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# Preliminary data for the implementation of an ecosystem approach of fisheries as a means of sustainable management of artisanal fisheries in the lower basin of the Comoé RIVER (Côte d'Ivoire)

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**Abstract**
This study aims to contribute to the implementation in the lower basin of the Comoé River basin, an ecosystem approach of fisheries as a fisheries management tool which is more holistic than conventional fisheries management. Indeed, the conventional fisheries management focuses solely on resources. It means that the specific focus is to identify stakeholders, issues and analyse risks, identify problems, assess risks and prioritise these issues. A total of 145 fishermen were recorded, including 133 Ivorians (91.72 %), 6 Malians (4.14 %), 4 Ghanaians (2.76%) and 2 Burkinabés (1.38 %). Several anthropogenic activities that may directly or indirectly affect fisheries and the ecosystem have been identified, including agriculture, with use of plant protection products, pigstries, deposition of household waste, direct or indirect discharges into the water. A total of 105 issues were identified. The distribution of these problems by the generic component indicates that 74 (70.47 %) relate to ecological wellbeing, human wellbeing and ability to achieve respectively represent 16.20 % and 13.33 %. From the hierarchy of problems by component of the generic tree, it appears that 76.19 % of problems are in the high risk category while 15.23 % have a medium risk and 08.58 % a low risk. The distribution of risk levels by the generic components shows that ecological wellbeing concentrates the majority of the high risk category at 75.47 % versus 15.00 % and 09.33 % respectively for human wellbeing and ability to achieve. For the sub-components of the generic tree, the selected species represent 58.75 % of the high risks, the general ecosystem 11.25 %, the local community and governance respectively account for 5 % and 08.75 % of all high-level risks.

**Keywords:** Preliminary data, ecosystem approach of fisheries, artisanal fisheries, lower basin, Comoé River, Côte d'Ivoire

## 1. Introduction
The lower basin of the Comoé river belongs to Grand Bassam wetland located in the southeast of Côte d'Ivoire. In this part of the Comoé watershed, there are many industrial plantations such as banana, palm trees, rubber, located near waterbodies (Coulibaly *et al*., 2012) [8]. According to these authors, these factors make the water resources of this area vulnerable to pollution because of the use of fertilizers and pesticides. Moreover, there are an intensification of agriculture and other anthropogenic activities around the river that threaten the quality of aquatic ecosystems and resources. The rarefaction of fisheries resources of this river have changed the livelihoods of fishing communities because of the overexploitation, growing demographics, non-regulatory fishing techniques and methods. To solve these problems, ecosystem approach of fisheries is advocated. But information is critical for this new concept [9]. However, the literature does not mention in Côte d'Ivoire any studies which could give adequate information base unlike some countries. Since the ecosystem approach of fisheries is an extension of current fisheries management practices, it must be based on broader information. It aims to identify the stakeholders involved, the types of fishing gears and boats, the socio-economic importance of the fishery. In addition, all potential direct and indirect effects of fishing on species and habitats should be described FAO (2006) [11] in order to improve the livelihoods of communities and strengthen their capacities for adaptation and resilience to crises and natural disasters.

It will also help them to support sustainable development efforts by improving the contribution of fisheries to poverty reduction, food security, and equitable economic growth. The main objective of this study is to gather as much information as possible with a view to putting into practice an ecosystem approach to fisheries in the lower basin of Comoé River. More specifically, it is a question of identifying all the problems that should be solved, evaluate the risks and prioritize them. This study should lead to the development of national management plans, namely: the completion of a baseline study on fisheries, ecological risk assessment.

## 2. Materials and Methods

### 2.1 Study zone and sampling sites

This study was carried out in the Grand-Bassam wetland which is located in the southeast of Côte d'Ivoire, less than 20 km from Abidjan. According to available literature, ''this region has an average altitude of 90 m, its climate is subequatorial with an average annual temperature ranged between 25 °C to 33 °C. The rainfall varies from 1400 to 2500 mm/year and an annual rate of humidity about 80 to 90 % (Brou, 1997) [4]. This climate is characterized by four seasons: two dry seasons (mid-July to mid-September and December to March) and two rainy seasons (April to mid-July and mid-September to mid-November) (Halle & Bruzon, 2006) [15]''. A total of six sampling sites (Motobé, Yaou, Palm-CI, Adjékro, Moossou, Kodjoboué) have been selected in the lower basin of the Comoé River as shown in Figure 1. These sites were sampled during eight sampling campaigns from June 2014 to May 2017.

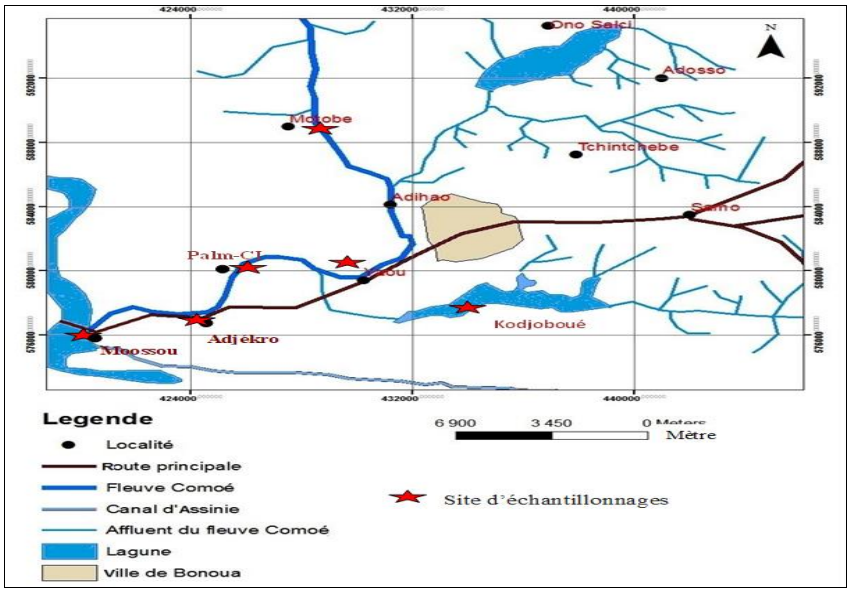


**Fig 1:** Location of sampling sites

### 2.2 Methods

#### 2.2.1 Data collection

Stakeholder identification has been done through a socio-economic survey. This socio-economic survey of the fishery in the lower basin of Comoé River was carried out by questionnaire and by interviews. It is about any person having an interest in the conservation and management of resources, such as: participants in a specific fishery, amateur fishermen, conservation movements, fishermen's craftsmen, processors and sellers of fish, government. The interviews have been carried out during the entire sampling campaign in the villages and camps on the shores. The surveys were carried out on evenings and rest days at the fisherman's home. The questionnaire lasts between 15 and 20 minutes, the interviewee is isolated from the members of his entourage in order to reduce their influence on his answers to be given. The questions are either closed or open in order to give fishermen the freedom to develop their views. The information gathered covered the age, nationality, ethnic group, level of education, difficulties and the way in which fishermen are organised. Only the activities carried out close to the main river bed have been retained (0 to 200 m).

For the identification of issues and risk analysis, the risk assessment "method" is based on the Australian and New Zealand fisheries-appropriate risk analysis standard (Fletcher *et al*., 2002; Fletcher, 2005; Nel *et al*., 2007) [9, 10, 19], also the EAF toolbox published by FAO (2012) [13]. It is a four-step process based on (1) the precise description of the fishery, (2) the identification of the key values of fishery and the associated high-level objectives, (3) the identification of problems related to the fishery and the risk assessment, and (4) the prioritization of problems based on their level of risk. The extent and values of the fishery was highlighted by answering the questions below in order to identify the stakeholders involved, the fishery to be managed, etc. The questions were: (i): Which fishery will be assessed or developed? (ii): What is the method of fishing involved? (iii): What groups of fishing communities are involved (traders, industrialists, craftsmen, sportsmen)? (iv) : What species are covered (target or non-target species)? (v): What institutions are involved (Fisheries, Marine; Customs; Immigration, Environment, etc.)? (vi) : What are the high-level values and objectives that the fishery must achieve? Components of the EAF generic tree as represented in Figure 2 was used to identify problems facing the fishery and their future evolution. This generic tree is a diagrammatic representation of the eight major components of ecologically sustainable development for fisheries.

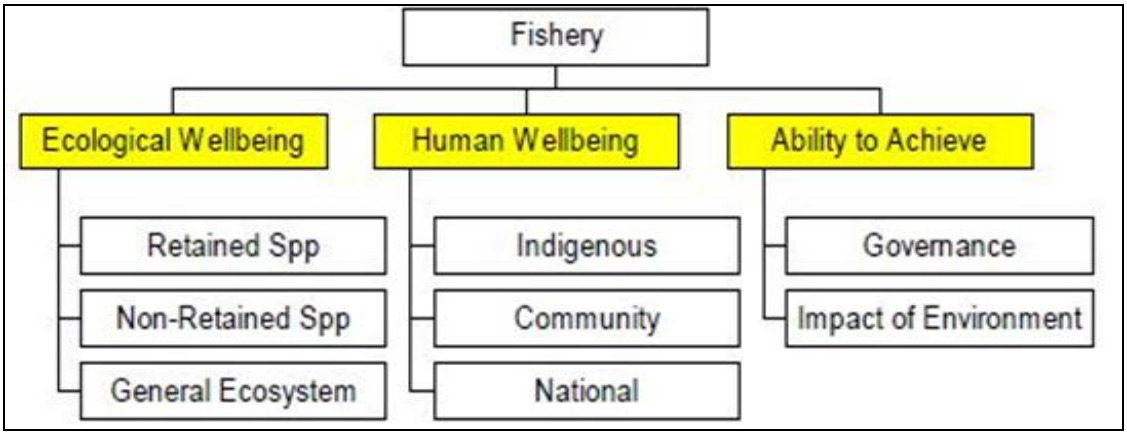


**Fig 2:** Generic Tree of the fishery as part of an Ecosystem Approach of Fisheries

The risks have been evaluated by multiplying the level of consequence by the level of likelihood. The scores generated by the risk levels have been between 1 and 16. As illustrated in Table below, there are three (3) risk categories in the EAF toolbox: (i) risks between 1 and 4 are Low, (ii) risks between 6 and 8 are Moderate and (iii) the last category between 9 and 16 are High. The risk assessment of problems helps to identify those who pose a threat to the management system. Because there are many high risks, they have been prioritized. Three categories of risks proposed by the EAF toolbox: Low, Moderate or High (Elevated) have been classified in each risk category. In general, low risks do not require management actions, while high risks require management actions. In this study, it was agreed to retain only the high risks to be managed have been considered.

**Table 1:** Conséquences and likelihoods

| Likelihood | | Level of consequences | | | |
|---|---|---|---|---|---|
| | | Minor | Moderate | Major | Extreme |
| | | 1 | 2 | 3 | 4 |
| Far | 1 | 1 | 2 | 3 | 4 |
| Unlikely | 2 | 2 | 4 | 6 | 8 |
| Possible | 3 | 3 | 6 | 9 | 12 |
| Likely | 4 | 4 | 8 | 12 | 16 |

### 2.2.2 Data analysis

The answers were analysed using Excel 2013 software. The positions of activities marked by a GPS, a distribution map was made using the ArcGIS 10.0 software as illustrated in Figure 5.

## 3. Results

### 3.1 Fishermen surveyed in the lower basin of the Comoé river

A total of 145 fishermen were recorded, including 133 Ivorians (91.72 %), 6 Malians (4.14 %), 4 Ghanaians (2.76%) and 2 Burkinabés (1.38 %) as shown in Figure 3. The distribution of fishermen by sex shows 142 men and 3 women. Of the 123 fishermen who agreed to take a decision on the acquisition of the first means of work, 98 (79.67 %) used own funds, while 17, or 13.82 % used a credit. Only 8 fishermen (6.50 %) received funding from somebody. As for their economic wellbeing, out of 143 fishermen, 82 (57.34 %) of them feel they are living well with fishing revenues. In contrast, 43 fishermen (30.07 %) say they do not live well with earnings. Only 18 fishermen (12.59 %) find economic wellbeing with the income generated by fishing.

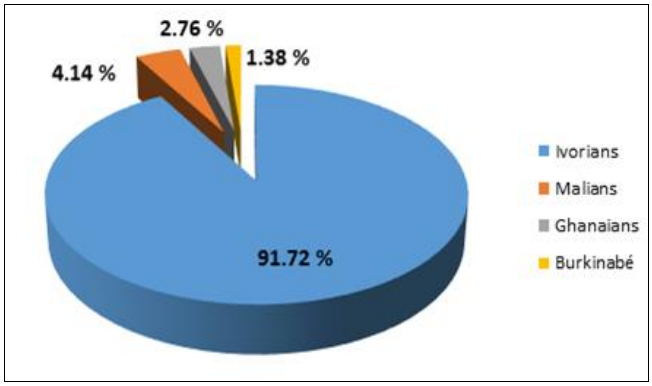


**Fig 3:** Distribution of fishermen surveyed in the lower basin of the Comoé River according to their nationality

### 3.2 Distribution of registered fishermen in the lower basin of the Comoé River by age group

In the lower basin of the Comoé River, fishing activity is more practiced by men whose age is between 20 and over 45 years as presented in Figure 4. The oldest actors (> 45 years) are more numerous (75 fishermen) than those whose age is between 30 and 45 years (54 fishermen), respectively 51.72 % and 37.25 % of the sample analysed. The youngest (under 30 years), 16 or 11.03 % are the least represented.

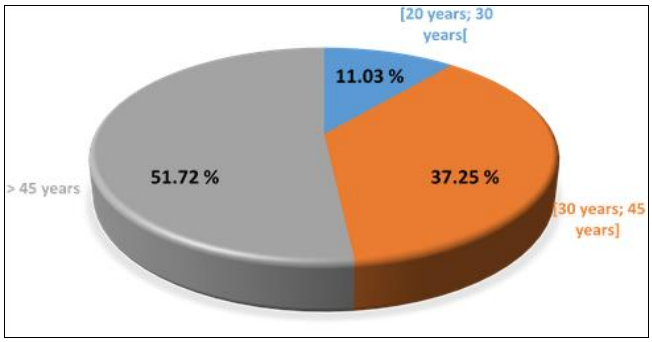


**Fig 4:** Distribution of fishermen identified in the different localities according to the age group in the lower basin of the Comoé River

Several difficulties which make the fishing activity painful have been mentioned. However, two of them have been reported by all the fishermen without exception. It is the massive presence of aquatic invasive plants and especially the closure of the mouth at the level of Grand Bassam. Another set of issues that have been raised by fishermen are the theft of fish and fishing gears, the destruction, throwing up and disappearance of gears due to the flow of water during

rainfall, the presence of reptiles (snakes, crocodiles), manatees (which destroy fishing gear), the presence of hippopotamus that create insecurity, water disruption by some fishermen, the capture of fish juveniles, the presence of plant debris, a decrease in stock, longline accidents, blood-sucking insects.

### 3.3 Other anthropogenic activities in the lower basin of the Comoé River

Human activities that may directly or indirectly impact fishing and the ecosystem have been identified around the main river bed. They are positioned on a map as illustrated by Figure 5. The estimated route gives a distance of 26.686 km, about 27 km.

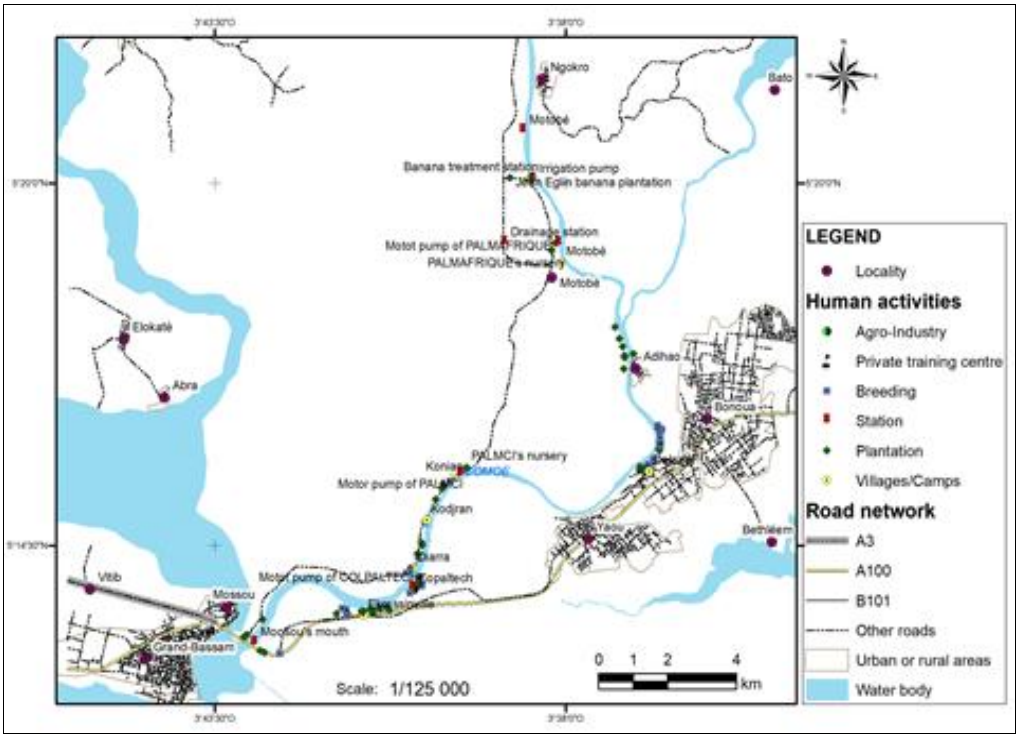


**Fig 5:** Location of stakeholders in the lower basin of the Comoé River

The study made it possible to identify three types of agro-industrial units in this part of the river. So, we have a coconut shell processing unit called COPALTECH which transforms dried coconut shells to produce organic fertilizers used to fertilize vegetable crops, palm trees fields, rubber, cocoa, coffee, banana and horticulture gardens. This unit has a motor pump that draws water from the river for its work. Maintenance water and waste are dumped into a stream that in turn, flows downstream into the river. Furthermore, around Motobé and close to the river, there is a 301 ha banana industrial plantation with a treatment unit, a motor pump to draw water for irrigation and drainage stations to remove excess water from the plantation in the river. For the maintenance of banana to be calibrated, it uses several pesticides. A total of 80 phytosanitary products are used. It is noted that fungicides (38 products), or 47.50 % containing 24 active ingredients in a single or combined dose, are the most used. Nematicides follow with 14 products consisting of 17.5 % of 13 active ingredients and herbicides with 11 products or 13.75 % mainly based on glyphosate and glufosinate-ammonium. All these products comprise 44 active ingredients, either in one or two doses. At the fungicide level, the most common active ingredients in the products are Propiconazole (5), Mancozeb (4), Chlorothalonil, Difenoconazole 250 g/L, Mineral oil, Thiophanate-Methyl (3). Lastly, two nurseries belonging to the agro-industrial companies Palm-CI (6 ha) and Palmafrique (8 ha including 6 ha developed) are located at the edge of the river around the village of Motobé. These nurseries have each one a motor pump to draw water from the river for watering plants. There are drains connected to a common collector which carries the surplus water into the river. Various phytosanitary products are used for the maintenance during the different stages of production.

On the other hand, around the river, several agricultural activities have developed. The study allowed to count 9 plantations of palm trees, 10 cassava fields, 1 corn field, 1 large rice field, 11 rubber plantations, 11 vegetable growing sites (zucchini, cucumber, eggplant, etc.). It uses uncontrolled and abusive phytosanitary products because machete weeding have been abandoned in favour of herbicides as shown in Figure 6.

**Fig 6:** Overview of phytosanitary products sold on the Bonoua market and their use in the field

A total of 17 piggeries which use the river water for animal and building maintenance are counted. Wastewater from these maintenance is directly discharged into the river through canals or PVC pipes without any treatment as illustrated in Figure 7. A number of products are used to treat, wash, treat animals against various diseases (galls, diarrhoea, etc.) and also to feed them.

**Fig 7:** Pig farms and sewage discharge canals directly into the Comoé River.

In total, 5 camps (Adjékro, Diarra, Konian, Kodjran and Ekressinville or 3 Kilos) and 4 villages (Adiaho, Delanoi, Motobé and Yaou) are located along the river. The relationships between the riparian populations and the river are multifaceted. Indeed, the river is used as an open-air shower where almost everybody comes to wash. It is also used to do the laundries and wash the dishes. The riverside is the favourite place for garbage disposal of all kinds. These rubbish end up in the water by leaching, runoff and flooding. The river serves as public toilets where one defecates directly or indirectly. The major issues affecting the sustainability of fisheries, as identified during the EAF field investigations are related to ecological wellbeing, human wellbeing and ability of achieve. Regarding the ecological wellbeing, we observed (i) : the use of non-regulatory gears and prohibited methods favouring the capture of juveniles and the threats of overexploitation of many species, (ii) : the abandonment and throwing down of gears that cause phantom fishing, (iii): destruction of habitats and spawning areas, (iv): the excessive presence of invasive aquatic plants reduces the surface of the water, (v): the garbage deposits along the river, (vi): eutrophication, (vii): the discharge of untreated wastewater from agro-industrial units and livestock, (viii): the defecation of populations in the water, and (ix) excessive use of phytosanitary products that probably end up in the water of the river.

With respect to human wellbeing, the study noted that what was recurring was (i): low access to basic social services, (ii): low income of fishermen, (iii): significant post-harvest losses, (iv): diseases prevalence (malaria) and (v): insecurity related to theft and presence of hippopotamus and manatees.

The major issues raised at the level of governance were: (i): the lack of enforcement of fisheries laws, (ii): the weakness of the fisheries data collection system, (iii): the weakness of consultation frameworks, (iv): the non-compliance with management measures by fishermen, (v): the lack of supervision of the administrative authorities regarding the use of prohibited gear, (vi): the lack of management plans for fisheries when taking into account is essential for sustainable resource management, (vii): the non-application of the legislation due to the absence of fisheries service is an issue to be addressed and (viii): the low level of development of fisheries research. On the other hand, at the level of the External Factors, the major problems observed were: (i): the problem of silting of the river at the mouth of Grand Bassam, (ii): invasive aquatic plant problems, (iii) the destruction of bank vegetation including the mangrove and (iv) the presence of hippopotamus and manatees. From the interview with fishermen for the enrichment of this study, taking into account the problems they were experiencing, namely: (i): the impact of invasive aquatic plants on the reduction of the surface of the river, (ii): the silting of the river responsible for the closure of the mouth and contributing to the shrinking and flow of water from the river, (iii): taking into account the problems of floods in Grand Bassam was important because an opening without prior study would cause enormous damage to the livelihoods of the communities living there, (iv): lack of statistical fishing data; (v): the exact number of

fishermen was difficult to assess and (vi) information on the role of village leaders in fisheries management was non-existent.

A summary of the questionnaire has been made to present the extent of the fishery in this study area and its importance, including the individuals and institutions involved. The exploitation of the survey data has identified a wide range of problems. A total of 105 problems were identified. The distribution of these problems by the generic component shows that seventy-four (74) cases, or 70.47 % are related to ecological wellbeing, the human wellbeing and the ability to achieve account for 16.20 % and 13.33 % respectively as shown in figure 8.

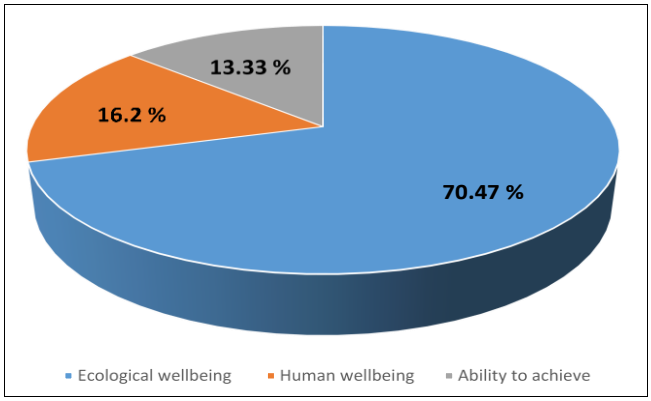


**Fig 8:** Distribution of the problems by the generic tree components

Among the 105 problems identified during the synthesis carried out on the basis of the result of the field data, one note that those related to the state of the resources (juvenile capture, overexploitation and stock reduction) are fifty-five (55), a proportion of 52.38 %. At the end of the prioritization of the problems by the component of the generic tree shown by Figure 2, it appeared that 76.19 %, or more than three-quarters (3/4) of the problems were in the high risk category, while 15.23 % had a moderate risk and 08.58 % had a low risk as represented in Figure 9.

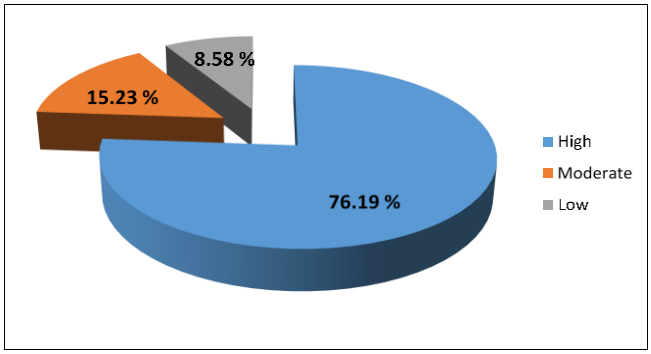


**Fig 9:** Proportion of risk categories in the lower basin of the Comoé River

The distribution of risk levels by the generic components as shown in Figure 10 showed that the ecological wellbeing concentrated the majority of the high risk category with a rate of 75.47 % versus 15.00 % and 09.33 % respectively for human wellbeing and ability to achieve. At the sub-component level of the generic tree, the selected species represented 58.75 % of the high risks, the general ecosystem 11.25 %, the local community and governance respectively represent 5 % and 08.75 % of the overall high-level risks.

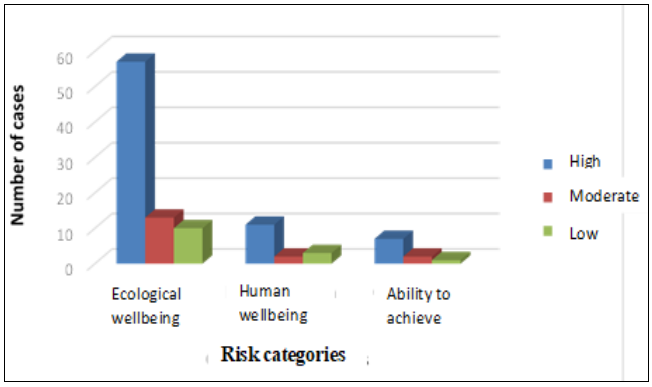


**Fig 10:** Risk proportions by category of the generic EAF tree in the lower basin of the Comoé River

## 4. Discussion

The fishermen in the lower basin of the Comoé River are artisans using traditional fishing gears and methods. They exploit a wide range of fish species within a fluvial environment of which they have a good knowledge. Fishing operations are an integral part of many domestic economies, as well as agriculture. A good proportion of the fish caught is consumed. The rest is sold to supply urban markets of Bonoua, Grand Bassam and Abidjan. However, due to the absence of the relevant departments of the Ministry of Fisheries in Bonoua, this production is not assessed. In general, the low capacity of the administrations to enforce the texts regulating the fishery has allowed fishermen who manage the fishing activities as they see fit. Thus, for the entire study area, fishing is managed as a routine activity but not from a perspective of sustainable resource use. Prohibited fishing gears and methods are used freely according to the common sense of the fisherman. Ultimately, the management of fishing activities in the lower basin of the Comoé River is done outside of any management plan capable of laying the foundations for sustainable exploitation. In such a situation, Charles-Dominique (2008) [6] observes that an open-access common good is destined for degradation through the competition between exploiters seeking to maximize their individual interest. In the same vein, Vanga *et al.* (2002) [23] indicate that a too intensive fishing leads to a shorter lifespan of the fish, a reduced size of the captured individuals, a decrease in abundance, etc.

As regards ecological wellbeing, in the context of the fisheries in this area all species are retained and have a market value. Regardless of the gears considered (gillnet, longlines, Chinese bamboo traps, wire mesh trays, mesh traps), there are no fish species that are not retained or are subject to incidental capture or release. These gears and fishing methods destroy habitats, including spawning areas. All of these fishing gears and methods are not selective. Their low selectivity causes a negative impact on the recruitment of the stocks. It is also noted that fishing methods could have significant impact on recruitment because of the capture of the species (carrier and juveniles females). Mono-filament gillnets and other fishing gears used on the river are in the vast majority non-regulatory. In addition, worn-out nets thrown into the watercourse, forgotten, abandoned gears moved by the stream or by thieves are sources of phantom or ghost fishing. Finally, the last problem relating to the ecological wellbeing is that of the destruction of the forests of the river banks, one of the probable causes of the silting at the mouth of Grand Bassam.

In terms of human wellbeing, fishing activities in the lower basin of the Comoé River generally contribute to provide fish-

based protein to riparian communities and to urban centers near the river. They also contribute to food self-sufficiency and job creation. The absence of a monitoring policy does not allow the exact contribution of these fisheries to wealth creation to be quantified. The persistence of post-harvest fish losses promotes pressure on the resource and the impoverishment of fishermen. Fishermen's specific problems are related to the low technical capacities, particularly in the field of fishing technology, conservation and marketing techniques, which results in the setting of purchasing prices according to the fishmongers. Fishing activities in the lower basin of the Comoe River should involve various stakeholders (fisheries administrations: Ministry of Animal and Fisheries Resources, development societies, riparian populations, etc.). During the investigations it was found the absence of the fishing service responsible for enforcing the laws governing fishing in the country, in particular in Bonoua, the nearest town as provided for in the mode of operation of the ministry in charge. In fact, this absence does not make it possible to fight against the non-respect of the laws by the actors who use large-scale prohibited fishing gears and methods.

The ecosystem approach analysis of the fishery identified a range of issues, including the associated levels of risk. From the hierarchy of problems by the generic component tree, it appears that 76.19 % of the problems are in the high risk category, 15.23 % are moderate risk and 8.58 % are low risk. This high proportion in the high-risk category could be explained, among other things, by the presence of the many ecological wellbeing problems related to the exploitation status of the various fish species of the Comoé River. To explain the situation of shortage of fish, the local populations in general and especially fishermen are unanimous and entirely convinced that witches have hidden the big fish. Any awareness campaign should take into account this perception of the problem by the fishermen. Because it is obvious that they do not perceive their share of responsibility in this situation. Hence, the need to opt for an ecosystem approach to fisheries. FAO (2010) [12] justifies why one should pay attention to the human dimensions of the EAF. This new concept stipulates that, on the one hand, in the case of all absence of any scientific data and, on the other hand, if human aspects are not taken into account, the EAF will be doomed to failure. Therefore, where there is a risk of serious or irreversible damage, the lack of full scientific certainty should not be used as a pretext for postponing the adoption of effective measures to prevent environmental degradation (FAO, 2006)[11].

To get rid of used fishing gears, fishermen find no solution but to throw them into the water. It happens that they lose or abandon their gears. However, the loss or abandonment of gears causes enormous problems. This situation is similar to that observed by (Colby & Mellano, 1994)[7] According to these authors, the loss or throwing down of gillnets or other gears intended to capture fish represents a danger that goes far beyond the mere presence in the water of another non-biodegradable object. It represents real means of inestimable pressure on the fishery resource. A gillnet can continue to fish, with decreasing efficiency, until 10 years after its loss. This phenomenon, known as phantom fishing, occurs primarily in deep water, where the majority of gillnets are lost (Colby & Mellano, 1994) [7]. If it is established that gillnet lost or thrown into the water causes as much damage, what will be the nets, the gillnet nets, metal grilled weaponry, PVC, bamboo or wooden traps? How much fish are they capturing and what are the losses? This phenomenon of phantom or ghost fishing is a priority for which an action plan is needed to develop methods for recovering lost gears. Among other things, it is a question of cleaning the bottom of the water in all areas where fishing is concentrated and especially to study the phenomenon to better understand it. Certainly the implementation of such action is expensive and the fundamental question is who pays. But obviously fishing cannot be the only explanatory reason. Indeed, aquatic resources can be affected by human activities resulting from modifications or destruction of ecosystem habitats and by various sources of overexploitation. The ideal would be to propose a rational approach based on the protection of bloodstocks during the breeding season. Thus, Ouattara *et al*. (2006) [20] propose a temporary closure period. But making such a decision should not be hasty, since each species reacts to environmental factors according to its ecological needs, its reproductive strategy, and within it, according to the different tactics it is likely to develop (Ouattara *et al.* 2006)[20]. The ecosystem approach to fisheries proposes another approach that places human activities, which can impact the resource, at the centre of decision to be made. It therefore takes into account all activities related to the aquatic environment. Prioritizing the issues to be addressed through an ecosystem approach to fisheries is about to clear aquatic invasive plants and open the mouth. The resolution of these problems, which in fact go together, is difficult at several levels. Indeed, the closure of the mouth would be the direct consequence of the Vridi Canal drivage in 1951 (Affian *et al*., 2008; Keumean *et al*., 2013) [1, 17]. The question is whether we should close this channel so that the mouth opens naturally without any financial expense. But the difficulty at this level is to find another passage for the boats to reach the port of Abidjan. It appears from the investigations with the Ministry of Environment and Sustainable Development, the competent structure of the file, in order to avoid the silting up of the Vridi Canal, ears had been built in its western part. Thus the blocked sand would have migrated to the eastern part which is closer (Grand Bassam) where no protection infrastructure had been planned. This part then undergoes the stock of sand which digs and pulls sediments to deposit at the mouth. In 2011-2012, the Prime Minister authorised a mission of the Minister responsible for Environment and Sustainable Development in Netherlands to find technical assistance and possibly financial assistance to deal with the problem of coastal erosion in Côte d'Ivoire. As a priority action, the government initiated the project to open the mouth of the Comoé River in Grand Bassam. A feasibility study was carried out at an overall cost of F CFA 1.010 billion. It made it possible to define the works of protection of the channel and the construction works as well as the costs of realization estimated to F CFA 20 billion.

The Comoé River has become a kind of garbage or dump for riparian populations. In fact, they reject their household garbage, bathe and defecate in it. On the surface of the water there is a proliferation of invasive aquatic plants. A similar situation was observed by Adingra & Kouassi (2011) [2] on the Ebrié lagoon. These authors considered this to be a cause of eutrophication. One of the many problems with this presence is that at the end of their cycle, these plants die by producing organic matter whose decomposition requires a lot of oxygen. If there is not enough dissolved oxygen, fish and invertebrates die by asphyxiation. These floating plants cause the decrease of fishing areas, the limitation of navigation and the reduction

of the depth of the euphotic layer. Indeed, by shielding the penetration of light, they limit primary production.

Several phytosanitary products are used on the same perimeters for decades in this study area. This situation is consistent with that of Bertonnier *et al*. (2012) [3] who argued that with the development of modern agriculture, chemical weeding has appeared and has quickly imposed itself. Most of the plantation located in this study area use large quantities of fertilizers and phytosanitary products such as insecticides, fungicides, nematicides, raticides and herbicides. According to Adingra & Kouassi (2011) [2], the leaching of these fertilizers and pesticides from the plantations to the coastal rivers and marine ecosystems induces the eutrophication and chemical contamination of the waters and fishing products. The herbicides used for this purpose are products designed to control weeds, unwanted plants safely and effectively. The problem is that they should be used correctly. However, according to Garric (1997) [14], an intensive use of pesticides in the environment is a source of contamination of aquatic receiving environments and disturbances on biological organisms. The phytosanitary products, which are synthesized to eliminate target organisms, are also likely to cause lethal toxic effects on all aquatic populations. In this regard, Coulibaly *et al*. (2012) [8] explain that the application of pesticides in this watershed is done with atomizers, hand sprayers and sometimes aircraft. The latter type of treatment is responsible for the loss of more than 50 % of the products outside the treated area (Pimentel & Levitan, 1986) [21], which increases the risk of environmental contamination, particularly water resources. Stormwater runoff contribute to the pollution of surface water while leaching contributes mainly to deep water (Hayo van der Werf, 1997) [16]. They are therefore a serious threat to the environment and represent a significant long-term risk to species, ecosystems and human health. They are eventually likely to lead to a change in ecological balances and a decrease in the productivity of the ecosystem, which may be acute and obvious, such as fish or invertebrate mortalities following massive spills, decreased reproductive capacities of a species or behavioural changes, difficult to show *in situ* (Garric, 1997) [14]. In this part of the river, machete work is replaced by these products, unaware that these hazardous substances are extremely stable and persist in the environment, accumulate in living organisms and food chains, toxic to humans and animals, causing chronic effects such as dysfunctions in the reproductive system, immune and endocrine systems, as well as cancers and are propagated in the environment over long distances to locations far from emission sources (Mörner *et al.*, 2002) [18]. This study identified 62 active ingredients containing biocidal molecules themselves and data relating to their toxicity even on non-target organisms including fish and aquatic life in general. This result is significantly higher than that of Coulibaly *et al*. (2012) [8] which identified 44 active ingredients throughout the Comoé watershed, 22 of which were found in the lower basin. For this part of the basin, there is an increase in active ingredients used, about three times. This result could be explained either by the lack of agricultural labour or by the fact that crops in this area require the use of many molecules to control insects, nematodes, weeds and induce certain stages of growth in plants (Coulibaly *et al*., 2012) [8]. The most characteristic impact reported by Chapman (1987) [5], is the decrease in dissolved oxygen, more or less quickly after treatment. This decrease would be due both to the decrease in oxygen production by plants, and to the demand for oxygen from the area, due to the decomposition of dead organisms. At the aquatic plant level, any herbicide in which the active ingredient is a trazine or hexazinone, causes up to 80 % decrease in the phytoplankton photosynthetic activity of the area after application at concentrations of 145 à 432 µg/L (Schneider *et al.*, 1995) [22]. According to these authors, the repeated use of these products is also likely to cause alterations in the invertebrate stands, the disappearance of non-target aquatic vegetation (algae, sanctuary plants, etc.) and thus have a long-term impact on the growth and reproductive potential of fish.

## 5. Conclusion

In a view of all of the foregoing, it could be argued with a small margin of error that the observation made on the structure of fish stocks in the lower basin of the Comoé River would be the resultant of combined fishing actions and direct or indirect discharges in the waters by the neighbouring populations. These actions degrade obviously the habitats of fish. The impacts of all these actions on the basin of this ecosystem include, among others, drinking water pollution, microbial pollution, excessive nutrient enrichment, habitat and community alteration, ecosystem loss, ecosystem modification, occurrence of invasive species and destructive fishing practices. During the investigations, the present study had been able to make the observation of the strong degradation of the ecosystem of this basin. In fact, the forests have been destroyed in places in favour of agriculture, leading to erosion and major landings in the watercourse, hence the closure of the mouth. If nothing is done, there will be many future pressures and likely consequences. For the river, in addition to sedimentation, eutrophication, the proliferation of invasive species, we could note the loss of fish breeding areas, the reduction of fish stocks due to the intensification of discharges of all kinds in the water, deforestation for agricultural use, the use of pesticides and fertilizers, inappropriate farming and fishing techniques, urbanization and anthropogenic activities. In general, the future pressures in this basin will likely result in loss of the biodiversity, loss of the flora and the fauna, soil degradation (erosion), reduced ecosystem functions and productivity, loss of the ecological balance, etc. It goes without saying that the probable consequences for the population will be the fall in income and purchasing power, the increase in poverty, the recrudescence of water-borne diseases, the emergence of conflicts between non-natives, indigenous and foreigners.

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