Journal of Agricultural Chemistry and Environment, 2023, 12, 206-222
https://www.scirp.org/journal/jacen
ISSN Online: 2325-744X
ISSN Print: 2325-7458

Problem of the Profitability of Irrigated Agriculture in the Sahel Environment: Case of Producers of the Konni Hydro-Agricultural Development

Saidou Abdoulkarimou[1], Illou Mahamadou[2]

[1]Département Environnement, Boubacar Bâ University of Tillabéri, Tillabéri, Niger
[2]Département de géographie, André Salifou University of Zinder, Zinder, Niger
Email: saidoul01@yahoo.fr, illou.mahamadou@gmail.com

How to cite this paper: Abdoulkarimou, S. and Mahamadou, I. (2023) Problem of the Profitability of Irrigated Agriculture in the Sahel Environment: Case of Producers of the Konni Hydro-Agricultural Development. *Journal of Agricultural Chemistry and Environment*, **12**, 206-222.
https://doi.org/10.4236/jacen.2023.122016

Received: April 6, 2023
Accepted: May 28, 2023
Published: May 31, 2023

Abstract

In Niger, a poor and arid country in West Africa, irrigated agriculture is undoubtedly the means with the greatest chance of ensuring food and nutritional security, increasing incomes and therefore reducing poverty, especially in rural areas. This research aims to analyze the profitability of irrigated agriculture at the level of the hydro-agricultural development of Konni. The methodological approach adopted is based on the method of "Rapid Participatory Diagnosis and Planning of actions to improve the performance of irrigated perimeters (DPRP)". The documentary research made it possible to capitalize on the information available on the question. The collection of primary data in the field was carried out using questionnaires and interview guides submitted to actors directly or indirectly involved in the management of Konni's AHA, taken individually or in focus group discussions. The data collected was processed with SPSS software to be analyzed and graphically illustrated with the Excel spreadsheet. The performance analysis made it possible to identify yields and constraints to the development of irrigated agriculture. The results show that on the Konni perimeter, there is a general trend towards a reduction in areas both in SS and in SH, with higher development rates in SH (80% to 90%), whereas they are very low in SS (8% to 25%). The main crops favored by Konni producers are onions, tomatoes, cabbage, corn and sorghum. Onion and tomato crops are more important sources of income than dune crops. In this context, the main challenges to be met for a better profitability of irrigated agriculture concern the socio-economic context of production, insufficient financing of infrastructures and their maintenance, small areas often below the break-even point, environmental degradation.

Keywords

Konni (Niger), Hydro-Agricultural Development, Yield

1. Introduction

Irrigation, "a technique which, in the broad sense of the term, includes all actions intended to increase agricultural productivity by increasing the availability of water for the roots of plants, greatly contributes to growth and to the fight against poverty" everywhere in the world ([1], 2008, p. 39). The involvement of public authorities and donors in supporting the development of irrigation is based on economic considerations, even if their nature varies according to the political objectives targeted: to develop (planning a territory), to produce (food autonomy of the territory), and to develop (increase in the income of rural populations, increase in exports and inflow of foreign currency) ([2], 2020, p. 77). According to ([3], 2003, p. 1), irrigated agriculture currently accounts for some 40% of global food production, even though it accounts for only 17% of cultivated land.

However, available data indicate that the areas under agricultural water management in Africa represent only 36% of the estimated irrigable potential of 42.5 Mha ([4], 2007, p. 3). In Niger, a poor and arid country, irrigated agriculture is undoubtedly the means with the greatest chance of increasing income and therefore reducing poverty. Very dependent on rainfed cropping systems with low productivity (94% of cultivated areas are devoted to rainfed agriculture), the agricultural sector has not been able to keep pace with population growth and the production deficit has led to a decline food self-sufficiency. However, agriculture remains the main source of growth in Niger, and irrigation, despite the constraints, one of the engines of growth in the agricultural sector. The initial local benefits of irrigation are construction jobs and services. However, the investments are justified by the individual gains of the farmers and the broader economic benefits. These individual and economic benefits depend on the actual increase in field production made possible by providing farmers with better access to water for production ([5], 2009, p. 4).

The contribution of irrigated agriculture (mainly rice and market gardening) is estimated at around 14% of the total value of agricultural GDP, corresponding to a monetary value of production of around 66 billion CFA francs. The Government's strategic objective is to increase it to 28%. Export earnings from irrigated crops (especially onions and peppers) exceed 10 billion CFA francs. Despite the small share of cultivated areas, the irrigation sub-sector accounts for nearly 30% of the monetary value and is preponderant with 90% of export earnings from all crop production in Niger ([6] 2015, p. 24).

Irrigated agriculture can make a significant contribution to the Nigerien economy as a whole. First, it is an economy dependent on the vagaries of rain-fed agriculture, and irrigation can help reinforce the stability of economic

growth. Secondly, and most importantly, in the face of unabated poverty in Niger, irrigated agriculture can help solve the problem of poverty which dominates in rural areas. It can help achieve food security and poverty reduction goals by providing food and bringing in income to farmers and foreign exchange to the state ([1], 2008, p. 10).

However, from the macroeconomic point of view, the development of irrigated agriculture is subject to enormous constraints. Irrigated crops are generally practiced on small areas. The irrigated perimeters have, for example, been designed for plots of 0.25 to 0.5 ha per family. The small size of the plots makes exploitation economically unviable during the division of successions. Funding problems, dysfunctions in the collective management of water and difficulties in maintaining the structures compromise the sustainability of these systems ([7], 2011, p. 15).

The Government estimates the potential of irrigable land at approximately 270,000 ha, but its exploitation poses enormous physical, economic and institutional problems. This potential is further reduced by the decrease in water availability offered by the Niger River, as well as by the impact of climate change also affecting availability from groundwater. However, around 200,000 farming households, representing more than a million people, are involved in the production of irrigated crops, without counting those, fewer in number, who supply inputs and services upstream and take care of the processing, handling, marketing and transport ([7], 2011, p. 15).

Therefore, development and access to markets is fundamental for the development of irrigated agriculture, but very difficult to achieve for a poor and landlocked country like Niger ([1], 2008, p. 11). The question thus arises: what is the profitability of irrigated agriculture for the producers of the Konni AHA? The objective of this research is therefore to analyze the profitability of irrigated agriculture at the level of the hydro-agricultural development of Konni. Starting from the fact that the profitability of a hydro-agricultural project is multiple, its assessment must be made at different levels and in different ways, for the community (economic profitability) and at the level of the main actors concerned (financial profitability of each type of actor). It is therefore assessed *at a minimum*, in a hydro-agricultural development project, at the level of the farmers who value the development and at the level of the manager of this development. Taking the Konni irrigated perimeter as a geographical framework, the aim here is first to characterize the irrigated production systems, then to assess the productivity of irrigated agriculture and finally to identify the constraints faced by farmers of the hydro-agricultural development of Konni.

2. Presentation of the Framework of the Study

The department of Birni N'Konni occupies the southwestern part of the Tahoua region, 417 km from Niamey, the capital, and 133 km south of the capital of the Tahoua region. Bordered to the east by the department of Malbaza, to the west

by that of Dogon Doutchi (Dosso region), to the north by the department of Illéla and to the south by the Federal Republic of Nigeria. The department of Birni N' Konni covers a total area of 3671 km^2 or 3.01% of the area of the region. The department of Birni N' Konni is subdivided into four (4) communes: Alléla, Bazaga, Tsernaoua and Konni which houses the irrigated perimeter (**Figure 1**).

The department has a canton and a Fulani group. The soils are typical of the southern Sahelian zone. There are three agro-ecological zones:

- The zone of valleys with clayey soil and fertile clayey sand;
- The zone of dune plains with medium to poor sandy soil;
- The high hills ironclad plateau area.

Irrigated cropland is essentially composed of lowlands with hydromorphic, clayey and clayey-sandy soils. The crops grown on these soils include cereals (sorghum, maize, wheat), legumes, arboriculture (mango trees) as well as traditional market garden crops (onion, cabbage, lettuce, okra, tomato, pepper, pepper, etc.). Irrigated crops take place from the beginning of October to the end of March depending on the type of crop, as some have a longer cycle than others.

The Maggia valley contains significant surface water resources thanks to the succession of several dams built in the middle valley. Apart from the interest of their reserve for agriculture, the dams locally regulate the supply of the alluvial aquifer and significantly dampen the seasonal variations in the piezometric level. Hydrogeologically, the study area is characterized by four aquifers: the alluvial aquifer of the Maggia valley, the continental terminal aquifer, the upper marine Cretaceous and Paleocene aquifer and the Hamadien intercalary continental aquifer.

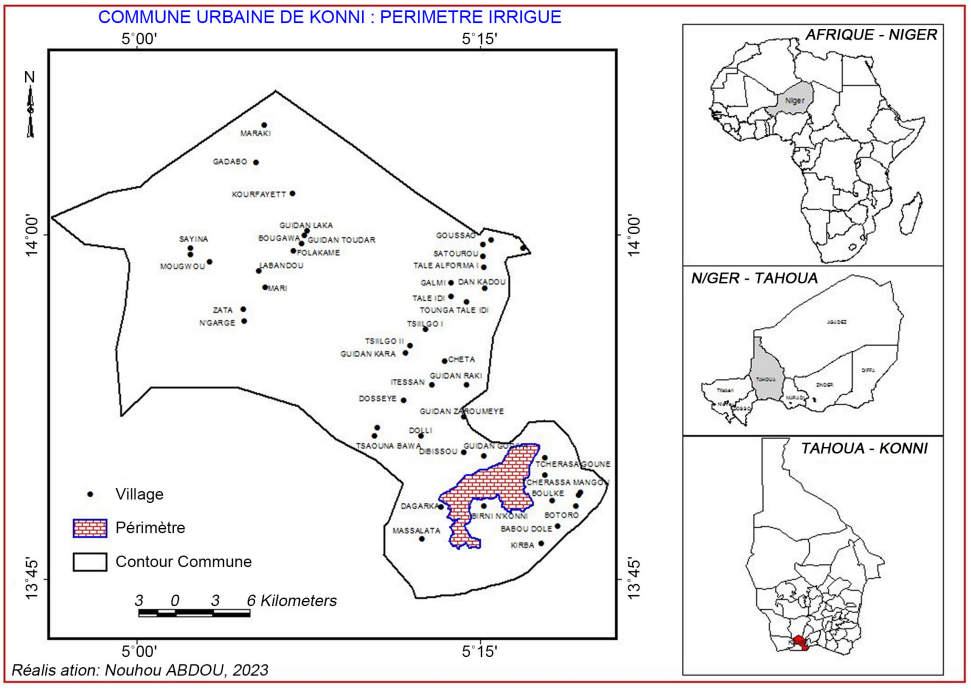

Figure 1. Location of the study area. Source: Republic of Niger, 2018, p. 38.

Demographically, the department of Birni N'Konni has experienced significant population growth since its population has almost doubled in more than thirty years (1977-2012) to reach 313,886 inhabitants in 2012. There is a slight male prevalence with 50.2% men. According to the RGPH of 2012, in Konni, the primary sector occupies 88.3% of the employed working population, the secondary sector 2%, and the tertiary sector 9.6%.

The hydro-agricultural development of Konni is located precisely at Longitude East: 5˚12'28" and at Latitude North: 13˚46'36". The Konni irrigated perimeter, created in two phases in 1976 (1384 ha) and 1982 (1068 ha), is located in the department of Birni N'konni (Tahoua region), about 417 km from Niamey on national road 1 Surrounding the town of Konni, it covers a gross area of 3000 ha, of which 2452 ha is net irrigated area. On the other hand, the dams of Mozagué and Zongo which supply it with the water necessary for the irrigation of the plots are on the territory of the commune of Tsernaoua. The Konni AHA is of the gravity type with a system in two main parts (**Figure 2**):

- The water mobilization and transfer zone composed of two (2) dams including Mozagué with an initial volume of 30 million m^3 and Zongo with 12 million m^3. These two dams are linked to the Tcherassa buffer reserve with an initial volume of 2.5 million m^3 and 1.4 to 1.5 million m^3 today, by a large intake channel of 15 km, then the main channel conveys water to the service area at Konni further downstream;
- The service area, for its part, consists of four (4) main canals, 23 secondary canals and tertiary ones with a plot unit of 0.75 ha.

As shown in **Figure 2**, the AHA was originally designed to provide supplemental irrigation to the entire irrigated area during the rainy season (July to October) and provide full irrigation to approximately 1200 ha during the rainy season. dried. But currently, given the situation of the reservoirs, the practice of the dry campaign is very limited. The area is farmed by 4836 farmers, 5% of whom are women ([8], 2017, p. 19) (**Figure 3**, **Figure 4**).

The study area (corresponding to the territories of the communes of Konni and Tsernaoua) in the department of Konni, is agro-pastoral in nature and contains significant agricultural potential. Agriculture is the main economic activity of the population and the main source of income for most households, especially in rural areas. In the urban commune of Birni N'Konni, agriculture employs 67% of household heads.

This agriculture, rainfed and/or irrigated, is exercised simultaneously with hut breeding. Located in the Sudanian agro-climatic zone, the sub-watershed of the Maggia is also a region of transhumance for herds from the pastoral zone which, for the most part, pass through the grazing areas of the communes of Tsernaoua and Konni in the dry season (opening of fields in November) to then move towards transhumance sites in the northern regions of Nigeria. Before the definitive installation of the winter season, these herds of cattle and small ruminants in general, redo the reverse route in accordance with the rules of the rural code.

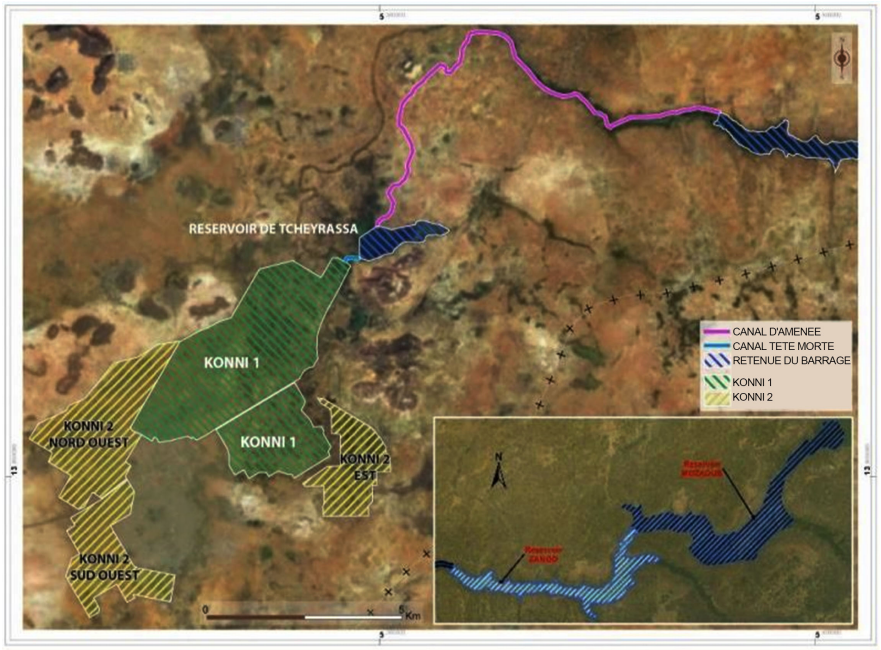

Figure 2. Location of the study area. Source: Republic of Niger, 2018, p. 8.

Figure 3. Headrace at Konni. Shooting: S. Abdoulkarimou, October 2021.

Figure 4. Market gardening in the Tsernaoua area. Shooting: S. Abdoulkarimou, October 2021.

3. Data and Methods

The methodological approach adopted is based on the method of "Rapid Participatory Diagnosis and Planning of actions to improve the performance of irrigated perimeters (DPRP)" developed by IWMI and ARID (11, 2007). It is an approach that seeks, in collaboration with farmers, to analyze the performance of their irrigated system, at the same time as diagnosing the main constraints. The methodological approach comprises three main phases: preparation, collection of secondary and primary data, analysis of performance.

The collection of secondary data made it possible to capitalize on the information available on the issue through documentary research. The technical, financial and organizational data on the site are recorded on a summary sheet. The collection of primary data in the field was carried out using questionnaires and interview guides submitted to individual actors or focus groups directly or indirectly involved in the management of Konni's AHA. It is broken down into two sub-phases: the one that takes place in the room and which consists of collecting data from interviews with the operators and the technical staff and the one that takes place in the field and which consists of covering the perimeter according to well-defined axes. In total, members of cooperative offices 1 and 2 were interviewed. It is the same for the members of the office of the union of Adaltchi cooperatives of Konni. Members of the offices of the 34 GMPs were taken into account for the interviews. A representative sample of 170 farmers (including 28 women) or 5 farmers per GMP was surveyed. To these are added interviews with two specialists working directly in support of producers: a representative of ONAHA and a representative of rural engineering.

The data collected was processed on the computer with SPSS for Windows software to be analyzed and graphically illustrated with the Excel spreadsheet. The performance analysis identified yields, financial revenues and constraints to the development of irrigated agriculture.

4. Results and Analyzes

4.1. Technical Itineraries and Irrigated Production Systems in Konni

4.1.1. Cultivated Areas and Agronomic Technical Itineraries

On the Konni perimeter, 60% of households own a field outside the irrigated perimeter, which field is sometimes smaller than the plots owned or operated within the perimeter (54% of cases), particularly in Konni, Dibissou and Guidan. Godia, and which produces less than the plots owned or operated within the perimeter (73.5% of cases). At the level of the irrigated perimeter, 3528 farmers work on 1625 ha (Table 1).

On the Konni perimeter, the parcel unit which is 0.75 ha is 100% exploited in the wet season (SH), but it occupies less than a third of the area in the dry season due to lack of water, *i.e.* 0.375 ha per farmer in the off-season (Table 2).

The analysis of the results (Table 2) allows us to note a general trend towards

a reduction in surface areas both in SS and in SH. Similarly, the sown areas are low in SS compared to the SH campaign, where water is not a limiting factor, this area fluctuates around 500 ha per year and has tended to decrease over the last five years. The valuation rates are higher in SH and oscillate between 80% and 90%, whereas they are very low in SS and oscillate between 8% and 25% in maxi. For a net area of 2452 ha totaled by the hydro-agricultural development of Konni, the average rate of agricultural development is 87% in SH against 18% in SS. Table 3 presents the crop calendar followed by Konni producers.

As shown in Table 3, it should be noted that this calendar is not always respected because of certain constraints, among others: failure to respect the official date for starting irrigation on November 15, the practice of polyculture, food habits and divergent interests of farmers. During the 2018 wet season, the rotation proposed in Konni 2 is very disparate (about 14 different crops) but mainly dominated by the cultivation of millet, sorghum and cowpea (Table 4).

Examination of Table 4 shows that this rotation is essentially oriented towards food crops for home consumption, market garden crops with high added value (HVA) such as tomatoes (yield 22.1 tonnes per ha), peppers (11.3 T/ha), squash (15.4 T/ha) was very poorly valued. In this context, it becomes difficult to establish a sector approach and to develop a strategy for setting up value chains geared towards the national and sub-regional market.

Table 1. Breakdown of Sites - Operators - Areas.

Commune	Number of sites	Number of operators	Areas (ha)	
			Exploitable	Exploited
Konni	20	3528	6774	1625

Source: 2021 campaign monitoring report, DDA/Konni.

Table 2. Evolution of exploited areas and development rate on the Konni Perimeter.

YEARS	Tot, Sup SH (ha)	Rate Enhancement SH %	Tot, Sup SS (Ha)	SS Enhancement Rate%
2017/18	2270.00	92.58	208.59	8.51
2016	2145.00	87.48	567.12	23.13
2015	2065.00	84.22	600.57	24.49
2014	2294.00	93.56	602.69	24.58
2013	2233.00	91.07	194.30	7.92
2012	2017.01	82.26	524.02	21.37
2011	2245.40	91.57	450.75	18.38
2010	1982.00	80.83	488.70	19.93
2009	2170.00	88.50	320.78	13.08
2008	1803.00	73.53	437.87	17.86
2007	2156.70	87.96	442.40	18.04
Mean	**2125.56**	**86.69**	**439.80**	**17.94**

Source: [9], 2019.

Table 3. Crop calendar on the Konni perimeter.

Campaign	Start date	End date	Main crops	Irrigation
Dry season SS	November 15	March, 31st	Corn, wheat, sorghum, donkeys and market gardening	10 days pre-irrigation followed by 3 days/week irrigation
Wet season SH	April 15	October 31	Millet, sorghum, cowpea, groundnut	Abolition of supplementary irrigation with the abandonment of cotton cultivation and also for the sake of source management

Source: [9], 2019.

Table 4. Rotation (in percentage) and average yields per speculation of the Konni 2 perimeter for the 2018 SH.

Crops	Percentage of land occupation	Yield (T/ha)
Mil	47.8%	1.4
Sorghum	37.7%	2.1
cowpea	6.0%	0.5
Moringa	1.7%	4.0
Tomato	1.5%	22.1
Squash	1.1%	15.4
But	1.0%	2.3
Peanut	0.8%	0.9
Pepper	0.4%	11.3
Onion	0.3%	15.7
Okra	0.3%	N/A
Cabbage	0.3%	23.5
Cassava	0.2%	21.3
Sesame	0.2%	N/A
Total	**100%**	

Source: [9], 2019.

4.1.2. Irrigated Production System

In the study area, two production systems under irrigation coexist: the semi intensive and the intensive. The semi-intensive system under traditional irrigation and/or flood recession crops, centered on the agriculture of onion, cowpea, cowpea and maize. This system has existed for a long time along the beds of the Maggia and its tributaries. The more intensive system established on the irrigated perimeters developed downstream of the dams or more recently by the multiplication of surface wells and small motor pumps at affordable prices. In addition to the areas under the influence of the Mozagué dam, the entire Maggia valley is enhanced as the water recedes; cowpea, cowpea and corn are sown there; these three speculations do not need to be irrigated they complete their vegetative cycle thanks to the capillary rise of the waters of the reservoirs, on the other

hand the cultures of the onion which is the most important followed by the culture of the tomato produced on the same site are irrigated.

Apart from the city of Konni and the villages exploiting the perimeter, the hydro-agricultural developments of the system of three reservoirs (Mozagué, Zongo and Tcherassa) are responsible for the appearance of a whole ecosystem of flooded and cultivated areas in decline, or favoring groundwater recharge and the development of irrigation from surface wells (Figure 5). In the Upstream zone, there are 18 villages and their attached hamlets that exploit the lowland of Mozagué after drainage of the water from the dam (Figure 6) for a total population of 22,912 inhabitants.

Thus, apart from the developed perimeter of 2911 ha of Konni (gross area) these developments are responsible for the popularization of irrigation over nearly 8900 ha in the entire Konni-Tsernaoua-Malbaza area. The generalization of small gasoline motor pumps and their low cost (80,000 to 200,000 FCFA) and the attractive price of contraband gasoline sold in the department (300 to 350 FCFA per litre), *i.e.* less than 50% of the price per liter at the pump are all factors that generalize irrigation by surface wells.

Figure 5. Irrigated crops outside the perimeter downstream of Tcherassa. Shooting by S, Abdoulkarimou.

Figure 6. Flood recession crops in the reservoir (Mozagué). Shooting by S, Abdoulkarimou.

4.2. Growth and Productivity of Irrigated Agriculture

Crop Choice and Yields

Several speculations are practiced during the same campaign. We thus note short-cycle and long-cycle sorghum, millet, cowpea, maize, sweet potato, cassava, groundnut, pepper, tomato, okra, onion, cabbage, carrot, eggplant, pepper and spices (Table 5).

Konni producers. But, in the dry season, several crops are grown on the Konni AHA (Table 6).

An improvement in the yields of market garden crops is possible if production techniques are improved, namely crop rotation and crop rotation techniques, irrigation doses and frequencies, phytosanitary treatment methods but also and above all the mineral and organic manure. It should be noted that cowpea is not quantified because producers harvest it for self-consumption.

4.3. Constraints of Irrigated Agriculture

4.3.1. Hydraulic and Agronomic Constraints

In terms of hydraulics, degradation is the greatest constraint on the ground. For operators, this constraint already hinders the development of part of the perimeter. The disappearance of parcel drains in favor of arable land does not in any way protect the perimeter from flooding which could be due to heavy rain.

Table 5. Distribution of some crops.

Type of crops	Plots sown (ha)	Percentage (%)
Onion	467	25.27
Tomato	266	14.40
Cabbage	196	10.61
Bean	82	4.44
Okra	64	3.46
Pepper	49	2.65
But	153	8.28
Sorghum	106	5.74
Potato	18	0.97
Carrot	37	2.00
Watermelon	90	4.87
Others		17.31

Source: according to APD STUDI study, 2018 [10], 2021.

Table 6. Crops and agricultural yields with irrigation on the Konni AHA.

Crop	onion	Wheat	cowpea	cabbing	tomato	maize	Anise	pepper	sorghum	cowpea
Area in ha	175	325	15	60	95	350	60	30	26	25
Yield (T/ha)	43.7	3.7		38.5	30.7	3.4	2.4	12.1	2.6	

Source: according to APD STUDI study, 2018 [10], 2021.

Similarly, several agronomic constraints can be noted. The first constraint would be the lack of arable land for farmers. This would be the cause of the exploitation of tracks, undeveloped spaces and drains. The lack of crop material is classified as the second constraint. Then come successively, the problems of inputs (seeds, fertilizers and phytosanitary products), the insufficiency of phytosanitary treatment materials as well as protective materials during treatments and finally parasitic attacks.

4.3.2. Production Load and Revenue Values

The total value of production and the expenses related to the exploitation of a plot of 0.375 ha were assessed by different groups of producers for different speculations during focus group interviews. Table 7 presents the summary of the results obtained in connection with irrigation.

Onion and tomato crops are more important sources of income than dune crops. You can earn nearly a million CFA francs on a plot grown in onions and/or tomatoes, for about 500,000 CFA francs invested in labor, the purchase of inputs, treatment products, royalties, l purchase of a motor pump and fuel for watering; what you cannot have on a dune culture locker regardless of the speculation. In the wet season, this relatively low margin can be explained by several reasons:

- Significant self-consumption of production (3/4 of production);
- Crops with lower added value (food crops);
- A drop in selling prices due to the increase in available products.

In the dry season, the average profit margin is much higher, and this can be explained in particular by:

- cash crops that bring in more money;
- lower overall production but higher demand which pushes prices up.

Thus, it can be assumed that food crops generally produce the same yields in the wet season as in the dry season, provided that they can be irrigated, while cash crops produce twice as much in the dry season as in the wet season. Similarly, producers who practice cash crops all use pumping to guarantee sufficient irrigation: in the dry season but also in the wet season. In total, irrigation accounts for 10% to 20% of production costs. On the basis of these elements, results per hectare have been calculated. Table 8 presents these results.

It appears that the cost of irrigation (Table 8) per hectare on the Konni perimeter is essentially linked to the pumping costs that farmers must put in place to guarantee a water supply adapted to the needs of the plants. This analysis confirms the issue of drilling on the perimeter of the Konni AHA. Thus, even if the yields are generally very good, off-season crops bring in more gross margin than rainfed crops; hence the need for the rehabilitation and maintenance of AHA's infrastructure and equipment to recover unused plots. The Compact Program of the Millennium Challenge Cooperation has undertaken since October 2019 the rehabilitation of all the irrigation infrastructure of the Konni Development. Currently, the rehabilitation works have been completed and the water tightness tests of the irrigation canals are continuing.

Table 7. Financial balance sheet of a surveyed speculation panel and associated irrigation costs.

Speculations	Cultivated area (ha)	Balance sheet			Irrigation (FCFA)		
		Expenses	Products	**Net revenue**	Royalty fee	Pumping	**Total cost**
wet season							
Sorghum	0.750	178,385	315,000	**136,615**	18,550		**18,550**
Mil	0.750	222,600	361,000	**138,400**	18,550		**18,550**
Sorghum	0.750	222,300	190,000	**−32,300**	18,550		**18,550**
Onion	0.375	520,050	1,100,000	**579,950**	18,550	40,000	**58,550**
Tomato	0.375	419,000	1,000,000	**581,000**	18,550	5000	**23,550**
Cabbage	0.375	575,550	1,050,000	**474,450**	18,550	62,500	**81,550**
Dry season							
But	0.375	186,850	346,000	**159,150**	22,600		**22,600**
Wheat	0.375	233,350	400,000	**166,650**	22,600	28,000	**50,600**
Wheat	0.375	202,350	300,000	**97,650**	22,600		**22,600**
Onion	0.375	404,600	1.5 million	**1,059,400**	22,600	35,000	**57,600**
Tomato	0.375	474,600	1,250,000	**697,400**	22,600	35,000	**57,600**
Cabbage	0.375	474,600	900,000	**425,400**	22,600	35,000	**57,600**

Source: [8], 2020.

Table 8. Financial issues of irrigation.

Speculations	Financial issues of irrigation					
	Product in tonnes/ha	Gross irrigation needs	**Irrigation cost (FCFA)**	Water productivity	Water valuation (CFA/m^3)	Valuation of water (CFA/ha according to allocation)
wet season						
Sorghum	2.67	10,000	**24,733**	0.27	18.22	182,153
Mil	2.80	10,000	**24,733**	0.28	18.45	184,533
Sorghum	2.00	10,000	**24,733**	0.20	−4.31	−43,067
Onion	21.27	10,000	**156,133**	2.13	154.65	1,546,533
Tomato	15.47	10,000	**62,800**	1.55	154.93	1,549,333
Cabbage	40.00	10,000	**216,133**	4.00	126.52	1,265,200
Dry season						
But	4.53	15,000	**60,267**	0.30	28.29	424,400
Wheat	5.33	15,000	**134,933**	0.36	29.63	444,400
Wheat	4.00	15,000	**60,267**	0.27	17.36	260,400
Onion	58.00	15,000	**153,600**	3.87	188.34	2,825,067
Tomato	38.67	15,000	**153,600**	2.58	123.98	1,859,733
Cabbage	80.00	15,000	**153,600**	5.33	75.63	1,134,400

Source: [8], 2020.

4.3.3. Constraints Linked to Sources of Financing for Irrigated Agriculture

The banking system is in a difficult situation and has very few branches in rural areas. In any event, only the AUEIs, the AHA cooperatives, and probably the medium and large commercial irrigators, have sufficient financial resources to interest the banking sector. Nevertheless, new financial products currently being tested could improve access to credit for irrigated agriculture. In the meantime, the public sector and TFPs continue to finance a large part of the investment in irrigation. However, it should also be noted that TFPs have lost interest in large-scale irrigation in favor of other forms of irrigation (particularly small-scale irrigation) and the use of water for agriculture.

4.3.4. Weak Financing Capacity of Operators

Irrigated agriculture faces many constraints that limit its development. These are mainly the structural weakness of the internal financing capacities of producers' organisations, the deterioration of major developments, the low capacities of the private sector to take on certain activities (water management), difficulties in supplying quality and quantity of fertilizers, water resources whose development is often difficult and expensive, a complex institutional framework and non-functional financial markets. In addition, the idea of creating a new national agricultural bank deserves careful consideration, given the importance of the risks associated with it.

4.3.5. Marketing Constraints

The markets for certain agricultural products produced by irrigation constitute a complex network of private and public interventions. Despite a degree of protectionism, national production faces stiff competition. Grain farmers face an inefficient market – which is in fact failing. State intervention prevents the development of a normal grain market. On the other hand, the strong growth of the onion market shows that only the normal development of the private sector can make it possible to develop a profitable commercial export market. There is still room to significantly increase the volume of onion produced and its added value. The input market is largely dysfunctional, and a reform program should be implemented.

In general, the most important boost that could be given to irrigated agriculture would be the opening of secure market outlets downstream, for example through contract farming or the development of agribusiness.

5. Discussion

The contribution of irrigated agriculture in Niger remains significant in the total value of agricultural GDP and the strategic objective of the Government of Niger is to double it in ten years. Small private irrigation with a variety of agricultural speculations is a particularly profitable activity. This is all the more true for the different types of pumping which are independent of fuel, namely the treadle pump or animal traction. Moreover, given their high added value per worker,

this form of irrigation has real potential in terms of sector growth as well as poverty reduction. This is why, according to ([11], 2020, p. 10), the development of irrigation is an important catalyst for agricultural growth.

In the development of Konni, several speculations are cultivated. We thus note short-cycle and long-cycle sorghum, millet, cowpea, maize, sweet potato, cassava, groundnut, pepper, tomato, okra, onion, cabbage, carrot, eggplant, pepper and spices. Some of these crops are grown in the rainy season with sometimes overlaps in the off-season (see crop calendar) thus requiring supplemental irrigation. The other crops, meanwhile, are grown during the off-season under irrigation. The results showed that onion and tomato crops are more important sources of income than dune crops. These conclusions do not correspond to the results obtained at the level of the perimeter of Galmi where it is off-season crops such as sweet potato, pepper and tomato that bring in the highest gross margin ([12], 2010, p. 46). Thus, as demonstrated by ([11], 2020, p. 15), the adoption of irrigation has significant positive impacts on households in terms of wealth creation and food security and also a positive impact on the development of the economy in general. There are obvious and hidden benefits as well as private and public economic benefits derived from household investments in irrigation.

Productions fluctuate from one year to another because of their strong dependence on rainfall. It is also observed that the yields of the wet season are significantly higher than those of the dry season. The data collected is confirmed by the statements of the farmers and their leaders regarding the fact that the availability of water remains the main constraint for agricultural production at the Konni AHA level. And yet, the results show that off-season (dry season) crops yield more gross profit margin than rainfed crops. This is what ([13], 2018), showed by pointing out that irrigation promotes an increase in cropping intensity of up to 300 percent in areas, such as in Niger, where rainfall only allows a single production per year. This means equivalent or greater production of food on one third of the land, thus reducing pressure on the land, and also the possible loss of biodiversity by limiting the need for the expansion of rain-fed agriculture.

In addition, as much as it seems obvious that irrigated agriculture must contribute to the profitability of farms, the search for direct profitability of the capital invested is not necessarily the objective of perimeter management ([2], 2020, p. 85). Based on the operating accounts drawn up during the research phase, the analysis shows that AHAs are financially profitable only with a yield of at least 4.7 t/ha generated by two successive rice crops per year. In other words, the current current situation (rice-rice, 4 t/ha) does not allow the household to generate a net profit sufficient to cover its needs. These results confirm the conclusions of the Direction de la coopération française ([14], 2000, p. 27), which specified that the irrigated food sectors of sub-Saharan Africa, particularly the rice sector, are often criticized for their lack of competitiveness, in the context of growing "price truth". However, these food chains have many advantages, in view of their im-

portance in the food security system, their relative independence vis-à-vis world markets, and the great ease of marketing on the spot.

Selective rehabilitation of AHAs should only be considered if accompanied by measures aimed at improving the productivity of irrigated agriculture on these perimeters. In particular, from a financial point of view, rice-onion cropping should be piloted, as it presents a promising alternative to the double cropping of rice that traditionally predominates in AHAs.

6. Closing

The extent and severity of climatic hazards, especially rainfall, have encouraged the adoption of irrigated agriculture for better water control in Konni. Irrigated crops contribute to food security and poverty reduction and, *ultimately*, to local and regional social and economic development. Thus, Niger has a diversified irrigated agriculture, with public and private investments, and varying levels of water control and productivity. Although practiced on a tiny proportion of cultivable land, irrigated agriculture contributes significantly to the national economy and to food security. It contributes to agricultural production up to 30% of its total value, and 90% of export revenues from all crop production, *i.e.* 1.5% of GDP. The main challenges to be met for a better profitability of irrigated agriculture concern the socio-economic context of production, insufficient financing of infrastructures and their maintenance, small areas often below the break-even point, environmental degradation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] World Bank (WB) (2008) Irrigation Development in Niger: Diagnosis and Strategic Options, Irrigation Sector Review, June (2008), Agriculture and Rural Development, AFTAR, AFCF2 Country Department, Africa Region, 151 p.

[2] Deram Malerbe, F. and Strosser, P. (2020) Should Irrigation Projects Be Profitable? Are Economic Analyzes Useful? In: Bouarfa, S., Brelle, F. and Coulon, C. (Coord.), *What Irrigated Agriculture Tomorrow? Responding to the Challenges of Food Security and Sustainable Development*, Éditions Quæ, Versailles, 77-89.

[3] World Bank (WB) (2003) Water for Agriculture: Determining the Future of Rainfed and Irrigated Agriculture, Agriculture and Rural Development (ADR), Washington, 2 p.

[4] Molden, D. (2007) Summary for Decision-Makers. In: Molden, D., Ed., *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*, Earthscan & Colombo: International Water Management Institute, London, 1-37.

[5] Gebregziabher, G., Namara, R.E. and Holden, S. (2009) Poverty Reduction with Irrigation Investment: An Empirical Case Study from Tigray, Ethiopia. *Agricultural Water Management*, **96**, 1837-1843. https://doi.org/10.1016/j.agwat.2009.08.004

[6] DGGR (2015) Small-Scale Irrigation Strategy in Niger (SPIN). Ministry of Agriculture, Niamey, 85 p.

[7] National Environmental Council for Sustainable Development (CNEDD) (2011) Impacts of Climate Change in the Agricultural Sector in Niger. Final Report, 64 p.

[8] CACG (2020) Study of the O & M Organization for Konni, Contractual Deliverable n°8.1.1, Revision n°00, Initial Version, Implementation of the Sustainable System Management Sub-Activity Irrigation (GDSI), 83 p.

[9] Abdoulkarimou, S., Luc, J.-P., Abdoulkader H.A., daurensan Nicolas, Assahaba, F.A. and Oumarou, A. (2019) Konni Status Report, Final Version, Implementation of the Sustainable Management of the Irrigation System Sub-Activity (GDSI), CACG, Millennium Challenge Account, 124 p.

[10] CACG (2021) Study on Uses Outside the Perimeters and Estimation of the Balance of Needs with the Availability of Water at the Level of the Konni AHA, Contractual Deliverable n°b1, Technical Report on the Directory of the Database and Mapping of Uses, Implementation of the Sustainable Management of the Irrigation System (GDSI) Sub-Activity, 165 p.

[11] AU (2020) Framework for Irrigation Development and Agricultural Water Management in Africa, African Union, 49 p.

[12] Mossi Maïga, I., Saidou, A.M., Amirou, S.I. and Haya, R. (2010) Rapid Participatory Diagnosis and Action Planning for the Galmi Area (Konni Department, Niger), ANID, Niamey, 67 p.

[13] Batchelor, C. and Schnetzer, J. (2018) Compendium on Climate-Smart Irrigation: Concepts, Evidence and Options for a Climate-Smart Approach to Improving the Performance of Irrigated Cropping Systems. Global Alliance for Climate-Smart Agriculture, Roma, 138 p.

[14] Ministry of Foreign Affairs (MAE France), DGCID (2000) Outlook for the Irrigated Agriculture Sector in Sub-Saharan Africa, Cooperation Strategy for the Sustainability of Large Irrigated Areas, Agricultural Policy and Food Security Office, DCT/EPS, Montreuil, 36 p.