

# Spatial analysis of the mode of management and conflicts of use of water resources in the watershed of the Lobo River in Nibehibe (central-western Côte d'Ivoire)

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## ABSTRACT

Water resources are essential for the survival of the populations of the Lobo watershed in Nibéhibé. They offer many multidimensional services. This is why their management is confronted with a difference in logic and action on the part of the various stakeholders. This study aims to study the different modes of water resource management and water-related conflicts in the watershed through a spatial analysis using mapping software. Using a mixed approach including semi-structured interview methods and surveys, qualitative and quantitative data were collected. The analysis of the data revealed on the one hand that the current management mode is either liberal or private, or participatory or community-based depending on the type of water resource and on the other hand that the different uses generate conflicts between the actors. These conflicts are perceived between indigenous people who are mainly cultural actors and economic actors such as the Water Distribution Company in Cote d'Ivoire (SODECI) and fishermen. Without forgetting the existence of conflicts between women, which can be summed up as disputes over water points. An integrated management of water resources in this watershed would therefore be beneficial to all actors.

*Keywords: Conflicts of use, Integrated Water Resources Management, Lobo watershed, spatial analysis, water supply*

## 1. INTRODUCTION

Water is a limited and vulnerable resource, essential for life, development and the environment [1]. It is a vital issue in all countries of the world. Therefore, Water resource is one of the major public assets which is a critical need for human wellness. Water use can be mainly divided for agriculture, industry and domestic supply as well as maintaining ecosystem, of which these usage and maintaining should be in equity in terms of quantity and quality [2].

In Côte d'Ivoire, the stakes of water management are high because the development of almost all sectors of the national economy depends on water resources. It is therefore imperative that sustainable management of water resources be integrated into Côte d'Ivoire's development programs in order to achieve long-term economic and social development [3]. However, water resource management faces both hydrographic and social interactions that have led to competition and conflict, making resource management a framework where different views among stakeholders in the stewardship process are manifested and where very different environmental, socio-economic and cultural interests, values and processes confront each other [4].

In the Lobo watershed, each sector of water use, i.e. agriculture, drinking water supply, pastoral hydraulics, mobilizes the quantities necessary to meet its needs, without worrying about the needs of other sectors or the long-term survival of ecosystems [5]. Also, it must be noted that this watershed is characterized by a crystallization of social relations between the different groups of actors involved. This crystallization revolves around conflicts of use and the intensity of water

scarcity. It thus appears opportune to understand the origin and the intensity of these conflicts linked to the mode of management of water resources in order to possibly propose solutions for its perpetuation, through an equitable and reasonable exploitation for the sustainable development of the catchment area. This will have to pass by a collection of quantitative and qualitative data through the realization of a field survey among the actors of these water resources. The constitution of a reliable database is the guarantee of a healthy appreciation of the relations that the populations maintain around the water plans and water sources.

Within the framework of this study, it is a question of making a diagnosis of the mode of management and the conflicts of uses related to the resources of the basin through a spatial analysis. A precise analysis of the spatialized information by a spatially referenced information system can allow to evaluate the modes of management of water resources and the extent of conflicts with regard to socio-cultural concerns.

## 2. MATERIAL AND METHODS

### 2.1 Study Area

The Lobo watershed is located in central-western Côte d'Ivoire between 6°17' and 6°44' W longitude and between 6°46' and 7°41' N latitude (Fig. 1). It drains an area of 7,000 km<sup>2</sup> with an outlet at Nibéhibé. This watershed has a catchment area that is not circumscribed within a single administrative entity. Most of the basin covers the departments of Daloa, Issia, Vavoua, and Zoukougbeu. The Lobo river has its source at an altitude of 400 m south of Séguéla and flows into the Sassandra river not far from the locality of Loboville. The town of Daloa represents the economic pole of the region.

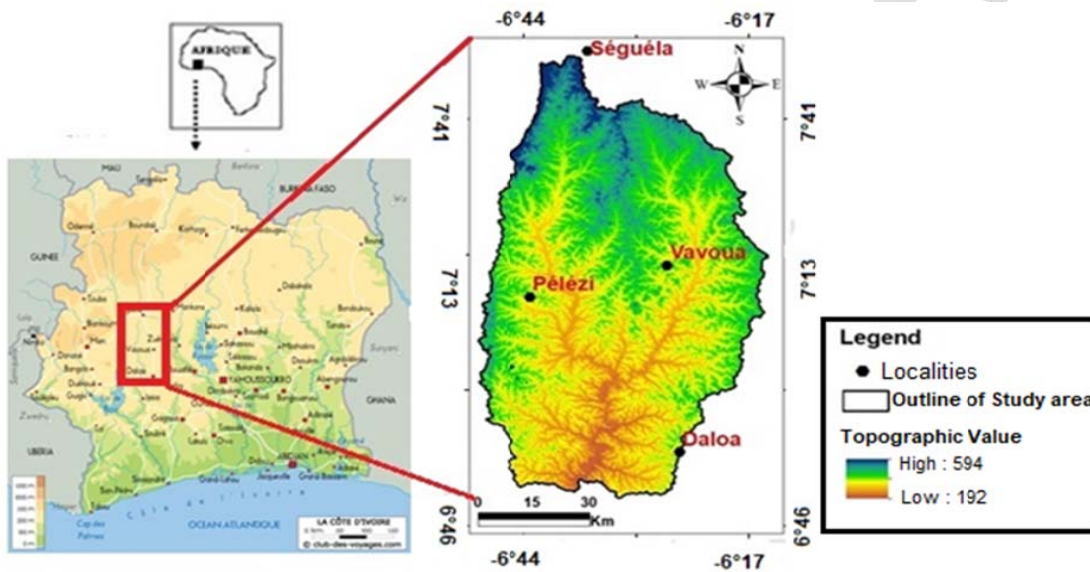


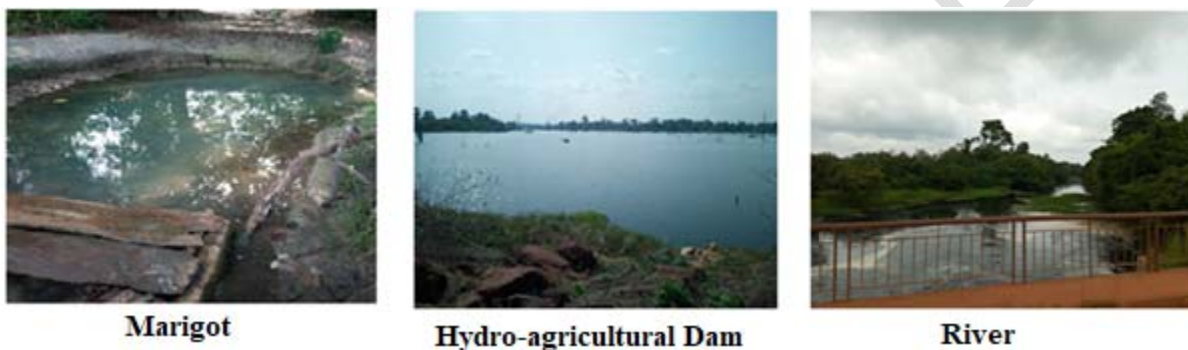
Fig. 1. Location of the Study area

To supply their water needs, populations rely on both surface water and groundwater. Thus, groundwater is captured by wells, springs and boreholes or village hydraulics (Fig. 2).



**Fig. 2. Groundwater Supply Source**

As for the surface waters useful to the populations' needs, they are represented by rivers, hydro-agricultural developments, marigots and lakes (Fig. 3).



**Fig. 3. Source of Surface Water Supply**

## 2.2 Material

The material consists of data and tools. The data concerns information on the problem of water resources in the localities and was collected through a questionnaire survey and interviews conducted with stakeholders in the Lobo watershed whose outlet is in Nibéhibé. Similarly, a topographic map, a GPS to record geographical coordinates and a digital camera for taking pictures were used.

The processing of the data collected during the exploratory survey and the field survey was done in the form of cartographic, graphic, statistical analysis through manual and computer processing. For this purpose, several software programs were used, namely, Excel spreadsheet to process statistical data, Adobe Illustrator and ArcGIS software for the implementation and mapping of spatially referenced data.

## 2.3 Methodological approach

In order to carry out this study, several methodological approaches were used to collect data. These are documentary research, field observation, questionnaire survey and semi-structured interviews.

Indeed, the study started with the documentary research and the activity reports of the services in charge of water management. Semi-directive interviews (with an interview guide) and a standardized questionnaire were administered to carefully selected stakeholders. In addition, direct observations were necessary for data collection. The study was carried out in 30 localities in the Upper Sassandra region, the choice of which was based on various criteria, such as :

### Accessibility

Indeed, at the watershed level, during the rainy season most of the roads become impassable. It then becomes perilous or even impossible to have access to the various localities. For this reason, the localities whose roads are practicable have been chosen;

### Spatial distribution

This criterion was taken into account to allow a wide coverage of the basin so that the information sought is representative of the reality of the basin;

### Number of households

The watershed having a large surface area, it was essential to select localities with a slightly larger and fairly significant population.

The sample size (n) for each locality was determined by the following statistical formula:

$$n = \frac{(z\sqrt{pq})^2}{c^2}$$

n = Representative sample size

z = Margin Coefficient

c = Margin of error

p = Proportion of households assumed to have the characters sought after.

This proportion varying between 0 and 1 is a probability of occurrence of a event. If no value for this proportion is available, it is set at 50% (0.5) and q = 1 - p. Assuming p = 0.50 then q = 0.50; at a 95% confidence level, z = 1.96 and the margin of error c = 0.05.

Thus, after calculation, the total number of households to be interviewed in the set is 384 households.

The interview guides were oriented towards state structures intervening in the field of water resources and also towards households. These include the Water Distribution Company in Côte d'Ivoire (SODECI) in the Daloa region and the Territorial Hydraulic Directorate (THD).

## 3. RESULTS AND DISCUSSION

### 3.1 Results

#### 3.1.1 Water Uses

Water uses were represented according to sources of supply, including SODECI, backwaters, river, human-powered pumps and wells. Thus, water uses are different depending on whether the water is surface water or groundwater.

Household water supply within the watershed for different domestic needs is provided by a variety of water sources at urban and rural scales (Fig. 4).

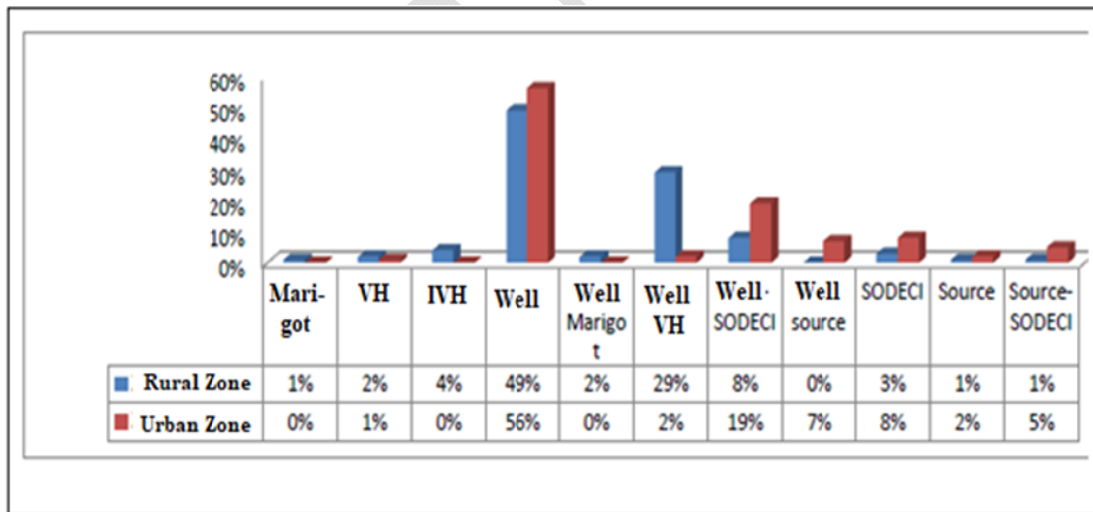
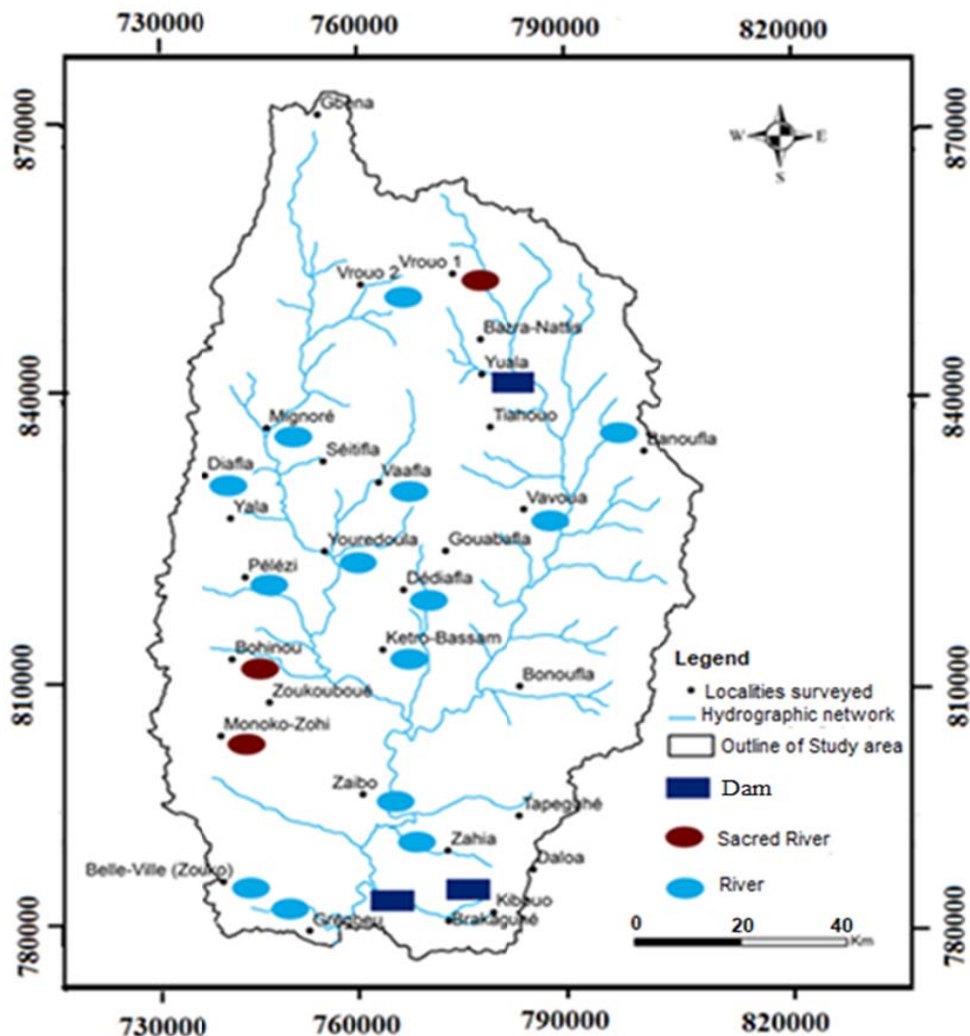


Fig. 4. Proportion of water supply sources by rural and urban areas

Groundwater resources are divided between traditional wells, village hydraulics (VH), improved village hydraulics (IVH) and natural water sources. This groundwater is mainly the source of water supply for people in rural areas. The use of this

water is mainly intended for domestic activities, whose consumption constitutes the main need, regardless of the type of resource.

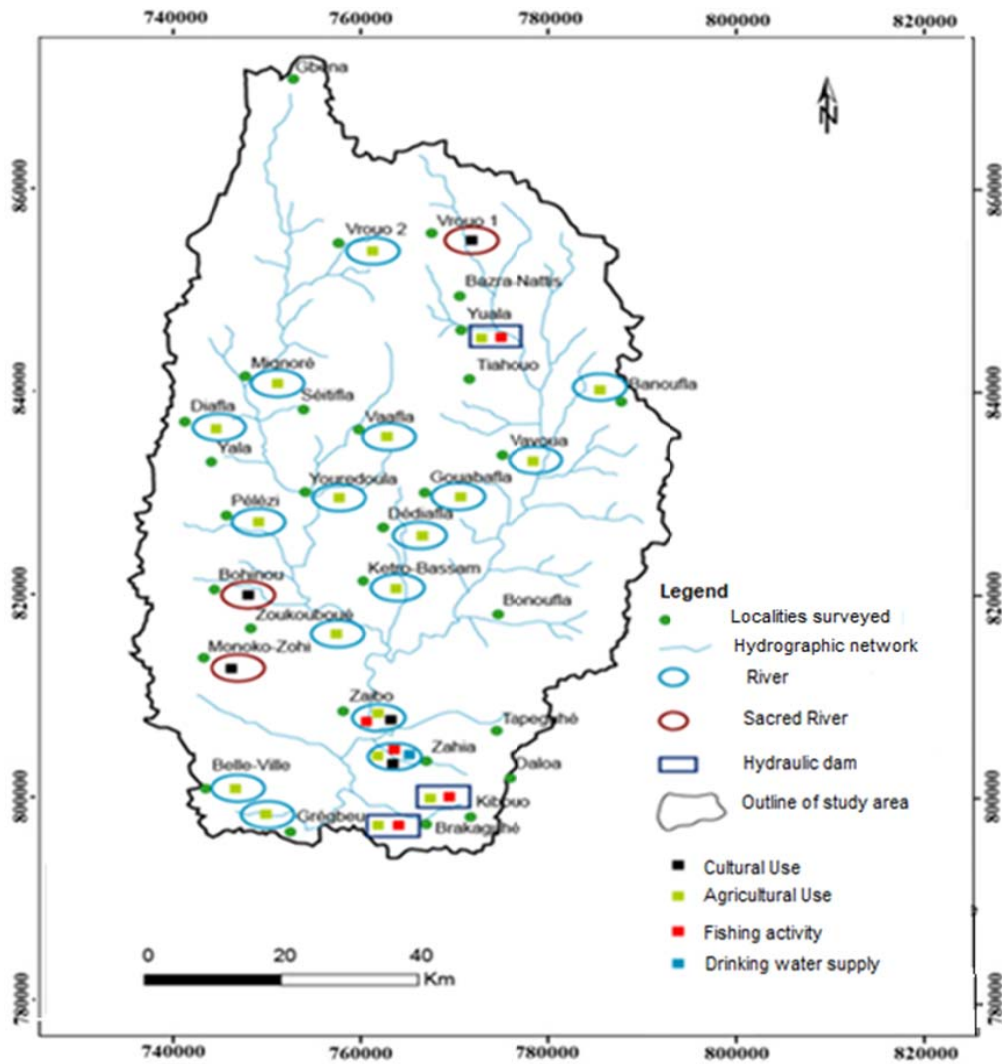
As for surface waters, they concern hydro-agricultural dams, rivers, marigots and lakes. Fig. 5 presents a spatial distribution of rivers and hydro-agricultural dams used in the daily life of the populations.



**Fig. 5. Spatial distribution of surface water sources (hydro-agricultural dams and rivers) on the catchment area use by people**

Rural populations have direct access to these water resources for their daily needs.

These water resources are used for several purposes. They are indispensable for life and most domestic needs, drinking water supply (SODECI) and human activities such as agriculture and fishing. Throughout the basin, these different categories of use are not distributed uniformly and not all resources are subject to the same uses (Fig. 6).



**Fig. 6. Spatial distribution of surface water resources and different uses**

The analysis of Figure 6 shows on the one hand, the concentration of several activities carried out on the same resource and, on the other hand, the presence of a single activity on several resources. Thus, at the level of the Zahia River (Zimeguhé, Château), four main uses of the water resource are perceived. Let us note that this river answers divergent needs which are among others related to the cultural practice, the agricultural activity, fishing and also to the supply of drinking water of the commune of Daloa by the SODECI. At the level of other surface waters, the water is either used for agriculture or is considered sacred and meets a cultural use precisely in the localities of Bohinou Vrouo 1 and Monoko-Zohi. For these populations the water resource is a heritage. In addition, on all the dams, two main activities emerge: irrigated agriculture and fishing. Table 1 presents a summary of the different actors and users of surface water.

**Table 1. Summary of the different uses of water resources in the Lobo watershed according to the actors**

<b>Actors</b>	<b>Interest of the exploitation of water resources</b>	<b>Activities practiced</b>	<b>Frequency of activity</b>	<b>Sites of realization</b>
<b>Natives people (Bété, Niamboua, Yandeboua, Gouro)</b>	Social	Domestic activities	Daily	Home
	Cultural	Subsistence fishing	Daily	River; Lowland
		Seasonal fishing	Periodical	River
		Adorations, rituals, libation	Periodical	River
Economic	Agricultural activity (market gardening, irrigated rice)	Daily	River; Dam; Lowland	
<b>Allochtones (Baoulé and other)</b>	Social	Domestic activities	Daily	Home
	Economic	Agricultural activity (market gardening, irrigated rice)	Daily	River(Tchrato); Dam; Lowland
<b>Allogens (Bozo)</b>	Social	Domestic activities	Daily	Home
	Economic	Fishing for profit	Daily	River (Tchrato)
<b>SODECI</b>	Economic	Drinking Water Supply	Daily	River (Tchrato), Borehole

Table 1. reveals a fundamental dependence on certain water resources, including the river. This dependency is most apparent on the Tchrato River, which has several actors, namely SODECI, the indigenous Bété, the Bozo and the farmers, with divergent usage logics. The total dependence of the Tchrato River on SODECI and some Bozo explains once again the intensity of the exploitations that the latter carry out in the river.

### **3.1.1.1 Heritage Value of Water Resources to Native People**

For indigenous people, water resources are a land heritage. They make these resources their own because they feel they are the first people to live around them, which gives them the right to have real control over these water resources. This perception of these resources is generally perceived in practically all the localities that are in contact with these waters. Moreover, these spaces are perceived as living environments of the gods and ancestors. These water resources have sacred values for the indigenous people. It is the living and dwelling place of the gods and ancestors. This reality is based on the fact that they are the only ones to worship the libations and cultural practices around water. There is also the aspect of protection and happiness that water represents for these natives. This easily justifies the importance that these peoples give to all the water resources in the basin because water is a source of life for all living beings: man, plants and animal species.

### **3.1.1.2 Economic stakes of the Trchrato River for SODECI**

The water resource in the watershed, more precisely the Tchrato River, is perceived differently by another type of user, namely SODECI. For this company, the land is the exclusive property of the State, which gives it the right to control everything on it, including water resources. Therefore, the State can use it to meet general interests. All these considerations suggest that water resources are not the property of rural communities or the people around them. On this basis, they do not find it necessary to have the permission of a local community before settling down for their activity. This company sees water as a real factor of development because water is the driving force behind the activities of several fields. There is a growing recognition that water, particularly access to safe drinking water, is at the root of some of society's most pressing concerns. Today, there is general agreement that the survival of humanity and all species on earth depends to a large extent on water resources. Therefore, people must be allowed to have as much water as they want. Behind this concern to satisfy people's needs for drinking water is the economic and even commodity nature of water for SODECI. In its drive to meet the needs of the population, SODECI provides households with meters for a fee. Subsequently, bills are distributed to the population according to their different consumptions. This reality justifies the

economic interest that water represents for this company. This form of perception differs from that which the natives have of the river.

### **3.1.1.3 Economic value of water resources among fishermen (Bozos)**

Fishing for commercial or economic purposes is carried out on waters developed for pastoral purposes and also on rivers to which the natives attribute a heritage value. In general, we find these Bozos around the different resources of the basin with a high concentration in Zahia (Zimeguhé, Castle) and Zaibo (Sikaboutou). For these fishing communities, water is an economic asset. Indeed, the Bozos live from the fishing activity that they practice all the time. This constitutes a source of wealth in the sense that it is the basis of the economy of these fishermen. Thus, we understand that water becomes a main instrument to generate wealth for these communities. Water is therefore exploited for profit and constitutes the central element for the economic development of the Bozos. Thus, they invest considerably in order to meet all their needs.

In short, let us remember that water is a universal good and a collective resource, but it can also be used as a private good or a vital economic commodity. It is imbued with cultural values and plays a major role in communities. This resource presents diverging perceptions and different interests among users in some localities of the Lobo watershed, with social consequences that can be summed up in the degradation of relations between them, leading to conflicts.

## **3.1.2 Management of the water resources of the basin according to uses**

In the Lobo River basin, there are two types of management, namely: liberal or private management and community or participatory management. These management methods depend on the type of water resources (surface or ground water).

### **3.1.2.1 Community Management**

Community-based management is one of the management models in the Basin. It is based on local or traditional management in which the various local actors are included. Community water management constitutes a coherent and organized structure in which water is perceived locally as a source of life and a common good. This promotes significant social inclusion. However, it is important to point out that this form of management remains dependent on social norms or is still informal. This form of management is generally perceived in the watershed and concerns VH, IVH, natural water sources and marigots. It should also be noted that this management is governed by customary laws and regulations such as the prohibition of certain practices. Generally, the populations are obliged to ensure the proper use of the water resource. Community disciplinary sanctions are imposed on the perpetrators of any contravention. In some localities, in the management committee of these water points, there is a treasurer who is responsible for collecting funds from each basin or bowl. These funds are generally used for the maintenance of the hydraulic equipment available to these populations.

However, it should be pointed out that the poor management or the non-existence of a management mode and committee for certain hydraulic pumps in most cases explains the abandonment of the failed structures and favors a large number of non-functional village hydraulic pumps. When we take the case of the locality of Pelezi, out of seven existing pumps, only one pump is functional according to the village chief. This situation is remarkable at all the sites surveyed. This could be explained by the lack of maintenance of the structures and also by the lack of a monitoring system after the installation of these pumps.

At the level of the hydro-agricultural dams, on all three sites that are Yuala, Kibouo and Brakaguhe that we visited, except for the Kibouo dam, there is a water management committee that is set up and this committee pilots the activities in order to satisfy each stakeholder, mainly the farmers. Moreover, in Yuala, after the construction of the dam for agricultural purposes, the management was entrusted to the surrounding communities who ensure the management. This consists in collecting funds from the fishermen known as Bozos. These funds allow the maintenance of the developed body of water. This committee is also in charge of looking after the fishing equipment.

### **3.1.2.2 Liberal management**

As far as groundwater is concerned, wells are generally the source of water most used by the population. In all households, everyone has a well at home or in their field, which they use as they see fit. The traditional well can be both private and public. The property is private, the use is public. Throughout our area of investigation, access to the well is free and generally free of charge. Its maintenance is a matter of good will: that of its initiators and its users. This leads to the so-called liberal management of the wells in the Lobo catchment area. The same applies to natural water sources.

This form of so-called liberal management is organized by households to have water available at any time and to ensure that cleanliness is maintained around these water points. Moreover, it is important to note that this organization does not actually benefit from a management method or a role assigned to each user for its management. Only regulations are established to maintain the environment in a state of permanent cleanliness through an adequate water treatment and environmental sanitation system. There is therefore no concerted action in the management of this water point. Each user uses it as much as he or she wants to meet his or her daily water demand.



### 3.1.3. Water-related conflicts of use

Water is a universal good and a collective natural resource. However, it can also be used as a private good. In view of the importance of this natural resource, it attracts many users with divergent interests. At the level of the lobo watershed in Nibehibé, the sources of conflicts between the different actors are, on the one hand, cultural (indigenous people) and on the other hand, economic (farmers, fishermen and SODECI). All these entities have different perceptions of water resources. Thus, most of these conflicts stem from the use of water for divergent purposes and the absence of a regulatory framework adopted by all stakeholders. Fig. 7. presents the spatial distribution of cases of conflicts or not related to surface water over the entire watershed.

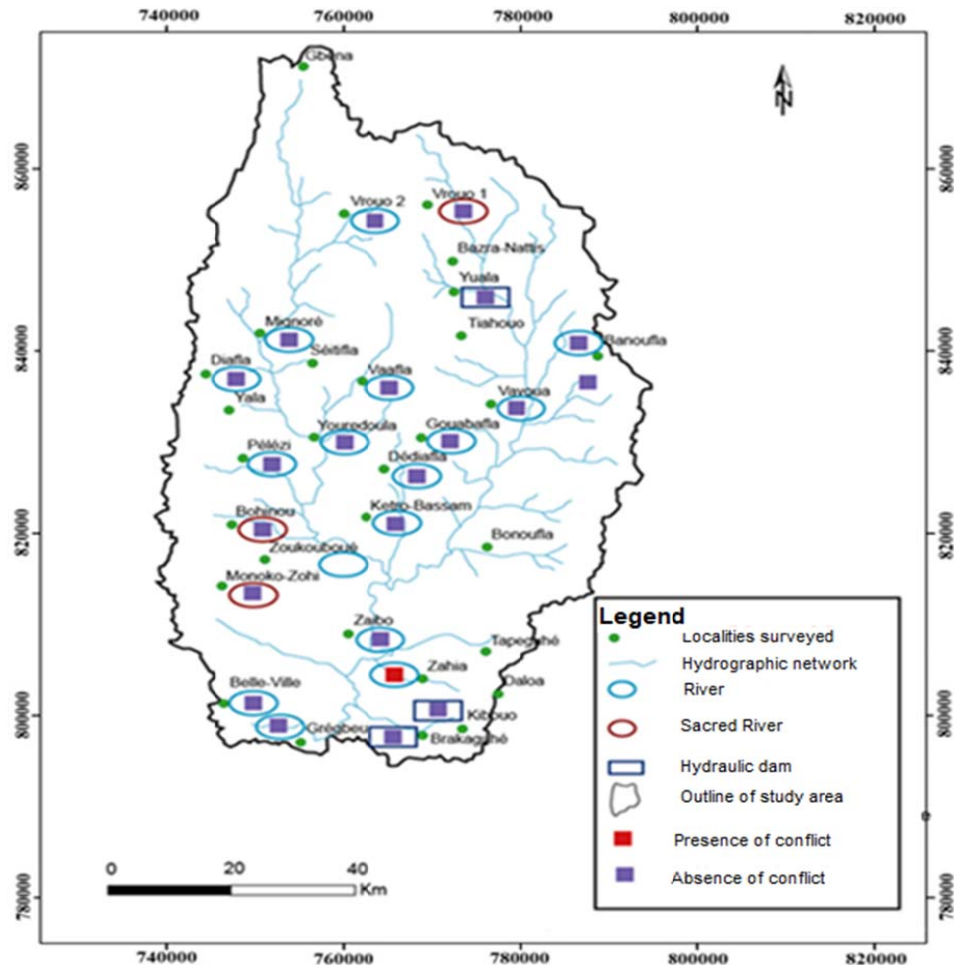


Fig. 7. Spatial Distribution of Surface Water Use Conflicts in the Watershed

Fig. 7 shows the conflicts we observe in the watershed. The cases of conflicts are perceived in the zones of Zahia, more precisely in the locality of Zimeguhé around the Tchrato River, which records two main types of actors and these show interests of divergent uses. This situation of conflict is not the case at the level of other water resources. Indeed, the absence of cases of conflict is explained by the fact that the indigenous people of these different places always have overall control of the water bodies which are generally managed by the land chiefs on the basis of certain principles imposed on the users, namely: for a harvest of ten (10) bags of rice, the farmers hand over one (1) bag to the landowners. Also, fishermen pay a sum of 9 dollards US per fisherman to have access to the water body.

In addition, on certain bodies of water such as the Yuala Dam, the management is ensured by the different villages sharing the plan, i.e. Déragon, Bazzra, Yuala and Brouafla. This management is qualified as inter-village participatory management. Thus, each village takes a critical look at the use and management of the water body and contributes to a

better management. These different realities seem to differ from that of the "Tchrato" river, which records cases of conflict between the different stakeholders with contradictory use interests that are the source of social imbalance in this locality. The results of the study relating to conflicts are summarized according to the conceptual diagram (Fig. 8) which presents the causes and effects of these conflicts.

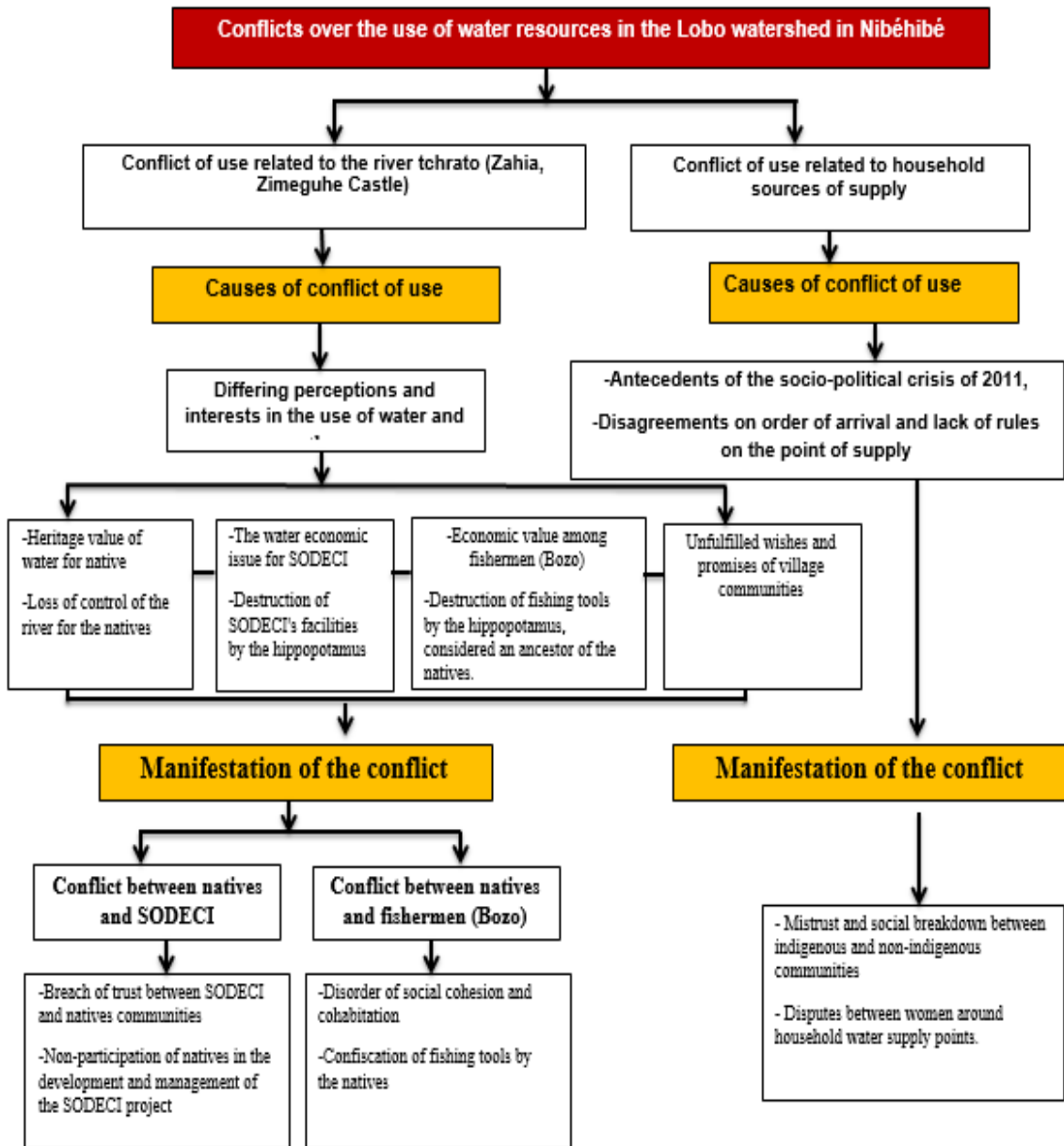


Fig. 8. Conceptual diagram of water resource use conflicts in the Lobo watershed at Nibéhibé

## 3.2 Discussion

### 3.2.1. Method of water resource management

Based on the results of this study, several water management options are available in the Lobo watershed in Nibéhibé. These modes of management are obviously linked to the different resources, whether underground or surface.

At the level of groundwater, which constitutes the main sources of household water supply, two types of management are presented, namely liberal or private management and community management. With regard to groundwater, it is a form of management set up by the holders of the various water points. There are really no established rules for its management. This form of management most often consists in the execution of orders to keep the premises of the water point in

adequate hygienic conditions. These results are in line with those of [6], who in his studies emphasizes that individual water management is observed at the level of water points (wells and boreholes). It is organized by the households in order to have water available at all times and to ensure that cleanliness is maintained around the wells and boreholes. [7] in turn talks about endogenous management: It is the way of managing in an environment without external interventions. It is the set of knowledge, beliefs, exploitation practices and adaptation strategies of a community of men (a socio-cultural group) concerned by the ecological potential in question. In this case, it refers to the water resources by its geographical position (resident of the commune), its knowledge of the environment (founding group or formerly settled group). Thus, the collaborative approach for sustainable management of watersheds is built on engagement of diverse stakeholders [8].

### **3.2.2 Conflicts over the use of water resources**

According to [9], the multitude of watershed planning and management objectives inevitably leads to conflicts among watershed stakeholders, or interest groups. In deed, the competitive and divergent use of water resources at the various water points is a source of conflicts of use in some localities in the basin. There are some cases of source conflicts (VH and IVH) that can be summarized as mistrust. On the other hand, other cases of conflicts are related to surface water. This reality is perceived more on the Tchrato River in the localities of Zahia (Zimeguhé and Château) between the natives who are the cultural actors and SODECI considered as an economic actor. Also, between natives and fishermen known as Bozo. Indeed, very often conflicts break out between SODECI and the indigenous populations because of the presence of the hippopotamus in the Tchrato River. This animal constitutes a real danger to the lives of SODECI agents in the exercise of their work in this river. Also, this hippopotamus is the source of many damages to SODECI's equipment. For their part, the natives cannot imagine that SODECI could sell them the water, because this water is their heritage. They also deplore the very high cost of the water meter and find the water bills exorbitant. Consequently, they consider that the damage caused by the hippopotamus is a sign of its anger, and therefore SODECI must pay an almond to calm the anger of the animal they consider to be their ancestor. This very often disrupts the permanent distribution of water in the watershed. Moreover, it happens that the fishing equipment of the non-natives is confiscated by the natives or destroyed by the hippopotamus present in the water body. Also, the non-natives see in this animal a mystical spirit because it only harms the foreign community. This favors attitudes of mistrust of these fishermen towards the natives.

According to [10], where water is perceived as a community heritage on the one hand, following social and cultural precepts, it is also conceived as an economic good for certain socio-professional categories and public water utilities whose work is oriented towards the principles of general interest. This explains the most often contradictory representations around water resources, which are the source of social imbalance. They continue in this vein by showing that conflicts are frequently linked to the increase in the number of users and the diversification of uses, which are interdependent aspects. The Lobo watershed is no exception.

[6] addressing this issue in the locality of Mbomboye (Senegal), points out that the demand for water is increasing sharply in this rural world, which creates competition between the different water users and the managers concerned, sometimes disturbing the social balance. He continues his argument by showing that conflicts often arise under conditions of misunderstanding created by the users of the water resource, each of them trying to protect these interests in the best possible way. While the results of this study show that water conflicts are rooted in the competitive and divergent use of water. Similarly, [11] noted problems of conflict over water use in Rwanda.

[12] shows other parts of the causes of water conflicts namely: population growth, climate disturbances and its consequences such as drought, desertification, poor soils, water scarcity, pasture degradation are often cited as the main causes of conflicts. And these are more perceived between farmers and pastoralists. Moreover, [13] demonstrates in his work that water management, which is sometimes transboundary, leads to conflicts between some countries. This situation is better illustrated in the work of [14] who highlights the Cameroon-Nigeria conflict. Indeed, this border conflict is related to the geo-economic (control of trade flows and their repercussions) and geopolitical (control of migration and territorial integrity) issues related to access to the waters of Lake Chad.

## **4. CONCLUSION**

Semi-directive interviews and a standardized questionnaire were administered to users of the water resources of the Lobo watershed in order to understand the mode of management and conflicts related to the use of these resources. The survey methodology was based on objective criteria for data reliability and representativeness.

Data processing and analysis revealed that the different modes of water resource management characterized by sectoral management that is either community-based, liberal or participatory with multiple interests constitute a threat to the sustainable management of these resources. This threat makes its use dangerous and disrupts social cohesion, which leads to social unrest between the different actors of the water resource, namely the indigenous people, SODECI and the fishermen. These social unrest would thus be at the root of the frequent shortages of drinking water supply for the population of Daloa whose treatment plant is located on the Tchrato River.

In view of all these realities facing the Lobo watershed, we need to think differently about the management of water resources. It will have to be part of an integrated water resources management approach to the detriment of sectoral management for a rational, equitable and sustainable use of water resources in this watershed.

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