Economic, Social and Environmental Sustainability of Carapa Farming: The Case of The Ziguinchor Region of Senegal*

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Abstract

The aim of the study was to determine the economic, social and environmental sustainability of the Carapa procera farming in the Ziguinchor region of Senegal. The data of the study were obtained from 151 producers determined according to snowball sampling method in the Ziguinchor region. In the study, the Sustainability Assessment of Food and Agriculture systems (SAFA) agricultural and food products sustainability assessment scale developed by FAO was used to measure the sustainability of Carapa procera farming. The results of the research shows that the environmental sustainability of Carapa farms was found to be 0.40, economic sustainability was 0.50 and social sustainability was 0.49. While the most contributor factors to the environmental sustainability of the farms are related to land use and biodiversity, the most contributor factors to the economic sustainability of the farms are related to the vulnerability of product quality and information. The most contributor factors to the social sustainability of the farms are related to human safety, health and equity. As the farm size increases in Carapa farms, environmental, economic and social sustainability increases. In order to increase the sustainability of Carapa farms, the measures on increasing farm scale and modernizing Carapa procera orchards should be taken by the authorities.

Keywords: *Carapa procera, SAFA, sustainability, Ziguinchor, Sénégal*

Carapa İşletmelerinin Ekonomik Sosyal ve Çevresel Sürdürülebilirliği : Senegal'in Ziguinchor Bölgesi Örneği

Özet

Çalışmanın amacı, Senegal'in Ziguinchor bölgesindeki Carapa procera işletmelerinin ekonomik, sosyal ve çevresel sürdürülebilirliklerini belirlemektir. Araştırmanın verileri Ziguinchor bölgesinde tesadüfi örnekleme yöntemine göre belirlenen 151 adet üreticiden elde edilmiştir. Araştırmada Carapa procera işletmelerinin sürdürülebilirliğinin ölçülmesinde FAO tarafından geliştirilen Tarım ve Gıda Ürünleri Sürdürülebilirliğin Değerlendirilmesi (SAFA) ölçeği kullanılmıştır. Araştırma sonuçlarına göre Carapa işletmelerinin çevresel sürdürülebilirliği 0.40, ekonomik sürdürülebilirliği 0.50, sosyal sürdürülebilirliği ise 0.49 olarak bulunmuştur. İşletmelerde çevresel sürdürülebilirliğe en fazla katkıyı sağlayan faktörler toprak kullanımı ve biyoçeşitlilik ile ilgili faktörler iken, ekonomik sürdürülebilirliğe en fazla katkı sağlayan faktörler ürün kalitesi ve bilgileri ile kırılganlık ilgili faktörlerdir. Sosyal sürdürülebilirliğe en fazla katkı sağlayan faktörler ise insan güvenliği ve sağlığı ile eşitlikle ilgili faktörlerdir. Carapa işletmelerinde işletme büyüklüğü arttıkça çevresel ekonomik ve sosyal sürdürülebilirlikte artmaktadır. Carapa işletmelerinin sürdürülebilirliğinin artırılmasında işletme ölçeklerinin büyümesine yönelik yetkililerce önlem alınması gerekmektedir.

Anahtar kelimeler: *Carapa procera, SAFA, sürdürülebilirlik, Ziguinchor, Sénégal,*

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INTRODUCTION

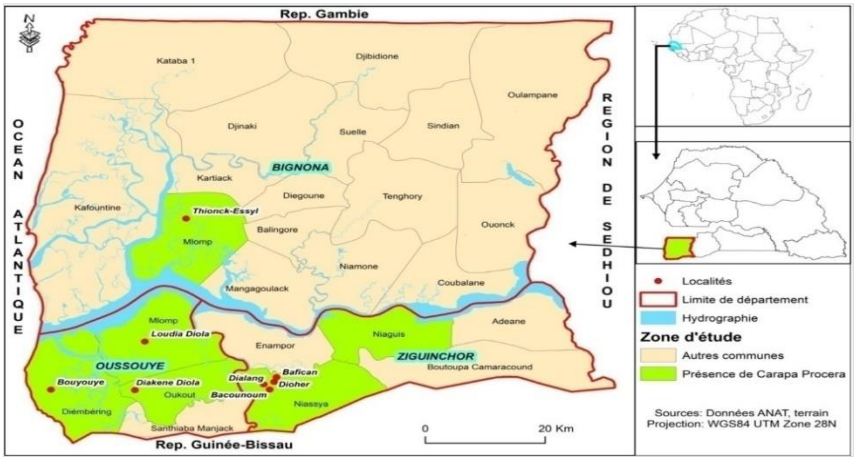
In the Ziguinchor region, Carapa species constitute an important source of forest products (Andel et al., 2003; DeFilipps et al., 2004). The processing of Carapa constitutes an activity aimed at diversifying sources of income and to some extent ensures the economic stability of households. Sustainability of agricultural sector is becoming increasingly more important as agriculture strives to produce more food while minimizing risk to the environment (Baser et al., 2017) and improve rural environment and to sustain natural resources in rural areas (Bozoglu et al., 2019). However, the evaluation of sustainability performance in farm under the different scales of farms is worth considering (Başer and Bozoglu, 2021).

It is important to ensure the sustainability of these plant species with high added value, such as Carapa procera. Carapa, which has economic and socio-cultural importance, is a neglected resource whose importance and potential are not used enough. In terms of rural development, the operation of Carapa offers great opportunities but many environmental and technical constraints are encountered. The main limitations of these limitations are the aging of trees, the lack of knowledge of domestic and foreign markets, and the deficiencies in cultural practice. Many studies have been conducted on Carapa procera. Guillemot (2004) states that Carapa is a tropical tree with promising ecological and economic benefits. Tiétiambou et al. (2020) conducted an organizational and economic analysis of the value chain of soap artisanal from Carapa procera DC oil in Burkina Faso. Silva (2004) conducted research on Carapa's potential. Sambou and Lambal (2015) investigated the contribution of high value-added plant species to conservation. Although there has been a great deal of research on sustainability, no studies have been found on the sustainability of Carapa procera farms. Carapa, which is a tropical plant, has a very high socio-economic value for local people. Both the realization of rural development and the research of the sustainability of Carapa, which is the most important source of livelihood of the local people, are important in terms of determining what will be the activities that need to be improved in the short and long term. The aim of the study is to determine the economic, social and environmental sustainability of Carapa farms in the Ziguinchor region of Senegal. In addition to contributing to the literature, it will also help to develop policies to increase sustainability.

MATERIAL AND METHOD

In this study, Ziguinchoz region was selected as the study area (Figure 1). The study was carried out in the regions of Nyassia in the Ziguinchor region, Thionkessyl in the Bignona region and Mlomp, Diembering and Oukoutin the Oussouye region. The data of the study were obtained from 151 producers using the snowball sampling method in Ziguinchor Region. In addition, FAO data were also used as the secondary datain the study.

Figure 1. Map of the working area



In the study, the SAFA agricultural and food products sustainability assessment scale developed by FAO (2013) was used to measure the sustainability of Carapa procera farms. In the research, a sustainability index was created with the help of indicators and then the normalization phase was started. The purpose of normalization is to convert indicators with different units into common units and combine them into a single indicator. The min-max approach is used to standardize indicators expressed in different sizes to provide a common basis. The quantitative indicators are then rated from 0 to 1 (0 corresponds to the possible worst value of the indicator; 1 corresponds to the best). The min-max method specified in formulas 2.1 and 2.2 was used in the study (Anonim, 2008):

$$I_{Ij} = \frac{X_{ij} - MinX_{ij}}{MaxX_{ij} - MinX_{ij}} \quad \textbf{(2.1)}$$

$$I_{Ij} = \frac{MaxX_{ij} - X_{ij}}{MaxX_{ij} - MinX_{ij}} \quad \textbf{(2.2)}$$

In the formula i, 1,2,3..... n refers to the number of indicators, j refers to the sustainability indicators, X represents the values of the ij indicators. In formulas, Formula 2.1 or 2.2 is selected according to its positive or negative impact on sustainability, and Formula 2.1 refers to positive applications on sustainability and Formula 2.2 refers to negative applications. In the formation of the index, equal weights were given to the indicators selected during the weighting and addition phase and the indices were calculated by linear addition method. The equations they used during addition are given in Formulas 2.3, 2.4 and 2.5:

$$ESI = \frac{\sum_i^n Iij}{n} \quad \textbf{(2.3)}$$

$$SSI = \frac{\sum_i^n Iij}{n} \quad \textbf{(2.4)}$$

$$CSI = \frac{\sum_i^n Iij}{n} \quad \textbf{(2.5)}$$

In the formulas, ESE refers to the economic sustainability index, SSE to the social sustainability index, EnSE to the environmental sustainability index and I_{ij} to the indicator values. After calculating each sustainability dimension, it must be calculated in the total sustainability index. The calculation of the total sustainability index is given in Formula 3.6:

$$TSI = \frac{W_1 * ESE + W_2 * SSE + W_3 * CSE}{3} \quad \textbf{(3.6)}$$

In the formula, TSI refers to the total sustainability index and W refers to the assigned weights. Environmental, economic and social sustainability indicators and results according to the SAFA scale are given in Table 1, respectively.

The environmental sustainability index values of the farms varied between 0.21 and 0.91, while the average was 0.40. The biggest contributors to the environmental sustainability index (0.97) were the amount of fresh water and the seed holding production activity (0.97). The high value of the indicators in environmental sustainability indicates good management in agricultural activities, good protection of crops from harvesting, especially seeds. Furthermore, the indicators that contribute the lowest to the environmental sustainability index were ecosystem services and ecosystems links (0.01), the total amount of direct energy consumed from sustainable and renewable sources (0.01), respectively. The social sustainability index of Carapa farms varied between 0.27 and 0.88 and the average was 0.49. The social sustainability index of farm layers also ranges from 0.47 to 0.47. The most contributor factors to the social sustainability index were human safety and health, especially well-maintained land, clean and safe (100) and measures not to pollute the local community (0.87). High values are explained by the importance given to human health and the protection of the environment. The economic sustainability index of Carapa farms varied between 0.26 and 0.88 and the average was 0.50 (Table 1).

This research was approved by Social and Human Sciences Research Ethics Committee of Samsun Ondokuz Mayıs University (date: 30.06.2022, decision no: 2022-634).

Table 1. Sustainability indicators for Carapa procera farms

	Frequency	Min	Max	Index
ENVIRONMENTAL SUSTAINABILITY INDEX (EnSE)		0.21	0.91	0.40
Atmosphere Factors				
Have you set a target to reduce greenhouse gas emissions in your operations?	55.9	0.00	1.00	0.56
Are you doing activities and practices to effectively reduce greenhouse gas emissions?	30.5	0.00	1.00	0.31
Have you set a target to reduce air pollutant emissions?	51.6	0.00	1.00	0.52
Do you carry out prevention activities and practices to effectively reduce air pollutants?	34.4	0.00	1.00	0.34
Factors related to the use of water				
Have you set a goal to reduce water consumption or water withdrawal in your activity?	16.5	0.00	1.00	0.17
Do you carry out activities and practices that prevent the amount of fresh water used in your product from decreasing?	97.3	0.00	1.00	0.97
Have you set a goal to improve the quality of water affected by your activities?	55.6	0.00	1.00	0.56
Do you engage in activities and practices that reduce or prevent the release of pollutants into the water?	13.9	0.00	1.00	0.14
Do you know the percentage of total waste water resulting from your agricultural activities?	5.3	0.00	0.1	0.05
Soil Factors				
Do you carry out activities and practices that improve the quality and fertility of the soil?	91.7	0.00	1.00	0.92
Do you use the physical structure of the soil, taking into account the local climate and bedrock?	63.2	0.00	1.00	0.63
Are you using the chemical quality of the soil, taking into account the local climate and bedrock?	12.5	0.00	1.00	0.13
Are you using the biological quality of the soil, taking into account the local climate and bedrock?	65.5	0.00	1.00	0.66
Are you using the organic matter content and quality in the soil, taking into account the local climate and bedrock?	50.0	0.00	1.00	0.5
Do you have a plan that describes the stages of conservation and improvement of soil health and rehabilitation of degraded soil?	56.9	0.00	1.00	0.57
Do you use effective soil conservation techniques and/or rehabilitation measures in your activities?	48.3	0.00	1.00	0.48
Do you know the proportion of degraded land and improved land due to your agricultural activities?	5.25	0.00	1.00	0.05
Biodiversity Factors				
Do you have a plan for the conservation or rehabilitation of various habitats in your area?	32.7	0.00	1.00	0.33
Do you have any activities to improve the functioning of ecosystem services and the connectivity of ecosystems?	1.6	0.00	1.00	0.01
In which part of the space used do you have great structural diversity?	81.4	0.00	1.00	0.81
Have you used the primary habitat for your agricultural activities in the last 20 years?	46.3	0.00	1.00	0.46
Have you set a conservation and rehabilitation goal for populations of rare and endemic species?	73.1	0.00	1.00	0.73
Do you engage in activities and practices to maintain, maintain and/or rehabilitate the integrity of wild plant and animal populations?	34.1	0.00	1.00	0.34
Diversity and abundance of threatened or vulnerable wildlife species and invasive species have they increased?	9.2	0.00	1.00	0.09
Do you rotate various plants and/or use more than one species at a time?	29.8	0.00	1.00	0.30
What practice do you have to preserve or rehabilitate the genetic diversity of wild species?	37.0	0.00	1.00	0.37
What is the share of production represented by locally adapted varieties/breeds?	93.0	0.00	1.00	0.93
What is the share of production represented by traditional varieties and breeds?	37.2	0.00	1.00	0.37
Is there an indicator of a large genetic variation that is not used in your activities?	9.9	0.00	1.00	0.10
Do you store/keep seeds in your production activities?	96.6	0.00	1.00	0.97
Do you do breed work to preserve traditional and/or rare breeds?	72.8	0.00	1.00	0.73
Materials and Energy Factors				
Do you engage in practices and activities to replace non-renewable materials with renewable materials and replace synthetic inputs with natural inputs?	10.5	0.00	1.00	0,11
Do you know the nutrient requirements of plants for nitrogen and phosphorus?	14.5	0.00	1.00	0.15
Do you know the share of inputs from non-renewable fossil sources in your agricultural activities in total inputs?	0.6	0.00	1.00	0.01
In the last 5 years, has the amount of material used per unit of production changed?	38.4	0.00	1.00	0.38
Do you have a target for the share of renewable and sustainable energy in your total direct energy consumption?	19.8	0.00	1.00	0.20
Do you carry out practices and activities to reduce the energy needs of your farm?	4.6	0.00	1.00	0.05
Has the total direct energy consumption changed in the last 5 years?	35.0	0.00	1.00	0.35
Do you know the total amount of direct energy consumed from sustainable renewable sources?	1.3	0.00	1.00	0.01
Have you set a goal to reduce waste generation in your operations?	92.0	0.00	1.00	0.92
Do you carry out practices and activities to reduce waste generation in the activities?	66.8	0.00	1.00	0.67
Do you know the amount of solid waste you produce during disposal, which is hazardous to humans and the environment?	57.6	0.00	1.00	0.58
Do you know the share of food lost or wasted and the share that is reused, recycled or recovered?	11.34	0.00	1.00	0.11
Animal Health Factors				
Are you doing activities and practices to improve animal health while reducing the use of veterinary drugs?	31.7	0.00	1.00	0.32
How much of the animals are healthy and do not require treatment with veterinary drugs?	14.9	0.00	1.00	0.15
Do you engage in activities and practices to effectively reduce animal suffering and the risk of injury?	43.0	0.00	1.00	0.43
How much of the animals can behave according to their specific needs?	26.5	0.00	1.00	0.27
How many of the animals have enough freedom to move, transport and live painlessly during slaughter?	26.5	0.00	1.00	0.27

Table 1 (Continue). Sustainability indicators for Carapa procera farms

	Frequency	Min	Max	Index
ECONOMIC SUSTAINABILITY INDEX (ESE)		0.26	0.88	0.50
Investment Factors				
What activities and practices have you invested in to improve social, economic, environmental and governance performance over the past 5 years?	23.8	0.00	1.00	0.24
Have community investments helped meet the needs of the community?	76.1	0.00	1.00	0.76
Do the investments aim to strengthen the conditions for protecting, generating and increasing the profits from your operations in the long term?	31.1	0.00	1.00	0.31
Do you have a document that expresses income streams and stipulates those financial resources will be replenished for the future?	2.6	0.00	1.00	0.26
Has your income exceeded the total expenses, including interest and taxes associated with the production of goods sold, over the past five years?	68.2	0.00	1.00	0.68
Do you have a method for calculating your breakeven point?	66.8	0.00	1.00	0.67
Have you considered a break-even point in all contracts to negotiate the selling price of your buyers?	27.8	0.00	1.00	0.28
Situation Factors				
What actions and mechanisms have you put in place to reduce the risks that could affect production volume and quality standards?	72,8	0.00	1.00	0.73
Do you produce a variety of products, species, or varieties of plants or animals to generate income?	58.9	0.00	1.00	0.59
What actions and mechanisms have you put in place to reduce the input supply problem?	92,0	0.00	1.00	0.92
Do you do actions and mechanisms to ensure a diversified revenue structure?	50.3	0.00	1.00	0.50
Have you generated positive net cash flow over the past five years?	35.0	0.00	1.00	0.35
Do you have access to formal or informal financial resources to resist liquidity crises?	11.9	0.00	1.00	0.12
Do you have plans to mitigate the risks that could potentially threaten your business?	87.4	0.00	1.00	0.87
Product Quality and Information Factors				
Are there food control measures?	44.3	0.00	1.00	0.44
Have you used very dangerous pesticides in the last five years?	9.2	0.00	1.00	0.09
Has there been chemical or biological contamination of food in the last five years?	69.5	0.00	1.00	0.31
How much of the total production volume complies with quality norms and standards?	89.2	0.00	1.00	0,89
Do you comply with product labelling standards and codes?	18.5	0.00	1.00	0.19
Does your system guarantee traceability at all stages of the food chain so that products can be easily and accurately identified and recalled?	95.3	0.00	1.00	0.95
Can you identify all the materials and inputs you use, as well as provide proof of their certified sustainable supply?	100	0.00	1.00	0.10
Local Economy Factors				
Have you hired only regional employees in the past five years?	70.8	0.00	1.00	0.71
Do you pay the taxes specified in the local regulations?	19.2	0.00	1.00	0.19
Do you buy your inputs from local suppliers and non-local suppliers?	82.1	0.00	1.00	0.82
SOCIAL SUSTAINABILITY INDEX (SSE)		0.27	0.80	0.49
Reasonable Livelihood Factors				
Do you spend time on family, rest and culture?	90.7	0.00	1.00	0.91
Do you and all employees earn the least living wage?	52.9	0.00	1.00	0.53
Do you want to increase your knowledge and skills in the field you are working in?	72.1	0.00	1.00	0.72
Do you have the necessary equipment, capital, and access to information or training?	12.5	0.00	1.00	0.13
Fair Trade Practices Factors				
Do buyers support suppliers' rights with fair contracts and agreements at affordable prices?	10.5	0.00	1.00	0.11
Do buyers support suppliers' right to freedom of association and collective bargaining?	11.9	0.00	1.00	0.12
Employee Rights Factors				
Do you have written agreements with your employees that comply with at least national and international employment contracts?	19.2	0.00	1.00	0.19
Do you employ young children aged 16 and under?	14.5	0.00	1.00	0.15
Equality Factors				
Do you discriminate with your employees?	74.8	0.00	1.00	0.75
Do you prefer women over men in your activities?	36.4	0.00	1.00	0.36
Do you employ disabled and elderly people in your production?	98.0	0.00	1.00	0.98
Human Safety and Health Factors				
Are your production areas well-maintained, clean and safe?	100.0	0.00	1.00	1.00
Can you help your employees in case of illness?	29.8	0.00	1.00	0.30
Do you take measures in your activities to avoid polluting the local community?	86.7	0.00	1.00	0.87
Humidity Factors				
Does your treatment contribute to the food sovereignty of the region?	30.4	0.00	1.00	0.30

RESULTS AND DISCUSSION

Socio-Economic Characteristics of the Farms

Table 2 showed the socio-demographic characteristics of Carapa procera farms. The average age of the representatives across the surveyed farms was 59 years old, the average age was 60 years old in the first layer farms, 59 years old in the second layer farms, and 58 years old in the third layer farms. Sambou and Lambal (2015) stated that most of the people active in Carapa businesses were elderly people (70%). The overall average of the active economic population of

Carapa farms was 7.79 persons, while the average of the highest active population was 8 persons in the third layer farms with. In terms of the amount of active population, there was statistically significant differences among the business groups ($p<0.01$). While there was a statistically significant difference between Carapa procera and farm groups in terms of the amount of population aged 0-14 years ($p<0.01$), there was no statistically significant differences among other age groups. While 70.9% of the farms were illiterate, 26.5% were primary school graduates. The high rate of illiterate could be explained by the fact that the majority of the respondents were women. In Senegal, the level of education in rural areas is low due to discrimination, poverty, school infrastructure and lack of teaching staff, especially against girls. Only 20.5% of Carapa's farm activity was registered, while 82.1% was engaged in farming. The amount of agricultural income of Carapa producers was Franc CFA (Fcfa) 53.172, while the amount of non-agricultural income was Fcfa 13.781.

Table 2. Socio-demographic characteristics of Carapa procerafarms

	1st Layer		2nd Layer		3rd Layer		All Farms	
	Average	SS	Average	SS	Average	SS	Average	SS
Population (person) **	7.60	2.21	7.90	2.16	8.20	2.78	7.79	2.22
Age (yıl)	60.82	10.13	58.51	10.80	57.90	10.20	59.51	10.47
*0-14 years***	0.84	1.18	1.07	1.43	0.90	1.10	0.95	1.30
15-64 years	5.63	1.93	5.64	1.95	5.90	2.42	5.66	1.96
>65 years	1.13	0.67	1.19	0.72	1.40	0.70	1.18	0.69
Education (%)								
Literacy	79.4	-	69.9	-	20.0	-	70.9	-
*Primary school***	20.6	-	27.4	-	60.0	-	26.5	-
Secondary school	-	-	1.4	-	10.0	-	1.3	-
High school	-	-	-	-	10.0	-	0.7	-
License	-	-	1.4	-	-	-	0.7	-
Profession (%)								
Farmer	83.8	-	83.6	-	60.0	-	82.1	-
Farmer&other	16.2	-	16.4	-	40.0	-	17.9	-
Operated (%)								
Non-registration	80.9	-	78.1	-	80.0	-	79.5	-
Registration	19.1	-	21.9	-	20.0	-	20.5	-
Agricultural income (CFA)	6,102.94	18,153	19,328	58,69	25,50	59,18	13,78	45,40
Non-farm income (CFA)	27,985	45,021	60,424	129,86	171,50	263,44	53,17	120,05

**There was a statistically significant difference at 1% level.

Environmental Sustainability and Its Effective Factors

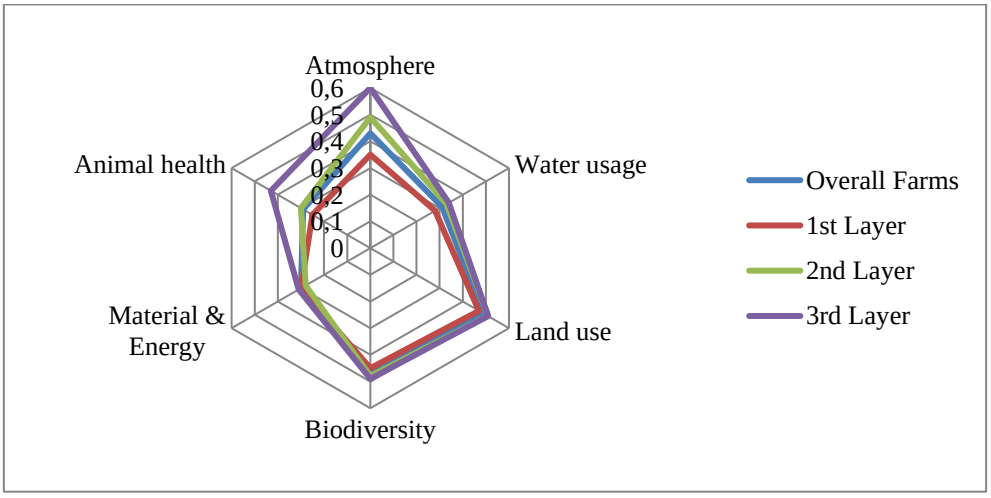
In this section, the results of sustainability indicators and effective factors on the environmental, economic and social dimensions of sustainability of the Carapa procera are given in Table 3. When the environmental sustainability results according to the business scale in Carapa farms were given in the Table 3. The environmental sustainability scores were determined as 0.40 in the overall farms, 0.37 in the first layer farms, 0.40 in the second layer farms, 0.43 in the third layer farms. Factors related to land use and biodiversity contribute the most to overall sustainability. Land use increases to 0.49 in the overall farms, 0.47 in the first layer farms, 0.51 in the second layer farms and 0.51in the third layer farms. In addition, biodiversity-related factors range from 0.45 to 0.49 in the first-layer farms and third-layer farms. The results show also that Carapa procera producers attach importance to protecting their soils in particular in order to increase their production. The least contributing factor (0.29) was related to animal health. Producers did not take animal health into account. Among the environmental sustainability groups, there was a statistically significant difference among the factors like soil use ($p<0.01$) and animal health ($p<0.05$).

Table 3. Environmental sustainability index results by layers

Factors	1st Layer		2nd Layer		3rd Layer		Overall average	
	Average	SS	Average	SS	Average	SS	Average	SS
EnSE**	0.35	0.10	0.40	0.10	0.45	0.10	0.40	0.14
Atmosphere**	0.35	0.43	0.49	0.44	0.60	0.41	0.43	0.44
Water use*	0.28	0.21	0.33	0.25	0.34	0.25	0.31	0.23
Land use*	0.47	0.30	0.51	0.30	0.51	0.29	0.49	0.30
Biodiversity*	0.45	0.33	0.48	0.35	0.49	0.38	0.47	0.35
Materials &energy*	0.30	0.47	0.28	0.41	0.31	0.23	0.30	0.45
Animal health*	0.25	0.30	0.30	0.34	0.43	0.33	0.29	0.32

** and * are statistically significant at the level of 1% and 5% levels, respectively.

Graphic 1. Environmental sustainability of Carapa businesses by layers



Economic Sustainability and Its Effective Factors

Economic sustainability index results in Carapa procera farms were given Table 4. The economic sustainability index varies between 0.26 and 0.88, the average was 0.50. The most contributor indicators to the economic sustainability index were the system, the easy and accurate identification of products and the guarantee of traceability at all stages of the food chain (0.95), respectively. The least contributing factors to the economic sustainability index were the use of harmful pesticides (0.09) and resistance to liquidity crises and access to official or informal financial resources (0.12). These low values are due to the importance given to the use of organic fertilizers compared to pesticides and the lack of financial means for the realization of some economic activities.

Table 4. Economic sustainability index results by layers

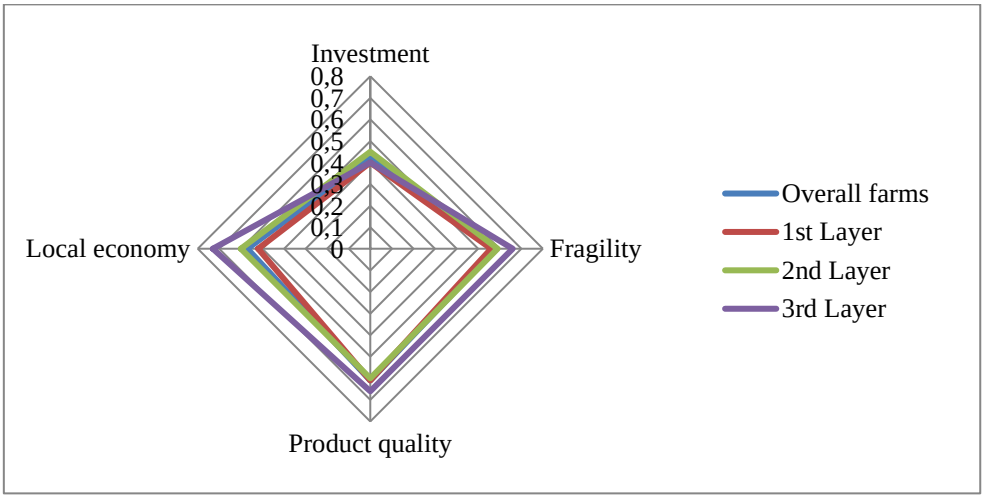
Factors	1st Layer		2nd Layer		3rd Layer		Overall Farms	
	Average	SS	Average	SS	Average	SS	Average	SS
ESE**	0.52	0.1	0.56	0.12	0.61	0.10	0.50	0.11
Investment	0.40	0.39	0.45	0.42	0.40	0.40	0.46	0.41
Fragility	0.56	0.37	0.59	0.43	0.66	0.37	0.58	0.41
Productquality	0.61	0.28	0.60	0.33	0.66	0.35	0.42	0.29
Local economy	0.52	0.38	0.60	0.41	0.73	0.46	0.57	0.41

**is statistically significant at %1 level

The average of the economic sustainability index in the first, second and third layers were 0.52, 0.56 and 0.59, respectively. Achieving these results could increase economic sustainability of the farms. The most contributor factors to economic sustainability in the first, second- and third-layer farms were determined as the quality and knowledge of the product (0.61) and the rural

(0.58), while the least contributor factor was related to activity (0.42). There is a statistically significant difference among farm groups in terms of economic sustainability index scores ($p<0.01$).

Graphic 2. Economic sustainability of Carapa farms



Social Sustainability and Its Effective Factors

Table 5 showed the results of the social sustainability indices of Carapa procera farms by farm layers. The less contributor factors to social sustainability were as follows; fair trade practices in the form of fair prices and fair contracts of suppliers (0.11) and their support for suppliers' right to freedom of association and collective bargaining (0.12). These low values indicate that the Carapa procera sector has not given sufficient importance and support. While the safety, health and health factors that contribute the most to social sustainability in the first, second- and third-layer farmswere the factors of human safety, health and community, the least contributor factors were language trading practices. There was a statistically significant difference among the farm groups on the factors related to occupational sustainability ($p<0.01$) and the factors related to human safety and health ($p<0.05$).

Table 5. Social sustainability index results by layer

	1st Layer		2nd Layer		3rd Layer		Overall average	
	Average	SS.	Average	SS.	Average	SS.	Average	SS.
SSE**	0.41	0.12	0.45	0.11	0.50	0.07	0.49	0.11
Reasonableprogress	0.52	0.41	0.62	0 .37	0.55	0.32	0.57	0.39
Fair trade	0.14	0.35	0.10	0.31	0.00	0.00	0.11	0.32
Rights	0.15	0.36	0.19	0.39	0.10	0.21	0.17	0.38
Equality**	0.69	0.36	0.71	0.35	0.70	0.30	0.70	0.35
Human safety&health*	0.72	0.25	0.74	0.28	0.63	0.25	0.72	0.27
Cultural diversity*	0.25	0.44	0.32	0.47	0.60	0.52	0.30	0.46

** and * indicates that there is a statistically significant difference at 1% and 5%, respectively.

Total Sustainability

The overall sustainability results of Carapa procera operations are given in Table 6. The current sustainability index ranges from 0.31 to 0.71, with an average of 0.46. Economic sustainability contributes the most to the overall sustainability of Carapa's businesses. The economic sustainability index of Carapa farms ranges from 0.26 to 0.88, with an average of 0.50. The environmental sustainability index ranges from 0.21 to 0.91, with an average of 0.40. ul Haq and Boz (2019) found the overall sustainability index to be lower (0.39) for tea farming. Başer (2021) calculated the economic, social, environmental and overall sustainability indexes for cattle farming as 0.37, 0.58, 0.50 and 0.49, respectively.

Graphic 3. Social sustainability of Carapa farms

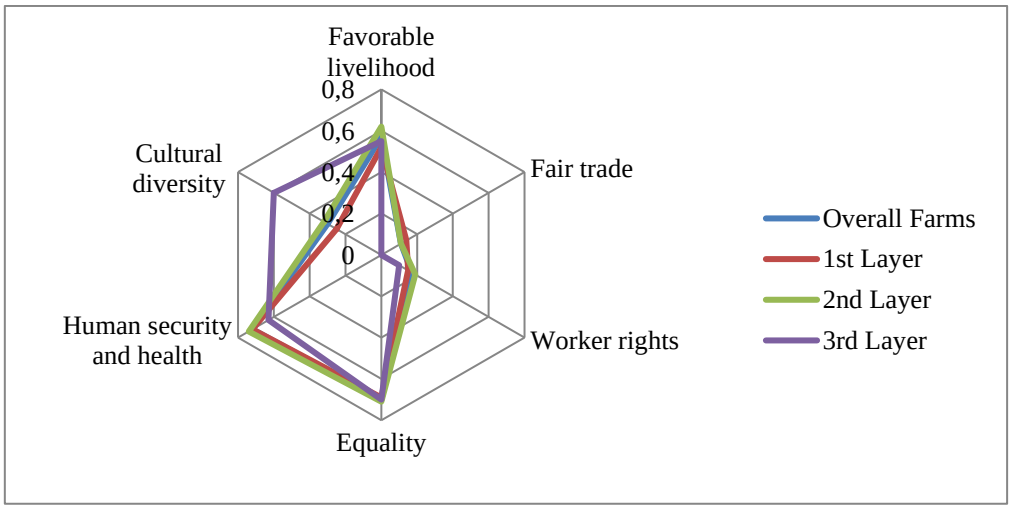


Table 6. Economic and social sustainability index in farms

	Smallest	Largest	Average	Std. Deviation
Overall Sustainability Index (GSE)	0.31	0.71	0.46	0.09
EnSE	0.21	0.91	0.40	0.14
ESE	0.26	0.88	0.50	0.11
SSE	0.27	0.80	0.49	0.11

Table 7 showed the correlation between ESE, SSE and EnSE for Carapa farming. The results of the analysis showed that there was a weak correlation between the dimensions of social, economic and environmental sustainability in Carapa farming. The correlation between social and economic sustainability was higher than the correlation between other dimensions of sustainability. The correlation coefficient between social and economic sustainability was 0.331, which was statistically significance at the level of 1% level. The correlation coefficient between environmental sustainability and economic sustainability was 0.237 and it was statistically significant at the level of 1%. The relationship between social sustainability and environmental sustainability was 0.206 and the correlation level was less than other dimensions. It can be stated that an improvement in this social dimension will positively affect economic sustainability rather than environmental sustainability. Başer (2021) found that the correlation coefficient between economic and social sustainability in beef fattening farms was 0.310, the correlation coefficient between social sustainability and environmental sustainability was 0.309, and the correlation coefficient between economic sustainability and environmental sustainability was 0.182.

Table 7. Correlation coefficients between ESE, SSE and EnSE

	SSE	EnSE	ESE
SSE	1.00	0.206*	0.331**
CSE		1.00	0.237**
ESE			1.00

** and * means that there was statistically significant difference between the farm groups at the level of %1 and *%5, respectively.

CONCLUSION

Carapa procera, which is cultivated as a forest species in the Ziguinchor Region, is of great socio-cultural, economic and ecological importance in the life of local populations. The increasing interest in this plant in Senegal due to its economic importance led to the emergence of research. In the research, the sustainability of Carapa procera farming was measured by means of the economic, social and environmental sustainability indices and the effective factors for the sustainability dimensions were revealed. Environmental,

economic and social sustainability scores for Carapa procera farming in the overall farms were found to be 0.47, 0.54 and 0.49, respectively.

The low contribution of index values to environmental sustainability was explained by the lack of information in the fields of activities. The less contributor factors to social sustainability were as follows; fair trade practices in the form of fair prices and fair contracts of suppliers (0.11) and their support for suppliers' right to freedom of association and collective bargaining (0.12). The least contributing factors to the economic sustainability index were the use of harmful pesticides (0.09) and resistance to liquidity crises and access to official or informal financial resources (0.12). Looking at the three sustainability dimensions, there is a need for extension services.

The increase in the size of Carapa procera farms positively affects economic, social and environmental sustainability. In addition, an improvement in one dimension of sustainability has a positive effect on other dimensions of sustainability. In order to increase the sustainability values in all dimensions, it is necessary to focus on the factors with low contribution to sustainability. For this more efficient and sustainable production systems in Carapa farming should be adopted.

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