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Assessment of the socioeconomic impact of the invasion of Ivorian beaches by Sargassum algae based on an ethnobotanical study

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Abstract

The Sargassum seaweed that washes up on Ivory Coast beaches consists of two species: Sargassum fluitans and Sargassum natans. These strandings pollute the beaches and have a negative impact on the socioeconomic activities of local communities. The overall objective of this study is to assess the impact of sargassum seaweed strandings on the economic activities of local communities, as well as their interest in these activities. To this end, an ethnobotanical and socioeconomic survey was conducted among tourists, anti-pollution associations, and relevant economic operators. The survey interviewed 340 people. 57.92% of economic operators considered that Sargassum seaweed poses a threat to their activities. Fishing is the most affected activity, with more than 50% of annual turnover lost, and no use is made of this seaweed. At the end of this study, the results reveal that Sargassum seaweed disrupts socio-economic activities and is of no interest to local communities.

Keywords: Socioeconomic impacts; Marine pollution; Invasive algae; Sargassum seaweed; Ethnobotanical survey

1 Introduction

The Sargassum seaweed that washes up on Ivory Coast beaches and in the waters of the Gulf of Guinea is brownish in color and consists mainly of two species: *Sargassum fluitans* and *Sargassum natans* **(Figure 1).** It is a source of water and beach pollution, with significant socioeconomic impacts [1,2,3]. Since 2011, these algae have been washing up in large quantities on the beaches of the Gulf of Guinea countries, causing numerous environmental and socioeconomic problems [4,5]. When they decompose on the beach, they release numerous gases, the most dangerous of which is hydrogen sulfide (H2S), which irritates the eyes and nostrils, causes migraines, and also causes water eutrophication [6,7]. According to several authors, they are an important source of active biomolecules with industrial, pharmacological, agronomic, nutritional, medicinal, and other properties [8,3,7,9]. Sargassum is therefore an important link in the blue economy. To date, no effective solution has been found to combat beach pollution by sargassum, and no means of recovery exists. The overall objective of this study is to contribute to the fight against sargassum pollution on Ivorian beaches by assessing its impacts and its benefits for local populations.

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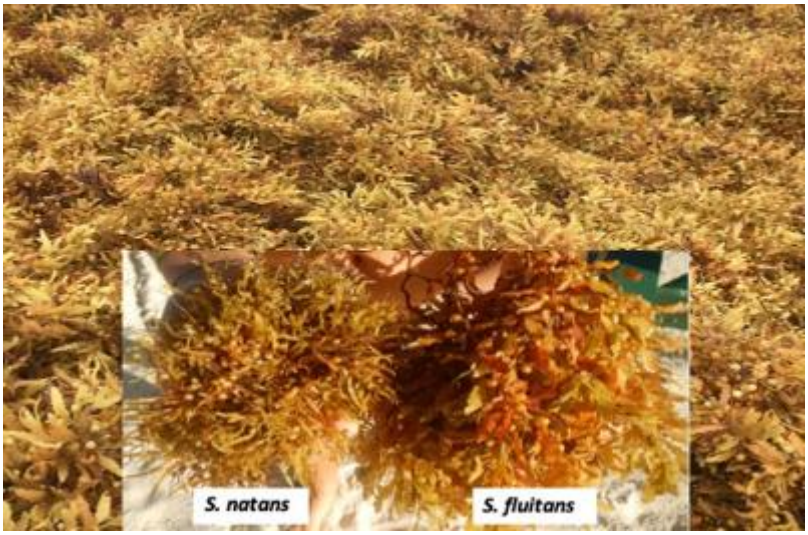


Figure 1 Piles of sargassum washed up on a beach in Guadeloupe

Source: Desrochers et al. [9]

2 Materials and methods

2.1. Materials

The materials used for this study consisted mainly of a survey form, a notepad, and a digital camera.

2.2. Methods

2.2.1 Ethnobotanical surveys

Choice of survey sites

The surveys were conducted in the South Comoé and Grands-Ponts regions, specifically in the municipalities of Assinie, Grand-Bassam, and Jaqueville, all located on the southeast coast of Côte d'Ivoire. These sites were chosen because, according to a study conducted by [10], these municipalities are among the areas most affected by Sargassum strandings. These municipalities also boast some of the most visited beaches in the country.

Field surveys

Several series of ethnobotanical surveys focused on a category of the population believed to be directly affected by the sargassum problem. These include hoteliers, fishermen, traders (owners of beach bars and restaurants) located on the beachfront, tourists, leaders of associations working in the field of beach clean-up, traditional leaders, and indigenous populations. These semi-structured surveys were conducted over a period of approximately two months from September to October using an interview guide. This guide contained open-ended and closed-ended questions. Respondents were selected at random. The key questions during the interviews concerned information about the respondent's identity, knowledge of Sargassum; the impact of sargassum on their activities and turnover, and any uses made of this seaweed. Most of the interviews were conducted in French, and often in Fanti with the help of an interpreter for Ghanaian fishermen who do not all speak French.

2.3. Determining the level of knowledge and consumption of sargassum

2.3.1 Level of knowledge

The level of knowledge (LK) of sargassum, expressed as a percentage, was determined by calculating the ratio of the number of respondents who were familiar with the plant (N) to the total number of respondents (Nt) using the following formula (1):

LK=N/(Nt)×100 (1)

2.3.2 Consensus index

To assess the degree of consensus among respondents on the various medicinal, food, or commercial uses of sargassum, a usage factor, also known as the Information Consensus Factor (ICF), was calculated using formula (2):

ICF=NIE/Nt (2)

Where: NIE = Number of Informants Surveyed who cited a use; Nt = Total number of informants.

The ICF varies between 0 and 1. When the value is low and close to 0, it means that the informants disagree on the uses cited. However, when this value is high and close to 1, it indicates a high or total consensus on the use of the plant [11].

2.3.3 Consumption rate

The consumption rate (CR) across all study sites was calculated using the method employed by [11]. This rate is calculated based on the number of respondents who consume the algae in question (n) out of the total number of respondents who are familiar with these algae (N), according to formula (3):

CR (%)=n/N×100 (3)

3 Results

3.1. Survey data

3.1.1 Sociodemographic characteristics of the populations surveyed

At the end of the survey, a total of 340 people were surveyed, including 80 fishermen, 40 hoteliers, 100 traders, 100 tourists, and 20 people who were association leaders, guides, and community leaders. Of these 340, 68.82% were men and 31.18% were women. Among the fishermen, 100% of those surveyed were male, while among hoteliers, 80% were men and 20% were women. Among traders, 53% were women and 47% were men. Among tourists, 62% were men and 38% were women. Finally, among association leaders, guides, and community leaders, 65% were men and 35% were women. People with no education accounted for 7.65% of all respondents. Three age groups emerged: those under 30 (35.59%); those aged 30-59 (55.59%); and those aged 60-89 (8.82%).

In terms of marital status, 14.12% were married, 57.94% were single, and 27.94% were cohabiting. In terms of nationality, 63.24% were Ivorian, 21.47% were Ghanaian, 5.29% were Burkinabe, and other nationalities accounted for 5.41% of those surveyed.

3.1.2 Level of knowledge, use, and interest in Sargassum seaweed among the populations surveyed

Among all the populations surveyed, 100% of people were aware of the Sargassum seaweed that washes up on beaches, and no uses (food or medicinal) were mentioned by these populations, resulting in a usage and consumption value of 0.00%. However, it was mentioned once for its use by certain artists as a decorative element in paintings and twice for its use as compost by gardeners.

3.2. Local perceptions of sargassum

Depending on the ethnic group, sargassum had different names in the local language. The various local names are listed in **Table I.** Some people also have preconceived ideas about the presence of this seaweed. For some of the N'zima people interviewed, sargassum is the leaves of a forest that is located in the sea. According to them, the appearance of sargassum is due to the fact that the trees in this forest lose their leaves at a certain time of year, as is the case with most terrestrial plants, hence the name “Gnévlékpôkêgna,” which means “leaves of the sea forest” in the N'zima language. For many other people interviewed, the appearance of sargassum in recent years is due to the fact that the animals that ate this seaweed in the water have all been killed, so there are no more animals to consume it in the sea, which explains why it washes up on the beach. Others believe it is a war being waged by the West against Africa to prevent its development. Still others say that the Americans are building a city in the Sargasso Sea and that this is what is causing the seaweed to wash up on beaches. Some respondents believe that oil exploitation or climate change is the cause of the sargassum washing up on the coast. Others also think that seaweed washing up on beaches is a natural phenomenon that is not new, but rather an old phenomenon, although the case of Sargassum seems to be a little more unusual because of the quantity of seaweed that washes up on the beach and the smell it gives off when it rots.

Table 1 Vernacular names for sargassum according to ethnic group

Ethnic group	Vernacular names	Meaning
Alladjan	Etchuéfi	Sea grass
Awanan	Ehoula	Herbs
Fanti	Effou	Leaves
N'zima	Gnévlékpôkêgna	Leaves from the sea forest
Other(s), including the above	N'glinglin Allassane	Sea plant It was during President Alassane Ouattara's term of office that these algae first appeared.
	Seaweed, sea salad	--
	Chakala	--
	Lawn	Because of their coverage of the beach

3.2.1 Control methods used by people working on the beach

Controlling the proliferation of sargassum on beaches remains a major problem, even a headache, for economic operators working along the beaches of Côte d'Ivoire. At present, there are no effective control methods. The alternatives found by local communities to combat the problem are collection, burial, or incineration on site of the piles collected after they have dried. As for the arrival of these waves of seaweed in bathing areas, there is currently no way to collect or divert this seaweed to other areas less frequented by the population in order to prevent it from washing up on the beach, as is the case in some Western countries.

3.3. Socioeconomic impacts of Sargassum

3.3.1 On fishermen

Fishing is one of the sectors most affected by Sargassum. The impacts of Sargassum seaweed on fishing activity have been very noticeable. Sargassum in the water destroys fishermen's equipment, causing collateral damage. Of a total population of 80 fishermen surveyed, 99% estimated that sargassum caused them to lose more than 50% of their turnover **(Figures 3 A).**

3.3.2 On hoteliers

Among hoteliers, 42% estimated that losses related to sargassum amounted to around 10% of their turnover, and 35% estimated that losses amounted to between 10% and 20% of their turnover. For 13% of the hoteliers surveyed, between 20% and 30% of turnover is lost due to sargassum. Five percent of these hoteliers estimated their losses at between 30% and 40%. Finally, for another 5%, more than 50% of their turnover is lost due to sargassum **(Figure 3 B).**

3.3.3 On retailers

Of all the retailers surveyed, 35% would lose between 20% and 30% of their turnover, while 32% cited losses of between 10% and 20%. Furthermore, 13% estimated a loss of less than 10%. In addition, 12% estimated their annual loss to be between 30% and 40%. However, 2% considered that sargassum causes them to lose more than 50% of their turnover, while 6% had no opinion (Figure 3 C). In summary, 37.72% of all economic operators surveyed estimated that sargassum causes them to lose more than 50% of their turnover, and 20.9% estimated that these losses vary between 10% and 20%. In addition, 18.18% estimated that their losses were between 20% and 30%, and 13.63% said they lost less than 10% of their turnover. For 6.81%, losses related to Sargassum amounted to between 30% and 40% per year. Finally, 2.72% had no opinion **(Figure 3 D).**

3.3.4 Threats posed by sargassum to socioeconomic activities

When asked whether sargassum posed a threat to their activities, all fishermen (100%) felt that the survival of their business was seriously threatened by the presence of sargassum in the water. Among hoteliers, only 27% saw sargassum as a threat to their activities, compared to 73% who were not particularly concerned about this seaweed.

Among traders, 52% said they were not threatened by the presence of sargassum, compared to 42% who were concerned about the survival of their activities. In total, 57.92% of the economic operators surveyed considered sargassum to be a threat to them, while 42.08% did not see it as a major danger.

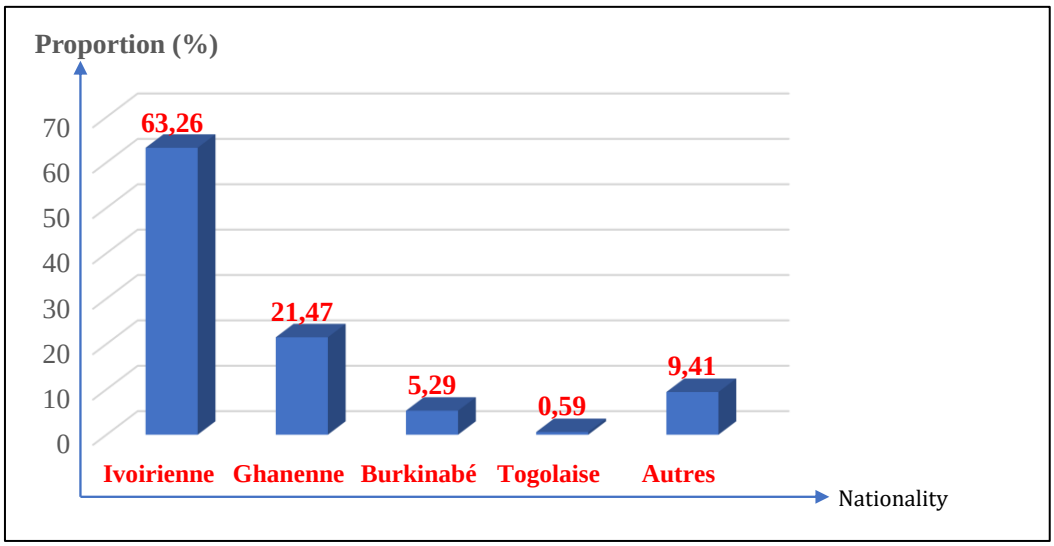
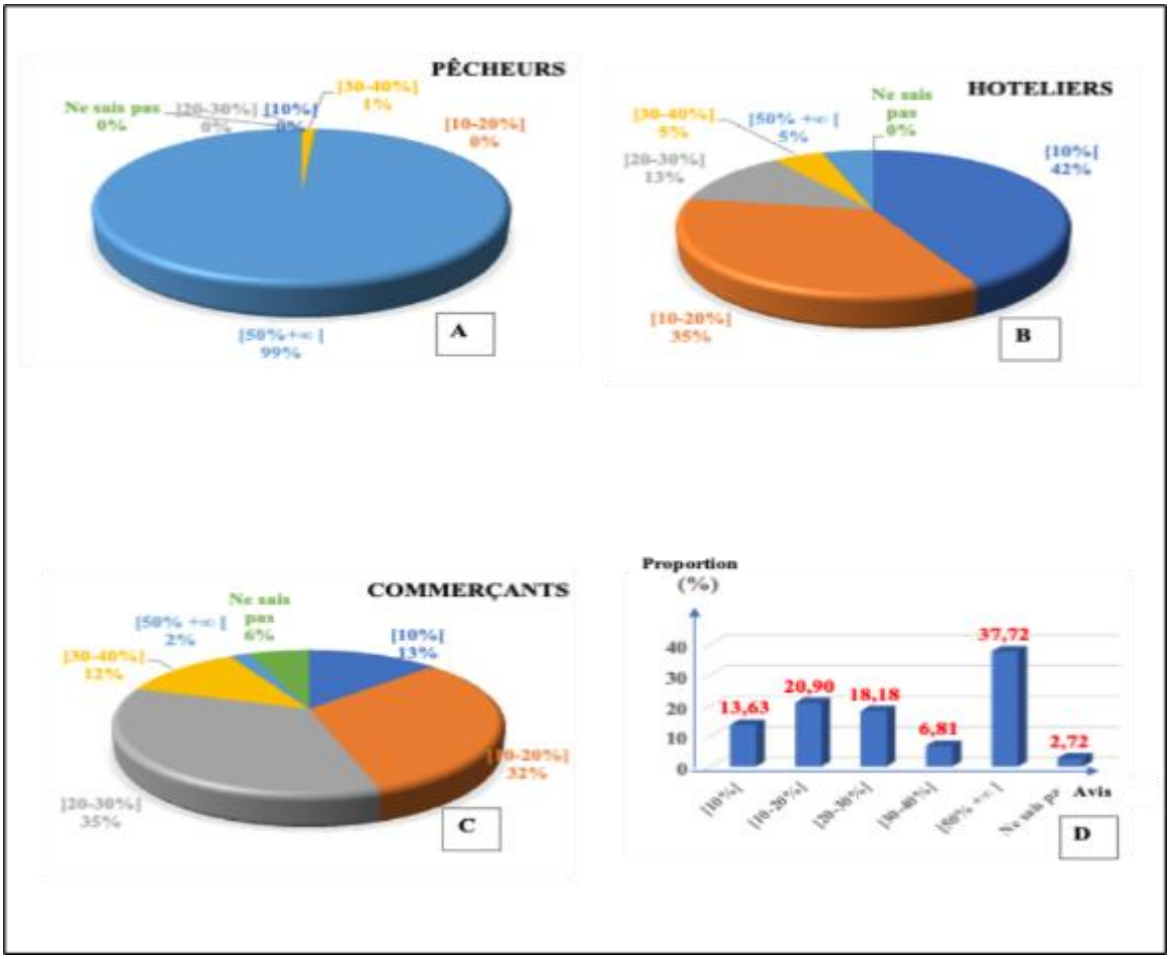


Figure 2 Distribution of nationalities among the populations surveyed



A: Fishermen; **B:** Hoteliers; **C:** Traders; **D: A+B+C.**

Figure 3 Impact of Sargassum on the turnover of economic operators

4 Discussion

The ethnobotanical survey showed that sargassum has a significant impact on fishing activity, with fishermen losing more than 50% of their annual turnover. These results are corroborated by Florenne [7], who showed in similar studies conducted in Martinique and Guadeloupe that fishing was one of the activities most affected by sargassum invasions, with more than 50% of turnover lost. In terms of hoteliers, the results obtained corroborate those of ADEME [12]. Doyle & Frank [13] and Mazeas [14] showed in their studies that Sargassum disrupts the activities of these same economic operators in several Western countries, particularly in the Caribbean islands and the Americas, with much greater losses in turnover compared to the figures recorded in Côte d'Ivoire. This observed difference could be explained by the fact that the scale of the Sargassum phenomenon is much smaller in Côte d'Ivoire than in these countries.

5 Conclusion

The aim of this study was to assess the impact of Sargassum on the socio-economic activities of local populations, as well as its various uses, through an ethnobotanical survey. The results reveal that Sargassum pollutes Ivory Coast beaches, disrupts the socio-economic activities of local populations, and is of no interest to them. Fishing remains the most affected sector, with more than 50% of turnover lost. However, these studies deserve to be further developed and expanded in order to improve knowledge about these algae, which cause many inconveniences to local populations.

Compliance with ethical standards

Disclosure of conflict of interest

We have no conflicts of interest to declare.

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