 1,2,3,4,…..,n. k≠ 1 ,then the weight vector is given by :

$$W' = [d'(C_1) , d'(C_2) , d'(C_3) , d'(C_4), \ldots, d'(C_5)]^T \quad (7)$$

4. Via normalization, the normalized weight vectors is given:

$W = [d(C_1) , d(C_2) , d(C_3) , d(C_4),\ldots..,d(C_n)]$ (8)

8. CALCULATIONS

Then applying the Equations (1),(2),(3) and (4) on making decision matrix for criteria in the **Table.3** to extract the values of Si as it shown below:

$\sum l$=1+ 0.25+5 + 2+ 1+ 0.25+ 0.14+ 2+ 1= 12.64

$\sum m$=1+ 0.33+6 + 3+1+ 0.33+0.17 +3+1= 15.83

$\sum u$=1+ 0.5+ 7+4 + 1+ 0.5+ 0.2+ 4+ 1= 19.2

$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1}$= (1/19.2 , 1/15.83 , 1/12.64)

S_1= (3.14,4.17,5.2) * (1/19.2 , 1/15.83 , 1/12.64)

= (0.164, 0.263, 0.411)

S_2 = (3.25, 4.33, 5.5) * (1/19.2 , 1/15.83 , 1/12.64)

= (0.169, 0.274, 0.435)

S_3 =(6.25,7.33,8.5) * (1/19.2 , 1/15.83 , 1/12.64)

= (0.326, 0.463 ,0.672)

Also applying the Eq. 5 to extract the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$ as it shown accounts:

$$V(S1 \geq S2) = \frac{0.411-0.169}{(0.411-0.263)+(0.274-0.169)} = 0.957$$

$$V(S1 \geq S3) = \frac{0.411-0.326}{(0.148-0.263)+(0.463-0.326)} = 0.298$$

$V(S2 \geq S1) = 1$

$$V(S2 \geq S3) = \frac{0.435-0.326}{(0.435-0.274)+(0.463-0.326)} = 0.366$$

$V(S3 \geq S1) = 1$

$V(S3 \geq S2) = 1$

Then applying Eq. 6 to get the values min V($M \geq M_i$) as follows:

d′(C1) = min (0.957,0.298) = 0.298

d′(C2) = min (1,0.366) = 0.366

d′(C3) = min (1,1) = 1

To calculate the weights of the criteria (W), the Equations (7) and (8) are applied as follows:

Priority weight (W′) = (0.298, 0.366,1)

$$W1 = \frac{0.298}{0.298+0.366+1} = 0.18$$

$$W1 = \frac{0.366}{0.298+0.366+1} = 0.22$$

$$W1 = \frac{1}{0.298+0.366+1} = 0.60$$

W = (0.18,0.22,0.60) . As showed in **Table.4**.

9. CONCLUSIONS

In this paper we conclude that the concepts and standards of sustainable development applied in the construction of buildings and infrastructure are the ones that enhance the economic welfare of countries.

One of the goals of sustainability is to reduce the costs of maintenance and energy, increase the comfort of residents and employees and reduce pollution. As conventional construction have economic and environmental consequences, where the decisions are vague and incomplete and the lack of technique to evaluate the data. When data are very few about the costs of sustainable construction we must use FAHP technique and usually the problem is the lack of information about standards and alternatives of better value، because technique gives an ideal result even with the lack of information and uncertainty.

As the financial decisions of the construction projects have great environmental and social impacts, so we must think about the economic benefits as well as their impact on society. At present, cost has become a major factor affecting the economies of countries in the current situation in the world where the effects on infrastructure and people have emerged and the trend towards long-term investments has become. Sustainability requirements should therefore be imposed on all projects and should be introduced as a consistent approach to project planning.

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Table 1. The standards of sustainability, **Hasan, 2016**.

Main Criteria	Sub-Criteria	Description
1) Economic	Financial	Consider construction cost for new infrastructures and updates to existing system. 3-Highlight major projects that significantly contribute to the capital cost.
	Infrastructure	1- Distance between transportation network are important factors for industrial and commercial land uses (Effect on transportation costs of materials and transportation costs for products). 2- Highlight on level of ability to balance infrastructure costs with level of urban growth.
	Land value	Land prices in the city.
	Costs	1- Capital costs 2- Operation and maintenance costs 3-Other contingencies
	Economic revenue	
	Ability to interact with another sector economy	Projects which interact with more than one sector of the economy and creating greater opportunities for diverse sectors of the economy.
2)Environmental	Noise pollution	The source of most noise caused by machines and transportation systems, motor vehicles, aircraft, and trains.
	Water pollution	Pollutants such as Materials' chemical,physical, radioactive …etc.
	Wastewater network	harmful to the environment
	Soil pollution	Soil contaminants may be a waste (industrial ,radioactive)
	Impact of carbon dioxide emissions	
	Local air quality	
	Aquatic impacts	Potential effects on water resources and not to overtaking on water natural that affect the environment.
	Environmental legislation	Global and local laws are restrictions.
	Protect the natural environment	Such as green space and Forests… etc.
3) Social	Services	1- Housing, transportation, schools, Medical, police, Firefighter...etc. 2- Utilization of existing infrastructure.
	Job opportunities	Redevelopment can create new jobs and increase incomes.
	Population	Population size, Household size, Population density and Distribution of population.

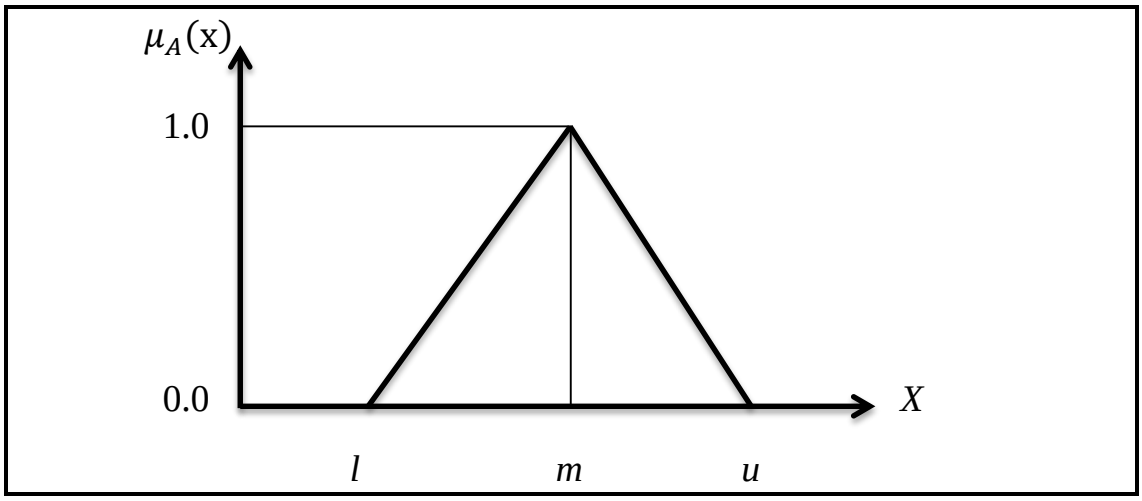

Figure 1. A triangular fuzzy number.

Table 2. Linguistic terms and the corresponding triangular fuzzy numbers, **Ayhan, 2013**.

Linguistic variable	Fuzzy number	Explanation
Equally important	(1 , 1 , 1)	The criterion i is equally important when compared to criterion j.
Weakly important	(2 , 3 , 4)	The criterion i is Weakly important when compared to criterion j.
Fairly important	(4 , 5 , 6)	The criterion i is Fairly important when compared to criterion j.
Strongly important	(6 , 7 , 8)	The criterion i is Strongly important when compared to criterion j.
Absolutely important	(9 , 9 , 9)	The criterion i is Absolutely important when compared to criterion j.
Intermediate values between the two adjacent judgments	(1, 2 ,3) (3, 4 ,5) (5 , 6 ,7) (7, 8 ,9)	When compromise is needed.
Reciprocals number	The reciprocals, such as 1/3, 1/5, 1/7, 1/9, etc.,	

Table 3. Fuzzy numbers decision making matrix.

Criteria	C1 (Social)	C2 (Environmental)	C3 (Economic)
C1 (Social)	(1,1,1)	(2,3,4)	(0.14,0.17,0.2)
C2 (Environmental)	(0.25,0.33,0.5)	(1,1,1)	(2,3,4)
C3 (Economic)	(5,6,7)	(0.25,0.33, 0.5)	(1,1,1)

Table 4. The relative importance of main criteria.

Main criteria	Relative importance	%
Social criteria	0.18	18
Environmental criteria	0.22	22
Economic criteria	0.60	60