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Leveraging Neutrosophic Uncertainty Theory toward Choosing Biodegradable Dynamic Plastic Product in Various Arenas

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Abstract: Numerous studies in recent years have documented the negative effects of plastic waste on the environment and human wellness. Due to their widespread usage in daily life, particularly in packaging, and their rising direct or indirect discharge into the environment, plastics are recognized as an emerging environmental hazard. Thus, this point is considered the first problem in this study. As a result, efforts to replace traditional plastics with bioplastics have intensified. However, studies regarding the effects of conventional and bioplastics (BioPs) are also important. Hence, biodegradable polymers for industrial and commercial usage are essential in the present day as an alternative to traditional plastic. Another point considered in this study is packaging which entails the quest for new natural materials that may be included in the production of reusable, eco-friendly, and long-lasting flexible polymers. Prior studies demonstrated that starches from both tubers and grains may be processed into malleable biopolymers. Since the quality of the carbs from different vendors varies, choosing which one to work with presents a Multi-Criteria Decision-Making (MCDM) challenge. This paper proposed a neutrosophic MCDM methodology to select the best biodegradable dynamic plastic product (BDPP). The neutrosophic method is used to overcome uncertain data. The neutrosophic is integrated with the Additive Ratio Assessment (ARAS) method. The weights of the criteria are computed then the rank of BDPP is obtained by the neutrosophic ARAS method.

Keywords: Bioplastic; Biodegradable; MCDM; Neutrosophic Set; ARAS method.

1. Introduction

Throughout 2017 scholars of [1] demonstrated that 348 million tons of plastic were produced worldwide. The rationale behind that [2] Plastics are popular because they enable societies to get the merchandise they want for a bargain price. In light of its incredible traits in endurance, brightness, equilibrium, and affordable expenditures plastics have been utilized extensively in industrial and daily life since its inception. Due to [3]where the increasing usage of plastic, there is currently an issue with white pollution since a lot of plastic litter has been released into the environment globally. Shen et al. [1] coined the term "White pollution" to describe the problem of discarded plastics causing environmental contamination. The usage of plastic items like packing bags, agricultural mulch film, throwaway dinnerware, plastic bottles, etc. causes environmental and landscape damage. That is the case [4] given the accumulating evidence that plastic pollution harms living beings in terrestrial ecosystems alike. That is why as mentioned in [5] whereas the detrimental environmental repercussions of plastics are becoming more well-known among consumers.

As a result, several studies have looked at this negative impact in different contexts. For instance [6] discussed how it has a detrimental influence on society context whereas the negative effects of plastics on human society have gotten worse, including the immediate damage they do to the environment and the potential hazards that pose to humans and other living beings. Regarding the financial and economic context, in accordance with statistics in [7] 192 coastal nations and areas created 280 million tons of plastic debris in 2011, and roughly 8 million tons of that waste ended up in the seas.

For several decades, efforts have been made to lessen plastic waste and the ensuing contamination of land and marine areas. Whereas [8] illustrated that in 1975, the European Union generated Waste Framework Directives and a hierarchy of waste management practices, with prevention, reuse, recycling, recovery, and disposal ranked from most to least advantageous.

Conversely, [1] had a divergent scepticism on recycling depicted in two points. First one, Plastic recycling is limited by the high cost of these stages, the poor economic value of recovered plastics, and the low cost of raw materials. Second one, when plastic garbage is burned, harmful substances such as greenhouse gases (CO_2) and other irritating gases are released.

Thereby in light of the growing social, economic, and environmental crises , [1] illustrated efforts have been made to discover a workable solution to plastics. This solution is utilizing Bioplastics (BioPs) as a practical replacement for conventional plastics. Biops in [9] are described as polymers that meet one or both of the following requirements: they are made from bio-based and biodegradable.

BioPs are often produced as mentioned in [10] using renewable raw materials such lignin, cellulose, starch, and bioethanol. Thereby, [11]summarized biodegradable plastic as a plastic material that satisfies formal biodegradability standards, where a defined amount of breakdown must be experimentally verified within a specific timeframe and under specific circumstances.

Others as [12] demonstrated that in the near future, a viable alternative to petrochemical plastics might be provided by biobased and biodegradable plastic, which can be considered as one of the alternatives to achieve this sustainable expansion of the plastic sector. BioPs and biobased might be a potential long-term tackle to the issue of waste disposal and worldwide plastic pollution.

Ultimately, Environmental concerns about the non-biodegradability of viscoelastic plastics motivated researchers to look for a safer, more sustainable alternative. Starch, fiber, sodium alginate, and other chymotrypsinogen are the next most studied and used resources in the production of biodegradable polymers, respectively. Since there are many different manufacturers that may manufacture this amylase, selecting the one that is most suited to the intended use is essential. During this narrowing down process, it is important to consider the properties of the manufactured flexible polymers. Every carbohydrate source has to compromise on one or more of several desirable qualities since none of them can reliably provide every one of them [5].

Herein, this study volunteering the neutrosophic set to overcome the uncertain data between criteria and alternatives. This study used the single valued neutrosophic set (SVNSs) as a kind of neutrosophic set. The unpredictability and variety of the initial data make it challenging for Decision Makers (DMs) to communicate their judgments appropriately in real-world Multi-Criteria Decision Making (MCDM) scenarios. Smarandache proposed neutrosophic sets (NSs) to convey assessment values in complex systems, which are characterized by the truth-membership, indeterminacy-membership, and falsity-membership degrees concurrently, to deal with imprecise and ambiguous data. In the same way that the NSs is a generalization of the classic set, and fuzzy sets. So this study used additive ratio assessment (ARAS) method under NSs to rank the alternatives[13],[14].

2. Relevant Fundamental Tenets with Study

According to the conducted survey for prior studies which related to our interested scope, we illustrate the basic concepts and tenets which are important and serve our study.

2.1 Bioplastic Life Cycles

The environmental impacts of using bioplastics, such as the mitigation of climate change, are considered in this part, along with the full scope of the bioplastic's life cycle, from initial usage of land to the analysis of the unprocessed ingredients and final disposal options. The production of Biops entails several stages as seen in Figure 1, from harvesting raw materials to bio-refining to metabolism to plastic cleansing to injection or blow molding to finished products before distribution, usage, and disposal decisions. Recyclable, sustainable, and biodegradable are often used terms; it is useful to define them in light of this cycle [15].

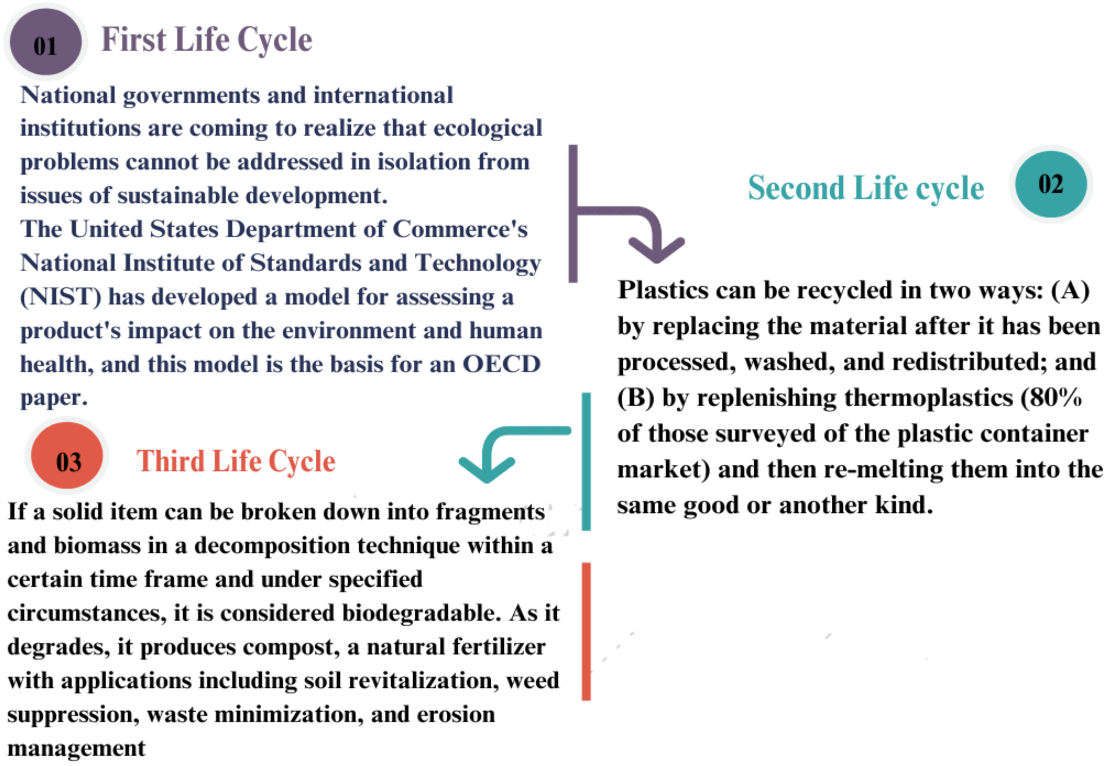

Figure 1. Bioplastic life cycles.

2.2 Biodegradable Plastics Productions

According to several studies as [16] both the terms "biodegradable" and "bioplastic" are commonly used interchangeably. Based on Fig 2 BioPs can be divided into two types.

Rising prices for biodegradable plastics are hard to predict because of how many variables affect consumption and how difficult it is to put a price tag on those variables. The generation of impact variables also involves a fair amount of difficulty. As people learn more about the need to conserve biodiversity and the environment, their interest in purchasing organic items increases. The manufacturing of BioPs stands to benefit from this [17].

As we've already shown, it's challenging to quantify the many influencing elements in order to apply them in an approach for forecasting interest in bioplastics. Time series data on the expense of crude oil, feedstock prices, and GDP provide the foundation for understanding the need for bioplastics. Many technical possibilities are being explored in previous research and in this paper because of the widespread ambiguity around their possible use. Future policy actions are particularly hard to assess since various policy initiatives have varying outcomes. Implementing national and international policies is problem-sensitive and may have varying outcomes. The perceptual impact will be harder to implement [18], [19]. Everything that helps keep bioplastic production prices low: Changes in technology and the results of education: Over time, more efficient processing techniques may be developed, and the price could go down as a result of the acquired effects.

Due to efficiencies of scale, businesses may generate more income at somewhat lower (unit) prices by increasing BioPs manufacturing. Manufacturing quantities for BioPs are still rather low, and the associated costs are quite expensive.

Effective environmental policy measures include but are not limited to: Price increases for conventional plastics may result from taxes imposed on products derived from fossil fuels. As a result, the price of BioPs would go down, increasing demand for them. Government subsidies allow bioplastic producers to cut their production costs and attract more customers.

The demand for bioplastic products would be bolstered if states banned the use of fossil plastics. Standardization may suffer, though, if the prohibitions are applied to all plastics, including bioplastics [20], [21]. The increasing need for bioplastics is strongly influenced by the price of crude oil. Since crude oil is used as the primary ingredient in the creation of conventional plastics, the cost is very variable. With the rising expense of both oil and traditional plastics, alternatives like BioPs have grown increasingly attractive. The need for bioplastics would rise in tandem with the cost of oil.

A rise in GDP has a multiplier effect on the manufacture and expansion of plastics, as well as on the use of BioPs. The market for BioPs will increase if market participants with better incomes spend more on green technologies. The costs of feedstock have a significant impact on the overall cost of producing bioplastics. Bioplastics are now manufactured mostly from maize starch or sugar cane. Manufacturing expenses, and hence BioPs prices, will rise if the cost of maize or sugar increases. In return, a decrease in bioplastic manufacturing follows price increases. The prices of both maize and sugar fluctuate wildly on the global market [22, 23].

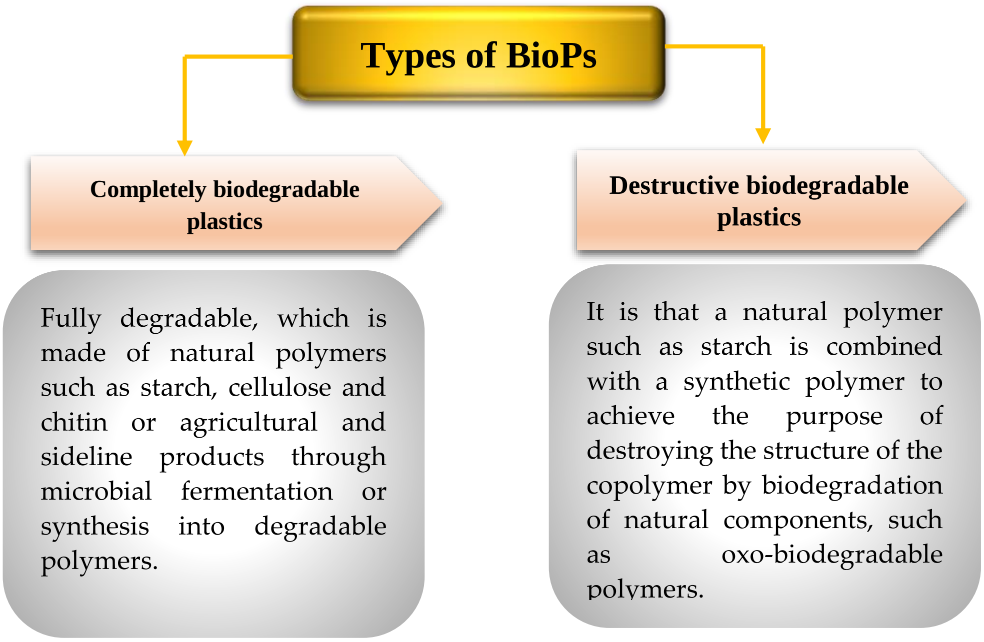

Figure 2. Bioplastic types.

3. Uncertainty Theory based Intelligent Ranker

Zavadskas and Turskis have presented a novel MCDM approach called ARAS. Its usefulness was quickly recognized, and it was quickly put to use in a variety of contexts [24]–[27]. This section introduces the ARAS method under single valued neutrosophic numbers. Figure 3 shows the steps of the proposed method.

Procedure 1: Build the decision matrix.

$$A_{aj} = \left(\prod_{k=1}^{r} A_{aj}^{k}\right)^{\frac{1}{r}} \quad (1)$$

$$A_{0j} = \max A_{aj} \quad (2)$$

Where j refers to the criteria and a refers to the alternatives.

Procedure 2: Normalize the decision matrix

$$NA_{aj} = \frac{A_{aj}}{\sum_{a=1}^{m} A_{aj}} \quad (3)$$

Procedure 3: Compute the weighted normalized decision matrix.

$$R_{aj} = w_{ij}^{r} \times NA_{aj} \quad (4)$$

Procedure 4: Compute the total performance for every option.

$$P_a = \sum_{j=1}^{n} R_{aj} \quad (5)$$

Procedure 5: Compute the utility degree.

$$U_a = \frac{P_a}{P_0} \quad (6)$$

Procedure 6: Rank the options.

The alternatives are ranked according to the highest value of U_a.

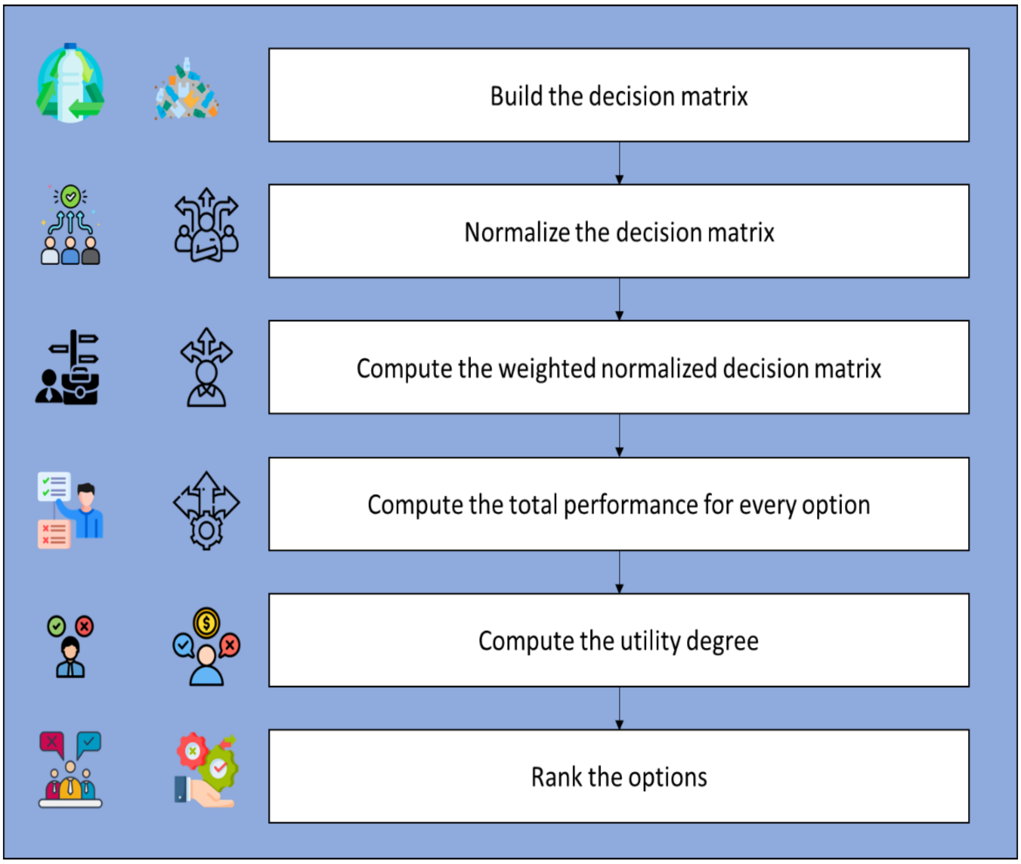

Figure 3. Procedures of uncertainty theory based intelligent ranker.

4. Verification and Results of Intelligent Ranker

Starch, often referred to as amylum, is a polymeric foodstuff composed of numerous glucose units joined together by hydroxylation. This material is synthesized throughout most stages of photosynthesis and used to store energy. Packaged types of corn, potatoes, rice (corn), maize, and cassava all have high concentrations of this nucleotide, making them some of the most common foods eaten across the world. Natural starch, a white, odorless, and flavorless powder, is insoluble in cold ethanol. Branched amyloid and symmetrical alpha helix starch are the two main components. Starch contains 20–25% amylase and 75–80% lipase by weight, based on the kind of plant. According to reports, ethanol may be made by fermenting cereal grains into glucose, which is subsequently used in the creation of alcoholic drinks, scotch, and biodiesel. Refined sugars derive almost entirely from glucose that has been synthesized in a laboratory. Pastes may be prepared from a variety of carbohydrates by mixing them with hot water. Corn starch paste is one example. It has adhesive and stiffening properties. Starch's most common non-food use in industry is as a glue in the papermaking process. Textile flour, applied before boiling, may stiffen most textile materials. The starch business uses a series of processes including a wet grinder, washing, sifting, and drying to collect and purify carbohydrates from seeds and potatoes.

This section introduces the results of the neutrosophic ARAS method. The ARAS method applied into eight criteria and seven alternatives as shown in Figure 4. The initial matrix is built by the decision matrix by using Eqs. (1), (2). Then compute the weights of criteria. The criterion 4 is the highest weight and criterion 8 is the least criteria. Then normalize the decision matrix by using Eq. (3) as shown in Table 1. Then compute the weighted normalized decision matrix by using Eq. (4) as shown in Table 2. Then compute the total performance of each alternative by using Eq. (5). Then compute the utility degree by using Eq. (6) as shown in Figure 5. Alternative 2 is the best and alternative 7 is the worst.

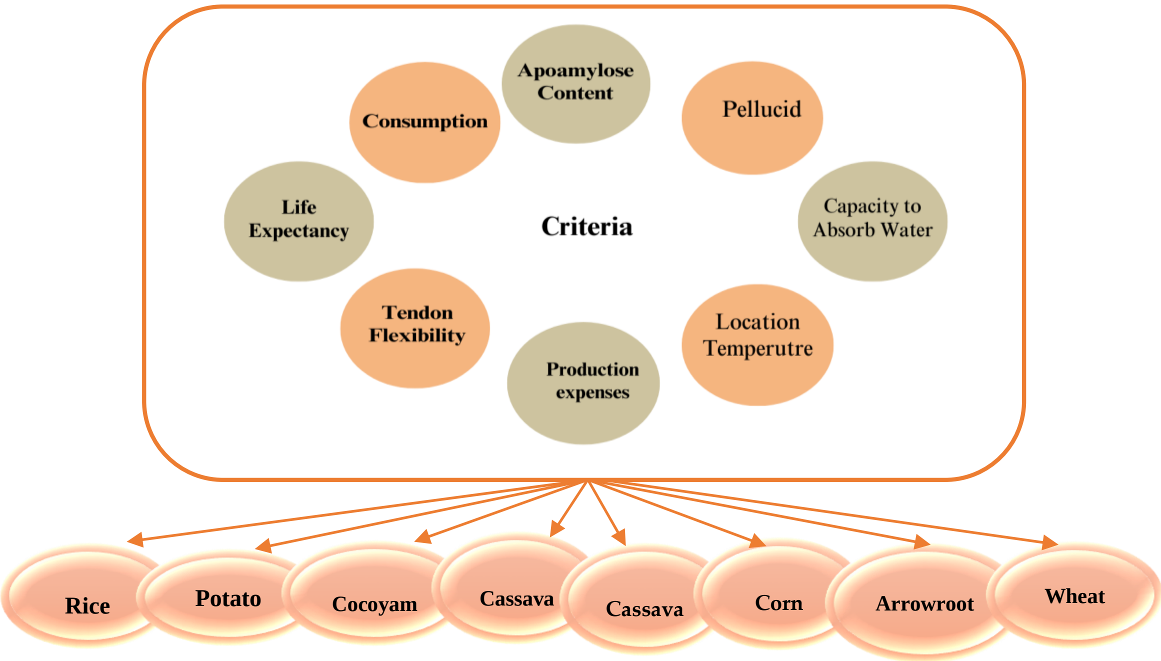

Figure 4. Utilized criteria and alternatives.

Table 1. The normalized decision matrix.

	PPC_1	PPC_2	PPC_3	PPC_4	PPC_5	PPC_6	PPC_7	PPC_8
PPA_1	0.120497	0.107723	0.120841	0.247223	0.164112	0.167586	0.184546	0.067845
PPA_2	0.154779	0.110416	0.119325	0.132211	0.070185	0.065549	0.2589	0.198847
PPA_3	0.222317	0.226308	0.186571	0.091723	0.190541	0.195694	0.098692	0.138438
PPA_4	0.129896	0.258027	0.186571	0.132211	0.101165	0.125159	0.068469	0.210163
PPA_5	0.222317	0.110416	0.11978	0.132211	0.064949	0.125159	0.257562	0.190764
PPA_6	0.074521	0.076693	0.186571	0.132211	0.245648	0.125159	0.06312	0.066282
PPA_7	0.075672	0.110416	0.080342	0.132211	0.1634	0.195694	0.06871	0.127661

Table 2. The weighted normalized decision matrix.

	PPC_1	PPC_2	PPC_3	PPC_4	PPC_5	PPC_6	PPC_7	PPC_8
PPA_1	0.007485	0.012045	0.008971	0.052985	0.030513	0.016449	0.039552	0.002653
PPA_2	0.009615	0.012347	0.008858	0.028335	0.013049	0.006434	0.055487	0.007776
PPA_3	0.013811	0.025305	0.01385	0.019658	0.035427	0.019208	0.021152	0.005414
PPA_4	0.008069	0.028852	0.01385	0.028335	0.01881	0.012285	0.014674	0.008219
PPA_5	0.013811	0.012347	0.008892	0.028335	0.012076	0.012285	0.055201	0.00746
PPA_6	0.004629	0.008576	0.01385	0.028335	0.045673	0.012285	0.013528	0.002592
PPA_7	0.004701	0.012347	0.005964	0.028335	0.030381	0.019208	0.014726	0.004992

Figure 5. The values of utility degrees.

5. Conclusion

This study aims firstly to display and aggregate various prior studies 'perspectives which related to sustainability and problems threatening it. Thus, this study concluded that biodegradable polymers can be used in place of conventional plastics, to enhance the environment and ensure the long-term availability of petroleum resources. Also, BioPs are a significant breakthrough in the modern era.

Secondly, the primary problem with the MCDM was deciding which flexible plastic manufacturing method would be the most sustainable, and this was solved using the ARAS approach. Then using empirical research results, a fair weighting of the requirements has been determined. This study investigated the sustainability of environmentally friendly biodegradable polymers. This study's use of neutrosophic MCDM methodology emphasizes the inherent uncertainty in developing biodegradable plastics due to the wide range of environmental variables that must be considered at each stage. This research contributes to our knowledge of green product innovation and the process of creating bioplastic products. The evaluation's clarity was rated higher than its other factors. This study used the single valued neutrosophic set to overcome the uncertain data. The neutrosophic ARAS method is used to compute the rank of alternatives. Alternative 2 is the best and alternative 7 is the worst.

Data availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare that there is no conflict of interest in the research.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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