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Factors in the invasion of the Comoé River estuary by Invasive Aquatic Plants (south-east Côte d'Ivoire)

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ABSTRACT: The contribution of remote sensing to controlling the proliferation of invasive aquatic plants is of paramount importance, as it makes it possible to better monitor the spatio-temporal evolution of these plants' occupation of water bodies. The surface of the Comoé River estuary has always been occupied by Invasive Aquatic Plants (IAPs). This study was carried out with a view to listing all the aquatic plant species colonising the surface of the estuarine water body and analysing the dynamics of their proliferation. To achieve this, the study's first stage consisted of carrying out an itinerant inventory along transects installed on the water body to record all the species encountered. In the second stage, the colonisation dynamics of the estuary were analysed using four Landsat (TM) 1986, 1989, Landsat 7 (ETM+) 2004 and Landsat 8 (OLI) 2022 satellite images. The floristic inventory identified 8 species divided into 8 genera and 8 distinct families at the surface of the estuary water body. Analysis of land use dynamics from 1986 to 2022 shows a variation in the annual rate of expansion of IAPs on the surface of the estuary water body. The recent period from 2004 to 2022 is characterised by a considerable rate of expansion of around 1240.2%. The results of this study could constitute a reliable scientific database for the implementation of a policy to control the proliferation of these IAPs at the surface of the water body of the Comoé River estuary.

KEYWORDS: Invasive Aquatic Plants (IAP), Comoé River estuary, spatio-temporal dynamics, Grand-Bassam, Ivory Coast.

1 INTRODUCTION

In Côte d'Ivoire, the eastern part of the Ébrié lagoon system and the associated lagoons have been more or less periodically invaded since the early 1980s by these three main species of floating macrophytes: water lettuce (*Pistia stratiotes* L. (Araceae), the water fern (*Salvinia molesta* D.S. Mitchel (Salviniaceae) and *Eichhornia crassipes* (Mart.) Solms-Lamb (Pontederiaceae) is commonly known as the water hyacinth [1]. This phenomenon of colonisation by invasive aquatic plants (IAP) has increased in the town of Grand-Bassam, particularly in the Comoé River estuary, which flows into the Atlantic Ocean. According to [2], the desalination of brackish estuarine waters following the natural closure of the Bassam outlet favours the clogging of the water by these plants. These exotic aquatic weeds, in the absence of their natural enemies, are causing serious problems in Côte d'Ivoire because they have rapidly invaded rivers and freshwater bodies and have spread especially in tropical regions [3]. Faced with this scourge that is pillaging this marine area, the Ivorian authorities have since taken steps to reopen the river mouth, following repeated closures in 1972, 1987, 1989, 1992, 1998 and 2004 [4]; [5]). Despite these attempts by the Ivorian government, the proliferation of IAP in the Comoé estuary continues, with enormous environmental and economic consequences. The deterioration in water quality is affecting aquatic biodiversity, making navigation difficult and reducing the scope for fishermen [6]; [5]. Today, the fish farming industry is experiencing enormous difficulties in the Sud Comoé region of south-eastern Côte d'Ivoire. With the frequent closure of the mouths of the Comoé River and the Ébrié lagoon at Grand-Bassam (40 km from Abidjan), several fishing villages are seeing their activities and income drastically reduced. Villages such as Moossou, Vitré, Ébra, Adiaho, Ono salci and the sub-prefectures of Grand-Bassam, Bonoua and Alépé have seen their fishing activities suffer for years. As a result, the mouth of the Comoé River has shifted over more than a century, covering more than

11 km of coastline between the village of Azureti in the west and the dead arm of the Comoé River at Mondoukou [7]; [8]. The history of the grau includes the period from 1951 to 1987, following the opening of the Vridi Canal in 1951, when the consequent drop in flushing currents in the estuary and the diversion of water from Moossou towards the Vridi channels led to siltation, the almost permanent silting up of the channels and the confinement of the environment. The emptying of this bifid estuary by the Vridi canal alone has led to the overloading of the lagoon waters. The seasonal invasion (flooding of the Comoé River) of the water bodies in the central and eastern sectors of the Ebrié lagoon by floating vegetation (*Eichhornia crassipes, Salvinia molesta, Pistia stratiotes*) in recent years is both spectacular and disturbing.

Given the negative impact on the well-being of local populations, managing these IAPs has become a priority objective for action. With a view to removing these plants to the sea via the Bassam grau, the National Environment Commission decided to reopen the mouth of the Comoé River. Unfortunately, these efforts were in vain. To counter this scourge, several studies have been carried out to combat the invasion of these IAPs on bodies of water in Côte d'Ivoire [9]; [5]. However, few studies have focused on the spatio-temporal evolution of these plants in the Comoé River estuary. For effective management of IAPs, the contribution of remote sensing and Geographic Information Systems is essential, as they enable better monitoring and control of the spatial proliferation of IAPs. Thus, in response to the lack of information on the state of evolution of invasive aquatic plants in the Comoé River estuary at Grand-Bassam, we set ourselves the general objective of improving knowledge of the state of congestion of the Comoé River estuary by invasive aquatic plants. Specifically, the aim was to determine the diversity of IAPs on the estuarine water body, to draw up land-use maps of the Comoé River estuary from 1986 to 2022 and to determine the spatio-temporal dynamics of these IAPs.

2 METHODOLOGY

2.1 STUDY AREA

The study took place in Grand-Bassam, in the South-Comoé region of Côte d'Ivoire. Its communal area covers 13,000 ha. It is bounded to the north by the sub-prefecture of Alépé, to the south by the Atlantic Ocean, to the east by the sub-prefecture of Bonoua and to the west by the sub-prefecture of Bingerville and the city of Abidjan (Sehi et al., 2018). In the past, almost all the water from the Comoé River flowed directly into the sea and into the Ouladines and Azurety lagoons at the mouth of Grand Bassam. After the opening of the Vridi Canal in 1951 in Abidjan, the waters of the Comoé River deviated from their initial trajectory and flowed directly into the Aghien - Potou lagoons and particularly into the Ebrié lagoon and entered the sea via the Vridi canal [10]. During floods, the waters of the Comoé River cross the Ebrié lagoon and act as a 'flush' that regularly cleans and depollutes the lagoon. In addition, the coastal current from the Gulf of Guinea enriches the old mouth with sediment to such an extent that it literally invades the dwellings.

The estuarine sector of the Comoé River is at the eastern end of the Ebrié lagoon. This area is the largest estuary on the Ivorian Coast [9] and covers the area around Morin Island to the north, the Moossou bridge at the confluence of the Comoé River and the Ebrié Lagoon and the barrier beach to the south. It includes the branch of the river Comoé to the northeast. The estuarine zone is supplied with fresh water by the Comoé River, which drains the entire hinterland and whose catchment area covers 78,000 km.

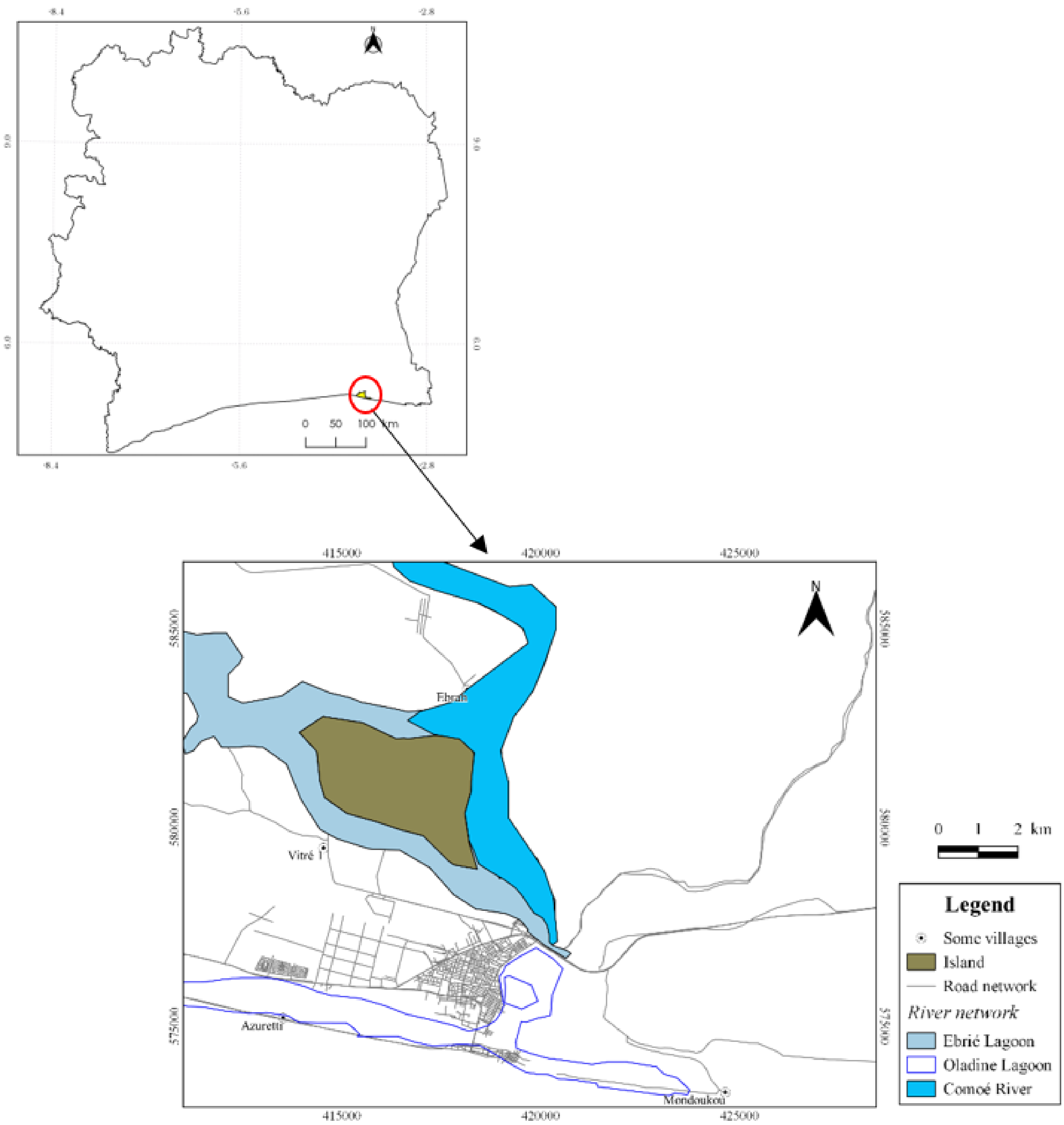

Fig. 1. Location of the Grand-Bassam estuary in Côte d'Ivoire

2.2 GATHERING DATA

During this study, two methods were used: firstly, a botanical inventory was carried out to describe the flora of the aquatic vegetation colonising the estuary. Then, remote sensing data collection techniques and a Geographic Information System (GIS) were used to map the vegetation cover of the IAP and monitor its evolution dynamics from 1986 to 2022.

2.2.1 FLORISTIC DATA

Floristic data were collected using the Transect method recommended by [11] and [12]. This consists of installing Transects marked out by a rope in order to delimit the zonation of existing vegetation on the surface of the estuarine water body. An inventory was carried out along Transects of different lengths in order to record all the species encountered. Four Transects were delimited in the dense mats of IAP, including two Transects installed along the course of the Comoé River (A and B) and two others at the mouth (C and D) (Fig.2).

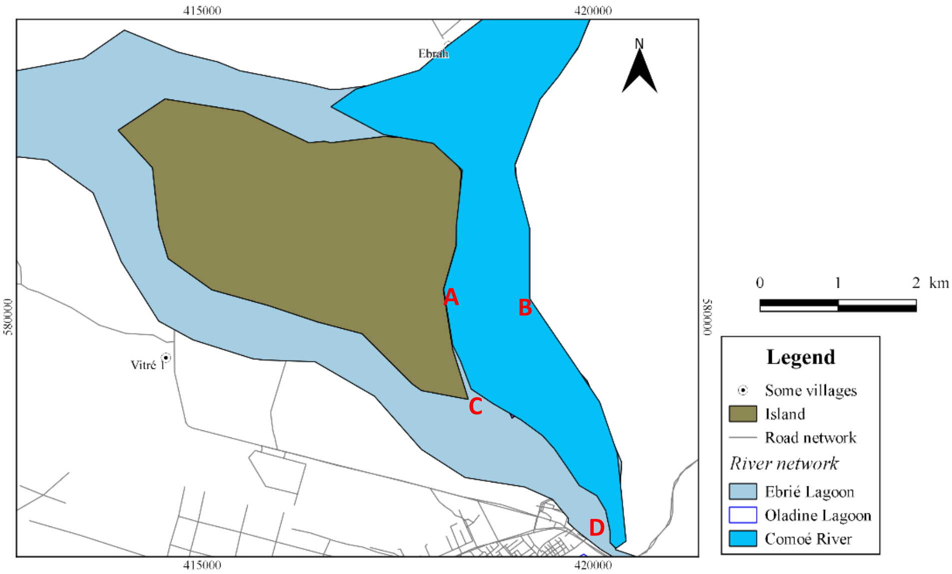

Fig. 2. Map showing the position of the transects on the study site

2.2.2 SPATIAL DATA

Two categories of data were used: satellite images and vector data of the study area. Firstly, four Landsat-type satellite images of the 195/056 scene covering the years 1986, 1989, 2004 and 2022 were used to map and monitor the spatial and temporal dynamics of the estuary's land cover. To do this, Landsat 4 TM images from 1986; Landsat 5 TM from 1989; Landsat 7 ETM+ from 2004 and Landsat 8 OLI /TIRS from 2022 in the UTM zone 30 system were downloaded. These images can be downloaded from the USGS website http://www.glovis.usgs.gouv/. In addition, "vector" data concerning the administrative division, the road network and the topographical map of the study area were associated with the processing of the satellite images.

2.3 DATA ANALYSIS AND PROCESSING

The floristic analysis focused on species richness, corresponding to the number of species, genera and families [13]. This species richness is determined without judging the frequency, abundance or even the size and productivity of the taxa encountered. In the present study, the nomenclature of species and families followed the classification APG IV [14].

The method used to analyse the satellite images was based on the visual image interpretation technique [15]. Using the topographic map of Grand-Bassam, geo-referenced to the WGS 84 ellipsoid and the 30 North grid, the study area was extracted by digitising its outline. To enable good discrimination of the different vegetation formations within this area of interest, colour compositions of type 4/5/7 for the TM and ETM+ sensors and 5/6/7 for the Landsat 8 OLI sensor were used. These compositions were used to identify and assess the spatial distribution of IAP over the water body [16]. On the basis of the colour compositions, 120 points were selected on the images according to their hue and their geographical coordinates noted. Field missions were carried out to determine the classes corresponding to the zones identified on the colour compositions. These different areas were then described in the field. In concrete terms, the geographical coordinates of the areas most infested by IAP were recorded using GPS. In this study, only the points representing the body of water made up of the Ebrié Lagoon and the Comoé River, the IAPs and the sandy areas were selected. The satellite images selected were classified using a supervised classification based on the likelihood algorithm. The quality of these classifications was assessed using the Kappa index obtained from the confusion matrix. A classification is accepted when the Kappa coefficient is between 50 and 75% [17]. A 3x3 median filter was used to eliminate isolated pixels before the maps were finally produced [18]. ENVI 4.7 software was used for all image processing operations. The analysis of IAP dynamics consisted of quantitatively distributing the different types of land cover for each year (1986, 1989, 2004 and 2022). To do this, the rate of growth or expansion of Invasive Aquatic Plants was calculated in order to estimate the evolution (growth or regression) of the surface area occupied by these species over the three periods 1986-1989; 1989-2004, 2004-2022 and 1986-2022. Its mathematical formula is as follows:

TC= (S2-S1 / S1) × 100

TC = expansion rate (%)
S1 = the surface area occupied by plants on the date t1
S2 = the surface area occupied at date t2 (t2 > t1).

Tests were carried out to compare the mean surface areas of the different types of occupation in the estuary. In some cases, Analysis of Variance (ANOVA) was used to compare the means of the estuary's land-use types. This comparison of the means of the three samples is based on three principles: the independence of the observations, the normality of the distribution, and the homogeneity of the variances (homoscedasticity). Normality is verified by the Shapiro-Wilk test. The homogeneity of variances was verified by the Levène test. The significance level chosen for these analyses was 5% (p = 0.05). Whenever the calculated probability was significant, the Tukey test was used to compare the means in pairs and to assess the significant differences between them. In other cases where the ANOVA conditions were not met, the non-parametric Kruskal-Wallis test was performed. In this case, Dunn's test was used to compare the means in pairs and assess whether or not there were significant differences between them.

3 RESULTS

3.1 FLORISTIC RICHNESS OF THE WATER BODY

The inventory of the water surface of the Comoé River estuary revealed 8 species divided into 8 genera and 8 distinct families. The distribution of species by transect is shown in Table I.

The analysis of the data showed that Transects A and B (TA and TB), located on the Comoé River, had the richest flora, with 8 species. On the other hand, Transects C and D (TC and TD), located in the mouth zone, i.e. the mixing zone between the fresh waters of the Comoé River and the brackish waters of the Ebrié lagoon, recorded 3 and 4 species respectively. During this inventory, two species were inventoried in all the Transects. *Eichhornia crassipes* and *Echinochloa pyramidalis* were the most abundant species.

Table 1. Breakdown of species inventoried by transect

N°	Species	Families	TA	TB	TC	TD
1	*Alternanthera sessilis*	Amaranthaceae		+		
2	*Commelina diffusa*	Commelinaceae	+	+		+
3	*Eichhornia crassipes*	Pontederiaceae	+	+	+	+
4	*Echinochloa pyramidalis*	Poaceae	+	+	+	+
5	*Ipomoea aquatica*	Convolvulaceae	+	+	+	
6	*Ludwigia octovalvis*	Onagraceae	+			+
7	*Pistia stratiotes*	Araceae	+	+		
8	*Salvinia molesta*	Salviniaceae	+	+		
Total			7	7	3	4

+: presence

3.2 SPATIAL EVOLUTION OF LAND USE TYPES

The study revealed different units of occupation in the study area. Three distinct classes were identified (Figure 2). These are the IAPs, which are all the invasive aquatic plants found on the surface of the water body; the estuary water body, which represents the balancing zone between the waters of the Comoé River and the Ebrié Lagoon; and the sand, which is the sedimentary sand deposit that has clogged the mouth of the Comoé River.

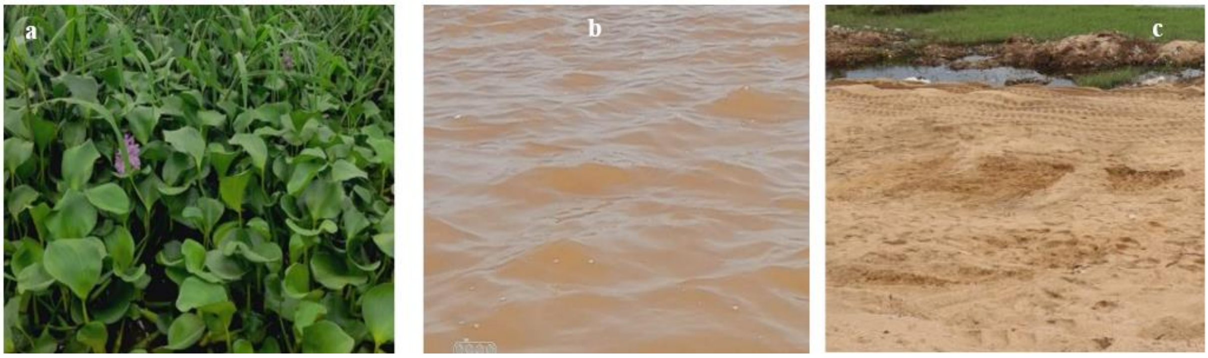

Fig. 3. Types of occupation of estuarine water bodies
a- An overview of an IAP: Eichhornia crassipes; b- View of the water body; c- Overview of sand on the study site

3.2.1 GLOBAL MAPPING DETAILS

The processing carried out resulted in cartographic accuracies of 98%, 97.2%, 97.1% and 96.41% respectively for the classification of images from 1986, 1989, 2004 and 2022 (Tables II, III, IV and V). For all the treatments carried out, confusion was observed between different land use classes. The highest levels of confusion were observed between the water body and the IAPs, with relatively high values of 19.22% for the classification of the 1986 image. Major confusion was observed between the IAPs classes and sand for the years 1989 and 2004, with values of 8.05% and 5.58% respectively. In 2022, the confusion was between the IAPs and the water body, with a value of 1.56%.

Table 2. Confusion matrix for the classification of the 1986 image

Class	Water body	Sand	IAP
Water body	**80,78**	1,9	10,21
Sand	0	**91,05**	4,98
IAP	19,22	7,05	**84,81**

Overall Accuracy = 98%; Kappa Coefficient: 0,95

Table 3. Confusion matrix for the classification of the 1989 image

Class	Water body	Sand	IAP
Water body	**97,61**	5,79	7,11
Sand	0,15	**86,16**	0,98
IAP	2,24	8,05	**91,91**

Overall Accuracy = 97,2%; Kappa Coefficient: 0,94

Table 4. Confusion matrix for the classification of the 2004 image

Class	Water body	Sand	IAP
Water body	**97,19**	0	4,84
Sand	0,03	**94,42**	0
IAP	2,78	5,58	**95,16**

Overall Accuracy = 97,1%; Kappa Coefficient: 0,95

Table 5. Confusion matrix for the classification of the 2022 image

Class	Water body	Sand	IAP
	98,39	0	0,09
Sand	0,05	**98,65**	0
IAP	1,56	1,35	**99,91**

Overall Accuracy = 96,41%; Kappa Coefficient: 0,93

3.2.2 Spatial and temporal dynamics of IAP in the estuary from 1986 to 2022

3.2.2.1 Overall trend in land use classes in the study area

The Land Uses in the study area shows a variation in surface area from 1989 to 2022. Visually, it can be seen that the IAP, which occupied a large surface area along the watercourses in 1986, had declined by 1989 and was growing strongly by 2022 (Figure 5).

The Kruskas-Wallis test carried out on the mean areas shows a significant difference for the different dates of the study (Figure 6). Thus, the high abundance of IAP to the benefit of the other types of occupation shows the closure of the mouth of the Comoé River. The various analyses carried out indicate that the occupation of the 1986 water body shows an abundance of IAP covering an area of 297.76 ha, i.e. 59.65% of the total area of the land-use types (Figure 6). The water body covers a total of 175.12 ha, or 35.08% of the total surface area. The sand class occupies the smallest area with 26.28 ha, or 5.26%.

The distribution of land-use classes in 1989 shows a considerable decrease in IAP on the water body, with a surface area of 24.55 ha, i.e. 5.26% of the total surface area (Figures 5 & 6). On the other hand, there was an increase in the amount of land occupied on the water and sand, with values of 363.60 ha (78.04%) and 77.74 ha (16.68%) respectively. The decrease in IAP marks the opening up of the mouth of the Comoé River, making navigation easier.

The 2004 land-use map (Figure 6) shows a slight increase in IAP with a surface area of 26.64 ha, or 5.90% of all land uses (Figure 6). There was also a slight decrease in the water surface area (312.12 ha; 69.15%), with the exception of the sand class, which increased its surface area to 112.56 ha, or 24.94% (Figure 6).

In 2022, there has been a considerable increase in the occupation of IAPs, occupying an area of 375.84 ha or 47.83% of the total surface area (Figures 5 & 6). Sand and water have declined considerably, to 52.83 ha (6.72%) and 175.84 ha (22.38%) respectively.

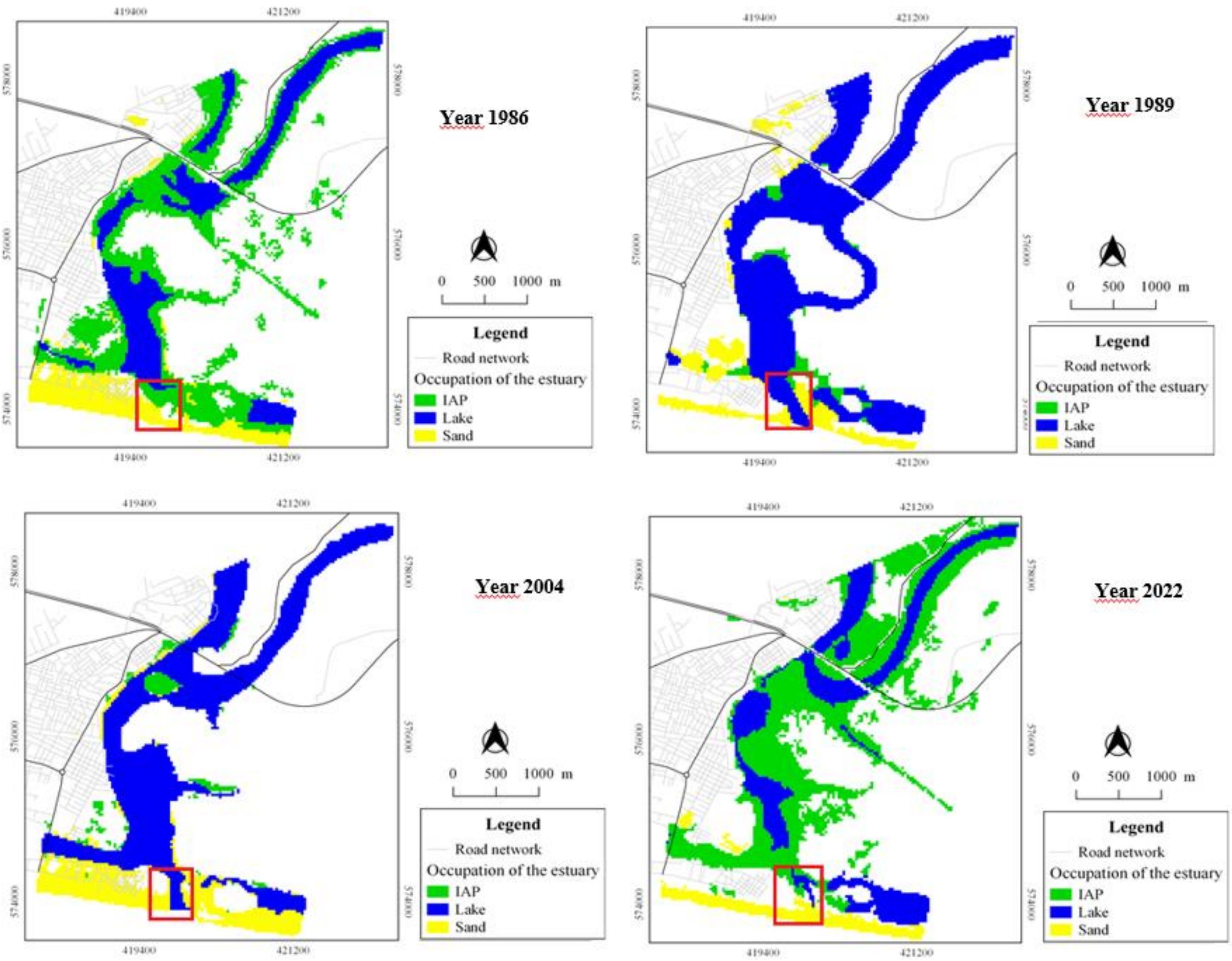

Fig. 4. Occupation maps of the estuary during the periods when the canal is open and closed for study

The area showing the river mouth

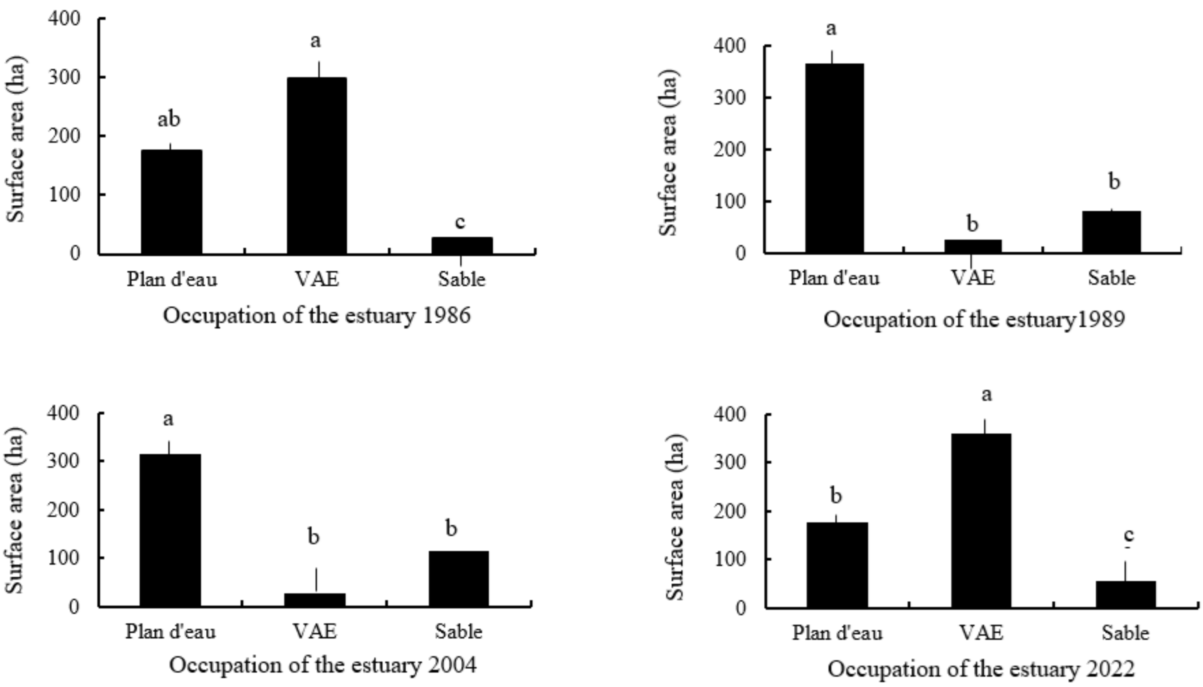

Fig. 5. Histograms of changes in types of occupation of the estuary over the years

AVERAGE ANNUAL RATE OF CHANGE OF IAP FROM 1986 TO 2022

Changes in the types of occupation of the Comoé estuary vary from one period to another depending on whether or not the Grand-Bassam grau is open (Figure 7). Thus, after the reopening of the grau between 1986 and 1989, the area of invasive aquatic plants fell sharply, from 59.7 ha in 1986 to 24.6 ha in 1989, with a rate of decline of -58.8% (Table VI). Following this period, i.e. between 1989 and 2004, there was a slight proliferation of IAPs on the water body, increasing from 24.6 ha in 1989 to 26.6 ha in 2004. During this period, the growth rate of IAPs was 8.5%. In addition, between 2004 and 2022, the Grand-Bassam grau closed naturally, allowing a strong proliferation of AEVs on the water body. Thus, from 26.6 ha in 2004, the surface area of IAPs has increased substantially to 357 ha, with a growth rate of 1240.2%.

Over the 36-year period (1986-2022), the surface area of IAP on the Grand-Bassam water body increased from 59.7 ha to 357 ha, with a growth margin of 498.5%. The growth of other types of occupation is shown in the table below.

Table 6. Surface of the types of occupation on the water body according to the years

	Surface area of land use types (ha)				Global changes			
Land Uses	**1986**	**1989**	**2004**	**2022**	**1986-1989**	**1989-2004**	**2022-2004**	**2022-1986**
Water body	35,1	363,6	312,1	175,8	936,4	-14,2	-43,7	401,2
IAP	**59,7**	**24,6**	**26,6**	**357**	**-58,8**	**8,5**	**1240,2**	**498,5**
Sand	5,3	77,7	112,6	52,8	1376,6	44,8	-53,1	903,3

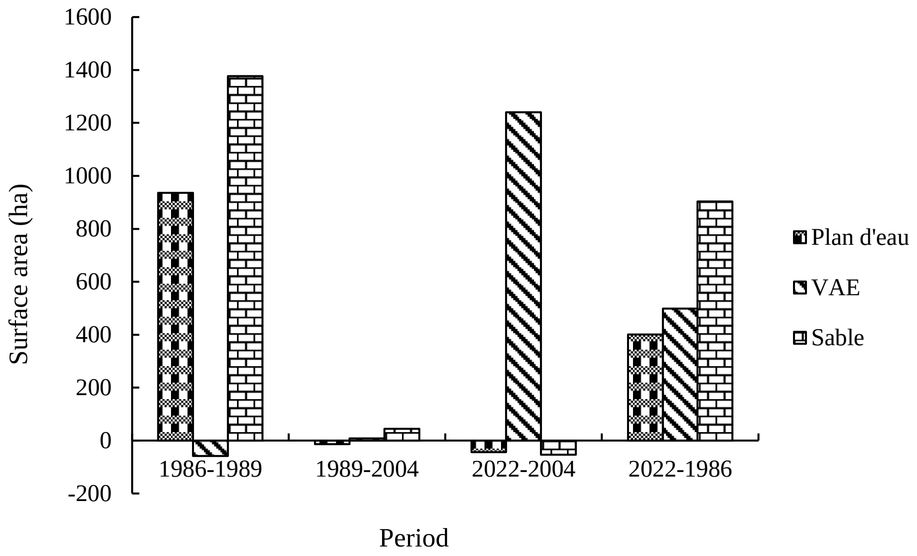

Fig. 6. Rate of change in land use classes

4 DISCUSSION

4.1 INVASION OF THE GRAND-BASSAM ESTUARINE WATER BODY BY VARIOUS IAPS

The flora of invasive aquatic plants in the town of Grand-Bassam is not very diverse. It is composed of only eight species divided into eight genera and eight families. This low diversity of IAPs in this area could be explained by the sampling period, which took place during the dry season when some species disappeared because of the high level of sunlight. These observations are similar to those made by [19] during his surveys of the French overseas territories. For this author, the appearance and proliferation of IAPs are also linked to the abiotic conditions of the environment. Nevertheless, the number of invasive aquatic plants identified in the present study is identical to the eight species identified by [6] in the town of Yamoussoukro. The similarity of these results is attributable to the sampling method used in the two studies. Although the study area is not very diverse in terms of IAP, a variation in floristic diversity was nevertheless observed from one Transect to another. Thus, of the four study Transects, Transects A and B (TA and TB) located on the Comoé River were richer in flora than the other two located on the Ebrié lagoon. This result may be due to the fact that this area on the Comoé River is subject to a great deal of pollution. In fact, the human activities carried out in this area have led to a significant deterioration in the quality of the river's water, encouraging the establishment and proliferation of IAPs. The massive use of chemicals in the surrounding agricultural plantations, livestock effluents, the defecation of people living upstream from the river and the discharge of water treatment residues would also lead to heavy pollution of the site. The conditions for these plants to proliferate would therefore be present in this location. Similar observations were made by [20] during their work in the water bodies of the town of Daloa. These authors state that chemical and organic pollution of aquatic environments influences the diversity and abundance of invasive aquatic plants.

It was found that the *Echinochloa pyramidalis* reedbed is fairly widespread on the water body of the Comoé River estuary [21]. These authors also noted that the mouth of the Comoé River is heavily invaded by the aquatic grouping with *Echhornia crassipes* and *Echinochloa pyramidalis*. Today, the proliferation of the latter species in the waterways of south-eastern Côte d'Ivoire is progressing at an alarming rate [22]. *Echinochloa pyramidalis* characterises the aquatic macrophytic vegetation of the Kambo River in Douala, Cameroon in many places [23].

4.2 DISCRIMINATING BETWEEN TYPES OF LAND USE

The digital processing of TM images from 1986 and 1989, ETM images from 2004 and OLI images from 2022 enabled land cover types to be discriminated with overall mapping accuracies of 98.5%, 97.2%, 97.1% and 96.41% respectively. In fact, the various classifications carried out in this study can be considered acceptable, since these values are above 80%. These remarks are similar to those of several authors including [24]); [25]. These authors stressed that an adopted classification is valid and that the results can be judiciously used when the overall accuracies evaluated in the classification operations are close to 80%. Also, the good overall accuracy for the set of images could be due to the low number of land cover classes discriminated. Such observations are in line with those of [17] during their work in the Forêt des Marais Tanoé-Ehy (FMTE) in south-eastern Côte d'Ivoire. These authors state that the fewer the land-use type classes, the greater the accuracy of the classification. A similar study by [26] on the spatio-temporal dynamics of invasive aquatic plants in the bed of the Niger River in Mali recorded very good overall mapping accuracies, including 99.07%, 98.41%, 98.06% and 97.99% in the discrimination of only four land-use types. Furthermore, kappa indices between 0.93 and 0.95 indicate that the results of this study are statistically valid. According to [27], a Kappa index greater than 0.5 demonstrates the validity of the classification. However, some of the confusion noted in 1986 between the "Invasive Aquatic Plants" and "Water Body" classes was recorded. En effet, cette confusion pourrait expliquer d'une part par la faible résolution du capteur TM de Landsat 5 comparativement au nouveau capteur OLI de Landsat 8 qui a une meilleure résolution radiométrique (16 bits) avec lequel l'image de 2022 de la présente étude a été téléchargée. On the other hand, this confusion could be likely due to the fact that very bulky, and often submerged, aquatic vegetation often gives the same spectral signatures as the river and the Ebrié lagoon, hence the fact that the spectral signatures of these two types of occupation are relatively close to each other.

4.3 DEVELOPMENT AND RELEVANCE OF IAPS ON THE WATER BODY

The analysis of the evolutionary trend observed during the present study reveals an alternating loss and gain in the surface area occupied by IAPs. This situation could be explained by the numerous natural closures and reopenings of the Grau de Grand Bassam. The intrusion of oceanic water into the Comoé River estuary after the reopening of the Grau is responsible for the death of the IAPs, which leads to a reduction in their surface area. Thus, the gradual closure of the pass after the last attempt to reopen it in 2004 would be the cause of the current high occupation of these IAPs on the surface of the estuarine water body. Similar observations were made by [1]. In their study, these authors demonstrated that the occupation of the water body by IAPs was due to the closing and reopening of the Grand-Bassam grau [22] also showed that hyacinth plants growing upstream of the Comoé River are carried to the estuary during the flood season, where they find conditions favourable to their multiplication, in particular the desalination of the brackish estuarine waters. Nutrient enrichment of surface waters also encourages the proliferation of IAPs. Our observations are in line with those of [28] and [29], who showed, respectively, that water pollution has led to the clogging of the water body of the River Niger and the surface waters of the Oued Inaouène catchment in Morocco by IAPs. In fact, the high growth rate of IAPs, of the order of 1240.2% over the recent 2004-2022 period, is thought to be due to the excessive nutrient enrichment of surface waters caused by the many human activities taking place in the surrounding area. In addition, the proliferation of these plants over time can be explained by the fact that they benefit from favourable conditions to extend their range even further. In fact, the ever-increasing degradation and pollution of aquatic environments due to various anthropogenic pressures would appear to be the cause of this proliferation. Our results are similar to those of [30]. This author showed that almost half the catchment area of the estuarine sector of the Comoé River is occupied by village or industrial plantations and food crops. Intense soil leaching during the rainy season results in nutrients being discharged into the estuarine waters.

Faced with this scourge, there is an urgent need to combat the proliferation of Invasive Aquatic Plants (IAPs), as navigation on the estuary is seriously hampered, making fishing difficult. The significant reduction in water flow capacity could also lead to ecological disruption, resulting in the loss of aquatic biodiversity. Invasions result in the loss or alteration of habitats, changes to specific interactions, trophic networks and water flows, the creation of new habitats favourable to other invasions, hybridisation and the spread of pathogens and parasites [31].

5 CONCLUSION

This study reviewed the state of knowledge of invasive aquatic vegetation in the Comoé estuary. Eight species occupy the surface of the estuarine water body. Of these, *Echinocloa pyramidalis* and *Eichhornia crassipes* are the most abundant. In addition, the study of the dynamics of this aquatic vegetation is of vital importance in that it has enabled us to trace the evolution of the plant cover encumbering the river estuary between 1986 and 2022. It shows that, following the gradual closure of the Grau de Grand-Bassam since 2004, the surface area of the estuarine water body has been considerably extended. The results of this study constitute a scientific database for the development of a policy to control and manage the proliferation of IAPs at the surface of the water body of the Comoé River estuary.

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