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Risk Perception Assessment of Sargassum Blooms in Dominican Republic

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Abstract: The *Sargassum* have become a cyclical phenomenon that generates ecological, economic, and social problems in the Caribbean. The situation becomes more serious in a context of voluntary acceptance of the problem, which generates difficulties regarding the behaviors to control it. This research addresses the phenomenon from the perspective of risk perception concerning *Sargassum* invasions in the Dominican Republic, using a tool that includes perceptual and behavioral questions. The results show an underestimation of the risk of *Sargassum* blooms attributed to its interpretation as a natural and inevitable phenomenon, with an insignificant effect. This underestimation does not notably affect the health or standard of living of the population involved but has not been sufficiently addressed by scientific institutions and the Dominican government. The alert about some erroneous beliefs regarding the phenomenon, as shown by these perceptions, can contribute to designing successful policies for the control and management of massive influx of *Sargassum.* This transformation can turn them from an environmental problem into an opportunity for sustainable development. Based on the risk analysis, actions are suggested to guarantee the sustainable management of *Sargassum* blooms in the Dominican Republic.

Keywords: *Sargassum*; social impact; economic impact; objective risk; subjective risk; risk perception assessment; sustainable development

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1. Introduction

Sargassum is a brown alga that has existed for millions of years ago in the oceans; however, increasingly well-known factors have caused its increase in its natural environment. The morphotypes of *Sargassum* arriving in the Caribbean are *Sargassum natans* and *Sargassum fluitans*. Although associated with uncertainties, studies carried out on this excessive increase point to anthropogenic factors attributable to the highly dependent development of civilization on an unsustainable interrelationship with the environment. These studies reveal causes of the phenomenon for which the world currently has no short-term solution [1–9]. If we add to this delay in solving the problem, the climatological inertia in the planet's response to reductions in emissions, we are facing a phenomenon whose causes will last for many generations. This growth, which has reached levels of beach invasions, has affected the environment, the economy, and society [10].

Among the environmental effects are those of an ecological nature. The large concentrations of *Sargassum*, for example, affect the reproductive cycle of sea turtles, making it difficult for the mothers to climb to the beaches. Additionally, they impact the emergence of hatchlings after the hatching of the nests [11–14]. These concentrations also lead to the death of marine species due to reduced light and oxygen in the seas, and they adversely affect the growth of corals. The latter is associated with the acidification of the seas [15,16].

Another example of an economic impact is on the fishing industry, which has seen its catches limited due to the inconvenience of such volumes of algae affecting the use of fishing methods, in addition to the death of marine species, as discussed previously [17,18]. Finally, an instance of societal impact, with economic repercussions, is its effect on tourism. Beaches are notably damaged by the massive influx of *Sargassum*, making them unattractive for sea bathing and the use of coastal facilities. Additionally, the loss of seagrass is causing increased erosion on beaches. The sun and beach tourist destinations in the Caribbean are among the most affected by the impact of *Sargassum* [19–22].

There is no doubt that resolving the origin of *Sargassum* blooms, addressing the difficulties they generate, and understanding their effects on various natural and/or productive fronts dependent on the sea, as well as the final uses of *Sargassum*, are pending issues. These challenges impact large populations linked to the oceans [23–26].

These threats pose new challenges to the survival of society in an aggressive environment due to unknown factors, which have not been sufficiently studied. The assessment should be based on understanding the perception of this new risk by the actors involved, considering not only the clear belief about the origins of the phenomenon but also the uncertainties of the population regarding such knowledge. More worrisome still is that the phenomenon is assumed to be a completely natural and inevitable process and is perceived as such. In this last case, efforts for its control will be more directed toward mitigation than prevention, if it were possible. From here, behaviors will be derived that tend to adapt to the phenomenon or that can lead to mitigation strategies [7,27–29].

It emphasizes the significance of investigating the risk perception regarding the excessive reproduction of *Sargassum*. This investigation will enable us to comprehend the actual impact it is causing in the various affected activities and predict the attitudes expected from governments and society in response to the phenomenon. Efforts to quantify risk have modern foundations in the development of statistical methods, allowing the calculation, initially postmortem, of human or material losses after natural or technological disasters [30].

Risk (R) is explicitly defined as the product of the frequency (F) of a hazardous event and its consequences (C), as indicated in Equation (1) [31].

$$R = F \times C \tag{1}$$

While frequency is quantified as events per time (e.g., accidents per year), consequences are measured in losses per event (e.g., dollars per accident or deaths per accident). Consequently, the risk result is measured in losses per time period (e.g., dollars per year or deaths per year).

The risk, defined as shown, is known as objective risk, and its establishment corresponds to experts. However, the general population regularly coexists with dangers, and various behaviors are derived from the public's interpretation. This second type of phenomenon is known as subjective risk or risk perception [32–34]. Risk perception is the reflection or sensation in our senses of danger, which manifests itself in the assumption of different behaviors when confronting it. In turn, knowledge or understanding of the danger constitutes one of the main variables in shaping risk perception [34].

In the scenario of the massive influx of *Sargassum*, we are facing a combination of economic, social, and environmental risks. The first is associated with effects on fishing and tourism, the second is related to the damage to the population dependent on the marine environment due to productive or recreational links, and the third is linked to the loss of species. Therefore, a multidisciplinary approach is necessary for the study of risk, in its subjective nuance, to consider the types of affectations or damages that can be expected from the phenomenon. Although not immediately catastrophic, this situation can have very serious long-term consequences, depending on the intensity of the phenomenon in each period [17,19,20,35].

Starting from this context, the general objective of this research was to implement a risk perception study on the *Sargassum* blooms in the Dominican Republic, with the aim of establishing measures that would transform this environmental problem into an opportunity for sustainable development. To achieve this, a research instrument of our own design, in survey format, was developed and validated.

2. Materials and Methods

The risk perception analysis of the massive influx of *Sargassum* was carried out in thirteen locations of six provinces of the Dominican Republic affected by the phenomenon: La Altagracia, San Pedro de Macorís, Santo Domingo, San Cristóbal, Barahona, and Pedernales (Figure 1).

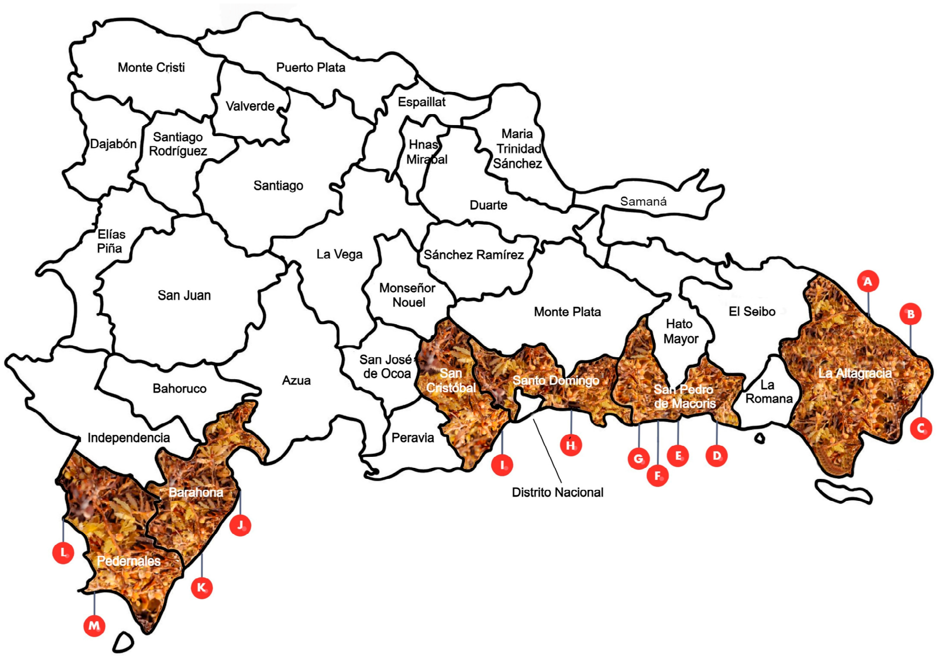

Figure 1. Study area for the investigation of risk perception due to massive influxes of *Sargassum* in Dominican Republic. Red points show studied locations (see UTM coordinates in Table 1).

2.1. Description of the Procedure for Creating and Validating the Survey Used

The survey used in this study was developed specifically for this purpose. It underwent a validation and adjustment process, which involved creating an initial version, administering it in Pedernales, and evaluating it with a group of five experts. The final version of the survey is available in the Supporting Information.

2.2. Procedure for Risk Perception Analysis

The study was conducted using the perceived risk profile methodology [33], which has been computerized through the RISKPERCEP Ver 2.0 code [33]. This tool corresponds to the algorithm presented in Figure 2.

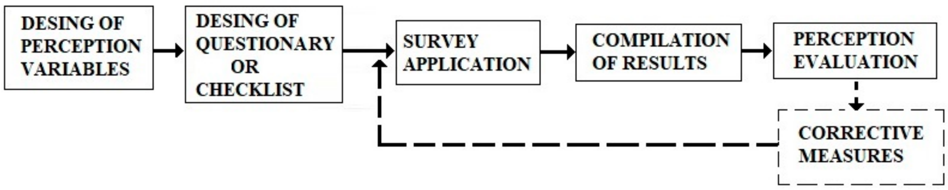

Figure 2. Algorithm for risk perception analysis.

The design of risk perception variables depends on the study's objectives [36–43]. For the analysis of psychosocial risks, three types of variables are utilized (Table 1): individual variables, those related to the nature of the risk or physical risk, and those associated with risk management or managed risk [40,44,45]. Table 2 presents the variables of the risk perception study, their classification, and their correspondence with the survey questions.

Table 1. Provinces' studied locations and coordinates in UTM.

Province	Locations	UTM-N	UTM-E
La Altagracia	(A) Uvero Alto	2,079,149	544,391
	(B) Bávaro	2,063,811	563,218
	(C) Playa Blanca	2,049,634	568,271
San Pedro de Macorís	(D) El Soco	2,037,885	479,525
	(E) El Faro	2,039,599	466,665
	(F) Juan Dolio	2,037,289	455,194
	(G) Guayacanes	2,036,489	452,537
Santo Domingo	(H) San Andrés	2,039,619	434,554
San Cristóbal	(I) Nigua	2,031,745	389,648
Barahona	(J) El Caimán	2,013,302	279,179
	(K) Guarocuya	1,975,500	263,132
Pedernales	(L) Pedernales	1,995,605	209,058
	(M) Cabo Rojo	1,977,510	219,744

Table 2. Variables from the risk perception study, and their classification and correspondence with the survey questions.

No.	Description	Code	Component	Cluster	Question
1	Familiarity of the subject with the risk situation	FAMI	Reverse	Individual	1
2	Risk understanding	COMP	Extreme	Individual	20, 23
3	Uncertainty	UNCE	Straight	Individual	2, 3
4	Willfulness	WILL	Reverse	Individual	4
5	Personal involvement	INVO	Straight	Individual	5, 6
6	Controllability	CONT	Reverse	Individual	13
7	Catastrophic potential	CATA	Straight	Nature	7, 8
8	Past history of disasters or dangers	HIST	Straight	Nature	9
9	Immediacy of consequences	IMME	Straight	Nature	10
10	Reversibility of consequences	REVE	Reverse	Nature	11, 12
11	Panic	PANI	Straight	Nature	14, 15
12	Risk-inequality/benefit	R-IB	Straight	Management	16
13	Expected benefits of exposure	BENE	Reverse	Management	17
14	Trust in institutions	INST	Straight	Management	21, 22
15	Role of the press or broadcast media	PRES	Straight	Management	18, 19

Another important aspect regarding the selection of variables is the analysis of their relationship with the perception of risk associated with each one. It was observed that some variables behave in a directly proportional manner, such as catastrophic potential, panic generated, and immediacy of consequences, while others behave inversely, such as familiarity, controllability, and reversibility. The risk compression variable has the particularity that its behavior with respect to the associated risk perception is extreme, meaning that both experts and non-specialists equally underestimate it. As a necessary simplification, to avoid introducing subjectivities into the study, the considered variables are treated as independent of each other, and each one makes a similar contribution to the quantification.

For the design of the survey, experts followed certain rules [33,42,44]. The questionnaire is adapted to the types of hazards and study groups; it must generate empathy and transition from the known to the uncertain, from the general to the particular, and from the institutional to the individual [38,41]. To facilitate evaluation, closed questions were used, and their answers are ordered in an increasing unidirectional manner with three gradations. This ordering aims to achieve a correlation with the associated risk perception scale, consisting of three levels, where level 1 indicates risk underestimation, level 3 indicates overestimation, and level 2 indicates an adequate estimation of risk [33,42,43]. This scale corresponds to questions with variables that correlate directly with the associated perception. When the variables correlate inversely or extremely, the survey software makes adjustments during the evaluation. The survey application was conducted individually using templates prepared for this purpose.

A new non-statistical estimator called Weighted Perception Score (hereinafter Score) was used for variable analysis [43,44]. As part of the calculation, the specific dispersions of each variable with respect to its Score value are also determined. This illustrates the unanimity of the group in representing the collective inclination towards a shared opinion.

Corrective measures are the corollary of the interpretation of the results. The application of the Pareto principle is key in determining the most important contributors (variables, respondents, and study groups) and in preparing tasks with the greatest impact for their solution. The state of risk perception should be reassessed after a period of applying the measures deduced from the study to verify their effectiveness [33,42–44]. Since the risk perception assessment software has been used in several studies, detailed information about it can be found in several references [43–47].

2.3. Information Processing

A detail description of the information processing is described elsewhere [43–45]. For the risk perception evaluation, each study provides information on variables, surveys, and compilation. These data allow for perception evaluations. Each perception evaluation contains analytical data that provides in-depth information on:

- Perception by variable for each respondent (each variable may be assessed by several questions, with the average of these questions representing the perception of the respondent's variable).
- Perception per respondent (each respondent will have a perception related to their variables, meaning the respondent's perception will be the average of perceptions per variable included in the study).
- Group perception by variable (each variable will have a group representation determined by the values of perceptions according to respondents' variables. This means that the average of perceptions per variable among all respondents will be the group perception for that variable).
- Group perception (each study is associated with a general group perception, which can be obtained in two ways, both yielding identical results: taking the perception per respondent as a source or using the group perception by variable as a starting point). In either case, these values are averaged, either among the respondents or among the number of variables.
- Perception of the group by group of variables. Variables are grouped based on their nature (e.g., individual, physical, or managed). Using information from perceptions per variable of a similar nature, averages are obtained to appreciate perceptions at the level of variables grouped by this characteristic.

Each of the previous evaluations is carried out using the average of the response values obtained during the survey as an option. For this quantification, the instrumental license requested during the design of the study indicators has also been utilized. The study tends toward an in-depth investigation, starting at the level of questions and then variables. It follows the in-depth research philosophy (from simple to complex) when investigating perception by variable of each respondent, perception by respondent, group perception by variable, overall group perception, and group perception by nature of variables. Each step allows new analyses that progress from the particular to the general. Variable and general studies have included dispersion analysis, which measures the representativeness of the average in the sample. If the representativeness is insufficient, the cell in question is differentiated with a color (yellow if there is no good representation of the average and red if the sample is incomplete). The dispersions are presented for each value of interest with three figures in parentheses at the end of the average value. The extreme values represent the numbers of respondents who underestimate or overestimate the average, and the central figure represents the numbers that are around the quantified average for the variable.

2.4. Statistical Analysis of the Results

To statistically validate the results of the study, it is necessary to determine the probability of obtaining a random response to the survey and the appropriate size of the study sample [48].

2.4.1. Probability of Random Response to the Survey

The questions were designed to have a single preferred and correct answer out of the three possible ones. Therefore, it is appropriate to apply a random response probability calculation instrument. With this instrument, all the parameters of the Gaussian distribution applicable to the case study can be calculated.

These parameters demonstrate that the Gaussian distribution (B), evaluated for the population Npob and with a probability of success p, is equivalent to posing the normal distribution N with a mean μ and a standard deviation σ. Mathematically, this is represented by Equation (2):

$$B[n,p] = N[\mu,\sigma] \tag{2}$$

where, substituting the terms μ and σ, Equation (3) is obtained:

$$N[\mu,\sigma] = N[\text{Npob} \times P \times \surd(\text{Npob} \times Q)] \tag{3}$$

Additionally, the probability of random success, considering Xmeta as the number of correct answers necessary to assess the survey as acceptable, can be calculated according to expression 4:

$$P(X > \text{Xmeta}) = P(Z > [\{\text{Xmeta} - \mu\}/\sigma]) = 1 - P(Z < [\{\text{Xmeta} - \}/\sigma] \tag{4}$$

To meet the requirement, starting with the Gaussian distribution and considering the number of questions applied (Npob = 23), the probability of success in each question (P = 0.4), the probability of failure (Q = 0.6), and the Xmeta to which tentative values are assigned, the process continues until it is verified that the probability of a random response (pazar) is zero. To calculate this parameter, the expression was programmed within RISKPERCEP, and it was determined that this goal was achieved with 19 questions or more.

2.4.2. Sample Size

Expression 5 is used to calculate the sample size.

$$N = (N \times Z^2 \times p \times q)/(e^2 \times (N = 1) + Z^2 \times p \times q) \tag{5}$$

where the following are defined:

n—sample size.
p—probability of the event occurring or the expected proportion.
Q—probability that the event does not occur.
e—precision (maximum allowable error in terms of proportion).
Z—probabilistic factor Z = f (confidence level).

N—starting population.

In this case, the assumed values for p were 0.6 and q were 0.4, with a confidence level of 99% and a precision of 2%, determining a minimum sample size of 182 people to be surveyed. To exceed that figure, 197 people were surveyed in the study.

2.5. Characterization of the Study Sample

Out of the total 197 respondents, 40.1% were women, and 59.9% were men. Regarding age distribution, 19.8% were between 18 and 35 years old, 65% between 36 and 50 years old, 15.2% between 51 and 60 years old, and none were over 60 years old. A total of 91.9% were Dominicans, and 8.1% were foreigners residing in the country. Finally, in terms of education, 6.6% were illiterate, 28.9% had primary education, 28.9% had secondary education, 25.4% had technical training, and 10.2% had university training.

3. Results and Discussion

Risk Perception Analysis

The distribution of responses by options in % of respondents, for the 23 survey questions (Supporting Information), is shown in Table 3.

Table 3. Distribution of responses in % of respondents (see questions and possible answers of the survey in Supporting Information).

Question Number	% of Responses to Answer a	% of Responses to Answer b	% of Responses to Answer c	Question Number	% of Responses to Answer a	% of Responses to Answer b	% of Responses to Answer c
1	65.1	29.2	5.00	13	55.7	29.2	6.50
2	69.8	22.6	7.64	14	46.2	46.2	71.7
3	14.1	43.4	29.2	15	67.0	21.7	11.3
4	26.4	31.1	40.6	16	13.2	39.6	43.4
5	96.1	3.02	0.00	17	78.3	19.8	1.51
6	92.5	5.57	2.08	18	25.5	53.8	21.7
7	44.3	45.3	10.3	19	19.8	53.6	27.6
8	7.64	20.8	71.7	20	84.9	13.1	1.51
9	34.9	5.57	59.4	21	94.3	3.59	50.0
10	18.9	28.3	53.8	22	82.1	16.0	1.04
11	15.0	46.2	37.8	23	47.4	40.6	96.1
12	13.1	31.1	52.9				

Only the average values for the investigated variables have been presented. The overall result shows a slight underestimation of the risk (1.98 as opposed to 2, which is the appropriate value), with the variables COMP, UNCE, INVO, REVE, PANI, and INST being the main causes of this underestimation.

In detail, the mean values and their dispersion by variable are presented in Table 4.

As Table 4 shows, there is dispersion due to the high heterogeneity of opinions in the variables FAMI, WILL, CONT, HIST, IMME, PANI, R-IB, and PREN. There are no real mean values for the variables shaded in yellow. For example, observe FAM, CONT, IMME, and RI-B, where the central values of the intervals are at zero. This implies that all opinions have been concentrated at the extremes. In FAMI, for instance, 68 respondents underestimate the risk due to familiarity, while 129 overvalue it. The average value for these cases is virtual. The contribution by variable is seen more clearly in the perceived risk profile (Figure 3).

Table 4. Group averages by variables and dispersion.

Variable	Mean Value (Dispersion)	Variable	Mean Value (Dispersion)
FAMI	2.68 (68, 0, 129)	IMME	2.30 (92, 0, 105)
COMP	1.20 (105, 70, 22)	REVE	1.77 (41, 60, 96)
UNCE	1.84 (78, 77, 42)	PANI	1.51 (82, 56, 59)
WILL	1.87 (81, 63, 53)	R-IB	2.38 (104, 0, 93)
INVO	1.05 (0, 178, 19)	BENE	2.71 (42, 155, 0)
CONT	2.66 (71, 0, 126)	INST	1.12 (0, 155, 42)
CATA	2.19 (31, 80, 86)	PREN	2.03 (64, 79, 54)
HIST	2.28 (79, 0, 118)	Average	1.98 (7, 174, 16)

Note: FAMI—familiarity of the subject with the risk situation; COMP—risk understanding; UNCE—uncertainty; WILL—willfulness; INVO—personal involvement; CONT—controllability; CATA—catastrophic potential; HIST—past history of disasters or dangers; IMME—immediacy of consequences; REVE—reversibility of consequences; PANI—panic; R-IB—risk-inequality benefit; BENE—expected benefits of exposure; INST—trust in institutions; PREN—role of the press or broadcast media. The texts highlighted in yellow background represent variables with a high dispersion of their source values with respect to the central value.

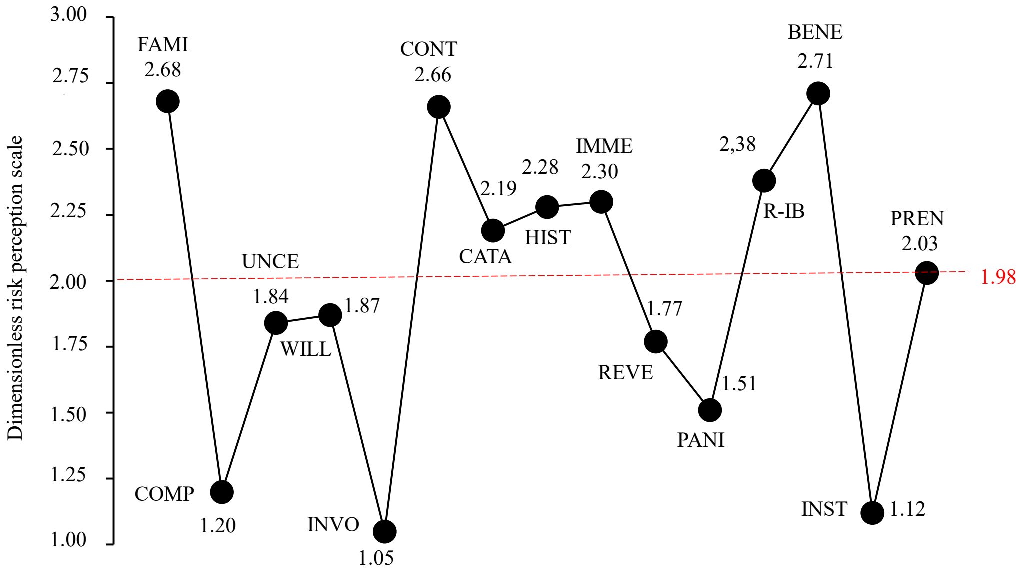

Figure 3. Perceived risk profile (FAMI—familiarity of the subject with the risk situation; COMP—risk understanding; UNCE—uncertainty; WILL—willfulness; INVO—personal involvement; CONT—controllability; CATA—catastrophic potential; HIST—past history of disasters or dangers; IMME—immediacy of consequences; REVE—reversibility of consequences; PANI—panic; R-IB—risk-inequality/benefit; BENE—expected benefits of exposure; INST—trust in institutions; PREN—role of the press or broadcast media). The dimensionless risk perception scale (Y axis) indicates the following: 1—risk underestimation; 2—adequate estimation of the risk; 3—risk overestimation.

The interpretation by variable is as follows:

- FAMI: Indicates an overestimation of risk (2.68) due to low familiarity (inverse variable, less familiarity plus perception), resulting in a heightened perception in this regard (interpreted from the infrequent exposure to news about *Sargassum* blooms).
- COMP: Indicates an underestimation of risk due to innocence (1.20), in this case associated with question 20. There is recognition of low knowledge on the subject, further emphasized by scattered and incorrect responses to question 23 regarding the relationship of climate change with the massive influx of *Sargassum*.
- HIST: Demonstrates some overestimation (2.28) linked to the memory of crash severity (question 9).
- IMME: Indicates an overestimation of risk (2.30) associated with the speed of the effects of arrivals (question 10) in less than 24 h.

- REVE: Reflects an underestimation of risk (1.77), associated with the answers to questions 11 and 12, which indicate option 3, corresponding, respectively, to the possibilities of reversibility by following appropriate policies or waiting for natural mechanisms to manifest (variable in reverse).
- PANI: Demonstrates an underestimation of the risk (1.51) since the answers to questions 14 and 15 preferably indicate little fear of landings.
- R-IB: Indicates an overestimation of risk (2.38) by considering the effects more important than the benefits (question 16).
- BENE: Demonstrates a marked overestimation of risk (2.71) by expressing a preference for the economic benefits derived from *Sargassum* exploitation strategies (question 17).
- INST: Displays a marked underestimation of risk (1.12), considering in questions 21 and 22 that neither universities nor government institutions play an adequate role in addressing arrivals.
- PREN: Indicates a slight overestimation of the risk (2.03) considering that the majority believes that the role of the media is adequate (questions 18 and 19).

The results clearly indicate an interpretation that considers it a natural phenomenon, of an inevitable nature, with an insignificant effect that does not affect the health or standard of living of those involved. However, it has not been sufficiently addressed by scientific institutions or the government. The distribution of the average perception per respondent shows a predominance of underestimation of risk, also reflecting this form of results representation.

Regarding the behavior of risk perception, taking into account demographic characteristics, Figure 4 illustrates how risk is perceived by men and women.

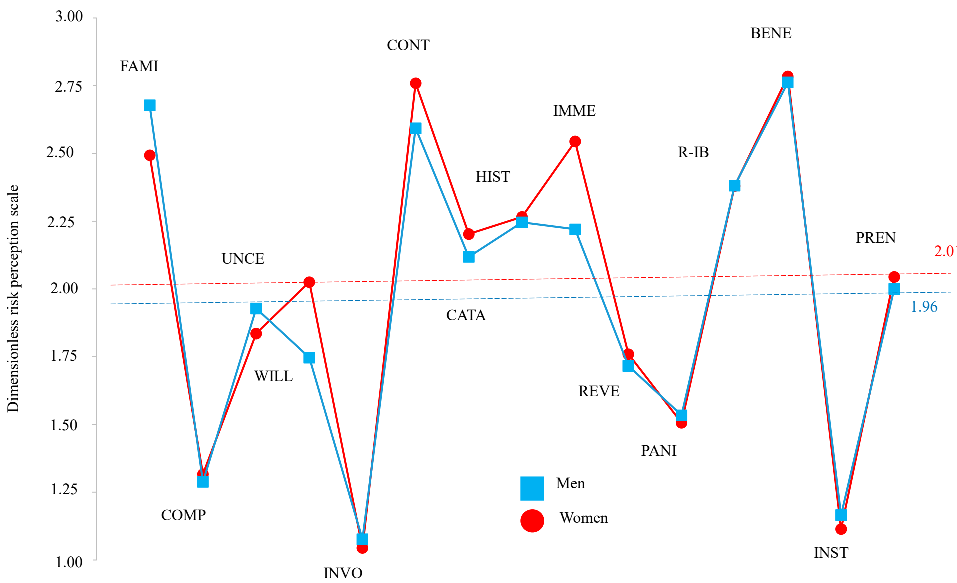

Figure 4. Comparison of risk perception according to sex (FAMI—familiarity of the subject with the risk situation; COMP—risk understanding; UNCE—uncertainty; WILL—willfulness; INVO—personal involvement; CONT—controllability; CATA—catastrophic potential; HIST—past history of disasters or dangers; IMME—immediacy of consequences; REVE—reversibility of consequences; PANI—panic; R-IB—risk-inequality/benefit; BENE—expected benefits of exposure; INST—trust in institutions; PREN—role of the press or broadcast media). The dimensionless risk perception scale (Y axis) indicates the following: 1—risk underestimation; 2—adequate estimation of the risk; 3—risk overestimation.

From Figure 4, it can be observed that women, on average (red dashed line: 2.01), have an adequate perception of the risk associated with the massive influx of *Sargassum* in the Dominican Republic, while men tend to slightly underestimate the phenomenon (blue dashed line: 1.96). The most significant differences are observed in four inverse variables: familiarity (FAMI), where men tend to overestimate more than women; controllability (CONT); immediacy of consequences (IMME); and expected benefits of exposure (BENE), where women overestimate when compared to men.

In terms of behavior by age (Figure 5), the age groups from 30 to 60 years old and those over 60 years old exhibit a similar average and adequate perception (close to 2 in each case, blue and green dashed lines), while the youngest people tend to underestimate the risk of *Sargassum* blooms.

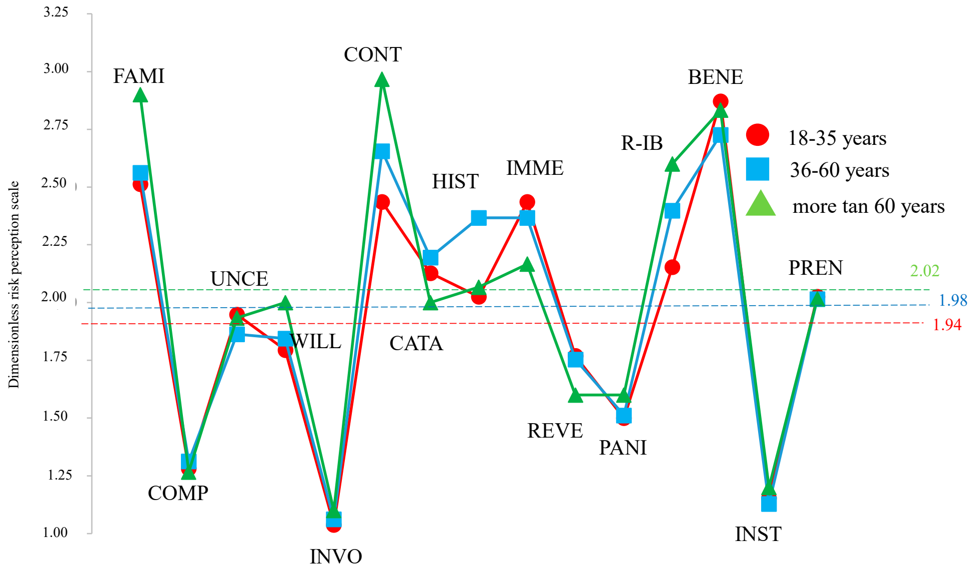

Figure 5. Comparison of risk perception according to age (FAMI–familiarity of the subject with the risk situation, COMP–risk understanding, UNCE–uncertainty, WILL–willfulness, INVO–personal involvement, CONT—–controllability, CATA–catastrophic potential, HIST–past history of disasters or dangers, IMME–immediacy of consequences, REVE–reversibility of consequences, PANI–panic, R-IB–risk-inequality/benefit, BENE—expected benefits of exposure, INST–trust in institutions, PREN–role of the press or broadcast media). The dimensionless risk perception scale (Y axis) indicates the following: 1–risk underestimation; 2–adequate estimation of the risk; 3–risk overestimation.

Regarding the variables separately, the main differences between age groups are observed for willfulness (WILL), past history of catastrophes or dangers (HIST), immediacy of consequences (IMME), and risk– inequity/benefit (R-IB). Concerning voluntariness, those over 60 years of age exhibit an adequate perception of the phenomenon, while those under 60 years of age tend to underestimate the risk. In terms of the past history of catastrophes or dangers, those with more experience have an adequate perception, while both groups under 60 years of age tend to overestimate the risk. A similar trend is observed with immediacy. Finally, when evaluating the inequity of risks and benefits, all three age groups are overestimated, with the lowest value corresponding to the youngest group (18–35 years old) and the highest value of the variable corresponding to those over 60 years old.

Lastly, the difference in risk perception was analyzed based on the educational level of the respondents (Figure 6). Citizens with technical and university education demonstrate an adequate average perception of risk (close to two, as seen in the black and brown dashed lines), while people without schooling and those with primary or secondary education tend to slightly underestimate the risk of *Sargassum* blooms to the coasts of the Caribbean.

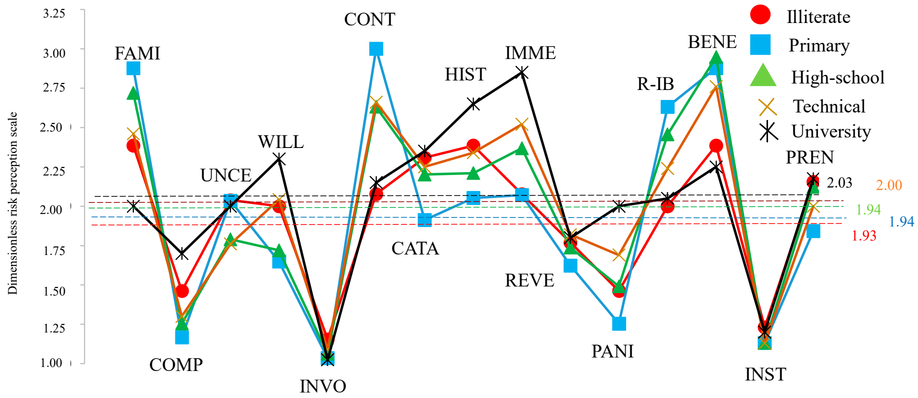

Figure 6. Comparison of risk perception according to level of education (FAMI—familiarity of the subject with the risk situation; COMP—risk understanding; UNCE—uncertainty; WILL—willfulness; INVO—personal involvement; CONT—controllability; CATA—catastrophic potential; HIST—past history of disasters or dangers; IMME—immediacy of consequences; REVE—reversibility of consequences; PANI—panic; R-IB—risk-inequality/benefit; BENE—expected benefits of exposure; INST—trust in institutions; PREN—role of the press or broadcast media). The dimensionless risk perception scale (Y axis) indicates the following: 1—risk underestimation; 2—adequate estimation of the risk; 3—risk overestimation.

4. Discussion

Faced with a phenomenon caused by anthropogenic causes (behaviors and attitudes of society) that generates an objective risk (environmental-ecological, social, and economic effects), it is necessary to understand the permanence of such attitudes and behaviors, de-spite the recognition of the causes of the risk of the given objective. The solution to the aforementioned bond is derived towards the analysis of subjective risk, in short, the origin of the permanence of the aforementioned attitudes and behaviors.

From a general perspective, the method's capability to study the subject has demonstrated strengths by fragmenting risk perception into variables. This fragmentation allows for the division of the problem into factors that can be assessed using analytical possibilities. Consequently, the Pareto principle [49] can be applied to identify the most significant contributors to the determined trend in the study (underestimation of risk) and channel efforts towards them. In this case, according to the results, the variables responsible for underestimation are COMP, UNCE, WILL, INVO, REVE, PANI, and INST.

A discussion of these risk perception results must be approached from two angles. The first involves comparing the scientific evidence of the phenomenon with the perception of those surveyed, while the second contrasts the results of the perception study with other similar ones, albeit with different study objects.

In terms of the first perspective, it must be acknowledged that knowledge of the problem, concerning the studied object, is limited among the surveyed population. Notably, the variable COMP (risk understanding) is one of the factors contributing to the underestimation, as it attributes the risk to natural causes rather than to climate change, as science has revealed with well-known anthropogenic causes. This is corroborated by the trend indicated by the uncertainty variable (UNCE) concerning the origins of the phenomenon, where the natural factor once again emerges as a significant response. Additionally, there is a perception of an inevitable risk in the WILL variable and in the high reversibility capacities of the phenomenon (REVE), even if it were due to natural mechanisms (reversibility by anthropogenic methods could be associated with forms of organic matter management). Concerning these last two variables, they further reinforce the idea of a natural mechanism beyond the control of humans. On the other hand, the INVO variable, which indicates little impact on health due to the massive influx of *Sargassum*, reveals a lack of knowledge regarding the toxicity levels of the given algae and its natural mechanism of concentration of some dangerous chemical substances [23,35,50,51]. The perceived lack of management regarding the role of the state and its scientific institutions is evident in the underestimation of the risk associated with low trust in institutions (INST).

It is evident that given these behaviors indicating low knowledge and the perceived inevitability of the phenomenon, the option of adapting to *Sargassum* blooms and leveraging its benefits may appear to be the most appropriate. However, attention should be drawn to the scientific evidence regarding the phenomenon and the actual possibilities of prevention. Without causing panic, it is crucial to emphasize that health effects may arise due to toxic concentrations of certain components in the *Sargassum*, particularly when consumed through the food chain if it is exploited as cattle fodder. Concerning the role of state and university institutions, there is no other recommendation than to actively engage in addressing the phenomenon. In this sense, this investigation itself represents an effort to reverse the current situation.

An analysis of the results, from their comparative nuance with other similar studies, shows that the one carried out on risk perception regarding climate change could be taken as a reference [46]. The characteristic of this study is that it reveals the risk perception of a human group in the face of a planetary phenomenon such as global warming, something similar in its magnitude to that of the massive influx of *Sargassum* for the affected populations. Therefore, it is interesting to understand that in this study, the variables COMP, UNCE, and INST also demonstrate an underestimation of risk, precisely for reasons similar to those contained in this analysis. The results for the variables WILL, INVO, REVE, and PANI are not comparable. Regarding VOLU, it was not included in the reference study. The INVO variable is overestimated in the study on climate change because the population surveyed feels affected by the phenomenon, including health and comfort conditions, which does not occur in this research. Climate change is not perceived as reversible (REVE) in the aforementioned study, and a slight feeling of panic (PANI) is reported, given its low control in that case. As recalled, in this research, the results regarding these variables (REVE, PANI) opposite (reversible and low panic phenomenon).

Another study similar to the one conducted is the study applied in universities in Honduras concerning climate change and natural disasters [45]. When comparing the variables responsible for underestimation in this study (COMP, UNCE, WILL, INVO, REVE, PANI, and INST) with Suazo and Torres' findings, similarities are observed in the COMP variables, UNCE, and INST. Honduran teachers express gaps in their understanding of climate change, and uncertainty in scientific knowledge about some issues related to the phenomenon, and they perceive the role of institutions in its management as deficient [45]. Once again, parallels emerge concerning the reference comments for these results.

However, the perception trends for the variables WILL, INVO, REVE, and PANI are not directly comparable. In the reference case, teachers exhibit low willingness to expose themselves to climate change, leading to an overestimation of the risk for this variable. They feel significantly involved due to the potential damage it can cause to them and their families, resulting in an overestimation of the risk associated with this variable. They do not perceive the risk of climate change as reversible (overestimation), and their panic is high, influenced by the magnitude of recent disasters attributed to climate change, such as Hurricane Mitch during the study period. The nature, consequences, and intensity of the *Sargassum* blooms differentiate it from climate change, explaining the divergences found.

In its conclusions regarding climate change and facing similar risk underestimation variables, the IPCC in its Fifth Assessment Report highlights the need for training, information on scientific advances related to the phenomenon, and the role of institutions in managing climate change-associated risks, guiding adaptation actions, and formulating mitigation strategies [44,52]. In this sense, it is advisable to consider measures similar to those outlined in the reference report.

The demographic analysis concerning the perception of the risk of the massive influx of *Sargassum*, as depicted in Figures 3–5, aligns with comparative nuances found in other references [53–56].

Moreover, the disparities in perception based on gender, consistent with this study, are linked to the societal gender roles through which men and women perceive themselves [57]. It is crucial to emphasize the traditionally assigned protective role within the home and society for women, making them more vigilant to dangers and leading to a higher estimation of risk.

A reference study analyzing the various perspectives of young people towards daily life activities with associated dangers has been conducted by [58]. The study reveals that in their daily actions, young people tend to underestimate risks, as reflected in their attitudes towards engaging with them. This observation aligns with the patterns found in the results of this research.

For a scientific demonstration, specifically of a physiological nature illustrating the lower perception of risk in young people, one can refer to the research conducted by UNICEF. UNICEF points out that the lower perception of risk in younger age groups is attributed to a predisposition to risk, stemming from their biological development. In this stage of life, the emotional part of the brain matures faster than the rational part. Consequently, there is a tendency towards emotional responses rather than decisions based on the prefrontal cortex, which is not as developed during adolescence and early childhood.

Finally, the disparities concerning educational levels are closely linked to the variable of knowledge or understanding of risk. Lower levels of comprehension align with less academic preparation, which typically does not cover specialized topics, such as the one under consideration. This lack of preparation corresponds to an underestimation of risk, as demonstrated by this investigation. With a higher level of knowledge, there is an awakening of research and understanding interests that facilitate the exploration of topics, even those not included in the respondents' formal training curricula [56,59–61].

From Risk Perception to Sustainable Management of Sargassum Blooms

From the risk perception study, a set of actions can be inferred to ensure the sustainable management of *Sargassum* blooms in the Dominican Republic. The results indicate the need for training, education, and communication initiatives targeting the general population, as well as company and government managers, to enhance their understanding of the causes, risks, and opportunities associated with this phenomenon. Currently, the country lacks a comprehensive plan to manage the massive influx of *Sargassum*, making it a priority to establish guidelines, similarly to how neighboring countries like Barbados and Mexico have successfully implemented them [62,63]. These actions are crucial to alter the population's perception of the roles played by the government and academic institutions.

It is worth noting that in the Dominican Republic, since 2015, the Dominican Fund for Science and Technology (FONDOCYT) has been financing projects related to *Sargassum* management. In January 2023, an inter-university network for *Sargassum* research was established, followed by the creation of a *Sargassum* combat cabinet in August of the same year, as per presidential decree.

The *Sargassum* management strategy in the Dominican Republic should focus on four main directions: monitoring and predicting *Sargassum* blooms; collecting *Sargassum*, preferably at sea, and disposing of it under conditions that guarantee environmental protection while minimizing potential impacts on human health, coastal areas, and marine ecosystems; developing and implementing procedures for valorizing and utilizing *Sargassum*, either alone or in combination with other biomass waste, to transform negative impacts on the environment, economy, and society into opportunities for sustainable development; and evaluating the impacts of *Sargassum* blooms to formulate adaptation and mitigation plans that account for the local conditions of the affected areas in the country.

5. Conclusions

The underestimation or low social perception of the risk related to *Sargassum* blooms poses a clear problem. This is primarily attributed to a limited understanding of the associated risks, the perception of its natural origin, a high willingness to tolerate its presence, the belief that it will not adversely affect health, the lack of fear it instills, and the inadequate role played by universities and institutions in its management. Comparisons with other reference data validate the results obtained, both concerning the objective risk and in relation to risk perception studies with similar characteristics. In both cases, the impact of ignorance and uncertainty about the origin of the phenomenon is evident. The lack of public confidence in institutional management is also a common factor with these references. Overall, the results can be considered indicative. A more exhaustive investigation would necessitate efforts to consider new questions for most variables, which, logically, would complicate the survey application. Additional population samples may also be required for surveys, assuming further research. Finally, based on the analysis of risk perception, a set of actions is proposed to ensure sustainable *Sargassum* management in the Dominican Republic. This includes establishing a comprehensive plan for the management of *Sargassum* blooms in the country.

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