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Impact of Urbanization on Forest and Lagoon Environments in Ivory Coast: Case of Abidjan

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Abstract: *Humanity, in its desire to achieve its economic development which leads in many respects to an expansion or transformation of the rural areas into urban centres, has led to the degradation of many ecosystems over the time. According to the latest assessment of global forest resources since the Rio Summit in 1992, forest cover continues to decline alarmingly. This particular rapid disappearance affects a range of irreplaceable natural environments, including tropical forests. This is happening all over the world at a high rate and Cote d'Ivoire (Ivory Coast) is no exception to this destruction. The case of present study space is a bit special in the extent or in addition to the forest that the city of Abidjan devours, the presence of beautiful lagoon water too suffers from year-to-year pollution constantly. This pollution is due to rapid urban growth and Abidjan's rampant demographics (a particular sign of the global metropolitan growth) with the absence of a life-size wastewater treatment program in the city. This study attempted to map the impacts and extent of influence of the population on the waters and forests in the Abidjan, the sixth largest city of African Continent. Whereas, several earlier studies have overwhelmingly generalized such issues, present work endeavoured to look into the details through the various maps and the analysis from a primary survey conducted online to assess the impacts and degraded environment of the city. Declining forest cover and polluted lagoon depict a dark side of the urban growth in developing countries.*

Keywords: *BNP, Deforestation, Developing countries, Pollution, Urbanization, Western Africa*

I. INTRODUCTION

Ivory Coast, being one of the important and largest countries of Francophone world, owing to its geographical peculiarities, is known for its equatorial environs and varied biodiversity. The relief and climatic diversities have been influencing its vegetations. Being a developing agricultural country, its growing population has been a threat to its forests for need of more and more agricultural lands (Kouadio and Singh, 2021). Over the time, its forest cover has been reduced to less than 2.7 million hectares since 1991, which was more than 12 million hectares in 1950s. This depletion of its green cover has really hindered the preservation of bio-diversity and poses a major challenge in its sustainable development policies (Zeta et al, 2012). Considering the depleting forest resources and environmental concerns, present study has been undertaken to explore the impacts of rapid urbanization on the forest cover and increasing pollution in its lagoons. As part of the required field survey, earlier observations have been supported with online survey, which was necessitated due to the ongoing pandemic situation. The vetted questionnaire was translated into French as well (to get responses from majority French speaking population) and transformed into google form to get responses from the sample respondents among residents of Abidjan, Government officials and relevant authorities. Over a period of two months, 98 responses could be gathered and analysed. Details of the current analysis and its discussions and results are elaborated in the following paras.

A. Social Characteristics Of Surveyed Population

Online survey was able to get 98 correct responses, out of these more than one fourth were females (26) and little less than three fourth (72) were males.

Table 1: Surveyed Population Details

Gender	Respondents	Percentage
Male	72	73
Female	26	27

Source: Primary Survey, 2020.

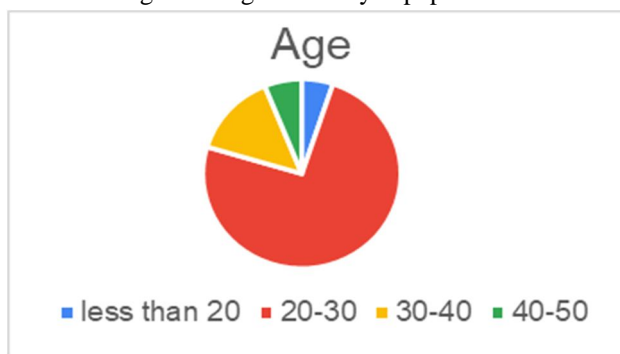
Table 1 depicts that among respondents, 73 percent (%) men and 27% of women responded for the online survey. Age subgroups of respondents could be ascertained from figure 1 and table 2, depicting majority of sampled population i.e., about 75 percent in 20-30 age group, and minimum of 5 percent in below 20 years of age.

Table 2. Age of Respondents

Age	Numbers	Percentage
less than 20	5	5.10
20-30	73	74.49
30-40	14	14.29
40-50	6	6.12

Source: Primary Survey, 2020

Figure 1: Age of surveyed population



It depicts that youth (students and college going) population actively participated and responded well for the survey. Majority of respondents (around 89 percent) from being from 20 to 40 years of age conforms to the fact that the protection of the environment for the well-being of future generations is well taken by the educated youth. Regarding the nationality of the respondents, it was found that out of 98 people there were 95 Ivorians and 3 non-Ivorian nationals. That made in percentage 97% Ivorian and 3% non-Ivorian (table 3).

Table 3: Respondent's Nationality

Nationality	Totals	Percentage
Ivorian	95	97%
Not Ivorian	3	3%

Source: Primary Survey, 2020

B. Economic Characteristics of Population Investigated

Among the respondents, 20-30 age group alone represents more than 74 percent, is grouped into different types of study level and occupation levels. 88 respondents were postgraduates, with university level education and only 10 were undergraduates depicting the well aware and responsible citizens of the country and city of Abidjan (table 4).

Table 4: Respondent's Education Level

Education	Totals	Percentage
Postgraduate	88	90
Undergraduate	10	10

Source: Primary Survey, 2020

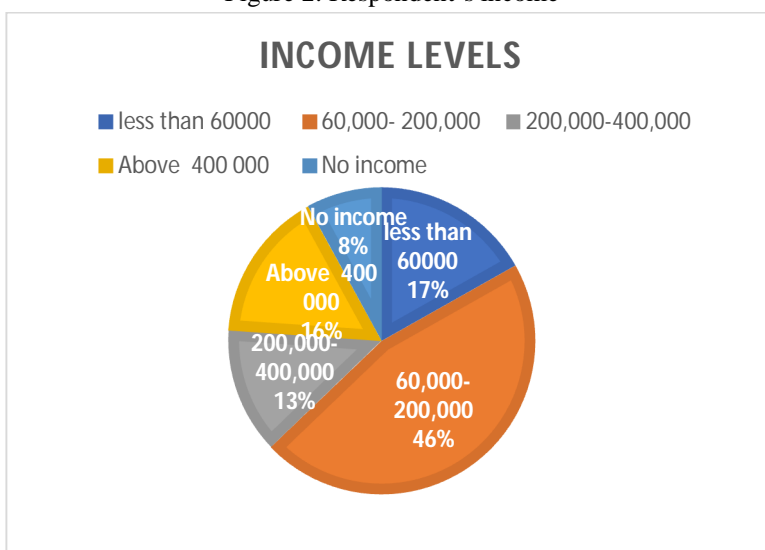
Depending on their level of study it was also noted that respondents were from varied services groups (Table 5) and majority in private service sector (33 percent) and other 22 self-employed. There are 4 people who are unemployed amongst respondents, and 33 percent students. others who practice in public administration, and others in the private sector or are self-employed. At each level of recovery, we also have the income which are different. Different services people demonstrating varied income levels, and majority (46%) falling within income group of 60,000 to 200,000 CFA francs (Figure 2).

Table 5: Surveyed Population Services

Service	Numbers	%age
Government service	8	8
Private service	32	33
self-employment	22	22
Unemployed	4	4
Student	32	33

Source: Primary Survey, 2020

Figure 2: Respondent's income



II. DEFORESTATION IN ABIDJAN DUE TO THE URBANIZATION

After independence, the Ivory Coast's government on its principal goal of economic development put forward an urban land development policy including that of the city of Abidjan, and in 1970s it created the Equipment Company of Urban land that was intended for the development and sale of urban land to individuals or to real estate companies. Space occupation poses a problem of land organization, planning and management at all levels of intervention, whether national, regional or local. This shows the importance of the human factor in land development planning. In order to not be left of this paradigm, the Ivory Coast governing body has therefore developed since independence a land planning policy that encompasses all developing economic sectors (GNAMBA-Yao, 2014). It depicted Ivory Coast's state rating as more focused on the development of its urban poles and economic growth.

A. Evolution of the city of Abidjan

As early as 1950, Côte d'Ivoire (Ivory Coast) entered a very important phase in its history and the development of economic and social growth. Thus, with the opening of the port of Abidjan in 1951, economic activity in Abidjan also grew. Also, in order to maximize the use of urban space to achieve its development, the State of Côte d'Ivoire continue to develop Abidjan to give it its full dimension as the main centre for the development of national territory. One of the most significant fact of the second half of the last century has been very fast urbanization in the African countries, which were observing growth rates that have been fluctuating between 7 to 10% for decades. Ivory Coast was not an exception to this phenomenon.

Between 1960 and 1980, the country experienced remarkable economic growth, which stimulated the country's rapid urbanization. Its rate of 14% in 1960 rose to 45% in 1980. Abidjan, the economic capital, the ultimate goal of all exodus and migration has seen its population and space growing exponentially. This situation has led to many problems of widespread inadequacy of urban facilities, environmental problems, the rise of bandits and urban crime. Degradation of the framework and living conditions are one of the most important urban problems. Very high population density, with the rapid growth of their municipalities, the behaviours of municipalities to health, all contribute to the deterioration of the fragile environment and living conditions.

Table 6: Population growth in Abidjan City

Year	Population
1934	17,000
1948	46,000
1975	904,000
1980	1,422,000
1988	1,929,079
1998	2,877,948
2014	3,450,000
2020 (Projected population)	6,000,000

Source: GNAMBA-Yao, and Census, 2014

Abidjan, has been marked by state initiative, population and economic growth since independence in 1960. Of the 17,000 inhabitants in 1934 (a building in the colony's capital), the city reached one million inhabitants by 1975, before committing to the process of a metropolis marked in 1998 by exceeding the threshold of 3 million people (table 6) with an area of 57 Km² (GNAMBA-Yao, 2014). Of course, the area of the city of Abidjan has evolved a lot since then, from 57 km² in 1998, it is currently having an area of 2119 km². Abidjan is amongst the largest cities of Africa with a growth rate of above 4% (Table 7).

Table 7: Rate of growth of Abidjan

Urban growth rate in %age	
1975-1988	5.6
1988-1998	3.8
1998-2014	4
2014-2020	4.5

Source: Census of Ivory Coast, 2014

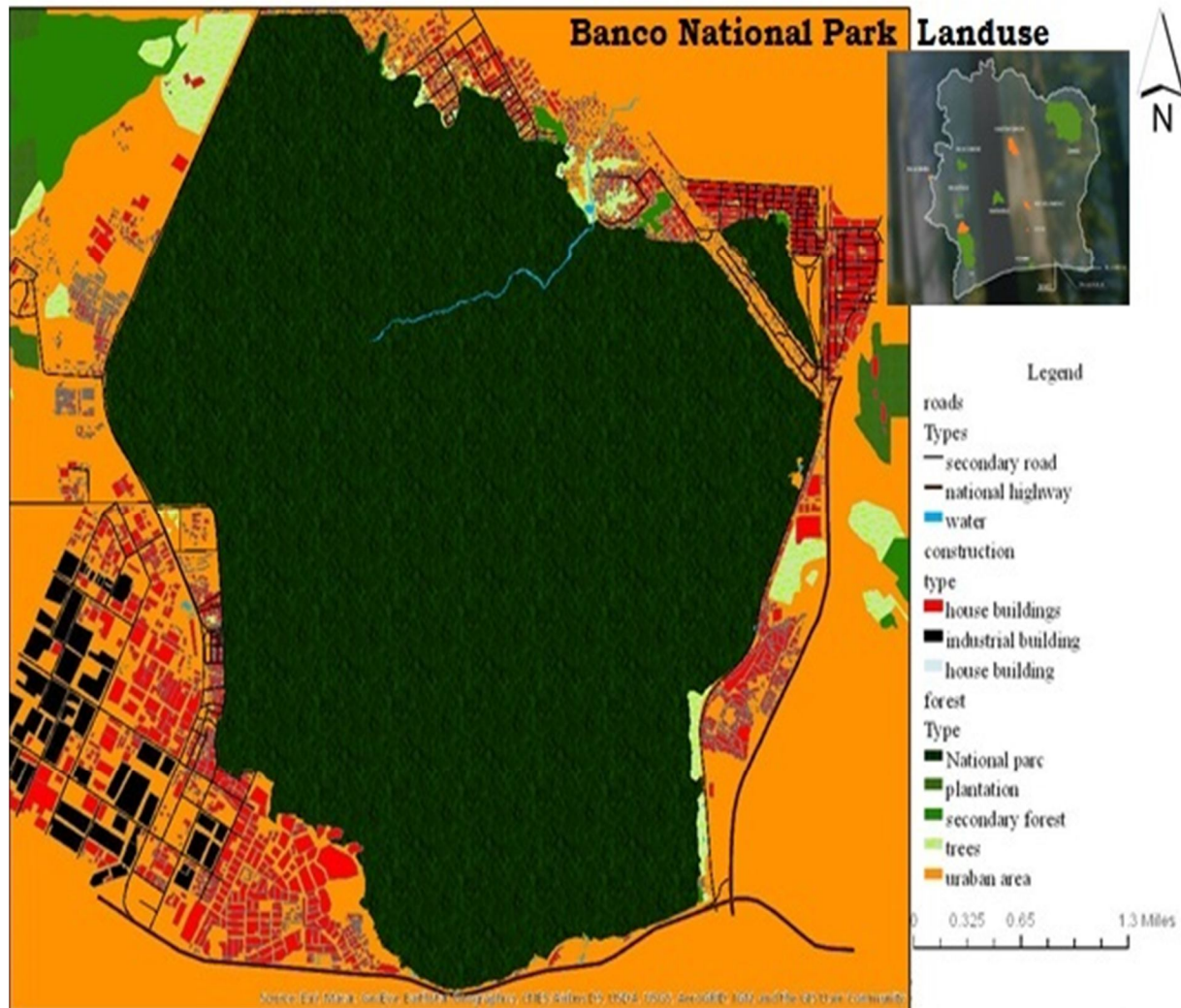
It is also important to understand that the city of Abidjan is located in the southern forest parts of the Ivory Coast, so its rapid urban growth the enlarging urban space is automatically impacting the clearing the forest. So, these 2119 km² constitute thousands of hectares of pure cut forest to be able to install factories, homes especially roads for the mobility of the population. To address the environmental problems successive Ivory Coast governments since the pre-independence period have set up refined protected areas to provide a better living conditions for the urban population now and for future generations. The question one might ask is: what are the real impacts of this rampant urban demographics on these forests?

B. Impact of Population on Protected Forests

In Ivory Coast, one of the main causes of anthropogenic pressures on protected areas, reported by the population, NGOs and public authorities, is rural poverty, which is the result of underdevelopment in peripheral areas of protected areas (Koffi A. 2016). It is also found that Ivory Coast's protected areas are underestimated (Beligne V., 1994). The use of protected areas of food use is characteristic of poor and developing countries. National parks, despite their strict conservation status, are considered to experience increasing degradation over the years due to crops and fraudulent logging, fires, poaching and gold mining. This means that the degradation of vegetation cover of all national parks in this country is estimated at about 6% of the total area of the network (Chatelain, 1996). During the surveys, respondents were also asked about their awareness regarding the existence of protected forests in the city where they have been living for numerous years. It is discovered that many of these were even not knowing about Banco National Park. However, this national park already existed before the decolonization of the country.

As for the city's newest nature reserve, neither the dahlia flower reserve nor the river's inhabitants have any idea of its departure. As a result, the various pressures that under these sustainable areas are under sustainable conservation and are largely anthropogenic (MECV, 1995). In any case, there are often objections to the interests with regard to the requirement of nature protection for the state (represented by protected area managers) and exploitation for economic and subsistence purposes for the population. This conflict of interest usually leads to violent conflicts (Aké-Assi, 1984). A significant consequence of these conflicts of interest is the complete disappearance of thousands of hectares of existing primary forests around the Banco National Park in its infancy. It completely isolates the park from an area of 30 km² within the city of 2119 km² with a population of about 6 million (Figure 3).

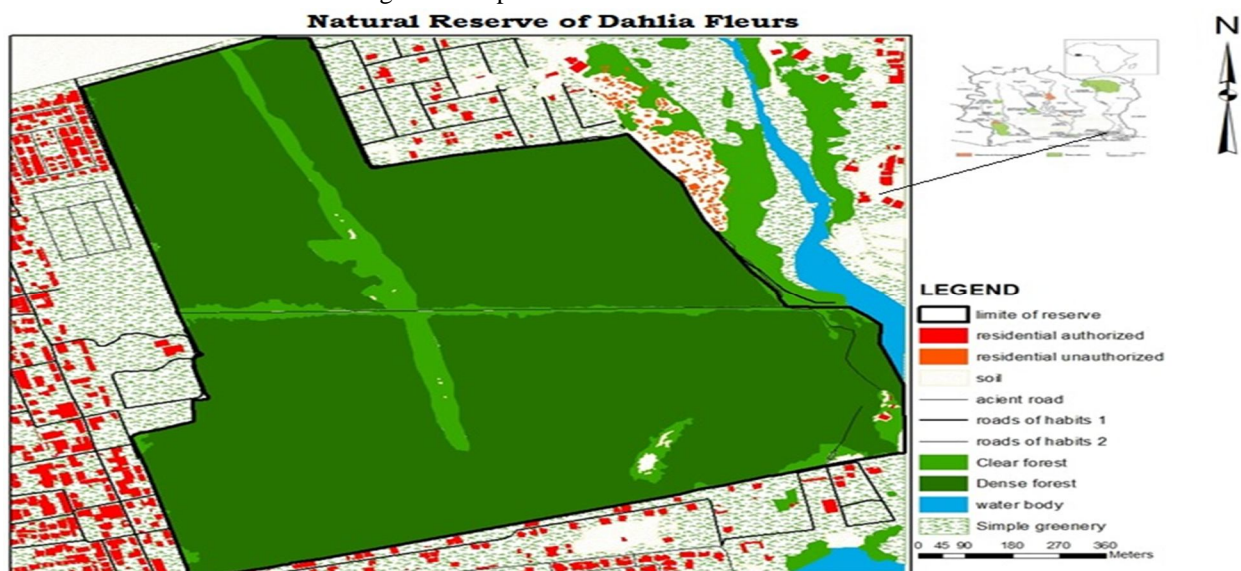
Figure 3: Map of Banco National Park, Abidjan, 2021



Note: Extracted from the supervised classification of the Esri satellite imagery of January 2021

It is observed even more that the concentration of insecure dwellings around the park represents a foreign as well as an indigenous population. These people also work in factories near the park. In fact, the BNP hails from the ancient villages of the "Ebri and AT" ethnic groups bordering the north and south, which forms many sources of pollution from household waste and economic industrial activities. Local residents discharge household waste and water directly from septic tanks into the park. This is the case in Adjama, Indukoi and Ababo, where this type of exclusion is important. In addition, many areas of the park are subject to claims, especially in the northeast and south. Natural reserve of Dahlia Fleurs is another important forest reserve (figure 4). The areas of conflict are from different parts, especially the villages of Anonkoh-Koti and Sigbi in the north, Agan-Ati and Agban villages in the southeast, and Andokoi in the southwest. The villagers have also exploited these areas, especially to collect timber, traditional and culinary plants.

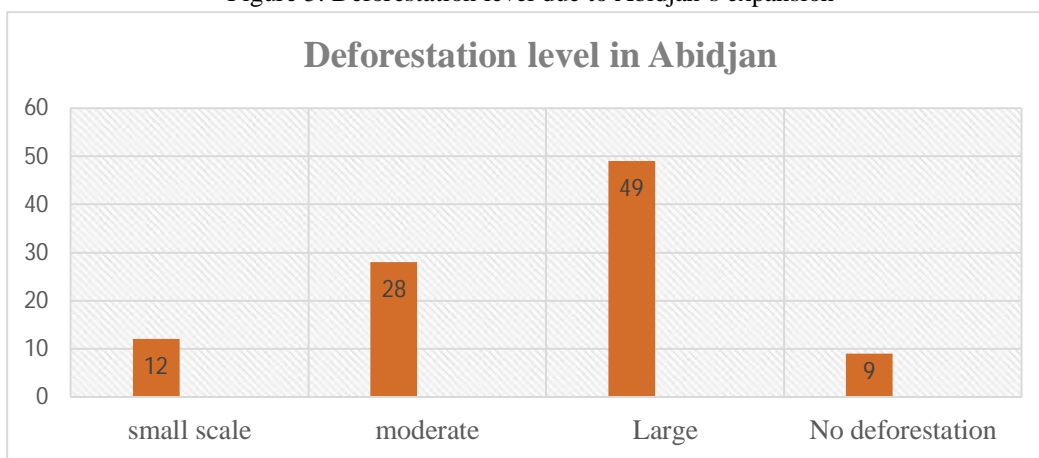
Figure 4: Map of Natural Reserve of Dahlia Fleurs



Note: Extracted from the supervised classification of the satellite imagery of January 2021

Ground pressure is extremely high in the northeast of the park, where locals openly claim a piece of land that is an integral part of the BNP and isolated from the passage of high-voltage power lines inside the park. Given the lack of space for this living population on the edge of an ever-growing park, people are not tempted to be stand up to the state and settle in the park as they move on. The finding is not yet very evident in the partial nature reserve of Dahlia Fleurs in the concentration of early dwellings. But for its part, the presence of social housing programs is very strong. Due to its partial reserve status, it could not last long. Findings from survey also showed that the majority of respondents admitted that there is indeed major deforestation in Abidjan. Out of 98 people only 9% said they did not report deforestation. So, although has different scales for 91% of them there is deforestation caused by the expansion of the city of Abidjan (Figure 5).

Figure 5: Deforestation level due to Abidjan's expansion



Source: Primary Survey, 2020

Figures 3 and 4 clearly depict the actual presence of dwellings around protected forests is not negligible. One of the glaring findings is the presence of both the land being given with the agreement of the Ivorian government up to the border of the park of the nature reserve. Figure 3 map shows in a general setting the urban area around the BNP. But for more precision in figure 4 an effective presence of the dwellings is shown in order to highlight the gravity of the population around Dahlia Fleurs forest. This situation is compounded when the number of factories and precarious neighbourhoods around the forests are increasing.

These factories work in various fields such as wood processing, and with the disappearance of forests from the interior of the country, the question is what would be the next source of raw material of these factories? Urban expansion is also cumulating owing to the populations driven by the rural exodus and also the entry of populations into the country from neighbouring countries such as Mali, Burkina Faso and Niger. Most of these populations, once in the economic capital, contribute to the growing number of precarious neighbourhoods. These are families who have lived there for years and make the deforestation around the park their main source of income.

III. POLLUTION OF LAGOONS IN ABIDJAN

For decades now, Lagoon Ébrié in Ivory Coast has been a receptacle for sewage effluent and household waste transported by runoff water. The coast of Côte d'Ivoire has a wonderful lagoon system. Although originally exceptional, the natural environments associated with this lagoon complex are now severely degraded, due to the intense human pressure exerted on this fragile space for decades. Since 1970 the growth of the city of Abidjan, there has been increasing concern about this damage. Industrial growth of Ivory Coast has been concentrated largely in the Abidjan capital region. In 2010, the National Institute of Statistics (Institut national de statistique, INS) determined that 92.8% of the 2,822 industrial establishments (agro-food, energy, chemical, textile, soap factory, oil refinery, and many informal industries) in the country were located in the only economic capital of the country (Abidjan), 60% of these enterprises were installed around Lagoon Ebrié (Figure 6). Abidjan is a metropolis which has widened a lot in a dense forest certainly, but also at the opening of a lagoon waters. On this map we see an intense concentration of dwellings in degraded colour around the Ebrié lagoon. The urbanized space and the limits on either side of the lagoon are almost identical throughout the city. This interlocking gives the population very easy access to the plan and, by extension, the connection of household and factory sanitation pipes on the one hand and of large pipes on the other hand to find their outlet directly into the lagoon. These actions all associated obviously give a cocktail of pollution in chemical compounds of the lagoon. Degradable waste causes intense eutrophication phenomena, especially in low regeneration areas such as bays (Zabi, 1982). Considering this threat to the urban water bodies, respondents were asked if they have perceived a plastic bottle or any other plastic object in the Ebrié lagoon. This water used for irrigation, livestock watering, sports days and recreational lagoon session, as you will see in the table below almost all answered yes (Table 8).

Figure 6: Map of Ebrié Lagoon in Abidjan



Note: Extracted from the supervised classification of the Esri satellite imagery of January 2021

Table 8: Presence of plastics in the lagoon

	Yes	No
Respondents	79	19
Percentage	81%	19%

Source: Primary Survey, 2020

To determine the quality of the lagoon Ébrié water, several studies have been conducted since the eighties. Koné (1995), showed that all industries in Abidjan dumped wastewater into the lagoon, with an estimated total volume of 12,000 m³ per day. These inputs likely contain metallic trace elements (ETM) such as lead (Pb), chromium (Cr), zinc (Zn), arsenic (AS), and cadmium (CD). Kouamé (2017) noted the significant bioaccumulation of hip and bear in crabs (used as indicators of mineral pollution) in Lagoon Abre. These studies focused on assessing biological and microbiological quality, pollution by oil, contamination by mineral deposits, and wastewater. In addition, the Ivorian Pollution Control Center (Côte d'Ivoire's Pollution Control Center, CIA) regularly analyses and patrols the natural waters of the National Monitoring Network (Réseau National d' Observation, RNO) as part of its mission. Thus, the water quality in Lagoon Ébrié is analysed periodically on site and in the laboratory, as part of this body's water monitoring. Faced with this increasingly alarming situation, the observation is that out of 98 people questioned only 17% have knowledge of a government structure in charge of the protection of water on the dividing side (Table 9).

Table 9: Water Protection Structure as Given by Population

Structure Names	Yes	No
ONAD (Office National de l'assainissement et du Drainage)	8	0
ONEP (Office National de l'eau Potable)	3	0
The Ministry of Water and Forestry	6	0
No answer	0	81
Total	17	81
Percentage	17	83

Source: Primary Survey, 2020

IV. CONSEQUENCES OF DEFORESTATION AND WATER POLLUTION IN ABIDJAN

A. Consequences of Deforestation

In countries in the equatorial strip with a common denominator called Third World countries, namely Brazil via Africa to Southeast Asia, that is, Indonesia. In these countries we have a large area of dense forest. But because of the precarious situation that is eating away the forests in these countries, agriculture is the main means of income for these populations. Of this area alone, these countries are the largest producer of cocoa, coffee and rubber. Another fact is also the rampant demographics in these countries, marked by a high rate of young people going in cases like ivory, rating up to more than 60% of the population with under 40 years of age. To accommodate this population these states are engaged in urbanization sometimes not mastered according to the protection of the environment due to the high demand for housing. To create large metropolises like Abidjan without a massive destruction of the virgin forest is a real utopia given its geographical location. During the survey, it was asked, what consequences this urbanization could have on the forest, and it was found that more than 90% admitted that urbanization or at least the expansion of the city of Abidjan mainly contributes to the destruction of the forest (Table 10).

Table 10: Consequences of Deforestation

Propositions	Strongly disagree	Disagree	Agree	Strongly agree
Inundation	4	23	20	43
Species extinction	1	1	11	85
Temperature increase	2	3	17	46
Disruption of seasons	0	0	18	80

Source: Primary Survey, 2020

Unsurprisingly, more than 80% of the population surveyed concluded that deforestation due to the city of Abidjan causes flooding, due to seasonal disruption, causing the concentration of rains over a few months. The amount of rain that normally occurs on Abidjan in the space of two to three weeks and the pipes of the city not being too suitable are overflowing and therefore causing floods. These floods lead to the loss of human lives each year.

B. Consequences of Water Pollution

Abidjan is one of the top ten metropolises in Africa in terms of area and population. Indeed, with its population estimated at more than 5 million at present. This economic capital like its African counterparts, suffers from the infrastructural gaps required for recollection and treatment of wastewater from households and factories. All or almost all of the major wastewater pipes are directed to the Ebrié lagoon. One can imagine, this wastewater is not without consequences for this body of lagoon water. According to the questionnaire we conducted in this study, more than 80% respondents have recognized that wastewater thrown into lagoons has consequences on several levels (Table11).

Table 11: Consequences of Water Pollution in Ebrié Lagoon, Abidjan

Propositions	Strongly disagree	Disagree	Agree	Strongly agree
Pollution of lagoons	9	10	10	69
Fish killing	1	12	22	63
Disappearance of Invasive Aquatic Specie	7	20	12	59
Disruption of the Aquatic Ecosystem	16	1	13	68

Source: Primary Survey, 2020

The very first consequence is the deterioration in the quality of the water, which is manifested by water pollution. This pollution leads to an imbalance of the aquatic ecosystem. But who speaks of the imbalance of an ecosystem also speaks of the death or the disappearance of living beings from this ecosystem? In the present case, pollution leads to the disappearance of certain species of fish from which they need a certain perfect balance of the chemical components of water. Wastewater from plants also causes invasive aquatic spaces, according to the survey.

V. CONCLUSION AND SUGGESTIONS

The BNP's ecosystem has undergone profound changes in recent decades. In the 1955s, the use of land in and around the park showed that the forest landscape was dominant, despite the presence of some urban spots. The area of dense forest described on the maps covers an area of 5462 hectares while the secondary forest covers an area of 9220 hectares. These two types of forest represent 90% of the landscape in the park. Decades later, in 1998, BNP planted 3,450 hectares of forest and 434 hectares of forest. This is due to the horizontal local expansion of the vibrant Abidjan that eats away at the peri-urban forest areas, especially on its western front where the BNP is located. This rapid expansion of urban space is creating environmental problems, especially pollution, the severity of which varies depending on the type of local people and the dominant activities of the local population. Regarding the pollution of the Ebrié lagoon given the thousands of cubic meters sewage that are directed straight into it every day if the Ivorian government does not take the bull by the horns, the situation could be irreversible within a few years, and this water will pose a danger to the people of Abidjan.

To curb the exploitation of wood and non-wood resources as well as poaching, co-management (community and mutual management system of the GNP) has been implemented since 2002 by the administrators of the BNP forest by integrating the populations into the protection policy of the forest with a view to sustainable development. The co-management policy is a participatory management system that allows neighbouring populations to participate voluntarily in the protection of the Banco forest area and to benefit in return from the financial losses generated by tourist exploitation and direct and indirect jobs linked to development activities. Tourist reception points, guide points and neighbourhoods' hostels are set up and managed by a local workforce recruited from women and young people.

Above all, effective monitor verify that the standard of protection is truly met in order to avoid any form of corruption and, submit the farm to expert controls, plant more trees than uprooted tree number. Respect for a quota in percent empty forest-land fix almonds to all those who do not comply with the measures set. Making alternative sources of cooking wood even more accessible and, raising awareness of the consequences of deforestation in detail. Introduce fines, severely punish those who engage in deforestation by charging them according to the established fine.

Reforestation must be instilled in schools for the next generations. Appropriate measures must be taken to treat wastewater to prevent it from entering lagoons to pollute it. Definitely, reforestation, planting of tree mass, toughening laws in this direction, avoid bushfires and sentence any tree-cutting person to jail.

About lagoon protection, it is suggested that, instead of taking new policies to protect environment, government should educate people to know more about the danger related to the destruction of our environment. Having a rigorous restriction regarding forest destruction and, increase the awareness among people to protect more environment. Also, new policies to involve more people in forestation and educating people to make it as a life style to not through away plastic bottles. Renewal, renovation and maintenance of wastewater management infrastructure is utmost required. Raising public awareness of the consequences and establishing awareness days on television and in train stations. Creating a protective brigade and, having stricter agents. Create a structure for wastewater treatment then stop pouring rubbish into lagoons. Let the government get involved so that pollution can find a solution. Use proper boats to navigate lagoons, push industrial plants away from water and creating waste recovery stations.

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