Multi-Criteria Data Analysis with Interval-Valued Neutrosophic Sets to Decrease Plastic Pollution rivers

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Abstract

Whether for human consumption, agricultural production, or industrial processes, groundwater, and rivers, in particular, are crucial. The river is a major water source; therefore, we must do all we can to keep it clean. Inconsistencies in data, algorithms and expert judgments have contributed to the growing recognition of ambiguity analysis' significance. However, it is not common practice to include vulnerability assessment in MCA based Interval-Valued Neutrosophic Sets (IVNSs). To better understand what causes MCA uncertainty, this research examines the factors that contribute to it. Probabilistic techniques, indicator-based methods, and neutrosophic logic are examined as examples of broad approaches to analysis methods in MCA. The practicality, financial and ecological consequences, unexpected social and environmental implications, possible scale of change, and confirmation of the impact of plastic reduction strategies were investigated using an MCA technique.

Keywords: MCA; Decision Support Analysis; Uncertainty; Rivers Pollution; Interval-Valued Neutrosophic Sets;

1. Introduction

Humans have been fixated on rivers and other surface water sources since infancy. Urban, manufacturing, and commercial hubs, as well as whole civilizations, tend to spring up near waterways. However, humans have been actively destroying natural habitats since the Industrial Revolution. One of the most crucial needs in water resource planning, development, preservation, and management is an understanding of the quality of the water resources at hand. Because of this, strategies must be utilised to keep an eye on and maintain the integrity of this renewable source while spending as little money and effort as possible. The consciousness capacity and self-regulating capabilities of rivers in their natural settings allow them to withstand the burden of natural pollution imposed by the environment and even solve it. The deterioration, degradation, and death of aquatic systems occur when the pollution liabilities exceed the rivers' maximum capacity and when both the load and the contamination are the result of human activity. As the world's population and different forms of pollution

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continue to rise, the quality of the world's rivers and aquifers deteriorate. The initial and fundamental first phase in water quality monitoring is the zoning monitoring of river water quality, which allows the analyst to see patterns and processes of pollution variations over time and about specific locations and circumstances. The Geographical Information System (GIS) has the potential to analyze and analyze massive amounts of data, making it more helpful in managing performance basins. More precise connections between potable water quality characteristics and the basin's effectiveness parameters may be obtained with this technology[1]–[3].

Chang used GIS to examine the temporal trend of adjustments in several rivers in South Korea, and he concluded that there are connections between land utilization and the drinking quality characteristics of these rivers. Yetik et al. used GIS-based software to fine-tune their river water quality model, leading to the development of a GIS-based water-quality modeling program. Through GIS, Yang and Jin could forecast the water quality in the Yawa River network in the Americas. According to their findings, hardly any studies use zoning in relation to the severity and area of river pollution. Those tend to be pass and more compatible with GIS and statistical approaches. Despite the many studies and options, zoning river pollution remains challenging. It relies heavily on observational data, which is problematic in and of itself. The use of calibration findings impacts numerical approaches because of the need for meteorological, hydraulic, and concentration-time data. Their numbers seem to be dwindling. However, solution methods have been combined with spatial-analytic approaches like those utilized in this work to increase effectiveness and simplicity[4]–[9].

Uncertainty arises when the probabilities of possible outcomes in a decision-making situation are unknown or may be approximated with low confidence. The ambiguity is a measurement of the danger that the judgment must take after establishing the probability of these events. Uncertainty analysis, then, seeks to quantify this amorphous quality as a measure of threat by selecting a set of possibilities for possible events. For example, when we do not know both teams well, the outcome of a football game is unknown; if we estimate that such a team has a winning chance of p, then we risk its losing chance of 1-p if we choose to bet on it.

The probable outcomes are the options based on the expected consequences of the various management practices being evaluated in the event of picking management approaches based on their ranking scores (assuming the one with the most incredible score is the desired choice). With known inputs, the outcomes of various management approaches are predictable, making the decision between them easy. The inputs are unknown. Hence the optimal technique to maximize the score is also a mystery. To improve decision-making confidence, or, as Knight puts it, to "find out all the risk in picking a certain management plan," it is helpful to calculate the likelihood that each option would provide the desired results.

Suppose the goal of uncertainty analysis is to quantify the risk associated with making a choice. In that case, one may use a metric other than the probability to assess that risk: the proximity of the second-best management approach to the best. One definition of proximity is the degree to which a change in one input causes a switch in the relative ranking of two methods. The likelihood of rank reversal and hence the fragility of decision-making increases if the relative shift is minor, that is, if the option is near to the best choice. This uncertainty analysis is related to "sensitivity analysis," which assesses the impacts of modest modifications to the inputs of a model in that it quantifies the angular displacement of input as the risk of ordering reversal in decision-making.

Confusion in the input data utilized by the judgment framework and the model itself are familiar sources of judgment risk. Uncertainty in the model comprises model structure and characteristics, whereas ambiguity in the input data encompasses user-introduced ambiguity in selecting features and opacity in measurement results. Assessment techniques may use mathematical and numerical probabilistic approaches, the latter of which are frequently observed in sampling techniques. The former only applies to basic modeling systems, such as linear systems, where the result can be characterized as a relationship of the unpredictability of the intake that impacts the outcome. These later methods, like the Monte Carlo methodology, are useful for analysing more complicated systems, such as non-linear system, that need more advanced methods for determining ambiguity and its transmission. Indicator-based ambiguity analysis techniques may be used if the risk is framed in terms of how similar the worst option corresponds to the best one. When there are relationships between points in space, ambiguities such as geographical attribute ambiguity and location ambiguity may spread across space, making the probability analysis more difficult.

Consumers' actions are crucial in driving innovation and bolstering ecological effectiveness. However, there is a shortage of research on the best ways for consumers to help lessen plastic waste in marine environments. Such reference data is crucial for encouraging efficient behavioral shifts concerning consumption. We build on the work of Winton et al.. They found that certain single-use plastics are overwhelmingly prevalent in European aquatic habitats, and we assess what can be done on the part of individual consumers to lessen the use of these materials. Because of their pervasiveness in freshwater environments and far too many solitary

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plastics are superfluous, we have decided to concentrate on them. Multi-criteria decision analysis (MCDA) is used to determine the order of these steps. Health, social, and climate scientists often use multi-criteria decision analysis to evaluate ecosystem services and wastewater treatment, water, air, power, and resource extraction challenges[10]–[13]. Plastic waste disposal solutions (i.e., disposal, recycling, incinerator, and pyrolysis) were evaluated by a panel of ecological researchers and engineers using MCDA with respect to their environmental and health implications, financial burdens, practical and regulatory issues. This is the first research we know to utilize MCDA to place plastic pollution in a broader perspective and establish priorities. To investigate the benefits and difficulties associated with the execution of certain priority activities, we integrate MCDA with a SWOT (strong points, vulnerabilities, opportunities, and threats) study[14]–[17]. Our research provides valuable insight into how governments and corporations may make better policy choices to curb plastic pollution, including how to design incentive systems to spur positive behavior shifts[18]–[21].

We compiled a body of research to determine what people may do to lessen their plastic use and the pollution that results from littering and improper disposal of plastics. Interventions presently advocated by consumers and companies to reduce plastic waste were identified and evaluated using relevant data found via a comprehensive search of the written and grey literature

We discovered and compiled both business and consumer behaviors into a centralised database. Then we picked them based on their relation to the top ten things indicated by Winton et al. Five of the top ten plastic items were related to eating (packaging, straws, cutlery, bottles, and takeout containers), two were sanitation facilities (cotton bud needles and hygiene towels). Three were smoking-related (cigarette butts and packaging), with the remaining item type being plastic bags.

2. Interval Valued Neutrosophic Sets and Multi-Criteria Decision Analysis (MCDA)

In this section, we review the foundational concepts of NSs, SVNSs, IVNSs, and the current ranking functions for IVNNs that serve as the basis for this study and inform our future investigations.

Definition 1:

We define the neutrosophic set A (NS A) as follows: $A = x: TA(x), IA(x), FA(x) >, x \in X$, where T(x), I(x), and F(x) are the truth, indeterminate, and false MS functions, respectively, and they meet the following condition: $T(x) = x: TA(x), I(x) = x: TA(x)$

$$-0 \leq TA(x) + IA(x) + FA(x) \leq 3 +.$$

We get the values for the three MS functions by plugging in]0,1+[. For this reason, Wang et al. proposed the use of an SVNS, which is a simplified version of an NS that may be applied to any real-world situation.

Definition 2:

The set... describes A, the SVNS in X.

Two conditions are met for the expression $A \ldots = x: TA(x), IA(x), FA(x), x = X$: in which $TA(x), IA(x), FA(x) \in [0,1]$ and $x \in X$.

$$0 \leq TA(x) + IA(x) + FA(x) \leq 3.$$

Definition 3:

An Intravenous Nutritional Support System in X, denoted by

$$A = \{\langle x: T{\sim}A(x), I{\sim}A(x), F{\sim}A(x)\rangle, x \in X\},$$

$$A = \{\langle x: [TLA(x), TUA(x)],$$

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$$[ILA(x), IUA(x)],$$

$$[FLA(x), FUA(x)]\rangle, x \in X\},$$

where the values in the interval $[TLA(x), TUA(x)]$,

$$[ILA(x), IUA(x)],$$

$$[FLA(x), FUA(x)] \in [0,1]$$

meet the condition:

$$0 \leq supTA(x) + supIA(x) + supFA(x) \leq 3.$$

We now look at some mathematical operations that may be performed on IVNNs, or interval-valued neutrosophic numbers.

Definition 4:

Let

$A = \langle [TLa, TUa], [ILa, IUa], [FLa, FUa] \rangle$

$andB = \langle [TLb, TUb], [ILb, IUb], [FLb, FUb] \rangle,$

$be\ two\ IVNNs\ and\ \eta > 0.$

Then

$A \oplus B = \langle [TLa + TLb - TLaTLb, TUa + TUb - TUaTUb],$

$[ILaILb, IUaIUb],$

$[FLaFLb, FUaFUb] \rangle,$

$A \otimes B = \langle [TLaTLb, TUaTUb],$

$[ILa + ILb - ILaILb, IUa + IUb - IUaIUb]$

$[FLa + FLb - FLaFLb, FUa + FUb - FUaFUb] \rangle,$

$\eta A = \langle [1 - (1 - TLa)\eta, 1 - (1 - TUa)\eta],$

$[(ILa)\eta, (IUa)\eta], [(FLa)\eta, (FUa)\eta] \rangle,$

$A\eta = \langle [(TLa)\eta, (TUa)\eta],$

$[1 - (1 - ILa)\eta, 1 - (1 - IUa)\eta],$

$[1 - (1 - FLa)\eta, 1 - (1 - FUa)\eta] \rangle,$

$where\ \eta > 0.$

Definition 5:

$x \ominus y = \langle [TLx - FUy, TUx - FLy],$

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$[Max(ILx, ILy), Max(IUx, IUy)],$

$\times [FLx - TUy, FUx - TLy]\rangle$

$where\ x = \langle[TLx, TUx], [ILx, IUx],$

$[FLx, FUx]\rangle$

$and\ y = \langle[TLy, TUy], [ILy, IUy],$

$[FLy, FUy]\rangle.$

Definition 6:

Deneutrosophic IVNSs as:

$$D = \frac{\left[\frac{TL + TU}{2}\right] + \beta\left[\frac{IL + IU}{2}\right] + (1 + \beta)\left[\frac{FL + FU}{2}\right]}{2}$$

Definition 7:

$$T(x) = \begin{cases} TL(x) & a^1 \le x \le b^1 \\ \alpha & b^1 \le x \le c^1 \\ TU(x) & c^1 \le x \le d^1 \\ 0 & otherwise \end{cases}$$

$$I(x) = \begin{cases} IL(x) & a^2 \le x \le b^2 \\ \beta & b^2 \le x \le c^2 \\ IU(x) & c^2 \le x \le d^2 \\ 1 & otherwise \end{cases}$$

$$F(x) = \begin{cases} FL(x) & a^3 \le x \le b^3 \\ \gamma & b^3 \le x \le c^3 \\ FU(x) & c^3 \le x \le d^3 \\ 1 & otherwise \end{cases}$$

To determine the relative merits of several courses of action, we used multi-criteria decision analysis (MCDA). A powerful and adaptable tool for dealing with inadequate and ambiguous information, multi-criteria decision analysis (MCDA) is an analytical approach used to assess various choice possibilities based on a standard set of criteria. We utilized MCDA to assess the costs and benefits of potential consumer-based actions. The procedure consisted of five main steps: (1) required various to determine the ranking criteria to be assessed; (2) weight execute a specific to assess the relative value of each criterion; (3) review and try to score each intervention even against criteria; (4) computation of the total intervention score; and (5) evaluation of the outcomes and internal consistency. We break down each stage for you here.

We established criteria to assess efforts to eliminate the top ten disposable materials found in ecosystems. For every factor, proof of effect was evaluated based on the following criteria: practicality, economic impacts, effects on the environment, ecological effects and unwanted side repercussions, the possible magnitude of change, and particular elements derived from relevant research.

Twelve experts in the field of plastics pollution (researchers, activists, and businesspeople) and three writers each gave a score (%) to the other criteria out of a possible 100%. Every criterion's median weight was computed, and the standard deviation was used to estimate the degree of precision with which each median weight could be reported. All 12 specialists whose names are included in the acknowledgements agreed to participate in the research after providing written permission.

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Using information on each action's prospective and immediate effects on the environment—such as the number of disposable goods that may be avoided thanks to that action—we gave each an overall score from 1 to 5. Actions with a greater positive effect (e.g. viability) to minimize plastic waste or fewer negative financial or ecological repercussions get higher marks. If there was no previous study, we gave it a 1..

(4–5) Each action's final score was calculated by multiplying the criterion's mean percentage weight by the criterion's 1–5 score (1).

$$Total\ Score = \sum_{i=1}^{10} score * weight$$

By combining the known yearly number of products sprayed, or the annual amount of items generated or gotten rid of, by the body density of personal plastic products or of the plastic constituent of a multi-material thing, we estimated the effects of every action in a million tons of plastic helped prevent from entering the atmosphere annually. Bag, cup, and straw littering rates statistics were not provided, nor was information on the amount of plastic included inside food packaging. So, we could not calculate how much plastic was kept out of the ecosystem thanks to these products. When we were done, we double-checked the final action score computation and added a measurement of uncertainty to account for the range of values we gave each of the ten criteria.

The SWOT analysis has been widely utilized in research to create and evaluate strategies. The Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis is a solid strategic tool for evaluating internal and external elements that impact a project, organization, or circumstance. This approach may serve as a springboard for formulating strategies that prioritize protecting against hazards while capitalizing on opportunities. Although SWOT analysis is often used, it does not offer a numerical evaluation of the weight of each aspect[22]–[26]. It also has the drawback of not being able to rank different tactics and components. The standard formula for a SWOT analysis includes the following 24 components. Figures 1 and 2 shows the SWOT approach and its framework.

Initially, you should build a SWOT matrix. In this stage, you will list your most critical strengths, weaknesses, opportunities, and threats.

The second phase involves figuring out a strategy by analyzing a SWOT chart. Here, the SWOT matrix is expanded into four strategy pairings of SO, ST, WO, and WT depending on the identified strengths, weaknesses, opportunities, and threats permutations. SO tactics aim to capitalize on existing resources and new openings when possible. WO tactics focus on using favorable external conditions to compensate for inherent flaws inside an organization. The ST strategies aim to counter external risks by capitalizing on available resources inside an organization. Finally, WT tactics seek to lessen the impact of threats from the outside by fixing any problems inside the organization.

We performed a qualitative SWOT (capabilities, limitations, chances, threats) analysis to examine further each of the 27 plastic waste minimizations identified. Corporations first utilized this approach to become more competitive, but it has since been adapted for the analysis of environmental initiatives. Using SWOT analysis, we evaluated the potential for each person, company, or policy action to either help (through their opportunities and strengths) or hurt (through their weaknesses and threats) the effort to lessen plastic pollution. In contrast to weaknesses and strengths, opportunities and threats are associated with possible good and bad elements of the execution of the different activities. Each action's impact on the system's internal characteristics and exterior context was analyzed. In this situation, the system's internal circumstances are the existing market trends of regularly used plastic goods, and the external context is the applicable regulations. Some examples of these positives are the existence of incentives for consumers to engage in more ecologically friendly behavior and the availability of different items on the market. Consumers might have negative effects, such as greater alternative product prices or more cumbersome purchasing processes, which were categorized as weaknesses.

One of the main drawbacks of the classic SWOT analysis is that it is difficult to determine which of the four factors impacts the ultimate strategic choice. To rephrase, the SWOT analysis does not provide a mechanism for analysing the weight of each factor or for determining whether or not a given alternative is a good fit (European Commission, 2004). The following are some of the major drawbacks of SWOT analysis:
The environmental factors are often considered in SWOT analyses via a qualitative study.

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ii) It doesn't assign particular weight to specific considerations or approaches;

An increase in the number of elements or agents will result in an exponential rise in the implementation strategies. If there are five components in a set of S, W, O, T, for example, the aggregate process will provide a result of approximately, making it very challenging to choose an appropriate approach;

It disregards possible elemental uncertainty.

Due to this, SWOT analysis cannot be used to provide a full evaluation of the strategic judgment process. The relevance of each aspect in the decision-making process may be quantified.

Figure 1: The neutrosophic SWOT method.

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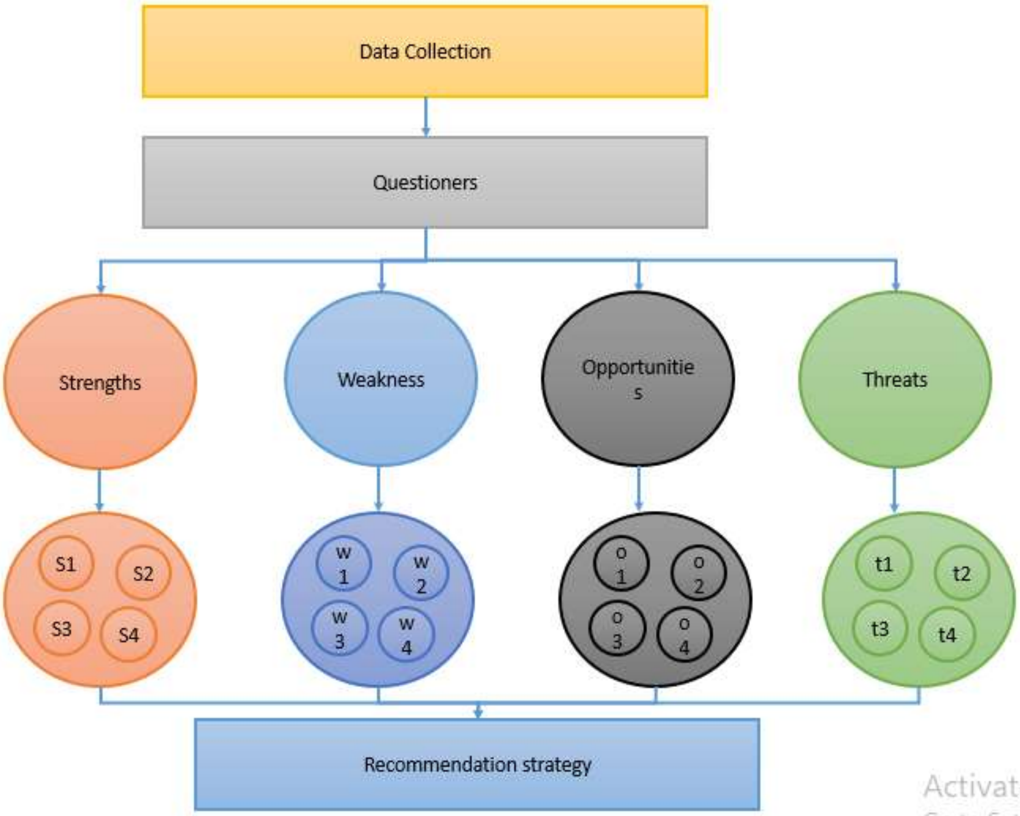

Figure 2: The neutrosophic SWOT method framework.

IVNS VIKOR method

In the first stage, the decision matrix must be made.
Secondly, we will estimate the weight factors.
Third, a normalised decision matrix is constructed.
The fourth step involves generating a weighted normalised decision matrix.
The fifth stage is deneutrosophizing the values.
Absolute distance is determined in Step 6.
Seventh, relative weights are determined.
The eighth step is to rank the possible solutions.

3. Interval Valued Neutrosophic Sets Results

At this point, a questionnaire was created and given to a panel of experts to categorize the elements into advantages, limitations, dangers, and chances, and Cronbach's alpha of variables in every category was calculated. The acquired alpha values proved that the classifications made up to this point were accurate. Table 1 displays the Cronbach's alpha for each component in each dimension.

Table 1: Neutrosophic SWOT analysis

Criteria	Alpha	Strategy
Advantages	0.76	5
Limitations	0.84	5
Dangers	0.86	5
Chances	0.81	5
All	0.82	20

The experts' assigned weights varied widely (5-16%) and were not regularly spread; this was especially true for the 'Chances of consumers executing the action' (LIK) weight as well as the 'estimated decrease in the amount of plastic litter entry into the environment' (RVEL) weight (Table 2). Different specialists were contacted, therefore, their opinions are reflected in the vast range of weights. The LIK criteria were the most heavily

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weighted at 16%, followed by the two economic effects (CON and BUS) at 16%, and finally carbon (CAR1 and CAR2), water (WAT), and other ecological effects (25%) at a combined total (UNI). The environmental criterion received a cumulative weight of 25%, while the socio-economic criteria (i.e., viability, financial consequences, scaling, and proof of impacts) received a weight of 60%.

Several options raise practical, monetary, or ecological concerns. Reusable straws and 100 % recyclable bottle beverages are two examples of items buyers are less likely to actively seek out because of limited availability (LIK: scores 1–2). Two-thirds of the activities were rated as feasible right now. However, many viable alternatives to plastic containers do not exist. Due to the significant expenses incurred by both customers and companies, milk delivery, reusable bottles, coffee cups, and reusable straws received low total action ratings (CON & BUS: scores 1–2; Table 2). The increasing carbon impacts upon that consumer end meant that actions like refilling detergent/shampoo bottles, that used solid soap, shampoo, and conditioner bars (i.e. greenhouse gases due to trying to travel to shops), and using carbolic soap and reusable sanitary towels (i.e. greenhouse gas emissions due to the shampooing required) had low overall action scores due to their high carbon implications on the corporate side (linked to manufacturing operation, disposal, and waste management), proper disposal of rotting food, cigarette butts, and inhaling packaging received low total action scores, along with the use of recyclable bamboo coffee cups, menstrual cups, compostable wet wipes, and reusable cotton tote bags . Two-thirds of the activities were rated as having high effects on water consumption (WAT: 1-2); the right removal of cigarette butts and cigarettes equipment and the use of disposable and compostable wet wipes were rated as having high unexpected negative ecological repercussions (UNI: 1-2). Figure 3 shows the weights of criteria. Then we applied the steps of the VIKOR method to show the best staregy. First the Table 3 shows the decision matrix. The compute the score values of decision matrix. Then normalize the decision matrix. Then compute the values of relative importance. Then rank the alternatives as shown in figure 4.

Table 2: Criteria, Weights, and score.

Criteria	Weight	Score
Viability	16.5± 16.5	1 to 5 (very bad to very high)
Financial	10.5± 8.5	1 to 5 (very bad to very high)
Ecological	5.5± 3.5	1 to 5 (very bad to very high)
Impact of indication	8.0± 4.5	1 to 5 (very bad to very high)

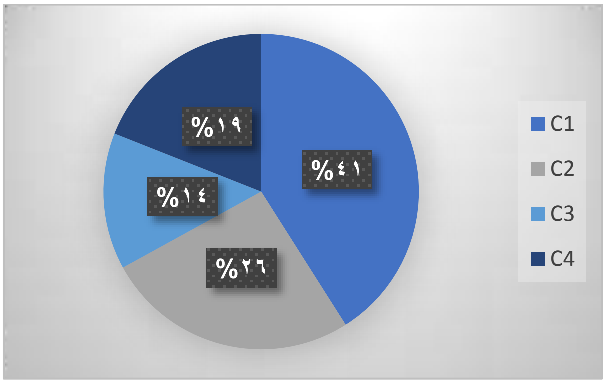

Figure 3: The weights of criteria.

Table 3: The decision matrix.

	C1	C2	C3	C4
Strategy 1	0.6	0.7	0.6	0.4
Strategy 2	0.3	0.6	0.6	0.2
Strategy 3	0.372222	0.316667	0.3	0.8

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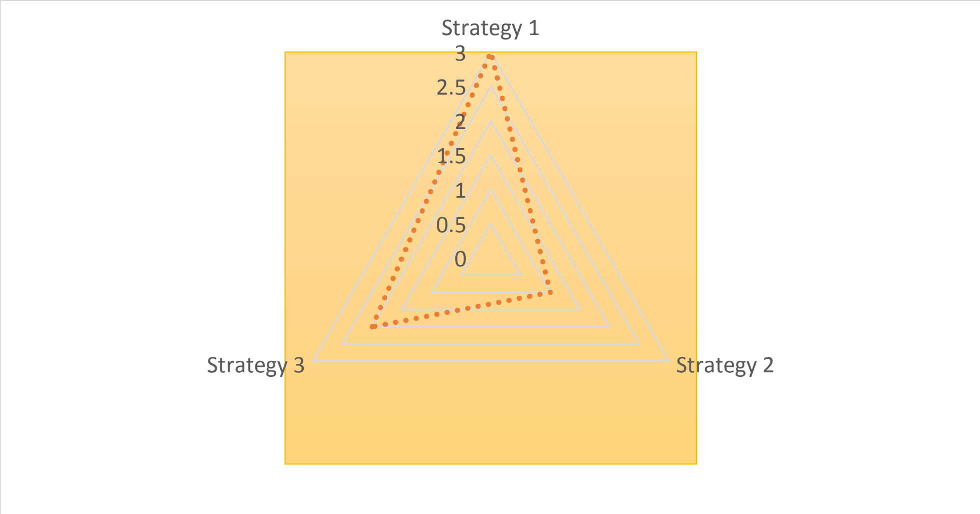

Figure 4: The renk of alternatives.

4. Conclusion

General guidelines for actions to reduce environmental degradation emerged from this study, including the following: (1) refuse unnecessary plastic containers, such as single-use plastics; (2) help cut down on traditionally plastic clamshell items, such as shampoo bottles, by replenishing or buying bigger bottles; (3) replace disposable items with recyclable or different options with a low carbon footprint; (4) correctly throw it away of items, such as disinfectant wipes. The refusal of problematic plastic goods remained the most direct approach to reducing plastic pollution without negative repercussions. Not everyone can follow all of our suggestions; for instance, some people have a medical need for plastic straws or other items we advocate avoiding.

Barriers to broad behavior change, both mental and practical, might slow the progress from knowledge to action. People often reject the harm they create to the environment when purchasing and quickly discard huge quantities of only one plastic container or bag. However, individuals may alter their actions in a self-determined manner, becoming more environmentally responsible, for instance, calculating costs and discovering the co-benefits of decreasing plastic consumption. Individuals under 25, who are still shaping their habits, have a unique opportunity to influence their group and those to come. To minimize plastic pollution in rivers, having more or clear insights on plastic usage and disposal would be helpful. Diverse people in different socio-demographic and cultural contexts use plastic products differently. Some people may require more time to process and integrate the information they've received. In contrast, others may benefit from speaking with trusted peers or leaders, including friends, coworkers, family members, or professionals. Reusable product usage and alternatives to plastics need many enabling competencies and skills (such as financial resources) and physical infrastructures.

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