A Study Using Treesoft Set and Neutrosophic Sets on Possible Soil Organic Transformations in Urban Agriculture Systems.

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Abstract

In the current context of accelerated urbanization and the urgent need for sustainability, urban agriculture has become a vital alternative to guarantee food security and ecological management of cities. This study addresses possible soil organic transformations in these systems using Treesoft Set and neutrosophic sets. Treesoft Set, an advanced tool for complex data analysis, is complemented by neutrosophic set theory, which allows you to manage the uncertainty inherent in natural and human systems. Together, these methodologies provide a more complete and detailed view of how urban land can adapt and improve under sustainable agricultural practices, highlighting the importance of integrating technology and ecology in the design of green cities. The analysis carried out not only unravels the dynamics of soil organic transformations, but also highlights the variability and complex interactions that occur in urban environments. Research shows that, through the application of Treesoft Set and neutrosophic sets, it is possible to identify patterns and trends that would otherwise go unnoticed. Additionally, it highlights how these tools can influence decision-making to optimize land use and encourage agricultural practices that improve the health of the urban ecosystem. This innovative approach opens new avenues for research and development of urban agriculture, promoting more resilient and efficient systems in the management of natural resources in an increasingly urbanized world.

Keyword: Treesoft Sets; Neutrosophic Sets; Conservation Measures; Sustainability.

1. Introduction

As the urban population grows, it is increasingly important to ensure food supplies. According to the World Bank, more than 50% of the population lives in urban areas and this trend is expected to continue. It is predicted that by the end of the 21st century most people will live in cities [1] Urban agriculture (UA) is a form of agriculture that originated in cities and aims to ensure access to high-quality food for all citizens. The UA is based on an organic urban management system that takes into account the risks of using chemicals in densely populated areas and emphasizes the use of organic soil amendments throughout the production process [2]

Urban agriculture has been around for a long time, but it was not until the 1970s, with the advent of organic farming, that it became popular around the world as an effective survival strategy [3]. Most studies agree on the benefits of universal adoption, such as access to healthy foods, greater social cohesion, revitalization of local economies, and support for disadvantaged communities.

In the Cuban context, urban agriculture emerged during a "special period" as a response to the economic crisis that followed the collapse of the Soviet Union. This change marks a paradigm shift in agriculture from mechanization to a subsistence approach, in which urban agriculture plays an important role. a key role. One of the most popular farming methods in Cuba is organic farming It involves growing vegetables in a mixed substrate in underground stone holes.

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This approach allows fallow land to be used for agriculture, but the substrate continues to degrade and requires a continuous supply of nutrients to maintain productivity [4]

To meet this need, the introduction of biofertilizers in urban agriculture has intensified, especially Chromococcus azotobacter, which can fix nitrogen in non-legumes and promote root growth and phosphorus solubilization. These biofertilizers have the benefits of promoting the growth, improve soil quality, resist pests and diseases, and increase yields [5]

In addition to biofertilizers, organic farming also uses mineral additives such as zeolites, which are known to retain moisture and increase soil pH, thereby increasing crop yields. Although research has been conducted on the impact of different types of biofertilizers in urban agriculture, more research is needed. it is necessary to optimize alternative nutrient options and support Da Nang University. Da Nang is a truly efficient and sustainable city [6]

Therefore, the objective of this work was to evaluate the effects of various biostimulants based on beneficial microorganisms and organic additives on the growth and yield of crops under organic farming conditions.

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2. Related work.

2.1. Organic Soil Transformations.

Urban agriculture, in its quest to redefine the urban landscape and provide food sustainability, finds a fundamental backbone in the organic transformations of the soil . These transformations, diverse and complex, not only enrich the soil but also promote biodiversity essential for the urban ecological balance . Thus, the integration of methods such as composting and vermicomposting are common practices that, by recycling organic waste, not only reduce waste but also generate humus rich in nutrients vital for plant growth . This process of Organic recycling then becomes a virtuous cycle where waste is transformed into resources .

At first glance, it may seem that these techniques are simple and straightforward – however, the reality is much more intricate – the quality of compost, for example, can vary significantly depending on the materials used, the carbon-nitrogen ratio, the temperature and humidity . A well-managed compost can accelerate mineralization, releasing nutrients such as nitrogen, phosphorus and potassium, which are essential for crop development . However, poor management can result in low-quality compost, potentially toxic to plants . This is where expertise and knowledge play a crucial role . Earthworms, particularly Eisenia fetida, are key players in vermicomposting . These small creatures consume organic waste and excrete humus, thus improving soil structure and its retention capacity. water . In addition, the activity of worms helps to aerate the soil, which favors the proliferation of beneficial microorganisms . However, the successful implementation of vermicomposting in urban environments is not without challenges . Factors such as temperature, humidity and Availability of suitable organic waste can influence the efficiency of the process .

Beyond compost and vermicomposting, cover cropping practices also play a significant role – These practices, which involve planting specific plants to protect and enrich the soil, help prevent erosion, improve soil structure and increase their organic content . The roots of cover plants penetrate deeply into the soil, facilitating water infiltration and reducing compaction . Furthermore, when decomposing, these plants return nutrients to the soil, thus closing a natural fertilization cycle . The challenge of Urban agriculture lies in the adaptation of these traditional techniques to an unconventional environment . Spatial limitations, pollution and waste management are obstacles that require innovative solutions . The implementation of vertical gardens and green roofs are examples of how it can be maximized space and improve air quality, while promoting biodiversity . However, these solutions also require a meticulous approach to substrate choice and water management to ensure their success .

The possible organic transformations of the soil in urban environments not only have an environmental impact, but also a social one . By involving communities in composting and horticulture practices, a sense of belonging and shared responsibility is fostered . Education and awareness about the importance of organic waste management and local food production can transform entire neighborhoods, creating greener and healthier spaces .

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2.2. Treesoft Set and neutrosophic sets.

This section provides some definitions of IVNS.

Definition 1

Let Y be a universe of discourse with a generic element in Y denoted by y. We can define the neutrosophic variable y as y = [T , I , F] where T, I and F refer to the degrees of truth, indeterminacy and falsity.

0 ≤ sup [[y]+ sup [I [y] + sup [F [y] ≤ 3 [1]

We can define the IVNS as:

y = [T L , T U], [I L , I U], [F L , F U]

Definition 2

Let y 1 = [[T yL 1, T yU 1], [I yL 1, I yU 1], [F yL 1, F yU 1]] and y 2 = [[T yL 2, T yU 2], [I yL 2 , I yU 2], [F yL 2 , F yU 2]] two neutrosophic numbers with interval values, then some mathematical equations can be defined as:

y 1 c = [1 , F y U 1], [1 − I y U 1 , 1 − I y L 1], [T y L 1, T y U 1] [4]

[1 + T yL 2 − T yL 1 T yL 2, T yU 1 + T yU 2 − T yU 1 T yU 2] ,

y 1 y 2 = [1 I y L 2, I y U 1 I y U 2], [5]

[1 F yL 2, F yU 1 F yU 2]

[1 T yL 2, T yU 1 T yU 2],

y 1 y 2 = [1 + I y L 2 − I y L 1 I y L 2, I y U 1 + I y U 2 − I y U 1 I y U 2], [6]

[1 + F yL 2 − F yL 1 F yL 2, F yU 1 + F yU 2 − F yU 1 yU 2]

Definition 4

We can define the bipolar neutrosophic sets [BNS] [7] – [9] as:

A = {< x , T + [x], I + [x], F + [x] , T − [x], I − [x], F − [x] > } [7]

Let y 1 = [T 1 + [x] , I 1 + [x] , F 1 + [x] , T 1 − [x], I 1 − [x], F 1 − [x]] and y 2 = [T 2 + [x], I 2 + [x] , F 2 + [x] , T 2 − [x], I 2 − [x], F 2 − [x]]

y 1 + y 2 = [− T − T 2− , −[− T 1+ I 1− + − T I 2+ 2− − − T I 1 1− + I T 2− 2+] , , I − 1+ [I 2 − + , F F 1− 1+ − F 2+ F , 2− − F 1− F 2−]] [8]

y 1 · y 2 = [1 − + T [2 − + , T I 1 1 − + + − I 2 T + 2− − − I 1+ T I 1− 2+ T + 2−] F , 1 + − I + 1− I F 2− 2+ , − − F F 1− 1+ F F 2− 2+,] [9]

Let U be a revelation of the universe and H be a non-empty subset of U, with P [x] $be\ a\ power$.

Let TSR be a set of attributes [criteria] of the problem,

TSR = { 1 , TSR 2 , … , TSR n}, n ≥ 1 [10]

Where TSR

1, TSR 2 , … , TSR n are criteria of the first level of the tree.

Each attribute TSR 1 , 1 ≤ i ≤ n , $is\ formed\ by\ sub - attrib\ utes$:

TSR 1 = { 1,1, TSR 1,2. …, } TSR 2 = { TSR 2.1, TSR 2.2. …, }

TSR n = { n,1 , TSR n,2. …, }

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Where TSR i, j are sub-attributes.

Tree Set Soft can be composed of:

: P [[TSR]] → P [H] [eleven]

$Tree$ [ ] = { | i 1 = 1 ,2,3 ,… } ∪ { TSR i | i 1, i 2 = 1,2,3, … } ∪ { TSR i | i 1, i 2, i 3 = 1,2,3,… } ∪ …

∪ { R i | i 1, i 2,… i m = 1,2,3,… } [12]

The next steps of the neutrosophic Treesoft Set with the VIKOR method.

Step 1. Build a tree and define nodes [13]–[14].

The tree has more than one level, in the first level the main criteria are entered such as

SWM 1, SWM 2 … , SWM n

At the second level, the sub-criteria are introduced as SWM 1.1, SWM 1.2, …. And SWM 2.1, SWM 2.2, … .

Step 2. Build the decision matrix

The decision matrix is built using information from decision makers and experts between criteria and alternatives.

i = 1,2,…, m ; j = 1,2, … , n [13] x mn

Step 3. Calculate the weights of the criteria.

Criteria weights are calculated using the average method.

∑ w j = 1 [14]

j =1

Step 4. Calculate the alternative closeness to the optimal solution.

U i = {∑ j =1 [∗ − r j −]] } = 1,2,… , m ; j = 1,2, … , n ; 1 ≤ P ≤ ∞ [15]

where r j ∗ is the best and r j − is the worst

r j ∗ = maximum x ij

{ r − = minimum i x ij [$positive$ $criteria$] i = 1,2,… , m ; j = 1,2, … , n [16]

Step 5. Calculate the values of S i

S i = ∑ , … , m ; j = 1,2, … , n [18]

Step 6. Calculate the values of R i

; j = 1 ,2 , …, n [19]

j [r j − r j]

Step 7. Calculate the VIKOR index.

S ∗ = minimum, S − = maximum, R ∗ = minimum R i , R − = maximum R i [twenty-one]

Where t = 0.5

Step 8. Classify the alternatives.

3. Results and discussion

The alternatives are arranged in descending order .

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Below are eight effects of various biostimulants based on beneficial microorganisms and organic additives on the growth and yield of crops under organic farming conditions:

1. **Increased Nutrient Absorption:** Beneficial microorganisms such as arbuscular mycorrhizae and phosphorus-solubilizing bacteria improve the availability and absorption of essential nutrients such as nitrogen, phosphorus and potassium, resulting in more vigorous plant growth .
2. **Improvement of Soil Structure:** Biostimulants help improve soil structure, increasing its water retention and aeration capacity, which favors root development and resistance to drought .
3. **Increase in Biomass Production:** The application of biostimulants can increase the production of both aerial and underground biomass, which translates into greater crop yield .
4. **Stimulation of Root Growth:** Microorganisms promote root growth and root branching, allowing greater exploration of the soil and better anchoring of plants .
5. **Reduction of Abiotic Stress:** Biostimulants can increase the resistance of plants to adverse conditions such as drought, salinity and extreme temperatures, thanks to the production of protective compounds such as osmoprotectants and antioxidants .
6. **Improved Soil Health:** Organic additives, such as composts and algae extracts, increase the microbial activity of the soil, improving its fertility and promoting a balanced and healthy environment for plants .
7. **Increase in Phytohormone Production:** Beneficial microorganisms can synthesize phytohormones such as auxins, cytokinins and gibberellins, which regulate and stimulate the growth and development of plants .
8. **Biological Control of Pathogens:** Some biostimulants include antagonistic microorganisms that can suppress the growth of soil pathogens, reducing the incidence of diseases and decreasing the need for chemical pesticides .

Evaluation criteria:

Below are eight evaluation criteria for the effects of various biostimulants based on beneficial microorganisms and organic additives on the growth and yield of crops under organic farming conditions:

1. **Increase in Harvest Yield:** Measured in terms of increase in the amount of products harvested per unit area, compared to crops not treated with biostimulants .
2. **Product Quality:** Evaluation of parameters such as nutrient content, uniformity, size and disease resistance of harvested products .
3. **Improvement in Nutrient Absorption:** Evaluation of the capacity of treated plants to absorb and use essential nutrients such as nitrogen, phosphorus, potassium, and micronutrients .
4. **Root Development and Health:** Observation of root growth, root density and overall health of the root system.
5. **Resistance to Abiotic Stress:** Evaluation of the capacity of plants to resist adverse conditions such as drought, salinity, extreme temperatures, and water stress .
6. **Soil Health:** Measurement of parameters such as microbial activity, soil structure, water retention and nutrient availability in soil treated with biostimulants .
7. **Effects on Microbial Biodiversity:** Evaluation of how biostimulants affect the diversity and activity of beneficial microorganisms in the soil and in association with plant roots .
8. **Sustainability and Environmental Impact:** Analysis of the global environmental impact of the use of biostimulants, including the reduction of the use of chemical fertilizers and pesticides, the conservation of soil and water, and the promotion of sustainable agricultural practices .

TreeSoft results using the BNS and VIKOR methods. This study used eight established criteria and eight alternative criteria. Three experts used the bipolar neutrosophic count [BNN] to evaluate criteria and alternatives.

Step 1. Create the tree and identify the nodes.

The tree structure has several levels; The main criteria are entered at the first level.

SWM_{first}, SWM_2 ..., SWM_n

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At the second level, enter the subcriteria . $_{1.1}$, $SWM_{1,2}$,…. And $SWM_{2.1}$, $SWM_{2.2}$,….

Step 2. Construct the decision matrix using Eq. Table 1 shows the decision matrix.

Table 1: Decision matrix.

	CRIT 1	**CRIT 2**	**CRIT 3**	**CRIT 4**	**CRIT 5**	**CRIT 6**	**CRIT 7**	**CRIT 8**
EFFECT 1	[0.90, 0.10, 0.10, −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10, −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70, −0.30, −0.50, − 0.50]	[0.90, 0.10, 0.10, −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10, −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70, −0.30, −0.50, − 0.50]	[0.90, 0.10, 0.10, −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10, −0.30, −0.50, − 0.90]
EFFECT 2	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]
EFFECT 3	[0.30, 0.20, 0.70 , −0.70 , −0.20, − 0.10]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0, 30, −0.50, − 0.90]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0, 50, 0, 70, 0.70, −0.30, −0.50 , − 0.50]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0, 30, −0.50, − 0.90]
EFFECT 4	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.30, 0.20, 0.70, −0.70, −0.20, − 0.10]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]
EFFECT 5	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.30, 0.20, 0.70 , 0.70, −0.20, − 0.10]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]
EFFECT 6	[0.90, 0.10, 0.10, −0.30,	[0.30, 0.20, 0.70	[0.70, 0.70, 0.70	[0.90, 0.10, 0.10	[0.30, 0.20, 0.70	[0.10, 0.50, 0.70, −0.90,	[0.30, 0.20, 0.70	[0.30, 0.20, 0.70

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	−0.50, − 0.90]	, −0.70, −0.20, − 0.10]	, −0.70, −0.70, − 0.70]	, −0.30, −0.50, − 0.90]	, −0.70, −0.20, − 0.10]	−0.20, − 0.10]	, −0.70, −0.20, − 0.10]	, −0.70, −0.20, − 0.10]
EFFECT 7	[0.90, 0.10, 0.10 −0.30, −0.50, − 0.90]	[0.10, 0.50, 0.70, −0.90, −0.20, − 0.10]	[0.30, 0.20, 0.70, −0.70, −0.20, − 0.10]	[0.50, 0.70, 0.70, −0.30, −0.50, − 0.50]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.30, 0.20, 0.70 0.70, −0.20, − 0.10]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.10, 0.50, 0.70, −0.90, −0.20, − 0.10]
EFFECT 8	[0.10, 0.50, 0.70, −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10, −0.30, −0, 50, − 0.90]	[0,10, 0, 50, 0, , −0.90, −0.20, − 0.10]	[0.30, 0.20, 0.70, −0.70, −0.20, − 0.10]	[0.10, 0, 50, 0.70, −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10, 0.30, −0, 50, − 0.90]	[0.10, 0, 50, 0.70, −0.90, −0.20, − 0.10]	[0, 50, 0.70, 0.70, −0.30, −0, 50, − 0.50]
	CRIT 1	**CRIT 2**	**CRIT 3**	**CRIT 4**	**CRIT 5**	**CRIT 6**	**CRIT 7**	**CRIT 8**
EFFECT 1	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.30, 0.20, 0, 70 , −0.70, −0.20, − 0.10]	[0.50, 0, 70, 0.70 , −0.30, −0.50, − 0.50]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.30, 0.20, 0, 70 , 0.70, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]
EFFECT 2	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70 , 0.30, −0.50, − 0.50]	[0.90, 0.10, 0.10, −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]
EFFECT 3	[0.90, 0.10, 0.10 , −0.30, −0.50 , − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50 , − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50 , − 0.90]	[0.10, 0, 50, 0.70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , 0.30, −0.50, − 0.90]	[0.10, 0, 50, 0.70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0.30, −0.50 , − 0.90]
EFFECT 4	[0.10, 0.50, 0.70 , −0.90,	[0.10, 0.50, 0.70 , −0.90,	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.10, 0.50, 0.70 , −0.90,	[0.50, 0.70, 0.70 , −0.30,	[0.10, 0.50, 0.70 , 0.90, −0.20,	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.10, 0.50, 0.70 , −0.90,

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	−0.20, − 0.10]	−0.20, − 0.10]		−0.20, − 0.10]	−0.50, − 0.50]	− 0.10]		−0.20, − 0.10]
EFFECT 5	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.30, 0.20, 0.70 , 0.70, −0.20, − 0.10]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]
EFFECT 6	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.10, 0.50, 0.70 , 0.90, −0.20, − 0.10]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]
EFFECT 7	[0.90, 0.10, 0.10 , −0.30, −0.50 , − 0.90]	[0, 50, 0.70, 0.70 , −0.30, −0.50 , − 0.50]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0, 50, 0.70, 0.70 , −0.30, −0.50 , − 0.50]	[0, 50, 0.70, 0.70 , −0.30, −0.50 , − 0.50]	[0.30, 0.20, 0.70 , 0.70, −0.20, − 0.10]	[0, 50, 0.70, 0.70 , −0.30, −0.50 , − 0.50]	[0.10, 0, 50, 0.70 , −0.90, −0.20, − 0.10]
EFFECT 8	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.10, 0.50, 0, 70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , 0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.50, 0, 70, 0.70 , −0.30, −0.50, − 0.50]
	CRIT 1	**CRIT 2**	**CRIT 3**	**CRIT 4**	**CRIT 5**	**CRIT 6**	**CRIT 7**	**CRIT 8**
EFFECT 1	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.30, 0.20, 0.70 , 0.70, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]
EFFECT 2	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70 , 0.30, −0.50, − 0.50]	[0.90, 0.10, 0.10, −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]

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EFFECT 3	[0.90, 0.10, 0.10 , −0, 30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0, 30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0, 30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0, 30, −0.50, − 0.90]	[0.10, 0, 50, 0.70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , 0, 30, −0.50, − 0.90]	[0.10, 0, 50, 0.70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0, 30, −0.50, − 0.90]
EFFECT 4	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.10, 0.50, 0.70 , 0.90, −0.20, − 0.10]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]
EFFECT 5	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.30, 0.20, 0.70 , 0.70, −0.20, − 0.10]	[0.70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]
EFFECT 6	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.30, 0.20, 0, 70 , −0.70, −0.20, − 0.10]	[0, 70, 0.70, 0.70 , −0.70, −0.70, − 0.70]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.30, 0.20, 0, 70 , −0.70, −0.20, − 0.10]	[0.10, 0.50, 0, 70 , 0.90, −0.20, − 0.10]	[0.30, 0.20, 0, 70 , −0.70 , −0.20, − 0.10]	[0.30, 0.20, 0, 70 , −0.70, −0.20, − 0.10]
EFFECT 7	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.30, 0.20, 0.70 , −0.70, −0.20, − 0.10]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.30, 0.20, 0.70 , 0.70, −0.20, − 0.10]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]
EFFECT 8	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.10, 0.50, 0.70 , −0.90, −0.20, − 0.10]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , 0.30, −0.50, − 0.90]	[0.90, 0.10, 0.10 , −0.30, −0.50, − 0.90]	[0.50, 0.70, 0.70 , −0.30, −0.50, − 0.50]

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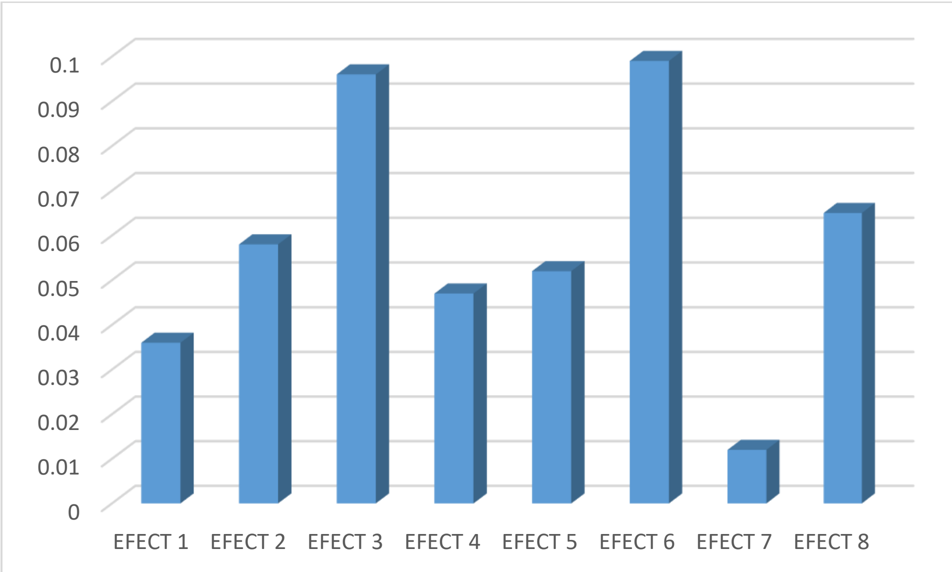

Figure 3: Weightings of the criteria.

Step 3. Calculate the criteria weights as shown in Figure 3.

Step 4. Calculate the substitution closeness of the optimal solution using Eq.

Step 5. Calculate the values of S_i Use equation [18].

Step 6. Calculate the values of R_i Use equation [19].

Step 7. Calculate VIKOR index using equations. [20 and 21]

Step 8. Arrange the alternatives as shown in Figure 4.

According to the calculations carried out, this order of the experts' assessment is obtained:

Effects	Order
Improved Soil Health : Organic additives, such as composts and algae extracts, increase the microbial activity of the soil, improving its fertility and promoting a balanced and healthy environment for plants.	1
Increase in Biomass Production : The application of biostimulants can increase the production of both aerial and underground biomass, which translates into greater crop yield.	2
Biological Control of Pathogens : Some biostimulants include antagonistic microorganisms that can suppress the growth of soil pathogens, reducing the incidence of disease and decreasing the need for chemical pesticides.	3
Improving Soil Structure : Biostimulants help improve soil structure, increasing its water retention and aeration capacity, which favors root development and resistance to drought.	4

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Reduction of Abiotic Stress : Biostimulants can increase the resistance of plants to adverse conditions such as drought, salinity and extreme temperatures, thanks to the production of protective compounds such as osmoprotectants and antioxidants.	5
Stimulation of Root Growth : Microorganisms promote root growth and root branching, allowing greater exploration of the soil and better anchoring of plants.	6
Increased Nutrient Absorption : Beneficial microorganisms such as arbuscular mycorrhizae and phosphorus-solubilizing bacteria improve the availability and absorption of essential nutrients such as nitrogen, phosphorus and potassium, resulting in more vigorous plant growth.	7
Increase in Phytohormone Production : Beneficial microorganisms can synthesize phytohormones such as auxins, cytokinins and gibberellins, which regulate and stimulate the growth and development of plants.	8

Effect number 6 is the most desired and important in the development of urban agriculture according to the evaluation of the experts and the calculation of the matrix carried out.

Improved Soil Health : Organic additives, such as composts and algae extracts, increase the microbial activity of the soil, improving its fertility and promoting a balanced and healthy environment for plants.

Number 7 being the least desired, although no less important: **Increase in Phytohormone Production** : Beneficial microorganisms can synthesize phytohormones such as auxins, cytokinins and gibberellins, which regulate and stimulate the growth and development of plants.

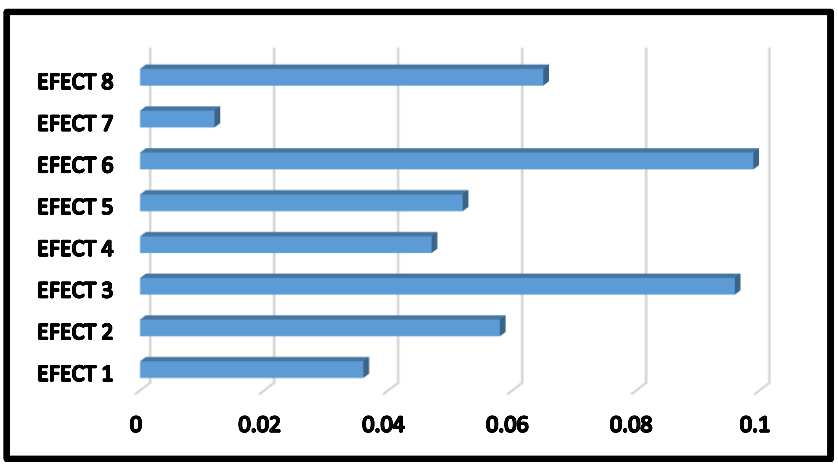

Figure 4: VIKOR - index value.

Based on meticulously carried out calculations and exhaustive evaluation by experts in the agricultural field, an order of assessment has been established that highlights the most significant effects of various biostimulation and soil improvement practices . At the top of this hierarchy is the crucial impact of improving soil health through organic additives such as composts and algae extracts – These elements not only increase the microbial activity of the soil, but also increase its fertility, creating a balanced and conducive environment for the flowering of plants, which which

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places this effect in the first position of the ranking . Following closely, in second place, is the benefit derived from the increase in biomass production, both above and underground, thanks to the application of biostimulants . This substantial increase of biomass directly translates into more robust and satisfactory crop yields, which is crucial for food security and the economic profitability of agricultural activities .

In third place, the biological control of pathogens stands out through biostimulants that contain antagonistic microorganisms - These agents are capable of suppressing the growth of pathogens in the soil, thus reducing plant diseases and reducing dependence on chemical pesticides, which not only benefits plant health, but also the environment and human health by reducing exposure to harmful substances . The fourth position falls on the improvement of soil structure facilitated by biostimulants, which increase the retention capacity of water and soil aeration . This structural improvement is essential for healthy root development and the resistance of plants to adverse climatic conditions such as drought, thus contributing to a more sustainable and resilient agriculture .

In fifth place is the effect of reducing abiotic stress, where biostimulants help strengthen the resistance of plants to adverse conditions such as drought, salinity and extreme temperatures – This benefit is achieved through the production of protective compounds as osmoprotectors and antioxidants, essential to maintain plant health and vigor under challenging environmental conditions .

The sixth place highlights the stimulation of root growth thanks to the microorganisms present in the biostimulants, thus promoting greater exploration of the soil and a firmer anchoring of the plants - This effect is crucial to optimize the absorption of nutrients and water, essential for the vigorous and sustained growth of plants . Seventh, the increased absorption of essential nutrients such as nitrogen, phosphorus and potassium is evaluated, facilitated by beneficial microorganisms such as arbuscular mycorrhizae and phosphorus-solubilizing bacteria . This improvement in the availability and Nutrient absorption is essential to ensure optimal plant development and maximize agricultural productivity .

Finally, in the eighth and last place in this classification, is the increase in the production of phytohormones by beneficial microorganisms – These phytohormones, such as auxins, cytokinins and gibberellins, play a crucial role in the regulation and stimulation of growth and development of plants, although this effect is considered the least desired compared to the other benefits evaluated . In summary, these findings underline the importance of considering various factors when evaluating the benefits of practices such as biostimulation and soil improvement in modern agriculture . Each effect identified not only has significant implications for agricultural productivity and food security, but also offers opportunities to promote more sustainable and environmentally friendly practices in the global agricultural sector.

4. Conclusion

The study emphasizes the crucial importance of urban agriculture in ensuring food security and promoting sustainable practices in highly populated regions. The research illustrates how the application of different biostimulants and organic additions can improve soil quality, promote plant growth and improve crop yields. The use of biofertilizers such as Chromococcus and Azotobacter has shown encouraging results in improving nutrient accessibility and plant well-being, thereby promoting vigorous and superior harvests. In urban agriculture situations, the inclusion of mineral additions such as zeolites improves soil fertility and moisture retention, which are crucial to maintaining productivity.

The study effectively evaluates the long-term effects of organic changes in urban agriculture systems by using a multi-criteria neutrosophic approach. The results indicate that the use of organic additives and biofertilizers not only increases the resilience of plants against pests and diseases, but also improves the overall sustainability of agricultural methods. The scenarios evaluated demonstrate that a soil with substantial physical and chemical composition, together with the strategic application of organic amendments, can generate substantial benefits for soil health, biodiversity, and resource preservation. This comprehensive approach emphasizes the importance of incorporating ecological and agronomic elements to establish robust and efficient urban agricultural systems, which ultimately help mitigate climate change and restore local economies. ·

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