

## **Ecosystem services in mangroves: potential for food security in coastal communities**

### **Servicios ecosistémicos en manglares: potencialidad para seguridad alimentaria en comunidades costeras**

**Greicy de la Caridad Rodríguez Crespo<sup>1</sup>**

**María Antonia Afre Socorro<sup>2</sup>**

**Oswaldo Domínguez Junco<sup>3</sup>**

**Yunleydi Rojas Permuy<sup>4</sup>**

**Arialys Pérez Troche<sup>5</sup>**

<sup>1</sup>Universidad de Pinar del Río «Hermanos Saíz Montes de Oca». Pinar del Río, Cuba. E-mail: greicy@upr.edu.cu, leinad@inder.cu, osvaldodj@upr.edu.cu, yunleydirp@estudiantes.upr.edu.cu, arialys@estudiantes.upr.edu.cu

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#### **ABSTRACT**

The research aimed to link the concepts of ecological integrity and ecosystem services in mangroves, in search of food security and greater resilience to climate change. It was carried out in two coastal areas in the southwest of the province of Pinar del Río, Cuba; namely, Protected Area of Managed Resources Punta Cortés and Coloma-Las Canas (one in a state of deterioration). A methodological proposal was developed that relates the concepts of ecological integrity, ecosystem services and food security in coastal areas with the presence of mangroves, for which indicators are taken into account to assess the ecosystems in question and compare results through the application of surveys and interviews with residents,

as empirical methods of support. In the case of Punta Cortés, according to the indicator range, a score of 28 was obtained, which places the area as high integrity, but not in the case of La Coloma-Las Canas, whose score was 11, remaining, according to the methodology, in the low integrity range. The results of the surveys carried out among the residents coincide with the previous ones, concluding that the La Coloma-Las Canas sector does not have the necessary food security for the local development of its residents due to the deterioration of its mangroves, which threatens the scarce possibility of resilience to climatic changes, especially hurricanes and tropical storms, as well as sea level rise.

**Keywords:** mangroves; ecological integrity; food security; ecosystem services.

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## RESUMEN

La investigación tuvo como objetivo relacionar los conceptos de integridad ecológica y servicios ecosistémicos en manglares, en busca de seguridad alimentaria y mayor resiliencia ante los cambios climáticos. Se realizó en dos zonas costeras del sur occidente de la provincia de Pinar del Río, Cuba; a saber, Área Protegida de Recursos Manejados Punta y La Coloma-Las Canas (una ha en estado de deterioro). Se desarrolló una propuesta metodológica que relaciona los conceptos de integridad ecológica, servicios ecosistémicos y seguridad alimentaria en zonas costeras con presencia de manglares, para lo cual se tienen en cuenta indicadores que permitan valorar los ecosistemas en cuestión y comparar resultados mediante la aplicación de encuestas y entrevistas a los pobladores, como

métodos empíricos de apoyo. En el caso de Punta Cortés, según el rango de indicador, se obtuvo una puntuación de 28, lo que sitúa la zona como de alta integridad, no así en el caso de La Coloma-Las Canas, cuya puntuación resultó de 11, quedando, según la metodología, en el rango de baja integridad. Los resultados de las encuestas realizadas a los pobladores coinciden con los anteriores, concluyendo que el sector La Coloma-Las Canas no posee la seguridad alimentaria necesaria para el desarrollo local de sus pobladores debido al deterioro de sus manglares, lo que atenta contra la escasa posibilidad de resiliencia ante los cambios climáticos, en especial huracanes y tormentas tropicales, así como los ascensos del nivel del mar.

**Palabras clave:** manglares; integridad ecológica; seguridad alimentaria; servicios ecosistémicos.

## INTRODUCTION

Focusing on ecological integrity and ecosystem assessment has major implications for regional, national and global food security. Yáñez, (2017). Montes, (1997) associates ecological integrity with all physical, chemical and environmental processes and adds that wetland ecosystems are of great functional importance, as they are energy reservoirs and examples for food security, life support and nutrient supply for mangroves, marshes and peatlands.

According to Rodriguez, (2003) and Rodriguez *et al.*, (2011, 2014), among the main services provided by the mangrove ecosystem, aimed at securing food for coastal communities, can be counted:

### Protector of the coastal littoral

- Maintenance of the food trophic network that implies an increase in biological diversity and, therefore, in coastal fisheries due to the presence of species consumed by man in his diet. According to the United Nations (UN), by 2017, mangroves provide an important breeding habitat for aquatic wildlife: about 75% of commercially exploited species spend part of their life cycle in mangrove ecosystems or depend on habitat for food.
- Containment of coastal erosion and ascents of the mean sea level, which favors the protection of housing and socioeconomic infrastructure.
- Beekeeper and medicinal uses.

Protector of environmental health in terms of air quality by capturing atmospheric carbon. - Bosques Azules is a collaboration between UN Environment, GRID-Arendal and a wide range of national and international UN allies. It aims to achieve better ecosystem management. It includes the development of the first global assessment of mangrove carbon sequestration and aims to demonstrate that the values associated with coastal carbon and ecosystem services can be harnessed to achieve climate, conservation and sustainable management objectives.

#### **Protector of adjacent land dedicated to subsistence agriculture**

- Hydrological filter that decreases the salinity of soils and water for domestic and agricultural use, among others.
- Improved water quality in aquifers.

It favors landscape values of tourist, recreational, educational, artisan interest, among others, that can be commercialized or not, but that contribute to improve the quality of life of the coastal communities.

In order to quantify to some extent this potential capacity for the food security of coastal communities, they must be related to the concept of ecological integrity of the ecosystem in question.

This is a concept closely related to the conservation capacity of an area. The ecological integrity of an area is related to the intensity of degradation produced by human or natural activities that result in the loss or transformation of its functional characteristics. It is considered low when the presence of native plants and medium wild herbivores is scarce, as well as when the natural processes of ecological succession have been significantly altered. The ecological

integrity of a region is medium when a reduced number of populations of native plants and fauna, including medium sized herbivores and vertebrate predators, are maintained in the region and is high when there are complete communities of plants and animals (including large predators), in which serial processes occur naturally.

Seen from the forestry point of view, according to the criteria of Maldonado and other authors, in 2006, mentioned by Komar, Schlein and Lara (2014), "it can be said that there is greater Ecological Integrity, insofar as the forest masses are formed by species typical of the formation or of the place and insofar as natural processes predominate in them, since these are the ones that finally generate the elements of structural diversity that we can appreciate, quantify and value".

According to the concept, it is related to the intensity of degradation produced by human or natural activities, which implies the loss or transformation of their functional characteristics. Elements to consider:

Low: the presence of native plants and medium wild herbivores is scarce. The natural processes of ecological succession have been significantly altered.

Medium: a reduced number of native plant and fauna populations are maintained, including medium-sized herbivores and predatory vertebrates.

High: there are complete communities of plants and animals (including large predators), in which serial processes occur naturally.

There is a guide structured by Komar, Schlein and Lara (2014) to provide clear definitions for ecosystem services, ecological integrity monitoring and integral biological monitoring. Criteria and indicators are established to assess ecological

integrity. Also included is a proposal for a tool to generate an ecological integrity index for Honduras and suggestions for the creation of monitoring programs. In particular, a format is provided for the creation of research and monitoring plans at the level of an area under management or conservation; however, this proposal allows for in situ analysis and comparison of sites using measurable indicators in a simple manner.

According to Gómez, (2017), in agroecological systems there are options and conflicts in the provision of

key services. This assertion is also true in protected areas and coastal zones.

In this research, a methodology is proposed with the objective of relating the concepts of ecological integrity and ecosystem services in mangroves, in search of food security and greater resilience to climate change.

As the scientific problem to be solved, how to relate the ecological integrity of the ecosystem, based on the ecosystem services provided by the mangroves, with the food security of the inhabitants of the coastal areas that possess them?

## MATERIALS AND METHODS

Theoretical methods of documentary research and empirical methods of surveys and scientific observation of professionals studying coastal ecosystems were used, using also the comparative method for the analysis in both areas selected for the study.

The concept of ecological integrity was taken to the ecosystem in question and the search for indicators was carried out. In this case, the following indicators were taken into account:

### Surroundings of the coastal marine coastline

- Presence of phytoplankton.
- Presence of diversity of fauna species: fish, juvenile species of commercial value, marine invertebrates, marine mammals.
- Terrestrial environment of the coastal litoral.
- Presence of the four Cuban mangrove species: *Rhizophora mangle* L.; *Avicennia germinans* L.; *Laguncularia*

*racemosa* L. Gaertn;  
*Conocarpus erectus*.

- Associated species.

### Presence of fauna:

- Bird fauna.
- Reptiles.
- Crustaceans.

### Celenterates.

### Terrestrial invertebrates.

Score: abundant: 3; moderately abundant: 2; low presence: 1; not present: 0.

### Indicator search

A total of 12 indicators were evaluated.

- High score 12 (3) = 36.
- Average score 12 (2) = 24 -  
Low score 12 (1) = 12
- Indicator ranges
- From 25 to 36 High Integrity.

- From 13 to 24 Half Integrity.
- From 1 to 12 Low Integrity.

Methodology of work (Proposal of the authors)

### Steps

1. Select two coastal areas, one with conserved mangrove and one with deteriorated mangrove, where there are communities close to it.
2. Delimit one hectare containing marine and terrestrial environment to carry out the assessment of ecological integrity. In order to do this, random sampling must be carried out in both environments by means of scientific observation points (these observations are carried out by experienced professionals who study the subject). Process information.
3. Carry out household research. Apply surveys and process statistically.
4. Verify if there is a correspondence between the Ecological Integrity of the ecosystem and the degree of satisfaction with the environment on the part of the coastal communities, so that they obtain food security.

### Application of surveys and interviews

Household research (food)

For the researcher who is going to apply the survey. Necessary data

Location of coastal community: total population.

To investigate in each dwelling: total number of tenants, occupancy of each one, salary income, housing conditions, hygienic-sanitary conditions, quality of drinking water, suffering from diseases.

Community survey questionnaire (prepared by the authors and carried out in October 2018).

"The objective of this survey is to determine your degree of satisfaction with your environment, as well as the food guarantee provided by the coastal ecosystem, especially the presence of mangroves, which are essential to maintain it. We collect your honesty and truthfulness in your answers, this survey is completely anonymous. (Thank you very much).

"Assign values from 0 to 3, with 3 being the maximum value for the following elements:"

The questionnaires appear in the results so as not to be repetitive. (Again, we reiterate our thanks).

## RESULTS AND DISCUSSION

### Application of steps of the methodological proposal

1. Two coastal zones were selected in the province of Pinar del Río: one with a certain degree of conservation and the other deteriorated, namely Punta Cortés and La Coloma-Las Canas, respectively.
2. In each one, one hectare is delimited with terrestrial and

marine environment, relatively close to communities and with the presence of mangrove species. An observatory inventory is carried out at randomly selected points, the results of which are shown below (Figure 1).

Zona Punta Cortés

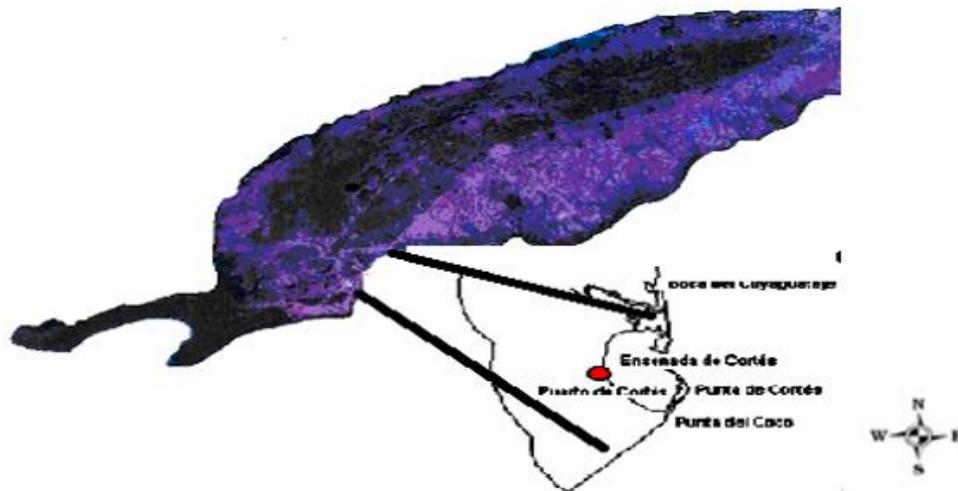


Fig. 1. Zona Cortés para selección del área conservada (Punta Cortés)

Protected Area of Managed Resources  
Punta Cortés (1 ha)

Score: abundant: 3; moderately abundant: 2; low presence: 1; not present: 0.

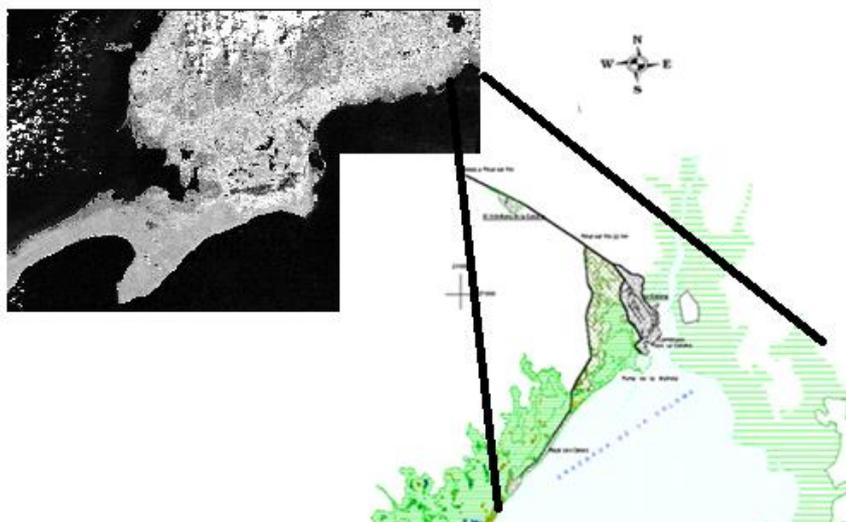
**Tabla 1.** Elementos indicadores a valorar en el espacio del ecosistema seleccionado. Área Protegida Punta Cortés.

<b>Elementos indicadores</b>	<b>Valoración</b>
Fitoplancton	3
Peces	2
Juveniles de especies de valor comercial	3
Invertebrados marinos	3
Mamíferos marinos	1
Especies del manglar cubano (Rm; Ag; Lr; Ce)	2
Especies asociadas	2
Avifauna	3
Reptiles	2
Crustáceos	2
Celenterados	2
Invertebrados terrestres	3
<b>Total: 12</b>	<b>28</b>

According to the indicator ranges, the score was 28, so it corresponds to High

Integrity, that is, from 25 to 36 (Table 1). This means that your ecosystem services are functioning properly (Figure 2).

**Sector Coloma-Las Canas**



**Fig. 2.** Sector Coloma-Las Canas para selección del área de manglar deteriorada

**Selection of 1 hectare of deteriorated mangrove swamp between La Coloma and Las Canas beach.**

Score: abundant: 3; moderately abundant: 2; low presence: 1; not present: 0.

**Tabla 2.** Elementos indicadores a valorar en el espacio del ecosistema seleccionado. Coloma-Las Canas.

Elementos	Valoración
Fitoplancton	1
Peces	0
Juveniles de especies de valor comercial	0
Invertebrados marinos	0
Mamíferos marinos	0
Especies del manglar cubano (Rm; Ag; Lr; Ce)	1
Especies asociadas	2
Avifauna	1
Reptiles	0
Crustáceos	2
Celenterados	1
Invertebrados terrestres	3
<b>Total: 12</b>	<b>11</b>

This places it in the range of Low Ecological Integrity, that is, from 1 to 12. (Table 2)

This means that their ecosystem services are not functioning properly.

3. The survey was applied to households, which once processed in both areas, both household research and general population, can highlight the following aspects:

### **La Coloma-Las Canas Sector**

#### **Household research**

Total inhabitants: 8 807, taking from them the closest to the monitored hectare, which was 1200, being the sample size, and therefore, the respondents 290 for an  $\alpha=0.05$ ,  $d=0.05$  for a 95 % confidence.

#### **For each house**

Total tenants: approximately four to six members.

Occupation of each one: generally, the men are dedicated to fishing and other work within the Combinado Pesquero; of the women, 56 % work in schools and the Combinado, as well as in other institutions, the rest are housewives. School-age children attend schools according to the type of education.

Income: between 300 and 600 pesos National Currency (MN), which is low compared to the price of products in the market.

Housing conditions: in the case of La Coloma the condition of the houses is better than in Playa Las Canas, although in the latter they are scarce due to migration to La Coloma.

Hygienic-sanitary conditions: there is no sewerage, the discharges are not properly controlled either, so there is pollution.

Quality of drinking water: it is generally brackish water because the aquifers in that area are salinized by overexploitation, mainly for agriculture.

Suffering from diseases: cases of suffering from diseases are isolated, in this sense it behaves normal according to the age of the settlers.

#### **General results of the surveys by questions**

Valued on a scale of 0-3, with 3 being the highest value, the following elements of the coastal ecosystem:

Coastal fishing: 80 % of those surveyed state that there is hardly any coastal fishing, giving a valuation of 1, that is, low, the rest values with 2.

Mangrove conditions: 100 % give a score of 0, which infers that the mangrove conditions in that area are highly deteriorated.

Terrestrial fauna: 63 % value with 2 this aspect, but they refer fundamentally to the presence of crabs in epoch, of insects and scarce birds, 27 % value with 1 and 10 % offers value of 0. From all this it is inferred that there exists shortage of terrestrial fauna, due to the terrible conditions of the mangrove.

Birds: 76 % value with 1 and 24 % give a value of 2. In general, sighting is scarce.

Presence of beekeeping: 100% value with =, so there is no beekeeping in the area.

Quality of the environment in general: 95 % value with 1 and the remaining 5 % gives a value of 2.

In spite of the results obtained in the surveys, in an interview with workers of the Combinado Pesquero about the fishing production, they indicate that it

behaves within the normal parameters, which is logical, since the majority of the species go to the mangroves of the cayería de San Felipe, which is in better conditions, to fulfill its first stages of life. Similar results were obtained by Milián, (2003), Rodríguez (2003) and Bustio, (2004), although the deterioration at that time was less in comparison with the present time.

2. How to use the mangrove swamp? Continue with the previous assessment.

Wood for firewood or charcoal: 55 % state a valuation of 3 in the use of the mangrove for firewood and charcoal, 20 % value with 2 and the rest with 1.

On a tour of the area it was possible to find out that this is due to the fact that there is non-compliance with legislation in this sense, as they sell charcoal to private pizzerias.

Coastal fisheries: this use is low, the valuation was 1 according to 90 % and 0 for the rest of the respondents, which coincides with the first question.

Red mangrove bark for medicinal or other purposes: 100 % value with 1, which means that this use is not typical in that area.

Hunting reptiles: 93 % rate with 1 and the rest with 2. In reality, reptiles are scarce under deteriorated forest conditions.

Catching crabs: 100 % value with 3, but in the rainy season and especially for sale.

Hunting sea turtles: 100 % value with 1, this is not a frequent use in the area.

Use of tree elements for handicrafts: 35 % value with 2 and 28 with 1 and the rest with 0. This use is restricted.

3. Continue with the same assessment

a) Do you feel comfortable where you live? 56 % say they feel comfortable with a rating of 3, the rest rate with 1.  
b) Do you think your family is food secure? The majority, that is, 65 % value with 2 and the rest with 1, this is due to the presence of the Combined that to some extent guarantees an average food security that does not reach the desired standard, to this is added the low wage level.  
c) What is the quality of agricultural soils like? 100 % give a rating of 1, most of them are salinized.  
d) Do you get quality food products from them? In the same way, they value of 1, that is to say, the few products that they manage to obtain do not have quality.  
e) Do you have a family garden? Yes 10 % No 90 %. If it is affirmative, say its quality according to previous evaluation 1, that is to say, it is not good.

As can be seen in the comparison with the assessment by ecological integrity indicators, there is a coincidence that the marked deterioration of the mangrove has an influence on the poor quality of ecosystem services, as well as not contributing to the food security of coastal communities.

### **Town of Cortés**

#### **Household research**

Total population: around 4,000, but those close to the monitored hectare are taken.

#### **For each house**

Total number of tenants: approximately between 4 and 6 members.

Occupation of each: men are mostly engaged in fishing and other work in the business sector; of women, 65% work in schools and the rest are housewives. School-age children

attend schools according to the type of education.

Salary income: varies between 300 and 600 pesos MN, which is low compared to the price of products on the market.

Housing conditions: housing in general has adequate conditions.

Hygienic-sanitary conditions: in some cases, there is no sewerage system, but in most cases there is and it is properly caused.

Quality of drinking water: it is generally potable water.

Suffering from diseases: cases of suffering from diseases are isolated, in this sense it behaves normal according to the age of the settlers.

General results of the surveys by questions

Value on a scale of 0-3, with 3 being the highest value, the following elements of the coastal ecosystem:

Coastal fishing: 90 % of those surveyed state that there is hardly any coastal fishing, giving an assessment of 2, which is average.

Mangrove conditions: 80 % give an assessment of 2, from which it can be inferred that the mangrove conditions in that area are regular.

Terrestrial fauna: 93 % value with 2 this aspect, 7 % value with 3.

Birds: 86% rate with 2 and 14 % rate with 3. In general, the sighting is from regular to good.

Presence of beekeeping: 100 % value with 2, so there is beekeeping in the area, but not of superior quality.

Quality of the environment in general: 95 % value with 2 and the remaining 5 % offers a value of 3.

Comparing results, in this zone mangrove conditions favor the provision of ecosystem services, although in a general average assessment, this is due to the fact that the proximity of the mangrove to the communities does not have the optimum quality; it should not result in the vicinity of the protected area, where the quality of the same is superior according to previous results of indicators that value ecological integrity. Similar results were obtained by Milián (2003), Bustio (2004), as well as Rodríguez *et al.*, (2014) who investigated the area.

2. How to use the mangrove swamp? Continue with the same assessment as above.

Its wood for firewood or charcoal: 55 % affirms valuation of 1 in the use of the mangrove for firewood and charcoal, 20 % values with 2 and the rest with 0. This shows that there is still legislative nonobservance. This coincides with the results of research carried out by Martínez, (2017).

Coastal fisheries: this use is average, the valuation was 2 according to 95 % and 1 by the rest of those surveyed.

Red mangrove bark for medicinal or other purposes: 100 % value with 1, which means that this use is not characteristic in this area either.

Hunting reptiles: 83 % value with 2 and the rest with 0. In reality, this use is medium to scarce.

Catching crabs: 100 % value with 3, but in the rainy season and especially for sale.

Hunting sea turtles: 90 % value with 1 and 10 % with 0; this is also not a frequent use in the area.

Use of tree elements for handicrafts: 25 % value with 2 and 38 % with 1 and the rest with 0. This use is also restricted.

3. Continue with the same assessment.

a) Do you feel comfortable in the place where you live? 90 % say they feel comfortable with a rating of 3, the rest rate with 2, which infers that they feel comfortable in the place where they

As can be seen in the comparison with the assessment by indicators, there is agreement that the better condition of the mangrove forest influences the quality of ecosystem services, as well as contributing to some extent to the food security of coastal communities. The results coincide with the studies of Days (2009) in the same sector Cortés

The methodology used made it possible to demonstrate, to some extent, that there is a relationship

live.

b) Do you think your family has food security? 75 % value with 2 and the rest with 1, this may be related to the low salary level.

c) How is the quality of the agricultural soils? 100 % give a rating of 2; most of them are regular, although those close to the Cuyaguaje river have better conditions.

d) Do you get food products with quality in them? They value 2, that is, the quality is average.

e) Do you own a family orchard?: Yes 70 % No 30 %. If yes, state your quality according to previous evaluation (2), that is, regular.

between the ecological integrity of mangrove ecosystems with the services they provide and, in turn, with the food security of coastal populations.

There is still a lack of legislative enforcement, which contributes to the deterioration of the mangrove as the main anthropogenic cause, as well as low salaries, an element that must be improved in order to guarantee higher quality food security.

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