



Economic And Health Impacts Of Agricultural Activities Around The Nianra And Nabyon Hydroagricultural Schemes In North-Central Ivory Coast

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SUMMARY

Considered as an essential step in the intensification of agriculture, hydro-agricultural developments have known a real boom since the drought years of the 60s and 70s in Africa. It is in this global context that Côte d'Ivoire set up large hydro-agricultural schemes in the northern regions, including Nianra and Nabyon. The Nianra and Nabyon sites, which are water reservoirs, have become the epicenter of agricultural activities in the north-central part of Côte d'Ivoire, due to the disadvantages of rainfall and the rapid drying up of surface water. Given the crucial role played by these irrigated perimeters, the objective of this study is to identify and analyze the economic and health impacts of agriculture on the populations living in these areas. To achieve this objective, the methodology used is a combination of several techniques: documentary research, observation, interviews and a questionnaire survey of 65 farmers in the Nianra and Nabyon hydroagricultural schemes. The results and analyses highlight that these two irrigated perimeters concentrate a major part of the rice and market gardening practices in the region's rural areas. These agricultural activities have undeniable productive and economic returns through the yields of irrigated rice and market garden crops, as well as the income they generate for farmers. In spite of these productive and economic advantages, which are well known to the farming population, there is a permanent and significant presence of diseases such as malaria, bilharzia and onchocerciasis among farmers around the Nianra and Nabyon hydro-agricultural developments.

Key words: Hydro-agricultural development, Nianra, Nabyon, Ivory Coast.

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RESUMÉ

Considérée comme une étape indispensable à l'intensification de l'agriculture, les aménagements hydroagricoles ont connus un réel essor à partir des années de sécheresse des décennies 60 et 70 en Afrique. C'est dans ce contexte global que la Côte d'Ivoire a mis en place les grands aménagements hydroagricoles dans les régions nord dont font parties Nianra et Nabyon. Défavorisées sur le plan pluviométrique conjugués aux tarissements rapides des eaux de surface, ces sites aménagés de Nianra et de Nabyon qui sont des retenues d'eau, deviennent l'épicentre des activités agricoles dans le Centre-Nord de la Côte d'Ivoire. Vu le rôle capital que joue ces périmètres irrigués, l'objectif de la présente est d'identifier et d'analyser les impacts économiques et sanitaires de l'agriculture chez les populations exerçant sur ces espaces. Pour atteindre cet objectif, la méthodologie utilisée est une combinaison de plusieurs techniques à savoir; recherche documentaire, observation, entretien et enquête par questionnaire auprès de 65 exploitants dans les aménagements hydroagricoles de Nianra et de Nabyon. Les résultats et analyses soulignent que ces deux périmètres irrigués concentrent une majeure partie des pratiques rizicoles et maraîchères des terroirs ruraux de la région. Ces activités agricoles ont des rentabilités productives et économiques indéniables et ce à travers les rendements des cultures du riz irrigué et du maraîcher ainsi que les revenus qu'elles génèrent pour les paysans. Malgré ces avantages productifs et économiques bien connus des populations paysannes, l'on observe une présence

permanente et non négligeable des maladies telles que le paludisme, la bilharziose et l'onchocercose chez les exploitants agricoles autour des aménagements hydroagricoles de Nianra et de Nabyon.

Mots clés : Aménagement hydroagricole, Nianra, Nabyon, Côte d'Ivoire.

I. INTRODUCTION

Throughout the world, the need for food is increasing with the evolution of the population. It is in this sense that agriculture appears as a real means to meet the food needs of men and women on a global scale. According to the World Bank (2021), agriculture, in addition to being the main source of income for 80% of the world's poor population, plays a decisive role in improving food security. To achieve this objective through agriculture, several techniques are used, including hydro-agricultural developments.

Considered as an essential step in the intensification of agriculture, hydro-agricultural developments have been flourishing since the drought years of the 1960s in Africa (O. Niébé, 1993, p.124). They are also social constructions, based on a production factor that must be mobilized, transferred and applied in an artificial manner (T. Ruf, 1992, p.7).

Côte d'Ivoire, a West African country, is not on the sidelines in the implementation of hydro-agricultural development systems. These systems are more common in the northern part of the country, where the short winter season and the rapid drying up of surface waters limit agricultural activities. In the mid-1970s, following a historic visit by President Houphouët-Boigny, the State decided to create several hydro-agricultural and pastoral facilities in many areas of northern Côte d'Ivoire, including Nianra and Nabyon. These two sites are in fact water reservoirs whose type of work seems the most suitable for agricultural production. It is because of these assets that the irrigated perimeters of Nianra and Nabyon have become, since the 1970s, the epicenter of rice and market gardening in the north-central zone of Côte d'Ivoire. In addition, many farmers have settled around these two facilities in order to develop agricultural activities that are essential to improving their living conditions.

However, due to regular contact with water, certain pathologies seem to be appearing in the populations living along the Nianra and Nabyon sites. These observations have led to the fundamental question of this research, which is: what are the economic and health impacts induced by agricultural activities in the Nianra and Nabyon hydroagricultural developments? The main objective of this work is to identify and analyze the economic and health consequences of agricultural activities in these two developed areas.

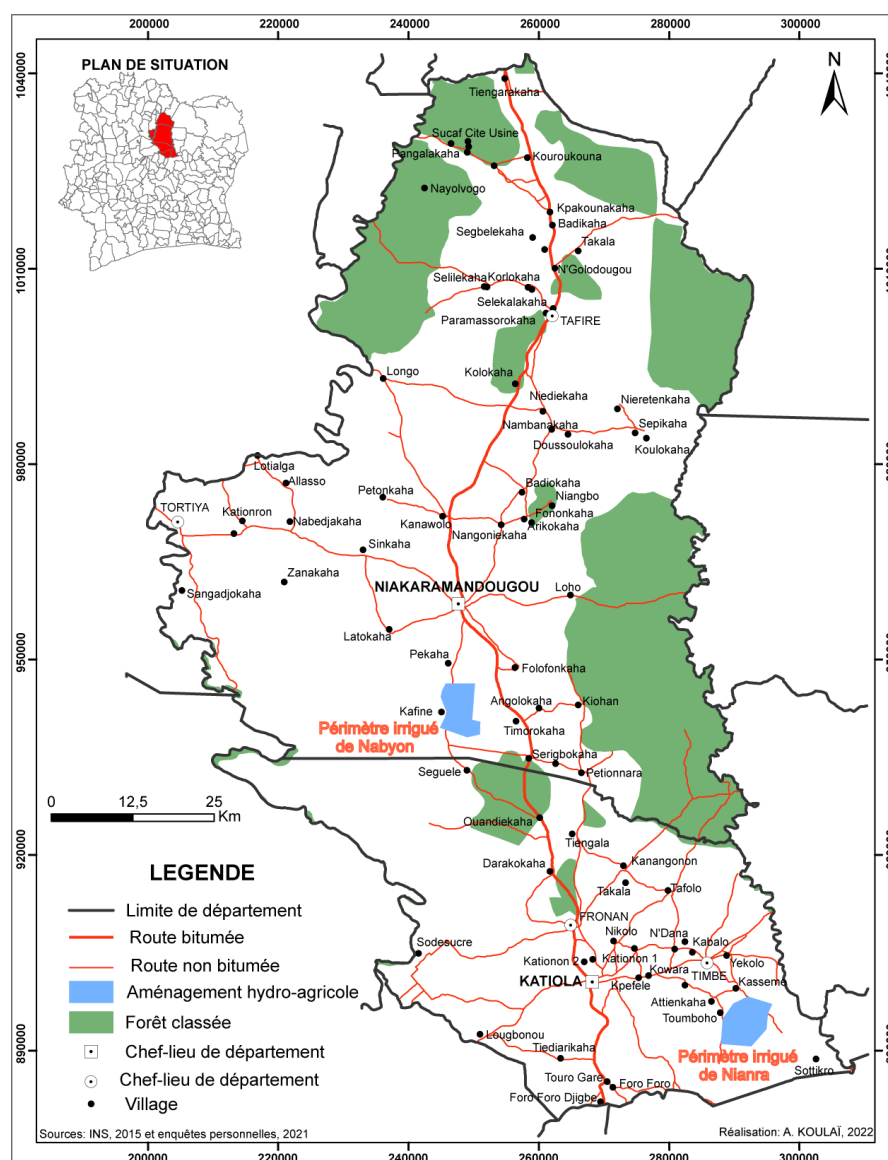
II. MATERIALS AND METHODS

1-The study area

The Nianra and Nabyon hydro-agricultural schemes are located in north-central Côte d'Ivoire, precisely in the departments of Katiola and Niakaramandougou (Figure 1). Created in 1976 as part of the Bouaké-Nord rice project, the Nianra and Nabyon irrigated perimeters are water reservoirs primarily intended for irrigated rice production.

The Nianra perimeter, with a developed area of 80 ha, is located about 25 km from the town of Katiola. It is attached to four villages, namely Toumbokaha, Kpéfélé, Kassémé and Attienkaha, whose inhabitants are the main farmers. It is developed downstream from a dam built on the N'Zi. The retention capacity of the dam is estimated at 3.6 million m³. The Nabyon dam is located 18 km from Niakaramandougou, in the village of Kafiné. It has a total developed area of 130 ha. Its dam is built on the Nabyon, the river whose name it bears.

Figure 1: Location of the Nianra and Nabyon hydro-agricultural schemes



III. Methods of data collection

Several methodological techniques were used to collect the data needed to identify and analyze the socio-economic and health impacts of agricultural activities around the Nianra and Nabyon irrigation schemes. These included documentary research, observation, interviews and a questionnaire survey of the populations involved in agricultural activities in these two developments. The interviews were conducted with ANADER (Agence National d'Appui au Développement Rural) authorities and the health structures of Katiola and Niakaramandougou. The questionnaire survey was conducted with 10% of the farmers working in the Nianra and Nabyon irrigated areas (Table 1).

Table 1: Summary of the sampling plan

Developed perimeters	Total number of farm operators	Number of people surveyed
Nianra	340	34
Nabyon	307	31
Total	647	65

Source : ANADER, 2021

It is useful to know that the field surveys around the irrigated areas of Nianra and Nabyon were conducted in April, August and November 2021.

IV. RESULTS

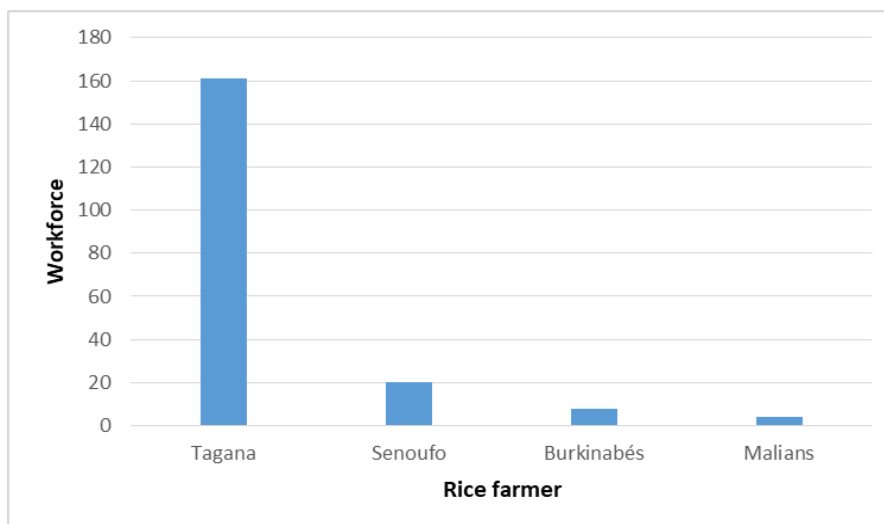
1-Agricultural activities around the developed perimeters

The hydro-agricultural facilities are used for agricultural production grouped into two types of speculation. On the one hand, these are cereal productions dominated by irrigated rice and on the other hand, market gardening.

1.1-Irrigated rice production: actors and production methods

It is practiced on the three hydro-agricultural perimeters of Lopé, Nianra and Nabyon. These perimeters have an essentially rice-growing vocation. They have been selected by the Rice Center Project as part of the program to revive rice production, which aims to eventually meet Côte d'Ivoire's rice needs. On the hydro-agricultural developments, several actors are involved in rice cultivation. These are nationals such as the indigenous Tagbana and Senoufo and non-nationals, notably Malian and Burkinabe immigrants (Figure 2).

Figure 2: Distribution of rice-growing actors according to their ethno-geographic origin



Source: CORIZ-CENTRE and Personal Surveys, 2021

The data in Figure 2 clearly indicate that rice production in the Katiola hydro-agricultural schemes is the business of nationals (Tagbana and Senoufo) with a clear domination of Tagbana natives, i.e., 86% of stakeholders. Non-nationals, in this case Burkinabés and Malians, are less numerous, with 2.07% and 1.04% respectively. The predominance of natives has not always been so. For 20 years, under the pretext that rice cultivation in the lowlands rendered people "impotent" (because of hernia and bilharzia) or blind (because of the presence of flies transmitting onchocerciasis), the Tagbana populations were not interested in this activity. However, the arrival of migrants and climatic problems (drought) have forced these peoples to reconsider the marshy areas (lowlands, hydro-agricultural perimeters). In terms of the distribution of rice-growing actors, there is a small presence of women, who make up 4% of all producers. These women, who claim to have received agricultural training, find irrigated rice cultivation difficult. They have therefore given way to men. The production of irrigated rice in the Katiola hydro-agricultural schemes is carried out in four stages: preliminary work, planting of crops, maintenance of rice fields, harvesting and post-harvest operations. These stages are detailed in Table 2.

Table 2: Irrigated rice cultivation operations in the hydro-agricultural schemes in Katiola

Growing phase	Activities
Preliminary work (1)	<ul style="list-style-type: none"> Maintenance of structures (canals, dikes, rice pits) by manual weeding, fire or chemical products Ploughing of rice pits The planing (reduction of the slopes inside the traps)
Setting up the crops (2)	<ul style="list-style-type: none"> Transplanting (from 18 to 20 days old transplants) Direct sowing (with pre-sprouted seeds in the 2nd cycle)
Rice field maintenance (3)	<ul style="list-style-type: none"> Fertilization (with nitrogen, phosphorus and potassium) Weed control (with Topstar 400SC herbicides) Control of insect pests (with the insecticides REGENT 3GR, FURADAN and DECIS 35 EC) Control of birds (with rock throwers, melts, noise of empty barrels and installation of scarecrows)
Harvest and post-harvest	<ul style="list-style-type: none"> Manual or mechanized harvesting (with sickle or mower)

operations (4)	<ul style="list-style-type: none"> • Manual or mechanical threshing of rice stalks (with stick or mechanical thresher) • Widdowing of the rice grains (with the traditional winnowing machine) • Drying • Bagging and marketing of the rice
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Source: Personal surveys, 2021

1.2 Market gardening: actors and production methods

Market gardening is the second activity practiced by farmers in the hydro-agricultural schemes of Katiola. The areas used in the various irrigated areas are generally small. Sometimes these crops are grown outside the formal irrigation perimeters. As with irrigated rice, market gardeners are of diverse origins (Figure 3). However, the gender distribution of these actors has a female connotation (Figure 4). In these figures, although the ethno-geographic origins are the same as those of irrigated rice, non-nationals dominate market gardening, representing 70% of all actors. In detail, the Burkinabés are the leading producers, while the Tagbana natives are in last place with only 10%. In terms of gender distribution, women are the main actors, representing more than ¾ of the market gardeners. All the market gardeners justify the high rate of women by the social fact. In this respect, they affirm that they actually feed the whole family. Originally, the production of food crops, in this case market gardeners, was their main activity because it was intended for family consumption. But with the market economy in the rural world of Katiola, the financial manna generated by this activity has attracted men to this area of female activity.

Figure 3: Distribution of market garden actors by ethno-geographic origin

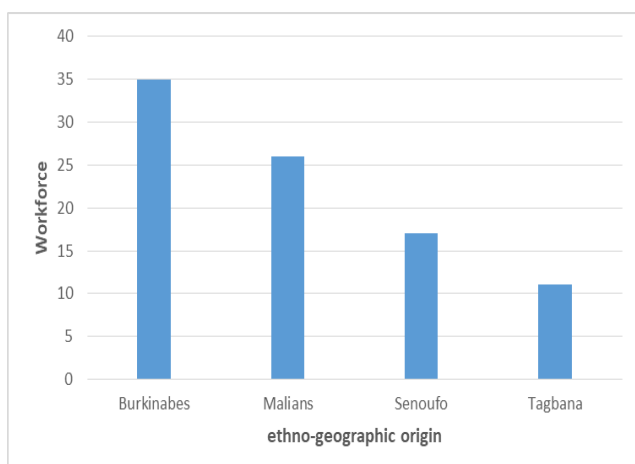
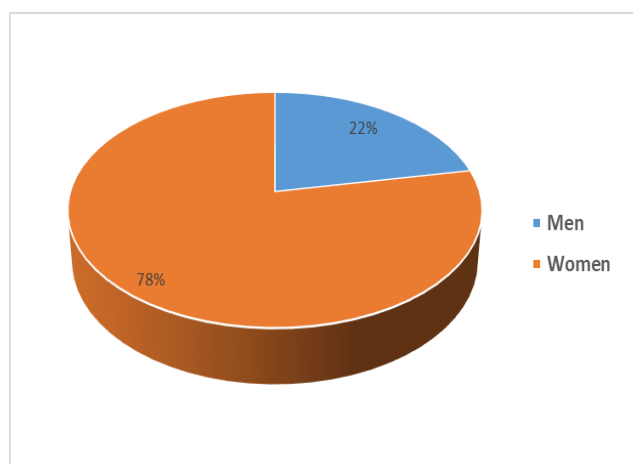


Figure 4: Distribution of market garden actors by gender



Source: Personal surveys, 2021

The production of vegetable crops follows the same stages as for irrigated rice. Thus, there are four cropping phases summarized in Table 3.

Table 3: Cultivation operations of market gardeners in hydro-agricultural developments in Katiola

Cultivation stage	Activities
Preliminary work (1)	<ul style="list-style-type: none"> • Drawing of the boards (garden) • Drawing of the boards of length inferior or equal 1, 20 meter and of width included between 10 and 15 centimeters.
Setting up the crops (2)	<ul style="list-style-type: none"> • Direct sowing • Transplanting of nursery plants after 3 to 5 weeks
Rice field maintenance (3)	<ul style="list-style-type: none"> • Fertilization with organic fertilizers (manure, compost, green manure, ash) • Fertilization with mineral fertilizers (nitrogen, phosphoric acid, potash) • Pest control (weeds, insects, birds, rodents)
Harvesting and post-harvest operations (4)	<ul style="list-style-type: none"> • Manual harvesting of the vegetables (with a sickle or by hand) • Preservation of vegetables in dry, airy and dark places • Marketing of the vegetables

Source: Personal surveys, 2021

2-Impacts of agricultural activities in hydro-agricultural schemes

Hydro-agricultural developments have economic and health impacts.

2.1-At the economic level

• Agricultural production and yields

The hydro-agricultural perimeters of Nianra and Nabyon are finally making farmers happy. According to the stakeholders, these developments have allowed for an increase in surface areas, leading to a real increase in yields of irrigated rice and market garden crops (Tables 4 and 5).

Table 4: Irrigated rice yields from hydro-agricultural schemes

Perimeter	Total area (ha)	Production (t)	Average yield per hectare (t/ha)
Nianra	80	440	5,5
Nabyon	130	754	5,8
Total	210	1194	11,3

Source : CORIZ-CENTRE, 2020

Table 4 shows that, in general, the area under irrigated rice is much larger in the Nabyon irrigated area, accounting for nearly 62% of the area under rice. This spatial supremacy of irrigated rice grown in Nabyon is also noted in terms of production, with 63% in this area. However, average yields per hectare are roughly the same for all hydro-agricultural schemes.

Table 5: Market garden crop yields around hydro-agricultural schemes

Perimeter	Total area (ha)	Production (t)	Average yield per hectare (t/ha)
Tomato	18,4	55,2	3
Eggplant	36,32	181,6	5
Okra	43	12,9	0,3
Onion	27	27	1
Cabbage	8,5	5,95	0,7
Pepper	23	9,2	0,4
Cucumber	4	2,8	0,7
Total	160, 22	294,65	11,1

Source : ANADER Zone Katiola, September 2020

Table 5 shows the cultivation of all market garden crops in the Nianra and Nabyon hydro-agricultural schemes. The productions show a productive supremacy of eggplant (62%), followed by tomato (19%) and onion (9%). This situation is also identical in the category of average yield per hectare.

• Farmers' Income

The production costs and operating results were used to estimate the income of farmers in the Katiola hydro-agricultural schemes. These estimates were made by means of operating accounts for one hectare of irrigated rice and one hectare of one crop (okra) for market gardening (Tables 6 and 7).

Table 6: Operating account for one hectare of irrigated rice per cycle

EXPENSES					PRODUITS				
Designation	U	Qté	PU	PT	Designation	U	Qté	PU	PT
Purchase of seeds	Kg	40	300	12000	Production average (t/ha)				
Purchase of inputs					Sale	Kg	5000	200	1000000
Water		15000cfa							
-NPK	Kg			9000					
- Urea	Kg			9000					
- Pre-emergent herbicide (Callistar)	L			4500					
- Post-emergence herbicide (Garil)	L			3750					
- Insecticide(DECIS)	L			3250					
Achat gasoil travail	L	40	700	28000					
Transplanting labor	h/j	10	1300	13000					
Location de motoculteur	Ha	1	65000	65000					
Tiller rental	Ha	1	22500	22500					
Location batteuse-vanneuse	Ha	1	25000	25000					
Thresher-cleaner rental	h/j	5	500	2500					

Purchase of bagging	Sac	55	300	16500				
Total production cost				201.000	Total operating income			1000000
Operating result				799.000				

Source: Personal surveys, 2021

The data in Table 6 show that a producer who has spent 201,000 CFA francs for an operating income of 1,000,000 CFA francs has a profit of 799,000 CFA francs. The producer therefore makes a margin of 589,000 CFA francs. These figures show that depending on market prices, the applicant or even the place of delivery of the seed, the rice grower's activity will be profitable. By extension, the 2020-2021 campaign has earned 645 farmers in the Nianra and Nabyon hydro-agricultural areas the sum of 369,300,000 CFA francs for two rice cycles, or 1,913,741 FCFA. This represents approximately 159,455 FCFA per month.

Table 7: Operating account for one hectare of okra, eggplant and tomato

EXPENSES					PRODUCTS				
DESIGNATION	U	Qté	PU	PT	DESIGNATION	U	Qte	PU	PT
Purchase of seeds	Kg	5	Free	Free	Production average (0,3t/ha)				
Purchase of inputs					Sale	Kg	300	90	
- NPK	Kg	100	Free	Free					
- Urée	Kg	75	Free	Free					
Insecticide	L	0,5	Free	Free					
Total production cost	0				Total operating costs	27000			
Operating result					27000				

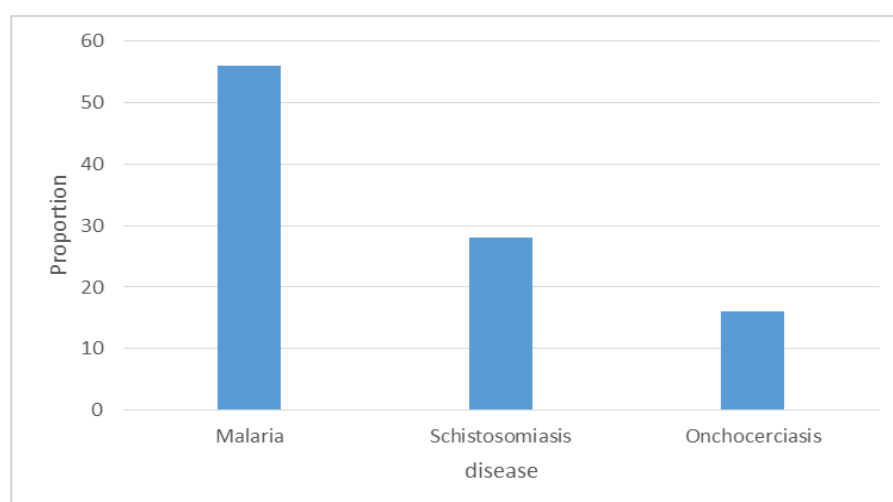
Source: Personal surveys, 2021

From Table 7, it should be noted that production in the dry season requires the use of irrigation, and prices to producers are higher than during the rainy season. The okra, eggplant, and tomato producer ends up with a profit margin of 27,000 CFA if all production is free. However, this profit margin can be lowered if he has to procure inputs, herbicides and pesticides with his own means. For the year 2020, the cultivation of okra, eggplant and tomato earned 110 farmers the sum of 1,822,500 FCFA, or 16,570 FCFA per month.

2.2-At the sanitary level

In terms of health, these hydro-agricultural developments favor the proliferation of certain vectors of water-related infectious diseases. Data from field surveys show the presence of various diseases among the populations working in the hydro-agricultural areas of Katiola (Figure 5).

Figure 5: Diseases encountered in the populations of the Nianra and Nabyon hydro-agricultural schemes



Source: Personal surveys, 2021

The actors in agricultural activities in the developed perimeters affirm that malaria is the main disease (56%). It is followed by schistosomiasis (bilharzia) 28% and onchocerciasis called "river blindness" 16%.

V. DISCUSSION

The results indicate that, in general, the main agricultural activities in the irrigated areas of Nabyon and Nianra revolve around irrigated rice and market garden crops, namely okra, eggplant, onion and tomato. However, in the spatial organization of these agricultural activities, it is clear that irrigated rice has a considerable spatial hold with nearly 60% of the cultivable area, compared to barely 40% for market garden crops. It is therefore in the irrigated perimeters where rice cultivation remains largely developed, while market gardening remains a secondary crop. This supremacy of rice in the Nabyon and Nianra hydro-agricultural schemes is also shared by S. Kohoun (2002, p.36-37), who writes :

« Rice cultivation occupies the bulk of the areas sown on the perimeter. Each farmer has a plot of 1.25 ha, of which 1 ha is used for rice (...). Market gardening is of secondary importance. These crops are used to improve the farmers' diet and their financial situation, with onions, tomatoes, cabbage, carrots and chili peppers as the main crops ».

Regardless of their spatial coverage, agricultural operations in the Nabyon and Nianra irrigated perimeters revolve around four (4) phases: soil preparation, crop planting, maintenance and harvesting. These cultivation phases are almost the same as those described by S. Kohoun (2002, p.40), namely soil preparation, transplanting, mineralization and harvesting.

Although the cultivation operations are almost the same, the yields of the agricultural activities differ at the level of the speculations. Indeed, the results of the field investigations revealed much higher yields of rice than of vegetable crops in the two developed areas. This supremacy in terms of the productive profitability of rice around the developed perimeters had already been mentioned by A. Hauhouot and K. Atta (1981, p. 124). Thus, the work of these two authors showed that in the hydro-agricultural development of Koubi-Tiébissou (central Côte d'Ivoire), rice and maize yields were 16 t/ha compared to 10t/ha for all market garden products.

With these yields, agricultural activities generated income for farmers around the Nabyon and Nianra schemes. In this regard, the operating accounts show the existence of income for both irrigated rice and market gardening. The use of the operating account as a means of assessing income had already been mentioned by A. Hauhouot and K. Atta (1981, p.125). These authors showed that in the market garden sector, the best farmers have a net income of about 300,000 CFA francs. Concerning irrigated rice, the work of J. K. Koffi et al (2018, p.13) revealed that around the hydro-rice development of Guiguidou (Central-Western Côte d'Ivoire), the rice activity is remunerative and this through the annual income of 64% of the producers, which is greater than 500,000 CFA francs.

In spite of these economic advantages, some health consequences have been observed around the hydro-agricultural developments of Nabyon and Nianra. Indeed, the results of field surveys have identified several diseases in the areas where agricultural activities are carried out. Thus, three major diseases are observed in the Nabyon and Nianra perimeters, namely malaria, onchocerciasis and schistosomiasis. Two of these three diseases, malaria and schistosomiasis, are the most common in the hydro-agricultural schemes. In this regard, P. Haudschumaker et al (1995, p.125-126) have shown the high presence of malaria and bilharzia (schistosomiasis) in the irrigated perimeter of Diomandou in Senegal. The prevalence of these diseases in hydro-agricultural schemes was also highlighted in Burkina Faso by S. Kohoun (2002, p.55 and p.59), who mentions that malaria and schistosomiasis are diseases for which the conditions created by hydro-agricultural schemes favor their propagation. The presence of bilharzia in Nianra, as shown by the results of the present survey, is corroborated by the work of E. A. M. Yapi et al (2021, p. 10-18) who, while doing research on ecological sanitation, proved the existence of urinary schistosomiasis and its mode of transmission. The other health impact noted around the Nabyon and Nianra hydro-agricultural developments is the significant presence of several cases of onchocerciasis among farmers. Although it was the third disease revealed by the surveys in Nabyon and Nianra, river blindness does appear from time to time in irrigated areas in Africa. Thus, S. Kohoun (2002, p.6) reports that the development of 1200 hectares of rice fields in the Loumana plain has indeed created the conditions for an outbreak of onchocerciasis, rendering 15% of women and 20% of men blind in five (5) years.

VI. CONCLUSION

The Nianra and Nabyon hydro-agricultural developments are water reservoirs that are best suited for the development of agricultural activities. To this end, these two irrigated perimeters concentrate a major part of the rice and market gardening practices of the rural areas of the region. These agricultural activities have undeniable productive and economic returns through the yields of irrigated rice and market garden crops, as well as the income they generate for farmers. In spite of these productive and economic advantages, which are well known to the farming population, there is a permanent and significant presence of diseases such as malaria, bilharzia and onchocerciasis among farmers around the Nianra and Nabyon hydro-agricultural developments. The lack of control of these health risks could be the main obstacle to the practice of agriculture in these irrigated areas of north-central Côte d'Ivoire.

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