

# Utilization of plant species in mangrove swamp: ruminant herders' perception of treats and strategies for mangrove sustainable restoration in Benin (west-Africa)

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## Research Article

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# Abstract

In Benin, mangroves are an important resource for the coastal populations who use them for firewood, salt preparation but also for feeding ruminants in the surrounding meadows. However, the pressure exerted by exploitation on fodder in the mangroves has not been quantified. This study aims to understand the relationship between mangroves and ruminants in the coastal zone of Benin. Ethnobotanical data were collected from ninety (90) ruminant breeders in fifteen (15) villages close to mangroves along the coastal belt, using individual interviews and group discussions combined with a tourist guide and a semi-structured questionnaire. The herders provided, among other things, mangrove species used as food and for ruminant health. Cross-tabulations, with calculation of chi-square statistics, were used as well as means and standard deviation values of continuous variables calculated and compared between mangrove trends observed using the non-parametric Kruskal-Wallis test. *Rhizophora racemosa*, *Avicennia africana*, *Paspalum vaginatum*, *Zanthoxylum zanthoxyloides* and *Blutaparon vermiculare* were the species mentioned. Local communities are aware of the need to restore and ensure the sustainable conservation of mangrove ecosystems. The main restoration and conservation measures indicated by the pastoralists are the planting of mangroves, rational logging through the control of logging, no fires after logging. These measures vary according to ethnicity and depend significantly ( $p < 0.001$ ) on the type of mangrove. However, these modes of exploitation of mangroves by livestock breeders have no effect on their dynamics. However, the involvement of farmers is dispensable for the conservation of mangroves.

## 1. Introduction

### 1.1 Background

All over the world, mangroves are considered as one of the highly vulnerable forest ecosystems (Rafique, 2018). Mangrove forests are located mostly at the transition between freshwater and saline water environments (Giri et al. 2011, 2015). With an estimated worldwide area of up to 16.4 million ha in 2014 (Hamilton and Casey, 2016), mangroves provide a variety of valuable ecosystem services or the benefits provided by ecosystems to humans, such as carbon sequestration, coastal barriers, shoreline protection, food, fuel, building materials, and biodiversity protection, among others (Estoque et al. 2018; BOBLME, 2014). Sometimes mangroves are deforested for urban development and for land and industries housing (Teka et al. 2019). Construction progress that makes use of protected zone as a new area significantly results in overlapping, and irregular space utilization (Hermon et al 2018). Accurate estimation of the rate of mangrove forest cover change is further essential to correctly inform conservation policies designed to reduce functional losses (Friess and Webb, 2014). Despite the remarkable social, ecological, and economic importance of mangroves, these ecosystems have become the most endangered habitats due to ever increasing human activities and climatic susceptibilities (Rafique, 2018).

A part from the different uses, mangroves are used as fodder by surrounding populations to feed their animals essentially ruminants in Republic of Benin and others countries of West Africa (Faye, 1993; Teka

et al. 2012). Livestock contributes on average 13% to the GDP (Gross Domestic Product) of the Republic of Benin (FAO, 2017). Mangroves are thus important pastures grazed by livestock according to 26.25% of the surrounding populations in the Republic of Benin, and parts of species such as leaves, grass, pods can be harvested as fodder and sold or preserved for the dry season according to 16.94% of the same populations (Baglo, 2005). Local communities use mangroves for fodder for their livestock (Rafique, 2018). Given the crucial importance of livestock systems for sustaining rural livelihoods in many arid and semi-arid parts of the world that are facing climate and non-climate threats, the need for empirical, micro-level analyses of the processes by which pastoral communities understand and experience climate change and utilize coping or adaptation pathways in response to these effects is emphasized (Fratkin, 2001; Krätli et al. 2014). Assessment and valuation of these mangroves services are increasingly advocated in development and conservation decision-making (Rahman et al. 2018). More recent evidence points, is how pastoralism can support livelihoods and food security, as well as biodiversity and conservation (Krätli et al., 2014). Indeed, given the ability of pastoralism in dealing with harsh environments, its relevance emerges in offering a robust and reliable production system in the face of climate or livelihood variabilities (Kalpana et Smita 2018).

However, some previous work on mangrove ecosystems in this area has focused on mangrove interests for human populations, in particular medicinal, food and other uses for human well-being (Adite et al. 2013; Dossou-Yovo et al. 2017) but also on the floristic and faunal inventory of mangrove ecosystems and coastal wetlands in Benin (Sinsin et al. 2018) and the conservation (Teka et al. 2019). Although these authors mentioned the use of mangrove species for livestock production mainly as fodder, they did not provide, as in other countries like Senegal, New Zealand (Faye, 1993; Maxwell, 2015; Maxwell and Lai, 2012), on their other potential uses, locally exploited mangroves for this purpose, the parts or organs used for each plant, how they are used and animals for each resource. Such information is important because it will improve future-focused models as well as climate change adaptation planning and restoration efforts (Osland et al. 2015).

## **1.2 Assumption and objectives**

The main objectives of the study were to assess the patterns of use of mangroves for livestock farmers, evaluate the threats that ruminant livestock farming generates on mangrove ecosystems and identify socio-economics determinants of mangrove restoration and conservation program success. With the present study, we hypothesize that the ethnic origin of the respondents affect their contribution in enhancing mangrove management and conservation actions in the coastal areas of Benin.

# **2. Methods**

## **2.1 Study area**

The study area included the communes of the coastal belt of Republic of Benin except Cotonou city (figure 1). This area constitute the strict part of the coastal area which spans between 1° 44' 30" to 2°37'00 Eastern longitude from Togo in the West to Nigeria in the East and between 6° 15' 50" to

6°44'85"Northern Latitude. It takes into account 39 communes and covers an area of about 12,000 km<sup>2</sup>, corresponding to approximately 10.5 % of the country territory (Teka et al. 2012). This study was conducted in the strict coastal zone that comprises the five coastal communes which have access to the sea (Sèmè-Podji, Cotonou, Abomey-Calavi, Ouidah and Grand Popo). However, Cotonou was not investigated for absence of mangroves swamps (Figure 1). The climate is sub equatorial type with two wet seasons, from April to July and mid-September to October; and two dry seasons, from December to March and from mid-August to mid-September. The annual rainfall ranges from 820 mm to 1300 mm, with temperatures varying between 25°C and 27.7°C. The most significant soil types are sandy soils, hydromorphic soils, and ferralitic soils (Adam and Boko, 1993). Though very diverse, the plant communities in the coastal zone are dominated by *Rhizophora racemosa* and at some extent *Avicennia africana*. *Rhizophora racemosa* grows in the intertidal zone while *Avicennia Africana* grow on the adjacent wetlands at the back part of *Rhizophora racemose* (Adite et al. 2013). The coastal area of Benin is mainly populated by the Fôn, Mina, Houeda and Xwla. The economic activities are composed of agriculture, fishery, livestock breeding, salt production, processing of agricultural products, small commerce, marine sand exploitation and hunting (Teka et al. 2019).

## 2.2 Sampling and data collection

An ethnobotanical survey was conducted in the surrounding villages of four (04) sites of mangrove (S1: Sèmè-Podji, S2: Abomey-Calavi, S3: Ouidah, S4: Grand Popo). Breeders were interviewed in fifteen (15) villages close to the mangrove swamps. Those villages were chosen regarding the existence of breeders that exploit mangrove swamps and the presence of others socio-professional groups which use the mangrove, such as traditional healers, fishermen and women specialized in salt production. The research population involved three type of breeders; cattle herders (n=15), sheep and goat breeders (n=75).

A total of ninety (90) breeders was selected using snowball sampling method and they were interviewed individually. Non-random snowball sampling consists to identify a competent informant for the study's subject then this informant after survey indicates in turn another competent informant in the same community (Houéhanou et al. 2015; Ahoyo et al. 2017). Basically, the data were collected from October to November 2017, using individual interviews based on semi-structured questionnaire combined to the tour guide, and the group discussions for a generalizing of information. The tour guide is a visit of field with some members of the investigated community that are qualified for the determination of the plants cited following their local names (Houéhanou et al. 2015). The breeders were asked to provide local names of the mangrove plant species used as feedstuffs and medicine, the diseases or disorders treated with them, and the plant organs used. They were also asked to indicate the breed of animal treated for each plant mentioned. Samples of species identified or not in the mangrove swamps were collected for confirmation or identification of their scientific name at the National Herbarium of Benin at the University of Abomey-Calavi.

Discussions were based on a semi-structured questionnaire around questions related to the socioeconomic characteristics of a farm, herd data and the feeding management of natural resources

including mangrove forests and others resources. From discussions with them corroborated with those of local authorities and association managers, mangrove swamps have a degraded status along coastal belt. While, important restoration efforts are implanted in the area, the current trend of mangrove swamps is either still degraded or in restoration. Farmers' were asked to give an evaluation of the importance of mangrove's resources. The questions related to the actual conservation status of mangroves, their management, threats for their sustainability and issues for their rational use were moreover discussed.

## 2.3 Data analysis

Ethnobotanical indices based on the popularity and the versatility of species (woody and herbaceous species) of the mangrove areas were calculated. It was applied the relative frequency of citation (RFC) according to Tardío and Pardo-de-Santayana, 2008; to assess the importance of each species through the use categories ('versatility of observed species'). The RFC was calculated then by dividing the number of breeders, who mention a given use of the species, by the number of breeders participating in the study. The Use Value (**UV**) of each species ('popularity of observed species') was computed for each ethnic group following Phillips and Gentry, 1993 simplified by Rossato et al. 1999 by:

$$UV = \frac{1}{N} \sum_{i=1}^{In} U_i$$

Where  $U_i$  represent the number of uses mentioned by a breeder  $i$  and  $N$  represent the total number of breeders interviewed. Afterwards, this index was used to perform a correspondence analysis in order to show use differentiation of each species between ethnic groups with R version 3.6.0 (package FactoMineR). The livestock production system was characterized in relation to the conservation status of mangrove areas revealed by interviews. Cross-tabulations with calculation of chi-square statistics at 0.05 probability level from its qualitative characteristics, were used to test the independence between the conservation status of mangrove swamps and the practice of farm activities around or into these ecosystems whereas means and standard deviation values of the continuous variables were calculated and compared across mangrove trends using the non-parametric test of Kruskal-Wallis W.

With regard to conservation strategies, cross-tabulations and chi-square statistics were used to analyse the relationship between ethnic groups and mangrove types. Then, a stepwise logistic regression analysis using the backward procedure was carried out to identify the socio-economic factors that affect the choice of a given future conservation (1: displacement or 2 others) and the adoption of food restrictions by the herders. All the analyses were performed in R version 3.6.0 (R Core Team, 2019).

## 3. Results

### 3.1 Ethnobotanical knowledge of breeders on mangrove use for livestock

#### 3.1.1 Characteristics of farm production systems

Descriptive results show that ruminant livestock farming in Benin's coastal belt was practised by both men and women. The average age of the cattle farmers was  $43.2 \pm 17.29$  years while the average age of the small ruminant farmers was  $51.04 \pm 16.02$  years. The origins were diversified, especially for cattle breeders with a seniority of  $31.53 \pm 18.79$  years. The latter almost all belonged to the Fulani socio-cultural group, and came from the country of Niger and Northern Benin (Natitingou, Savè, Malanville and Karimama) and were using mangrove swamps for  $19.93 \pm 16.62$  years. Livestock farming was their one and only activity.

The small ruminant farmers were almost all Beninese and raised sheep and/or goats with a use period of  $14.71 \pm 11.58$  years. This group practiced animal husbandry as a second activity, while the main activity related to the use of the mangrove was fishing and/or traditional medicine for the men, and for the women salt production. They were all indigenous and belonged mainly to the Xwla, Peda, Fon ethnic groups and to a lesser extent to other groups (Yoruba, Goun, Evé and Nago), with a duration of mangrove use of  $21.65 \pm 13.53$  years.

Three types of farming systems related to livestock have been identified in the area. These are family farming (81.11%), open-air farming (13.33%) and coconut plantation farming (5.56%). For family farming, the animals encountered were only sheep and  $5.59 \pm 3.12$  goat heads that were reared in a controlled area, either rambling, in sheepfolds or folds. The size of the livestock encountered is  $42.20 \pm 52.29$  head of cattle in the open-air farms and  $101.40 \pm 65.65$  head of cattle in the coconut plantations. For the group of cattle, the breeds most commonly found in the zone were the lagoon, followed by the Azawouak, Gougali, and to a lesser extent the Bobodji, Yakana, Borgou, and Djabadjaba breeds. In contrast, for the small ruminant group, the breeds encountered were mainly Djallonké and some Sahelian breeds.

### 3.1.2 Plants used by herders

Five mangrove species were used in ruminants breeding. There are trees like *Rhizophora racemosa*, *Avicennia africana*, herbaceous perennial legumes such as *Zanthoxylum zanthoxyloides* and *Blutaparon vermiculare* and, a grass *Paspalum vaginatum*. For each species, parts used, the animal type fed and the using areas were documented (table 1).

#### **Table 1. Mangrove species used in ruminants breeding**

Species used	Local names	Parts used	Animal type	Using areas
<i>Rhizophora racemosa</i>	Xwéto (Xwla, Fon) or Guiogba (Goun)	leaves, bark, flowers, young stalk, seeds, wood	Sheep and Goats	Abomey- Calavi Ouidah Grand Popo
<i>Avicennia africana</i>	Akpontin (Xwla)	leaves, bark, young stalk, seeds, wood	Sheep and Goats	Ouidah Grand Popo
<i>Paspalum vaginatum</i>	Gbakon (Xwla) or Woko (Goun) or Tchitchiri (Fulani)	leaves	Cattle, Sheep and Goats	All 04 communes
<i>Zanthoxylum zanthoxyloides</i>	Hêtin (Xwla, Fon)	leaves	Sheep and Goats	Abomey- Calavi Ouidah Grand Popo
<i>Blutaparon vermiculare</i>	Djèdjè (Xwla)	leaves	Sheep and Goats	Ouidah

Table 1 revealed that, according to the breeder, the mangrove species *R. racemosa* and *A. africana* were used only for small ruminants. Cattle mainly grazed the grasslands of mangrove ecosystems, where *Paspalum vaginatum* is prevalent. Almost all parts of the two mangroves species (*R. racemosa* and *A. africana*) were used whereas only leaves from the other plant species were used.

### 3.1.3 Pastoral importance of the mangrove species for breeders

Mangrove species were mentioned in four (04) use categories namely feeding, health, sheepfold or fold building, and reproduction management. However, for each species mentioned above, the number of use categories varied as presented in table 2.

**Table 2. Use categories with citation rate and parts used per species**

Species used	Use categories	Citation rate (%)	Parts used
<i>Rhizophora racemosa</i>	Feeding	55.55	leaves, bark, flowers, young stalk, seed
	Sheepfold or fold building	5.55	wood
	Health	2.22	leaves
	reproduction management	1.11	leaves, bark
<i>Avicennia africana</i>	Feeding	27.77	leaves, bark, young stalk, seed, wood
	Sheepfold or fold building	1.11	wood
<i>Paspalum vaginatum</i>	Feeding	64.44	leaves
<i>Zanthoxylum zanthoxyloides</i>	Feeding	21.11	leaves
	Health	21.11	leaves
<i>Blutaparou vermiculare</i>	Feeding	8.88	leaves

All species cited were used for animal feeding; and *R. racemosa* (55.6%), *P. vaginatum* (64.44%) and *A. africana* (27.78%) were mainly cited for this use category.

*Z. Zanthoxyloides* (21.11%) leaves were used for animal health especially against diarrhoea and skin diseases. *R. racemosa*, mentioned in all the use categories, was used for sheepfold building (5.56%), and its leaves and bark in reproduction management (1.11%), indeed, this specie is given to sheep for obtaining more male descendants than female ones.

In particular, the different parts of native mangroves species like *R. racemosa* and *A. Africana*, were diversely used in animal feeding (Figure 2). Leaves (55.55% and 27.77%) and bark (35.55% and 16.66%), respectively for *R. racemosa* and *A. Africana*, were most parts ingested by small ruminants. Also, flowers and young stalks from *R. racemosa* and wood of *A. africana* were well used.

### 3.1.4 Mangrove plant's utilization according to ethnic groups

The correspondence analysis performed (Figure 3) showed that the two first axes explained 93.34% (axis 1=67.92% and axis 2=25.42%) of the total variation. Only these axes were used to describe the relationship between ethnic groups and mangroves species use in ruminants breeding.

Considering axis 1, *R. racemosa*, *B. vermiculare* and *A. africana* constituted the resources used by autochthon fisheries areas ethnical groups Xwla and Peda. In contrast, *P. vaginatum* was the only species

preferably used by foreigners from Fon and Fulani ethnic groups. On axis 2, *Z. Zanthoxyloides* was correlated with other ethnic groups namely Goun, Nagot, Evé and Yoruba.

### 3.2 Ruminants production systems

#### 3.2.1 Perceptions of the causes of mangrove degradation

Irrespective of age, almost all the herders interviewed (100%) indicated that they perceived some changes in mangrove swamps. Indeed, 42.2% of herders surveyed perceived degradation of mangrove ecosystems and 57.8% perceived mangrove restoration.

Figure 4 presents data on the causes of degradation of mangrove ecosystems according to the herders identified. It is clear that anarchic exploitation and the use of mangrove species for firewood (57.82%) and salt production (26.30%) are the main source of perceived degradation. Many (47.39%) breeders acknowledged their dependence on mangrove swamps and surrounding grasslands for livestock breeding and that their full degradation could constitute a hindrance for their activity.

The farmers surveyed mentioned some restoration measures to ensure the conservation of degraded mangrove ecosystems in southern Benin. Informants agreed to plant mangroves (*Rhizophora racemosa* and *Avicennia germinans*), but suggested finding alternatives for firewood. According to the same informants, the restoration and effective conservation of mangrove ecosystems in southern Benin requires a participatory approach between the state and the resident population.

#### 3.2.2 Socio-economic characteristics of farms around degraded or restoring mangroves

The socio-economic characteristics of mangrove farms that have been degraded or are being restored in the selected farming systems are presented in Tables 3 and 4. The level of formal education of the herder, his ethnic group and religion, his form and scale of use of mangrove resources, and his main livestock, vary significantly ( $p < 0.001$ ) from one area to another where mangroves are being restored or degraded. In areas characterized by a strong degradation of mangroves (mainly Sèmè-Podji and Abomey-Calavi), nearly half of the herders were not enrolled in school and were from the Peulh (23.7%), Fon (21.1%) or other ethnic groups (Yoruba, Mina, Goun, Nago, Evé) (15.8%). They mainly practiced Islam or Christianity. Cattle were raised significantly with an average of  $56.70 \pm 63.29$  heads associated or not with a small herd ( $2.71 \pm 2.05$  heads). The number of mangrove trees and related species mainly coveted for animal feed was on average  $1.39 \pm 0.95$ , but were much more used as substitute feed by 52.6% of them. The remaining pastoralists used these resources as their main feed.

**Table 3. Qualitative characteristics of farms around mangroves areas**

Variables	Mangrove trend		$\chi^2$	$P (\leq)$
	Degradated	Restoring		
	(%) n=38	(%) n=52		
<b>Areas</b>			30.825	0.000
Ouidah	28.9	57.7		
Abomey-Calavi	15.8	0.0		
Sèmè-Podji	31.8	0.0		
Grand-Popo	23.7	42.3		
<b>Gender</b>			0.454	0.500
Male	68.4	61.5		
Female	31.6	38.5		
<b>Formal education</b>			10.092	0.006
Elementary	23.7	55.8		
Secondary	28.9	11.5		
None	47.4	32.7		
<b>Another occupation</b>			6.239	0.101
Fishing	28.9	44.2		
Salt preparation	18.4	23.1		
Traditional medicine	0.0	3.8		
None	52.6	28.8		
<b>Ethnic group</b>			16.842	0.002
Xwla	34.2	61.5		
Peda	5.3	19.2		
Fulani	23.7	7.7		
Fon	21.1	7.7		
Others	15.8	3.8		
<b>Religion</b>			8.190	0.017
Traditional	42.1	71.2		
Christian	31.6	19.2		
Muslim	26.3	9.6		
<b>Farming types</b>			2.372	0.305
Family	73.7	86.5		
In fresh air	18.4	9.6		
Under coconuts	7.9	3.8		
<b>Mangrove resources as alternative feedstuffs</b>			5.227	0.022
No	47.4	71.2		
Yes	52.6	28.8		
<b>Breeders' groups</b>			4.409	0.036
Cattle	26.3	9.6		
Small ruminants	73.7	90.4		
<b>Age</b>	42.2	57.8	8.246a	0,01

<b>≤ 30 years</b>	10.0	2.2
<b>31 - 59 years</b>	22.2	35.6
<b>≥ 60 years</b>	10.0	20.0

Conversely, sheep farming was more developed ( $9.36 \pm 10.35$  head) associated with a significant development of goat farming (90.4% of the herders) with an average of  $6.20 \pm 3.70$  head in areas very characterized by mangrove restoration (mainly Grand Popo and Ouidah). Mangroves and related species used to feed these animals were significantly higher ( $P < 0.05$ ) with an average of  $2.02 \pm 1.17$  species and were used by 71.2% of the herders as their main food. Vodoun" was the religion practiced by the majority of herders (71.2%) who belonged to an Xwla (61.5%) or Peda (19.2%) community. Here, the majority of herders (67.3%) attended school. Herders in degraded mangroves were younger ( $46.42 \pm 16.72$  years) than those in mangroves under restoration ( $52.15 \pm 15.89$  years). In fact, the age group that perceives the most changes is between 31 and 59 years old, both in degraded mangroves and in areas under restoration. Age varies significantly according to the proximity of degraded or restored mangroves ( $p < 0.01$ ).

**Table 4. Quantitative characteristics of farms around mangroves areas**

Quantitative variables	Degradation (n= 38)	Restoration (n= 52)	P-value
<b>Oldness (years)</b>	$15.58 \pm 13.32$	$18.92 \pm 15.08$	0.251
<b>Cattle size (heads)</b>	$56.70 \pm 63.29$	$72.40 \pm 63.50$	0.759
<b>Sheep size (heads)</b>	$2.71 \pm 2.05$	$9.36 \pm 10.35$	0.012
<b>Goat size (heads)</b>	$4.60 \pm 2.25$	$6.20 \pm 3.70$	0.118
<b>Use duration of mangrove areas (years)</b>	$19.24 \pm 13.52$	$22.92 \pm 14.27$	0.213
<b>Number of mangrove species used</b>	$1.39 \pm 0.95$	$2.02 \pm 1.17$	0.02

The results of the logistic regression analysis are presented in Table 5. Socio-economics characteristics of the farmers which was likely to influence their willingness to participate in the mangrove conservation strategy were used in the analysis. The age of the herders, his education level, ethnic group, farm localization in the coastal area, religion and herders types (cattle or small ruminants' keepers) were selected as predictors. Variables much correlate with the others like education level, religion and herder types were removed from predictors list. Among the remaining variable, the backward logistic regression permit to retain the age of the herders and his ethnic group as suitable to predict farmers willingness to contribute in enhancing mangrove restoration and conservation. Indeed, the full model was statistically significant, indicating that the predictors (age and ethnic group) as a whole, reliably distinguish farmers' with practices contributing to mangrove restoration and the others ( $df = 6$ ,  $\chi^2 = 24,470$ ,  $p < 0,001$ ). The Nagelkerke  $R^2$  value of 0.320 indicates a moderately strong relationship between prediction and aggregation. The non-significance of Hosmer and Lemeshow's test confirmed the validity of the regression model. The success of the prediction as a whole was 68.42% for the group of herders who

reported degradation and 76.92% for those who contribute to restoration strategy for better conservation of mangrove resources. The  $e^{\beta}$  values indicate that when the herders is an adult (31-59 years old) the odds ratio is 0.130 times as large. This odds ratio is 9.328 and 19.85 times greater that when the herders is of Peda or Fulani ethnic groups, respectively. These results imply that the probability that a herder contribute in enhancing actions for mangroves conservation increases in adult herders farms and around farms kept by Fulani and Peda people.

**Table 5: Prediction of the contribution to mangrove restoration in southern Benin by logistic regression analysis (n = 90)**

Predictor	$\beta$	SE of $\beta$	Wald's $\chi^2$	df	P value	$e^{\beta}$ (odds ratio)
<b>Constant</b>	-0,495	0,382	1,681	1	0,195	0,609
<b>Age (<math>\leq 30</math> years)</b>			5,75	2	<b>0,056</b>	
<b>Age (31-59 years)</b>	-2,037	0,946	4,63	1	<b>0,031</b>	0,13
<b>Age (<math>\geq 60</math> years)</b>	0,083	0,561	0,022	1	0,882	1,087
<b>Ethnic groups (Xwla)</b>			13,733	4	0,008	
<b>Peda</b>	2,233	0,897	6,194	1	<b>0,013</b>	9,328
<b>Fulani</b>	2,988	1,163	6,599	1	<b>0,010</b>	19,851
<b>Fon</b>	0,602	1,032	0,340	1	0,560	1,825
<b>Others</b>	0,764	1,043	0,536	1	0,464	2,147
<b>Test</b>						
<b>Overall model evaluation (Model <math>\chi^2</math>)</b>			24,47	6	0,001	
<b>Goodness of fit test (Hosmer and Lemeshow)</b>			3,669	6	0,721	
<b>-2 Log likelihood= 98.110a</b>						
<b>Cox &amp; Snell R Square=0,238</b>						
<b>Nagelkerke R Square= 0,320</b>						

### 3.3 Breeders' point of view about sustainable use of mangrove swamps

People surveyed revealed some threats to mangrove sustainability. Uncontrolled exploitation including burning of stumps after cutting (24.6%), salt preparation and firewood needs (68.8%), human settlement (4.4%) and fishery (2.2%) were mentioned. Paradoxically, no threats were mentioned regarding ruminant grazing around or into mangrove swamps. Nonetheless, breeders suggested some issues for its sustainable use. Figure 5 presented the proposed strategies for mangroves restoration and conservation.

This figure showed that most of small ruminants' owners suggested mangroves trees planting (42.7%) and cutting control (32%), while cattle owners emphasized a better management of conflicts farmer-breeder (33.3%), for this resource conservation. Management review including participative management was also proposed by both cattle's breeders and breeders of small ruminants. Figure 6 showed that close to degraded mangroves, the strategies most used by farmers are planting mangroves (52.61%), followed by rational exploitation by controlling cutting (18.48%). On the other hand, close to restored mangroves, the most used conservation strategies are mostly rational exploitation through the control of cutting and management (38.41%) followed by mangrove planting (28.89%) and participatory management and resource sharing (15.40%). These strategies varied significantly ( $p \leq 0.001$ ) between the two groups.

Regarding its conservation strategies according to ethnic groups, Figure 7 shows that the local ethnic groups Xwla (20%) and Peda (4.4%) are the most involved in the conservation or restoration of mangrove ecosystems through planting and rational exploitation through logging control. However the Peda are the only ethnic group that prohibits the burning of stumps after logging. On the other hand, for the Fulani and fons ethnic groups, apart from mangrove planting and their rational management, propose participatory management and the planting of other species for fons populations while the Fulani suggest mainly the promotion of good management of conflicts between farmers and herders. The adoption of these strategies has been strongly influenced by the ethnic group of the herder ( $p \leq 0.001$ ).

## 4. Discussion

### 4.1 Mangrove swamp use by breeders

Mangrove forests provide critical services around the globe to both human populations and the ecosystems they occupy (Romanach et al. 2018). These mangrove wetlands, found globally in tropical and sub-tropical coastal areas (FAO 2010), offer a wide range of ecosystem provisioning, regulating, cultural and supporting services (Rahman et al. 2018). Our results show, on the one hand, that along the coastal belt of southern Benin, five species of mangroves have been used for ruminant breeding. All these species were named in a diverse manner according to the ethnic groups encountered in the area. The species, which had a wide geographical distribution or were used by many ethnic groups or for many purposes, were named in a much more varied way. For example, *Paspalum vaginatum* was the most diversely named species. It was mainly named by the Xwla, Peda and Fon as Gbakon, by the Goun as Woko and by the Fulani as Tchitchiri. This species, which characterizes wetlands, was distributed along the coastal zone in southern Benin and was used in animal feed for cattle, sheep and goats by all the ethnic groups encountered. This is explained by the fact that this grass dominated the grasslands surrounding the mangrove swamps, where cattle as well as sheep and goats mainly grazed. Their leaves were the preferred parts of these animals, as well as for four other species mentioned. On the other hand, the *Blutaparon vermiculare* was only named as Djèdjè by Xwla and also by Peda. Indeed, this plant was only found in the town of Ouidah where these ethnic groups were important. It was only used to feed goats and sheep after its harvest in the mangroves. Similarly, *Zanthoxylum zanthoxyloides* was only named as Hêtin by Xwla, Peda and Fon, and was used in cattle feed mainly for phytosanitary treatments.

Among the two woody species, *Rhizophora racemosa* appeared to be the most useful and was named as Xwéto by all ethnic groups, except Goun who named it as Guiogba. Nevertheless, it was known to all ethnic groups but was not used by all. It was only used for feeding sheep and goats and rarely for their health, the construction of their folds and the control of reproduction in sheep farming. The latter was not used in Sèmè-Podji despite their presence in the mangroves of this commune. As for the *Avicennia Africana*, this last species was mainly used for feeding sheep and goats and also for fold construction, but these uses were only encountered in Ouidah and Grand Popo where this plant was named as Akpontin by Xwla and Peda. In addition to the leaves, many parts of these mangroves were eaten by sheep and goats, including bark, seeds and flowers. These results confirm a high use of natural vegetation for feeding ruminants (Sarr et al. 2013; Sèwadé et al. 2016). Compared to previous studies, the local names recorded for the mangrove species were identical to those reported by (Dossou-Yovo et al. 2017) for the same species in the coastal zone of Benin. Similarly, the diversity of their local names according to ethnic groups was similar to that reported by (Gouwakinnou et al. 2011) for *Sclerocarya birrea* in the northern part of Benin.

On the other hand, the results showed that the leaves of *Paspalum vaginatum*, *Zanthoxylum zanthoxyloides* and *Blutaparon vermiculare* constitute the main recourse of livestock farmers for feeding ruminants (sheep and goats) in dry periods because the animals' diet is essentially based on natural pastures such as mangrove resources. Indeed, *Z. zanthoxyloides* were used for animal health, particularly against diarrhoea and skin diseases, while *R. racemosa*, mentioned in all use categories, was widely used for sheepfold construction, and its leaves and bark were used for reproductive management. This species is fed to sheep to obtain more male than female offspring. Compared to other studies carried out in Benin, these results corroborate those of (Baglo, 2005) and (Téka et al. 2012) in the southern zone of Benin. However, this use was only reported by (Téka et al. 2012) in Sèmè-Podji. The survey conducted revealed the opposite. This discrepancy could be explained by the fact that no differentiation was made between the use of mangroves and other mangrove plants for feeding ruminants. Indeed, the current study showed that only *Rhizophora racemosa* and *Avicennia Africana* were the mangroves found in the mangroves of Benin, useful for ruminant breeding. For example, mangroves such as *Laguncularia racemosa* and *Conocarpus erectus*, which are also found in these forests, were not used by the herders. It is likely that earlier studies had considered the mangrove ecosystem as a whole without distinguishing between mangroves and other plants. Other studies have shown the food use of *Avicennia marina*, which is a mangrove like *Avicennia africana* and *Rhizophora racemosa*, for livestock including by (Baba, 2016) in the Indian region and by (Faye, 1993) in the Djibouti region. Contrary to these results, cattle did not ingest part of the two mangroves used by cattle and small ruminant breeders in the Republic of Benin. In addition, (Maxwell, 2015) and (Hong and Tuan, 1981) reported that *A. marina* is used as fodder for cattle (in Vietnam and the Middle East) because of its palatability and high protein content, which contribute to its feed preference. Among other uses, goats graze on fallen leaves and propagules of the mangroves of the genus *Rhizophora sp.* Livestock occasionally descend into the mangroves, particularly in the Ouidah region to graze on the leaves and diaspores of *Rhizophora sp.* and *Avicennia germinans*. This study showed that Fulani cattle breeders did not have a thorough knowledge of mangrove resources, unlike

other ethnic groups. This trend does not correspond to the report of (Ahoyo et al. 2017) in the central part of Benin, where the Fulani have the capacity to identify the greatest number of useful forest species. Availability and especially palatability criteria would explain preferences in the pastoral uses of these mangrove species.

#### **4.2 Ruminant production characteristics around mangrove swamps**

Livestock production system is based on three main poles namely human pole, environment and herd (Lhoste, 1999). This term is used to denote a farming system of interest not only for the study of livestock but also for the purposes of livestock development (Janhke, 1982). A large range of factors were identified by the households surveyed affecting mangroves management and local livelihoods (Bateman et al., 2013). The livestock production system around mangrove swamps described in this study was mainly based on animal-land relationship considering cattle - small ruminants set. It presented variability from an area to another. The results revealed that this fact was linked to the conservation status of these ecosystems or more clearly their trend. Two opposite trends namely restoration and degradation were indeed recorded. The degradation implies a regressive trend of a mangrove swamp which is undergoing area loss and meanwhile fully plays its socio-economic and ecological roles for one whilst the restoration expresses a progressive trend up to a stable ecosystem from a degraded mangrove ecosystem in the past. From human pole to environment via herd, a significant variability was in fact observed. This study reported that this variability was linked to formal education level of the breeder, its ethnicity and religion, its use form and use scale of swamp resources, and its main farm animal. Formal education means attending of the breeder to school. Continuous degradation of mangrove swamps was partly explained through this aspect. Findings of (Koura et al. 2015b) has mentioned this same characteristic for Beninese farmers who practiced no crop-livestock integration and had a low flock and low cattle herd (1.61 heads). From crossing of these results with those of current study, it appears a high difference in cattle herd size. In fact, the current study has reported a significant cattle herd size (56.70 heads) which constituted main farm animal, associated or not to a low flock for farmers with no formal education. Plus, the concerned farmers had no occupation outside herding; they therefore did not practice cropping and consequently its integration with livestock. This fact might explain their pressure on uniquely natural resources surrounding them. Such description is similar to features of 'the sole livestock systems' from classification of livestock production systems proposed by (Seré and Steinfeld, 1996) and (Fernández-Rivera, 2004) whose feeding is based on rangelands, pastures, annual forages, and purchased feeds. This latter aspect was also reported by (Faye, 1993) mentioning that ruminants depended on various grasses of grasslands on the coastal plain and shrublands in which the surface runoff of seasonal streams terminates. In fact, the livestock system around mangrove swamps exploited surrounding grasslands and mainly related grasslands, and corresponded to the 'pastoral farms' from proposed typology of cattle farms in periurban areas of Benin by (Koura et al. 2015a) which were dependent on communal pastures. According to this same work, 'pastoral farms' were neither involved in crop cultivation, nor tree plantation, and were predominant in study areas of the current study characterized merely by the degradation of mangrove swamps (Adite et al. 2013).

### 4.3 Socio-economic characteristics influencing the contribution of herders to mangrove conservation

Our result show that no perception about implication of livestock production activities in the regression of mangrove swamps was recorded. This trend was indeed imputed to others drivers like an uncontrolled exploitation including burning of stumps after cutting, salt preparation and firewood needs, human settlement and fishery activities. Such drivers were also reported in Benin and West-Central Africa (Feka and Ajonina, 2011). Main threats to the mangrove in the coastal areas of Benin (Teka et al. 2019) according to local communities are the extraction of wood (54.4%), urbanization and non-rational settlement (40%), disrespect of traditional rules (30%) and the climate change (26.1%). Fishery, cooking salt production, fodder and wild fires were less mentioned. Nevertheless, grazing pressure by cattle was observed particularly into mangrove swamps of Sèmè-Podji and Abomey-Calavi. As for Ouidah and Grand Popo, fodder collection from mangrove trees for goats and cheep was more recorded. Practices like these, could disrupt or trouble normal growth process of mangrove trees and related species. This deduction is further supported by some authors through the world. (Stewart and Fairfull, 2008) and (Baba et al. 2013) reported that an uncontrolled livestock access, notably cattle and camels, can cause large scale damage to mangroves by killing the young seedlings and stunting of the growth of trees and shrubs, and can destroy root systems or pneumatophores by trampling. This fact match up also with findings of (Hoppe-Speer and Adams, 2015) which reported that slower and stunted growth of mangroves, and lower frequency of flowering and fruiting are attributed by grazing pressure made by camels, fodder harvesting for cattle in India region and South Africa. Such behaviour may be explained by the accessibility of the mangrove sites and the fact that those animals had a high preference for foliage of mangrove trees, or that herdsman are at times helpless regarding the regulating of animals access to this wetland as reported by (Baba et al. 2013). Another explanation can be linked to the non-availability of other pastoral resources not far from farm sites due to urbanization. Study area of the current work constituted indeed the surroundings of Cotonou city, the biggest of Benin. A similar report was made by (Koura et al. 2015a) indicating that urbanization is a main factor influencing feed availability in periurban areas. Nonetheless, recent changes in the political situation and government structure have re-emphasized agriculture as a key sector for enhancing livelihood and food security with contemporary approaches in irrigation infrastructure, agriculture mechanization, genetic varieties, and management practices (Torbick et al. 2017). This, coupled with galloping urbanization, shows that the pressure on mangrove resources will increase over the years. Ruminant husbandry around mangroves could be improved and maintained through management options such as reducing the average herd size, better integration of animal and crop production, and increasing the total area of pasture available.

In addition, our results also show a differentiation of mangrove resource use according to ethnicity and age. These results corroborate those of some authors such (Latorre et al. 2014; Lamsal et al. 2015; Lau et al. 2016; Ramli et al. 2017). Independent from ethnic group and age, all informants proposed that another tree planting is a possible new strategy to save mangrove ecosystems from degradation in southern Benin. However, some of these authors have shown that apart from ethnicity and age, gender and poverty are factors contributing to the conservation of mangrove resources. Although the status of mangrove forests varies by country and region, many mangrove forests experience similar threats to their

persistence from urban development and timber harvest to conversion for other land uses such as agriculture and aquaculture (Romanach et al. 2018).

A large number of mangrove plants grows natural and exploited especially, for use in indigenous pharmaceutical houses (Vinoth et al., 2019). However, our study did not effectively prove how the use of mangrove species could contribute to the treatment of human ailments. This could help explain the state of degradation of mangrove resources in our area.

#### **4.4 Prospects for mangrove conservation and involvement**

According to our study, farmers mentioned that ruminant breeding, especially cattle, is not feasible for them outside of mangrove exploitation. However, mangrove resources are used as substitute feed. Indeed, livestock farmers are confronted in the coastal zone with a reduction of natural rangelands in favor of urbanization and agricultural activities. In addition to these factors, climate change has increased the vulnerability of these herders to their livelihood. Thus, in order to avoid conflicts related to crop destruction, cattle breeders exploit mangrove resources during the dry season. These coastal herders are aware of the importance of these ecosystems for them, their regression too. For that, some strategies based on social realities have been proposed by the breeders for a sustainable use of mangrove resources. Near the degraded mangroves, the strategies most used by farmers are the planting of mangroves, followed by rational exploitation through the control of cuts. On the other hand, near restored mangroves, the most used conservation strategies are mainly rational exploitation through control of cutting and management.

Close to the degraded sites, the Xwla and Fulani are the dominant ethnic groups, which justifies the state of the mangrove in these areas because of livestock breeding and especially fishing activities that require the cutting of mangrove woods. On the other hand, close to the sites under restoration, the dominant ethnic groups are the Xwla and Peda because of the importance of mangroves for their livelihood, these indigenous populations contribute strongly to their restoration. These results on the impact of the use of mangrove ecosystems for ruminant feeding corroborate those of (Koura et al. 2015b). Participatory co-management of mangroves remains the most acceptable strategy (Borrini-Feyerabend and Hill 2015) at the level of sites under restoration and planting at the level of degraded sites (Teka et al. 2019). In addition, a frequently observed practice in mangroves was the burning of stumps after cutting. This practice, which concerned some mangrove trees, was an obstacle to the regeneration of this species. Therefore, stopping and expanding the planting of mangroves and other trees could be an alternative to reduce the pressure on this particular ecosystem. Concretely, to ensure the sustainability of mangrove management in the coastal areas of Benin, collective action and support for the establishment of policies and institutions is necessary (Medina, 2013). To this end, there is an urgent need to prioritize the integration of socio-economic factors while improving local livelihoods and focusing on local institutions that help strengthen and popularize traditional regulatory mechanisms for pastoralists. Thus, the implementation of the following activities could contribute to the conservation of mangrove ecosystems : (1) reforestation of mangrove sites; (2) sensitization and training of herders for the establishment of

fodder crops; (3) promotion of fast-growing species to support the demand for timber and fuelwood; (4) promotion of natural resources and enhancement of pastoral areas and spaces; (5) contribution to food security and poverty alleviation by improving animal productivity (genetic potential, better feeding and secure watering).

## Conclusion

This study helped to understand the use of mangrove ecosystems by ruminant breeders and their contribution to its degradation and potential restoration in Benin (West Africa). Five (05) species of mangroves, namely *Rhizophora racemosa*, *Avicennia Africana*, *Paspalum vaginatum*, *Zanthoxylum zanthoxyloides* and *Blutaparon vermiculare* were used for ruminant breeding. Among the categories of use, feed use was the most cited. The use of these resources varied according to ethnic groups. Native herders were much more covetous of the organs of the mangrove trees, *Rhizophora racemosa* and *Avicennia Africana*, for their herds, which include small ruminants, while herders from outside the region went to the surrounding grasslands with their cattle herds in unfavorable times. At the same time, other activities are carried out in the mangroves, such as salt preparation, fishing, and harvesting wood for fuel services and human settlements. All this, in addition to use for ruminants, poses a significant threat to the sustainability of mangrove ecosystems. The characterization of the farming system has shown that ethnic group and age are factors influencing the management of mangroves according to sites. Livestock breeders in the coastal zone suggested conservation measures through mangrove planting, controlled cutting and participatory management, which are mitigation measures that will ensure the preservation/conservation of this ecosystem.

## Declarations

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## Figures

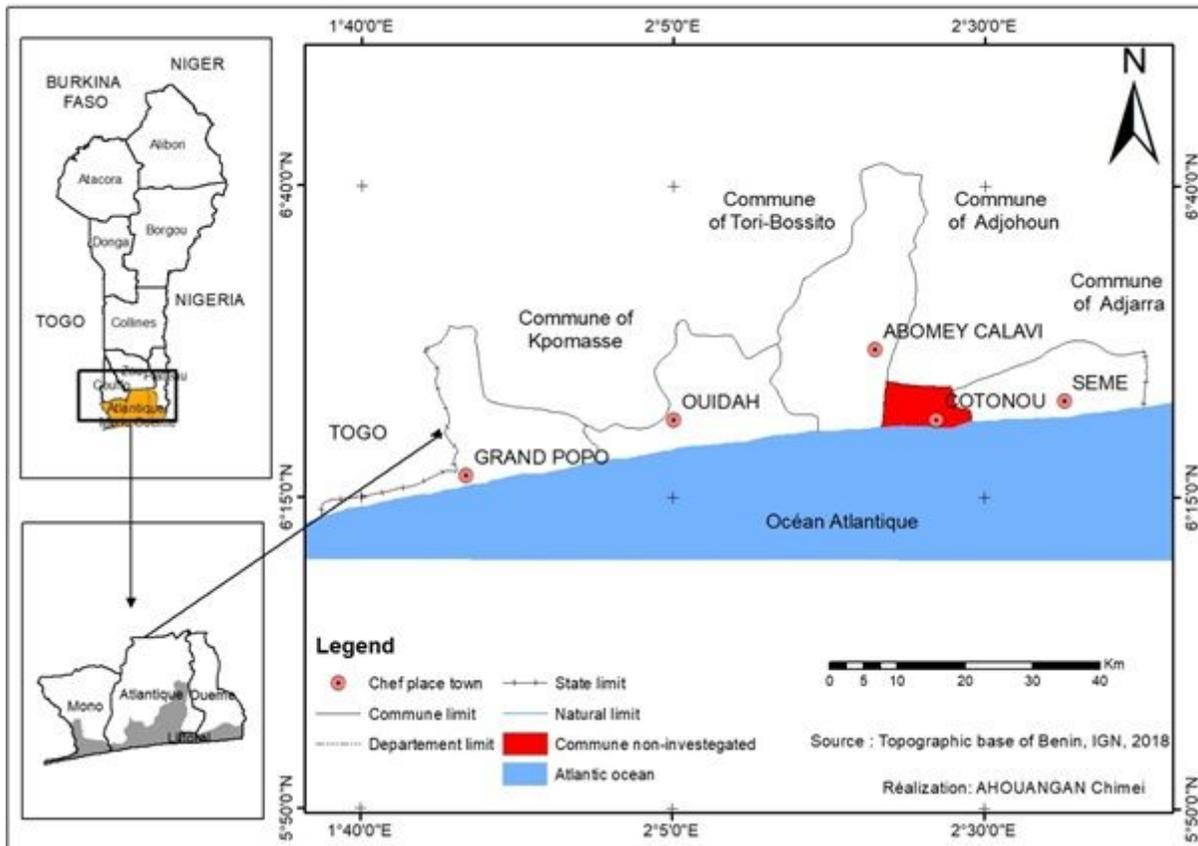


Figure 1

Map of the study area

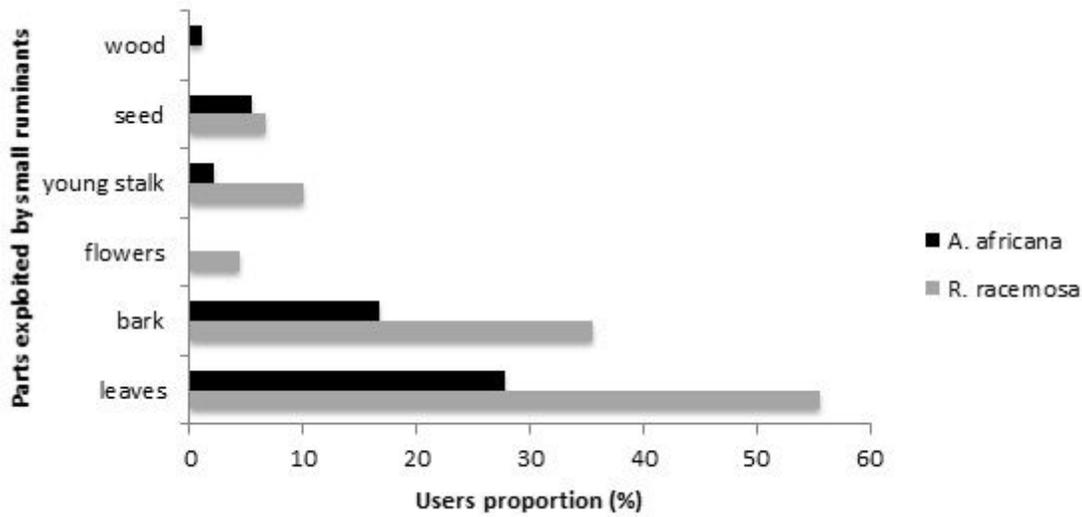
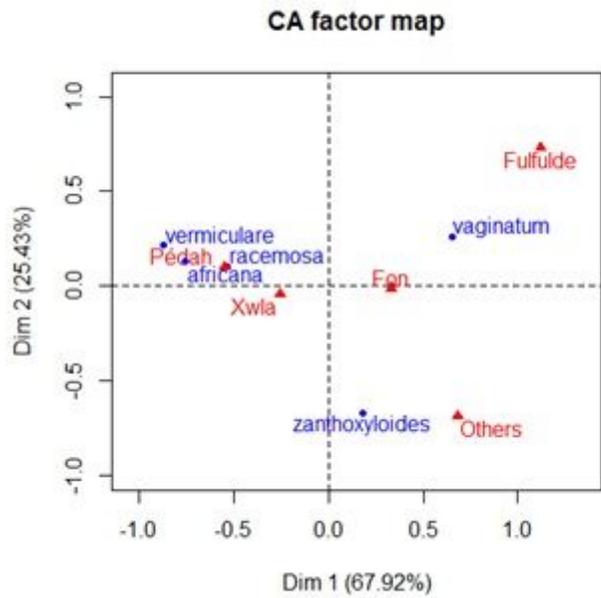


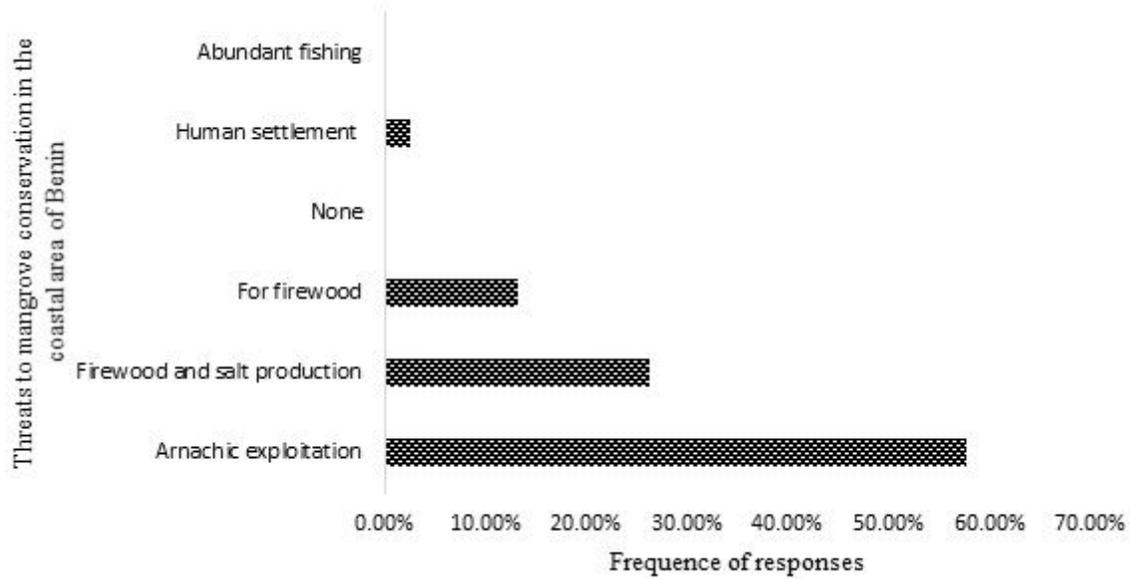
Figure 2

Uses of parts of mangroves species for ruminant feeding.



**Figure 3**

Correspondence Factor Analysis results of use values of mangrove species according to ethnic groups



**Figure 4**

Trend perception of mangrove degradation

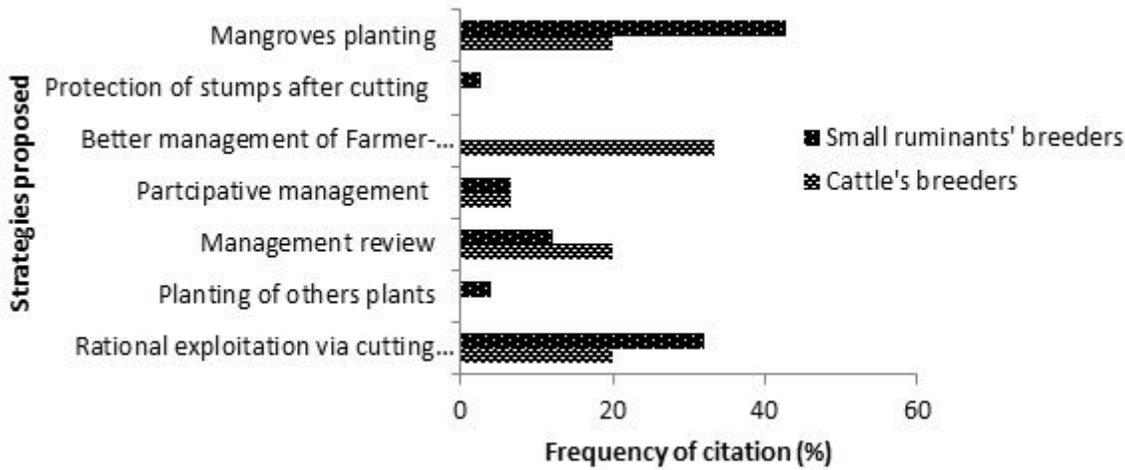


Figure 5

Frequencies citation of proposed strategies by herders

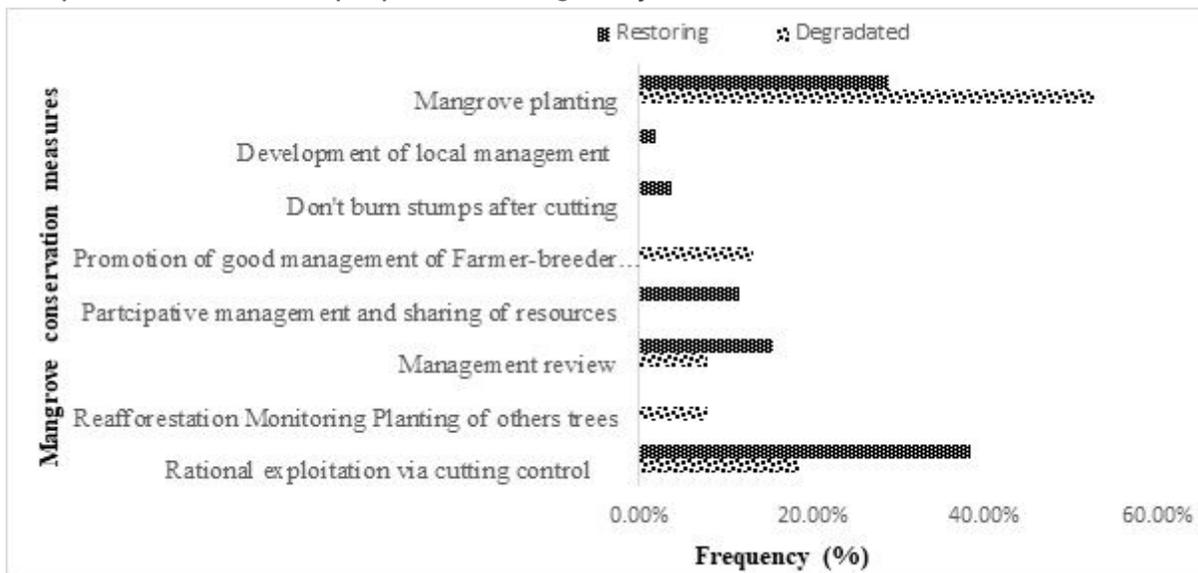
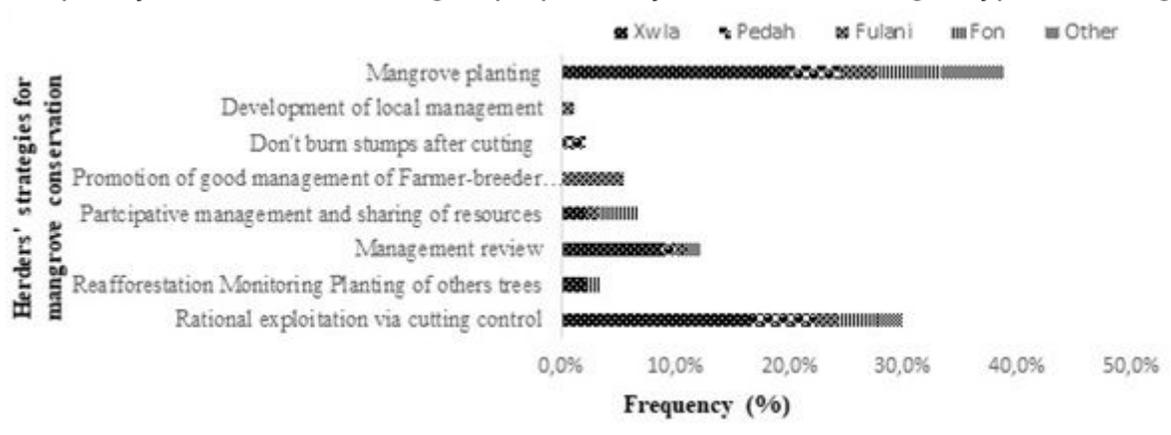


Figure 6

Frequency of citation of strategies proposed by herders according to types of mangroves



## Figure 7

Frequency of citation of strategies proposed by herders according to their ethnic group