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MAPPING DRINKING WATER SUPPLY SOURCES: CASE OF AVOCATIER-AGNISSANKOI, CÔTE D'IVOIRE

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ABSTRACT

This study was conducted to highlight the difficulties of access to drinking water of avocatier-agnissankoi dwellings and the sanitation risks related to the supply sources of this resource. A field survey was conducted in 646 houses in the six suburbs of the study area. Using geographical information systems (GIS) and multicriteria analysis, a map of the drinking water supply sources was generated. This map shows Water Distribution Company of Côte d'Ivoire(SODECI) coverage rate of 64.5 PC for drinking water supply. However, more than half of the population is supplied by water resellers because of frequent water cuts in the SODECI pipes and also because of the low cost of reseller's subscriptions.

Keywords: Drinking water, supply sources, sanitation, Avocatier-Agnissankoi, Côte d'Ivoire.

1. INTRODUCTION

In Côte d'Ivoire, urban water supply management has made significant progress in terms of reliability of distribution, network performance and customer service. However, drinking water supply in urban areas is still a problem. If the rates of drinking water supply in urban areas in Abidjan seem very favourable, between 80 and 85 PC according to [15], these numbers do not indicate the actual proportion of consumers connected directly to the public network and those having access indirectly (resellers, purchase from a neighbour, etc.). A better indicator of access to drinking water would therefore be to consider the number of houses with a particular connection. According to the urban indicators database of the metropolitan area of Abidjan, 74 PC of houses living in suburbs equipped with the public drinking water distribution network (PRSP, 2009). SODECI (Water Supply Company of Côte d'Ivoire) has undertaken in recent years a voluntaristic policy of connections whose number has progressed significantly. However, while resale practices have not disappeared, they seem mostly limited to an island. They are provided by flexible pipes passing from plot to plot over the fence walls. 26 PC of houses living in the study areas are not covered by the water distribution network. In these suburbs, 68 PC of houses have access to drinking water through resale systems from public standpipes or through an extension of the public distribution network by private individuals; 32 PC of houses in unserved suburbs use other sources of water supply than the public network (rainwater, village pump or surface water) [6]. This study is conducted to highlight the difficulties of access to drinking water sources of avocatier-Agnissankoi houses and the sanitation risks related to drinking water supply methods.

2. MATERIALAND METHODS

2.1. Study area

The municipality of Abobo is one of the 13 municipalities constituting the district of Abidjan (Figure 1) It is located in the north of the conurbation of Abidjan, about ten kilometers from the city center. It brings together 28 suburbs and villages. The population of the



municipality of Abobo has reached 1.030.000 inhabitants in 2014 [11]. The annual growth rate is 2.69 PC. The municipal territory of Abobo covers an area of 7.800 hectares. It is a vast plateau bordered by talwegs covering almost 31 PC of its surface. The maximum altitude is about 125 m. The climate of Abobo is tropical humid with 2.200 mm of rainfall per year over seven months[10] (Figure 1)

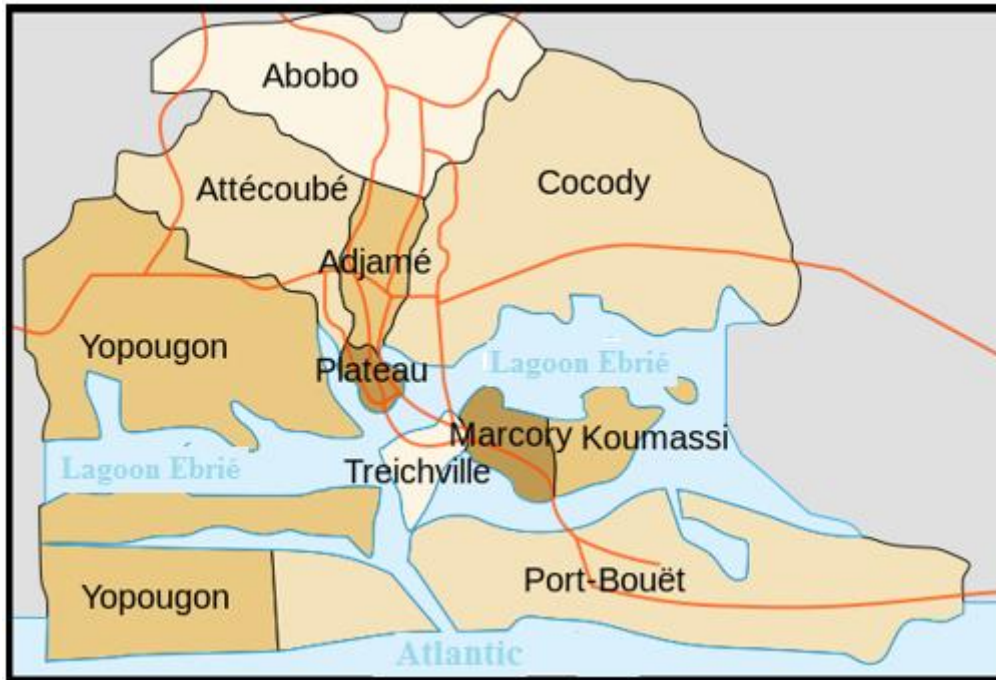


Figure 1: Map of Abidjan

The precarious suburbs that is the subject of this study is a suburb of Abobo called Avocatier-Agnissankoi. Avocatier-Agnissankoi covers 282 hectares between latitudes $5^{\circ} 26'4''$ and $5^{\circ} 27'4''$ N and longitudes $4^{\circ} 01'4''$ and $4^{\circ} 02'06''$ W. It is limited to the northeast by the suburb of Akeikoi, to the south-east by the suburb of Abobo Nord-SETU, and finally it is limited to the North by a large gulf that separates it from the municipality of Anyama (Figure 2). The study area consists of 6 suburbs that are: Belle Cité (BC), Dépôt 9, Quartier Perdu, Château, Ayébi and Agnissankoi.

2.2. Geological and hydrogeological context

The study area belongs to the sedimentary basin of the Continental Terminal (southern part of the country), and consists essentially of clayey sand and Quaternary sandstone, specifically Pliocene [17] (figure 3). On a morphological level, this region belongs to the area known as the "highlands". Groundwater nap maintained by the rainfall is contained in fine sands, coarse sands and sometimes medium sands[10].

2.3. Study material

The data collection consisted in providing a survey form with the dwellings during the months of July, August and September 2017. The notion of "dwelling" in the survey refers to the concessions sharing the same structures of water supply. These cards contained open and closed questions for the respondent. These cards were divided into three parts. A first part gives information on the socio-economic situation of the dwelling; the second part provides information on the source of water supply to the dwelling. A total of 646 dwellings were visited, for a total population estimated at 12332 inhabitants.

The processing and correction of the data was done using three (3) softwares.

- Sphinx V. 5.1.07: It was used to enter survey data for computer processing,
- Excel 2016: It was used to correct the survey data,
- EasyGPS: For importing GPS coordinates and correcting erroneous or unnecessary coordinates resulting from improper GPS operation or loss of GPS signal. For example, the elimination of points that leave the study area or that we have sampled outside the study area.

The data processing also required the use of two (3) softwares including:



- Expert Choice 2000: Specialized software for multicriteria analysis
- ArcGIS and
- QGIS were used to develop base layers (outline of study area, vegetation delineation) and to generate thematic maps.

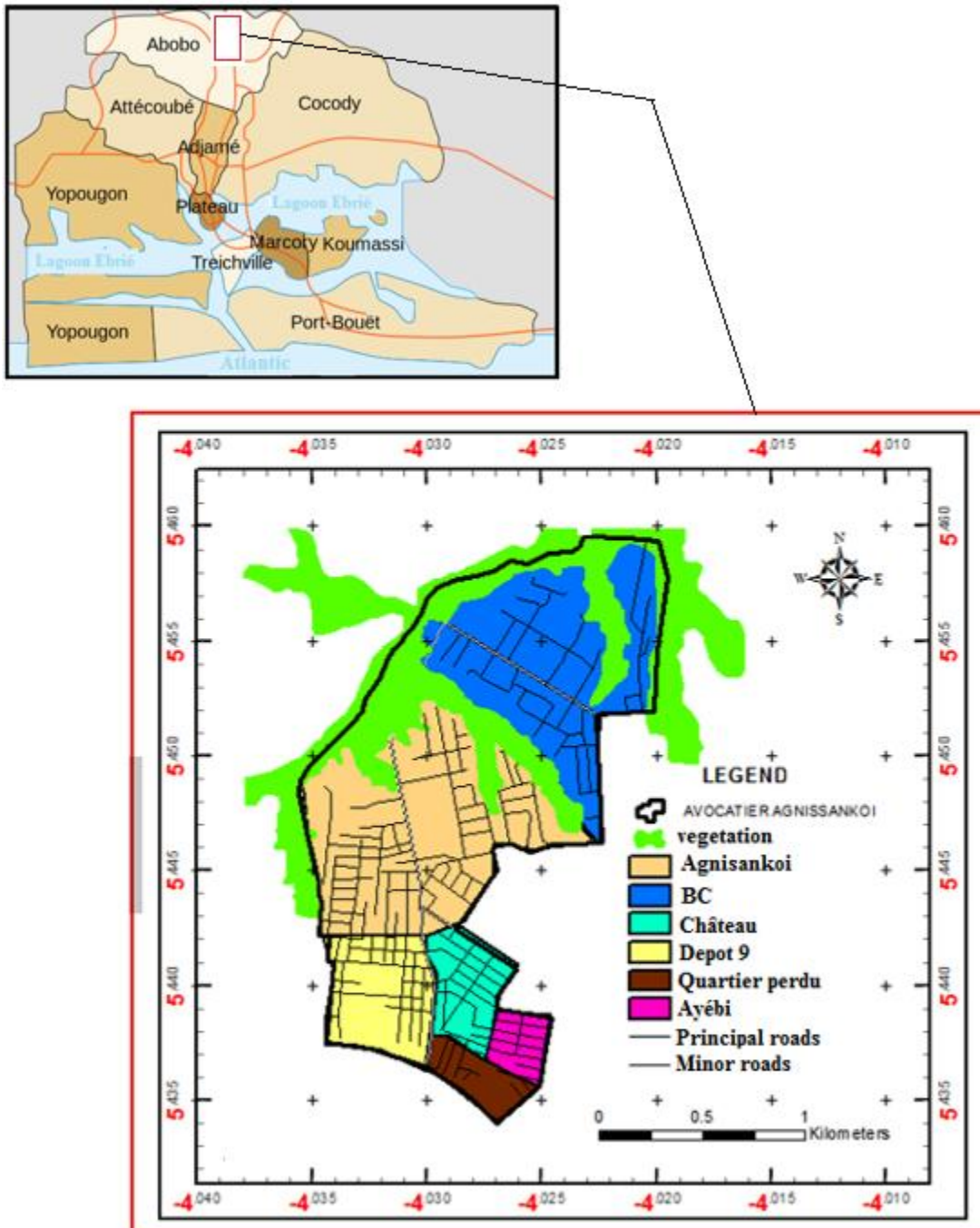


Figure 2: Geographical location of the study area

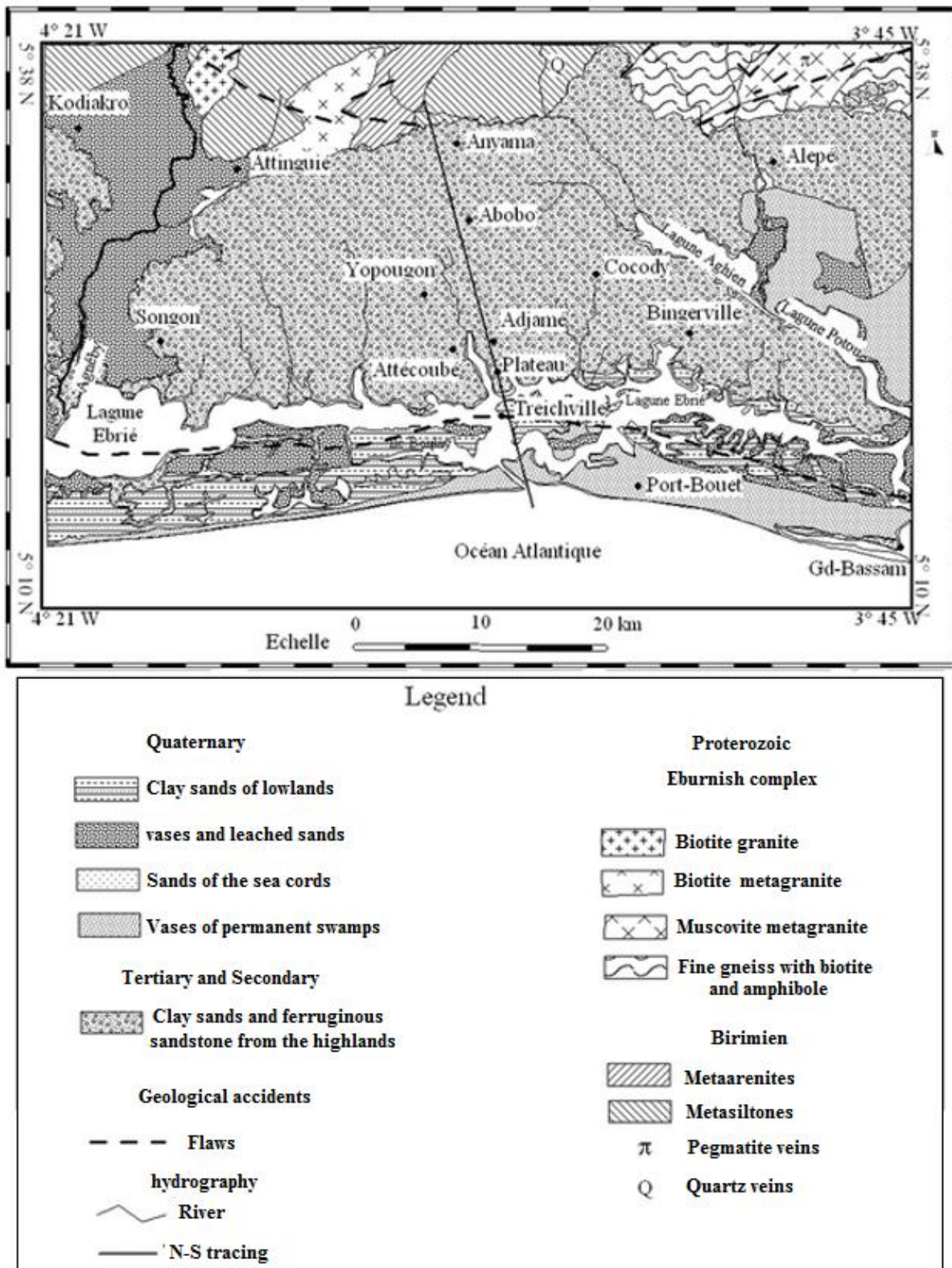


Figure 3: Geological map of the city of Abidjan



2.4.Method

Access to drinking water is measured by means of an indirect indicator, the proportion of the population using improved water supply sources: piped water supplying homes, fire hydrants / public fountains, cased wells / drilled well, protected well dug, protected source, rainwater cistern. Resellers of water are classified by the WHO as an unimproved source of supply. Thus, we have focused our criteria at the level of the objective "Drinking water supply", on the sources of House Drinking Water Supply (SAEP).

2.4.1. Data processing

This step involves the multi-criteria analysis and the development of the map itself. It consisted of determining the weighting coefficients of the criteria to be applied to the thematic map. Among all the methods adapted to our problematic (sorting problem), we chose the AHP method. The AHP (hierarchical analysis process) developed by [12], reveals the weight of the evaluation criteria on the basis of pairwise comparisons for each criteria. The highest weight is then assigned to the most important criteria. Pairwise comparisons are made on the basis of a comparison scale (Table 1)

Table 1:Scale of comparison.

Verbal and numerical expression of the relative importance of a criteria compared to another	Notes
Even importance	1
A little more significant	3
More significant	5
Strongly more significant	7
Extremely more significant	9
A little less significant	1/3
Less significant	1/5
Strongly less significant	1/7
Extremely less significant	1/9

The objective was to highlight the map of water supply sources by applying to the thematic map the corresponding weights determined from the comparison scale (the previous step). The elaboration of the thematic map goes through the standardization of the criteria. It consists in evaluating the different answers of the respondents on the basis of the "drinking water supply" scale in order to give notes to the answers obtained.

2.4.2. Scale of "source of drinking water supply"

This scale is for the SAEP criteria (Table 2). At this level, there are two responses from the respondents to the question "What is your source of drinking water supply?". These are "SODECI" and "Reseller of Water". On a scale of 1 to 9, we assigned the value of 7 (instead of 9) to "SODECI" given the untimely cuts in water. A "Reseller" we assigned the value 5 because of the availability of the resource but also the exposure of this water to pollution.

Table 2: Scale of Assessment of Drinking Water Sources

answer	Note
SODECI	7
reseller	5

It should be noted that no map overlay will be required for the "Drinking water supply" objective because it consists of a single criteria. The thematic map of this criteria will therefore correspond to that of the objective.



3. RESULTS

The quality of a better life in an urban space is appreciated by both the setting and the living conditions of the population. Hence, the usefulness of the study of the socio-economic organization in order to apprehend the behavior of the dwellings with regard to the supply of drinking water.

3.1. Socio-economic conditions of dwellings

The suburbs of Avocatier-agnissankoi have a high human concentration. The study area is expanding on the Belle cité (BC) suburb where new modern buildings are being built. Avocatier-Agnissankoi presents a population density profile that grows from the North (Belle Cité) to the South (“Quartier perdu”). Approximately 89 PC of residents have been living in Avocatier-Agnissankoi for at least two (2) years. The spatial organization of the habitat highlights two sets of land use, namely, individual plots or single dwelling units occupied by a single house (33 PC of the sample) and collective plots consisting of several houses (60 PC) and 7 PC for other types of dwellings (hotels, churches, mosques). Single family dwellings are characterized by roads in good condition and served by urban technical networks ranging from 25 PC to 50 PC with basic urban health and education services. Collective plots made up of several houses, also called "common yards", are characterized by plots that are difficult to access (roads in bad functioning order) and the remoteness or absence of water networks and basic urban services. Single family houses have an average size of 6 people. The “common dwellings” which can contain about ten houses, have an average size of 60 people. However, their level of education remains low (Figure 4).

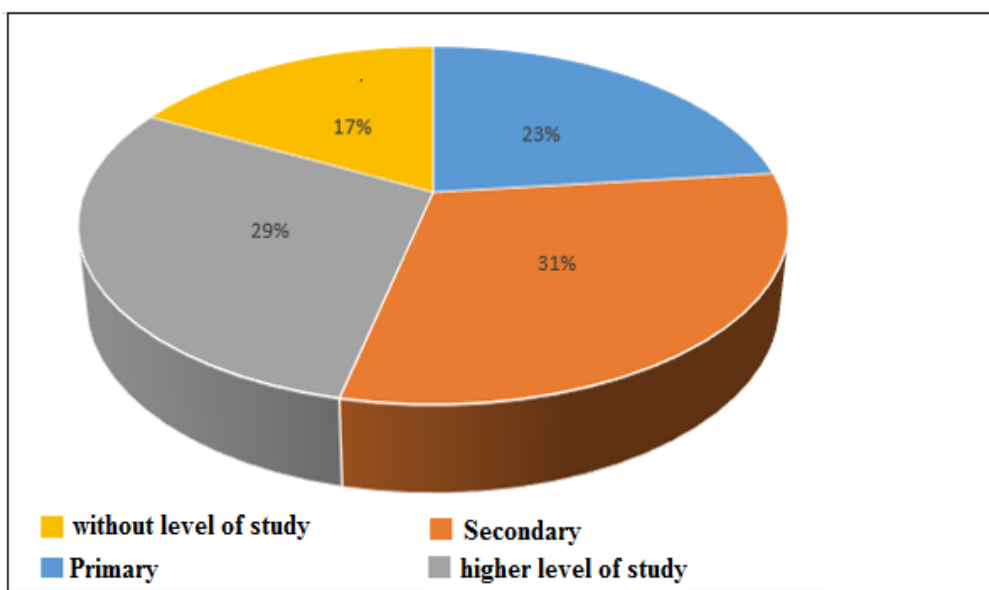


Figure 4: Distribution of heads of households by level of education

The illiterates and those of the primary cycle represent 40 PC of the surveyed houses against 30 PC having reached the secondary level and 29 PC the higher level of school education. The social vulnerability of the dwellings of Avocatier-Agnissankoi is also noticeable by the socio-professional profile of its inhabitants. The informal sector is the main source of employment for heads of dwellings (Figure 5).

Precarious settlements are the ideal place of living for the unemployed and the economically weak. Heads of dwellings in the informal sector represent 81.33 PC of the respondents in Avocatier-agnissankoi. They carry out liberal activities such as masonry, carpentry, plumbing, guarding, tradesmen or without activity. There is also a presence of public service employees (4.46 PC) in respect of heads of houses in activity and those working as private agents (13.68 PC). The level of income of Avocatier-agnissankoi's heads of house remains low and constitutes a constraint to guarantee better living conditions for these populations. It varies from less than 25.000 FCFA francs to more than 200.000 FCFA. More than half of the heads of dwellings have a monthly income level below 50.000 FCFA. Only the civil servants, the big traders and some private agents who represent about 8 PC of the surveyed houses have an income in excess of 100.000 FCFA. These results explain the precarious living conditions of the vast majority of Avocatier-agnissankoi residents.

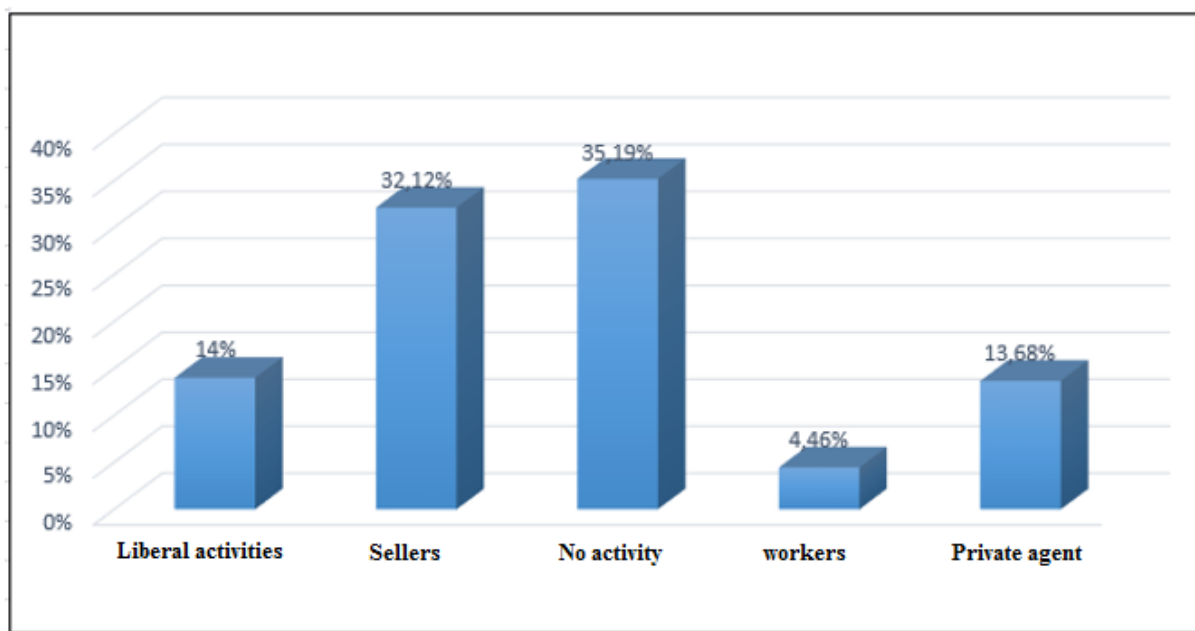


Figure 5: Distribution of heads of dwellings according to their professional status

3.2. Source of drinking water supply

Water is essential for the well-being of families. The water supply is one of the main daily concerns of the visited houses. At Avocatier-Agnissankoi, there are essentially two sources of drinking water supply. The first is the supply by the Water Distribution Company of Côte d'Ivoire (SODECI) and the second is the supply by the resellers. Dwellings living in single-family homes benefit from a home connection (SODECI) with a coverage rate of 68 PC compared to 32 PC of houses who buy from resellers. As for large concessions ("common houses"), the service rate with SODECI is 48 PC against 46 PC who buy with resellers. We also counted 6 PC of dwellings living in common houses and use water from standpipes and some wells for their water needs (Figure 6).

It has also been noted that 10 PC of dwellings living in large common houses and supplied by SODECI, associate to connect to a SODECI meter and share the bill. Supply from resellers is a common practice in the precarious suburbs of Abidjan. It is done in two ways. In the first case, the reseller installs a pump in the yard of his client who pays a fixed amount per month. This amount is based on the number of people in the dwelling and concession's activities. The quality of the water services offered by this informal system results in decreases in water pressures up to recurrent cuts. In the second case, the dealer has a water point in his concession which is often temporary where people come to stock up with containers. The results of the surveys show that to cope with frequent water cuts, the vast majority of Avocatier-Agnissankoi's house heads (75 PC), even though they have a home connection, are also supplied with drinking water thanks to the clandestine network serving the suburbs (resellers). All this information was used to generate a map of the drinking water supply in our study area (Figure 7). This map reveals a rate of SODECI's coverage of AEP, which amounts to 64.5 PC. However, more than half of the population buys from water resellers. Because many of the houses with a SODECI subscription are supplied with it quite often.

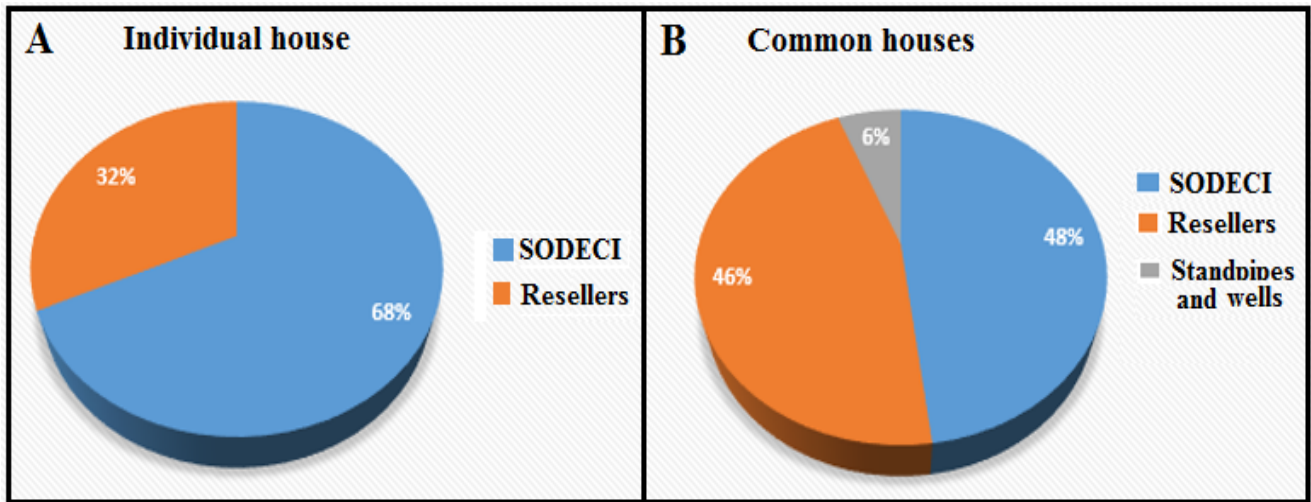


Figure 6: Distribution of dwellings according to the source of supply

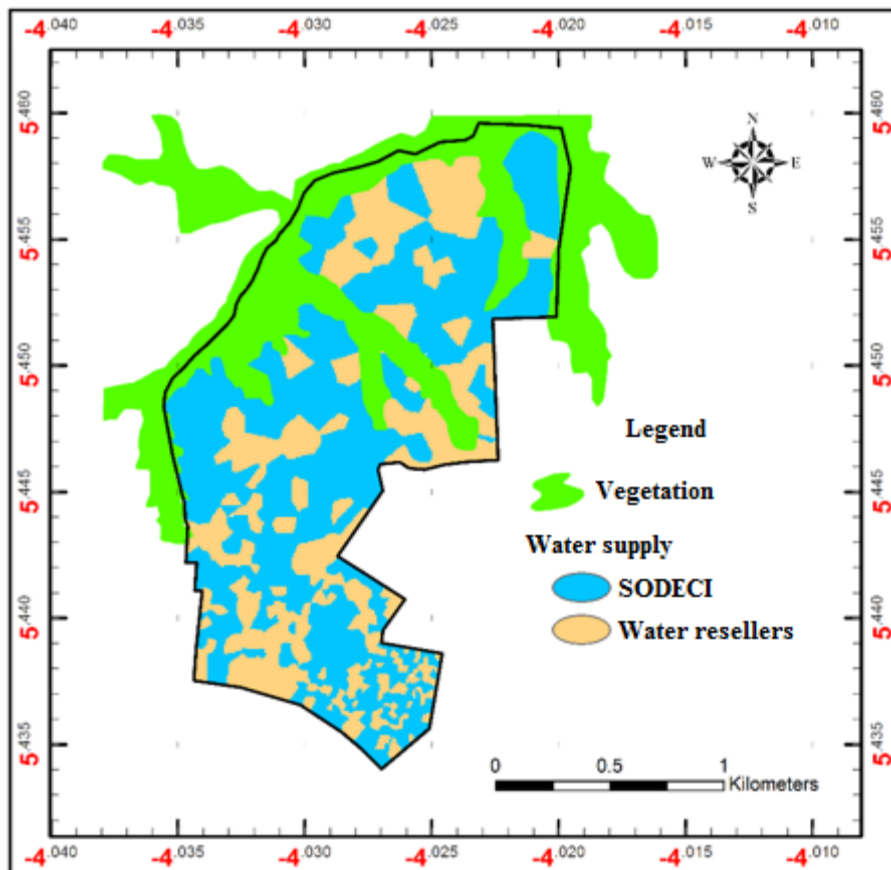


Figure 7: Spatial Distribution of Sources of Supply (EAF Criteria)



4. DISCUSSION

The results obtained in this study highlight the occupation of Avocatier-agnissankoi by low-income populations. These precarious suburbs inhabited by hundreds of dwellings are characterized by a lack of subdivision and cadastral plan reveals that it difficult to adapt to planning and urban planning standards [7]. These populations are settled by socio-economic constraints. The level of school education of heads of houses remains low as 40 PC have not gone beyond the primary cycle. This illiteracy can be a handicap for improving quality of life because education models people's attitudes toward health and sanitation [3]. The more an individual is educated, the better the hygiene of his living environment improves. Also, the precariousness of the income level of the populations (between less than 25.000 FCFA and 150.000 FCFA) does not allow certain populations to be able to claim a connection to the official drinking water supply network. Although SODECI's water supply network is present throughout the Avocatier-Agnissankoi area, the results reveal that more than 50 PC of the population buys water from water resellers. The same observation was made in several low-income inhabitants of Abidjan [2], [7]. This finding could be explained by important factors that should be taken into account. These populations find the cost of the home water subscription of SODECI fairly expensive (167.130 FCFA francs) and the possibility of not being able to pay the bill every three months. Indeed, houses that have individual meters (51 PC of the population) or several (10 PC) spend an average of 5800 FCFA/month or 17.400 FCFA every three months for their water consumption from SODECI. On the other hand, people who buy water from water resellers spend on average 3200 FCFA per month. In addition for those who are not subscribed to a water dealer, this amount is spread over the month since it is by type of container that water is paid from the dealer (50 FCFA francs and 100 FCFA francs). Supply from resellers appears to be beneficial for Avocatier-Agnissankoi's populations. This finding seems different from those of [1] who worked on Abobo and Yopougon. Indeed, these authors claim that water from resellers is within the reach of all populations, but that the transport of this water makes it more expensive. In addition to buying water with resellers, people are forced to use carriers to transport their water that represents an additional cost to their budget. However, at Avocatier-Agnissankoi, the majority of houses sourcing from resellers by home subscription. The transport constraint is avoided. The interview with heads of houses victims of fraud and theft on their SODECI meters, reveals that water resellers would vandalize the SODECI pipes or fraudulently connect to the counters of SODECI customers for to feed their customers. This same observation is made in the Kuwait suburb in the commune of Yopougon where this type of fraudulent behavior is developing [4]. Although it is true that the supply of resellers is cheaper to the population, the fact remains that this practice is dangerous from a health sanitation point of view. Indeed, the risk of contamination of this water is very real. The various manipulations of water from resellers reduce residual chlorine levels and expose it to pathogenic germs, increasing the risk of diarrheal diseases [5], [8]. It should be noted that in Avocatier-Agnissankoi, according to the population, two months before our investigations, untimely cuts of water were very frequent, despite the presence of a water tower. This situation fits in well with the general observation in most suburbs in Abobo [10]. With these cuts, when the water comes back into the pipes, it is with a low pressure and most often late at night. These are the reasons that lead SODECI customers to buy from resellers [18]. Despite all these realities encountered in the provision of drinking water in the precarious suburbs of Abidjan, the concern to provide drinking water to the people of the city of Abidjan remains a concern for the Ivorian Government. In order to strengthen the service of some communes (Abobo and Anyama), a new water treatment machine was created in Songon. It was inaugurated Monday, October 31, 2016. This machine comes to ensure, in a sustainable manner, the supply of drinking water to the people of the district of Abidjan. The technical characteristics of this new machine, according to Minister Achi Patrick, include the construction and equipment of 15 drill holes, the provision and laying of cast iron pipelines between the capture field (the place where the borehole is dug) and the suburb of N'dotr , the electric supply of this one and the station, the construction and equipping of a station of 2100 m³ / h, the construction of two covering tarpaulins of 5000 m³ and a recovery hall at an investment cost estimated at 27.6 billion FCFA [16].

5. CONCLUSION

The data collected from the dwellings reveals the types of drinking water supply of Avocatier-agnissankoi. This study shows that dwellings living in single-family houses benefit from a home connection (SODECI) with a coverage rate of 68 PC compared to 32 PC of houses who buy from resellers. As for large concessions ("common houses"), the service rate with SODECI is 48 PC against 46 PC who source with resellers. However, frequent water cuts lead more than half of the population to obtain supplies from illegal operators who informally sell water to houses.



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