

Irrigation Water Piracy by Off-Plan Operators: What Impact on the Operationalization of the Irrigation Water Users Association for the Konni Hydro-Agricultural Development Project in Niger?

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Abstract

A continental country in West Africa, Niger is characterized by particularly arid climatic conditions due to the fact that more than 3/4 of its surface area is located in the Saharan and Sahelian zones. Knowing that the agro-climatic characteristics of the country do not allow the establishment of intensive agriculture (arid climate, sandy or clay-sandy soils and poor in nutrients and organic matter), the Nigerien authorities have focused from the outset accession of the country to independence in 1960 on the development of water resources. Irrigation became the priority investment sector after Niger gained independence in 1960. With the financial and technical assistance of its development partners and hastened by the emergency of famines, hydro-agricultural developments developed rapidly during the 1970s, a period marked by significant droughts which raged throughout the Sahel sub-region. The two areas of the Konni hydro-agricultural development were carried out respectively in 1979 and 1982 and are irrigated from 2 dams (Mozagué 32 million m³) and Zongo (12 million m³). A 15 km supply canal carries water from the Zongo dams to the Tchérassa buffer reserve where it is stored before being distributed to the development through various canals (primary, secondary and tertiary). If the Konni hydro-agricultural development is located on the territory of the commune of Konni, all of the irrigation equipment and infrastructure which stores and conveys water is located in the rural commune of Tsernaoua. Seven administrative villages are crossed by an open canal which facilitates piracy, not to mention the illegal withdrawal of water by local pop-

ulations for various users including, among other things, the practice of off-season crops. By practicing irrigation using water from dams, non-development operators who do not pay hydraulic fees and do not contribute to the operation of the association of Konni irrigation water users constitute a real bottleneck for this young association whose failure would jeopardize the very existence of the Konni hydro-agricultural development. The results of this study show that sometimes more than 200 ha of agricultural land on average per year are not exploited by producers in the Konni development due to lack of water pumped upstream by operators outside the development of the commune of Tsernaoua. By carrying out a cross-analysis between the areas lost due to water piracy and the amounts of royalties to be paid to producers, the shortfall for the AUEI of Konni amounts to more than 5,000,000 F CFA for an area estimated at 200 ha. The study revealed a lot of frustration and incomprehension on the part of other populations in the two municipalities. If for the operators of the Konni development, the water from the dams is their property, on the other hand, the operators outside the development think that they have the right to use even for agricultural purposes this water from the Maggia which has always crossed their lands hundreds of years ago. The effects of this complex situation negatively impact the operationalization of the Konni AUEI.

Keywords

Konni (Niger), Hydro-Agricultural Development, Irrigated Agriculture, Farmers, Water Piracy

1. Introduction

To combat the harmful effects of recurring droughts and famines and ensure food self-sufficiency for its population, the State of Niger undertook hydro-agricultural development projects in the early 1970s, initially along the Niger River valley and subsequently in the watersheds of the fossil valleys, including the Maggia valley. It was in this context that two irrigated perimeters were established in 1976 and 1982, covering a net area of 3000 hectares, of which 2452 hectares are usable during the rainy season and 1200 hectares during the dry season. According to a census of farmers conducted in 2019 by MCA Niger through the MSA consulting firm, the development is operated by 4832 farmers from 11 administrative villages and 9 neighborhoods in the city of Konni [1] [2].

With the withdrawal of the state, the management of the Konni irrigation scheme was entrusted to cooperatives. However, after some thirty years of management, studies conducted by Niger's partners, such as the World Bank and the Millennium Challenge Corporation (MCC), clearly showed that farmers and their organizations were not prepared to assume the technical and financial responsibilities assigned to them. This led to the deterioration of poorly maintained irrigation

equipment and the cooperatives' continued indebtedness. Irrigation efficiency declined sharply, and over the years, the cultivated areas gradually shrank due to a lack of adequate water supply. Around ten villages located far from priority irrigation zones lack access to water and, consequently, can no longer cultivate off-season crops [1] [3].

Faced with the ongoing deterioration of the Konni irrigation scheme, the State of Niger requested and obtained funding from the United States government for the rehabilitation of the irrigation infrastructure and equipment. Thus, within the framework of the Millennium Challenge Compact, a program concluded between the United States of America through the Millennium Challenge Corporation (MCC) and the Republic of Niger (with the objective of reducing poverty through economic growth), an Irrigation and Market Access Project was integrated. This project aims to increase rural incomes by improving the productive and sustainable use of natural resources for agricultural production and increasing sales resulting from the modernization of agricultural irrigation and flood management systems, while ensuring sufficient access to various existing sectors and markets [4].

MCC funding is intended, among other things, to modernize the Konni hydro-agricultural development through the rehabilitation of irrigation infrastructure and equipment at an estimated cost of \$18 million, land reorganization and resettlement of PAPs (Personal Agricultural Projects), the restructuring of two cooperatives, and the creation and capacity building of an Irrigation Water Users Association (IWUA), whose mission is to ensure the long-term preservation of the irrigation infrastructure and equipment financed by MCC. Water conservation activities in the watershed are also planned to address the problem of siltation, as well as repairs and renovations of the irrigation system to reduce water losses and improve efficiency [3] [4].

The Compact-Niger program was officially launched on January 26, 2018, thus initiating the five-year implementation period. This program comprises two projects, including the Irrigation and Market Access Project, led by MCA-Niger, which aims for the following overall objective: To increase the incomes of rural populations through improved agricultural productivity and increased sales resulting from modernized irrigated agriculture and better access to inputs and markets. This project is divided into four closely linked sub-projects:

- 1) Development of irrigated areas in two regions: Tahoua (Konni) and Dosso.
- 2) Management and facilitation services for market access activities, broken down into three sub-activities:
 - a) Agricultural Support Service (SAA);
 - b) Sustainable Irrigation System Management (GDSI), the subject of this contract;
 - c) Land tenure security.
- 3) Road infrastructure for market access.
- 4) Targeted policy reforms.

The main objective of the "GDSI" sub-project is the establishment, within the

Konni irrigated areas, of an irrigation water users' association (AUEI), thus operationalizing the legal framework established by decree in 2016.

GDSI was tasked with operationalizing the irrigation sector reform through the emergence of a functional, efficient, sustainable, and self-sufficient Water Users' Association (WUA) for the Konni hydro-agricultural development, with a strong focus on professional water management.

Estimated at over US \$18 million (excluding subsequent amendments), the Konni irrigated perimeter rehabilitation project was initiated to improve its performance. The deterioration of the irrigation infrastructure, due to insufficient maintenance, aging, and siltation of the two reservoirs, had significantly reduced the efficiency of the irrigation system and the productivity of the perimeter. Rehabilitation work began in October 2019 and was scheduled to last 33 months [4].

Two years after the creation of the Konni irrigation water users association on March 14, 2020, and the strengthening of its capacities through training, study trips to Senegal and France, and the provision of materials, equipment, and office furniture to the Konni irrigation water user management committee, the following question, which constitutes the focus of our research, remains relevant: what negative impacts does upstream irrigation water piracy have on the operationalization of the Konni hydro-agricultural irrigation water users association in Niger?

What is the point of such a significant investment (over 20 billion CFA francs invested in the Konni irrigation scheme) if the Water Users' Association (WUA), intended to preserve and ensure the long-term viability of the newly constructed equipment and infrastructure, cannot be operational due to water scarcity caused by various billing issues, the most significant of which is water theft by farmers located outside the scheme?

Indeed, local populations living directly outside the scheme (water users outside the designated irrigation scheme) cultivate crops near the main supply canal and draw water directly from it. They also use the shallow Maggia aquifer by pumping from wells. Farmers also cultivate crops around the Tchérasa collection reservoir and the two upstream storage dams.

Yet, the implementation of the Konni WUA is supposed to guarantee the long-term operation of the irrigation infrastructure and, moreover, maintain the production and yield levels of the irrigation scheme.

This article will analyze the negative impacts of water withdrawals by unauthorized operators on the performance and operationalization of the Konni Water Users' Association (WUA), a model intended for all WUAs in Niger. The activities of these "pirates" (the local term for water users) directly affect water availability and the functionality of the irrigation scheme.

Before delving into the heart of the matter, it is necessary to define two key concepts or terms used in the article: "water piracy" and the "operationalization of the AUEI." Water piracy refers to the illegal and fraudulent abstraction of water intended for irrigation within the Konni hydro-agricultural scheme by unauthorized operators—individuals who are neither members of the AUEI nor payers of

the water fee. As defined by the Larousse dictionary, operationalization is the process of making a project, system, or concept operational. In this context, it refers to the mechanisms and processes implemented—step by step—to make the Konni AUEI functional and sustainable. The operationalization of the AUEI is measured by a combination of several criteria (such as irrigated area, fee collection, infrastructure maintenance capacity, and organizational capacity), with the ability to prevent irrigation water piracy being the foremost among them.

2. Presentation of the Study Framework

The study area is located in the southwestern part of the Tahoua region, specifically in the Birni N’Konni department, which covers a total area of 3671 km², representing 3.01% of the region’s total area. The Birni N’Konni department is subdivided into four (4) municipalities: Alléla, Bazaga, Tsernaoua, and Konni, which encompasses the irrigated perimeter. The study area extends across the municipalities of Konni and Tsernaoua. The climate is Sahelian-Sudanian, semi-arid. There is a single rainy season, from June to September. The average annual rainfall is 530 mm. Average temperatures in the project area range from 24.2°C in January-February to over 40°C in April-May. The soils in the department are typical of the southern Sahelian zone. Soils vary according to the toposequence of the environment. Three soil types are characteristic of the southern Sahelian zone:

- The valley zone with fertile clay and sandy-clay soils;
- The dune plain zone with medium to poor sandy soils;
- The zone of the lateritic plateaus of the high hills.

According to the latest general population and housing census (RGP/H 2012), the population of the commune of Konni, predominantly Hausa, is estimated at 149,414 people, including 74,819 men and 74,595 women, distributed among 21,345 households. It comprises 45 administrative villages, 6 hamlets, and 3 tribal areas. The average annual growth rate is 3.6%. Based on the projections from this census, **Table 1** below shows the projected population of the Konni commune by 2030.

Table 1. Projected population of Konni by 2030.

Year	2013	2015	2017	2019	2021	2030
Population	158,827	177,653	196,479	215,305	234,131	318,848

Source: National Institute of Statistics (INS).

Agriculture is the main economic activity for the region’s population and the primary source of income for most households, particularly in rural areas. In the urban commune of Birni N’Konni, agriculture employs 67% of household heads. The main agricultural production during the rainy season focuses on food crops such as cereals (millet, sorghum, and wheat) and cowpeas, which form the staple diet of the population, while off-season production is intended for sale. Livestock farming is of three types: agro-pastoralism, sedentary livestock farming, and small-scale fattening, primarily carried out by women. Fishing takes place at dams

(Mozagué and Zongo Nadabar) and ponds (Tchérasa Gouné, Dossey, Folakam).

The AHA was implemented in two successive phases with joint financing from the National Investment Fund (FNI), the Kuwait Fund (FK), and the Islamic Development Bank (IDB):

- Konni 1 in 1979, covering an area of 1384 ha;
- Konni 2 in 1982, covering an area of 1068 ha.

It covers a dammed area of 3000 hectares, of which 2452 hectares are arable. The total cost of construction, including the dams and the buffer reservoir, amounted to 12.5 billion CFA francs. This cost is broken down as follows:

- Mozagué Dam: 800,000,000 CFA francs;
- Zongo Dam: 600,000,000 CFA francs;
- Tchérasa Buffer Reservoir: 400,000,000 CFA francs;

Konni I and II hydro-agricultural development, including the 14.7 km intake canal: 10,700,000,000 CFA francs.

This area was subdivided into 0.75-hectare plots at the time the perimeter was established. Over time, through succession, inheritance, and succession, these plots were subsequently subdivided into smaller parcels. MCA-Niger undertook a land consolidation effort and supported the issuance of a decree (No. 155/MAG/EL/2018 of May 3, 2018) setting the minimum area allocable to a farmer on the Konni Agricultural Area at 0.25 ha (and a maximum of two 0.75 ha parcels), in order to limit further fragmentation.

Prior to rehabilitation, the area was cultivated by 3970 households organized into two agricultural cooperatives until 2020. The Konni hydro-agricultural development was designed to accommodate a dual agricultural season (dry and wet seasons), but currently, due to the poor condition of the infrastructure and equipment, dry season farming is very limited.

Thanks to \$18 million in funding from the Millennium Challenge Corporation, the rehabilitation of the irrigation infrastructure, encompassing all canals both inside and outside the development, began in October 2019 and is scheduled to last 33 months.

The Konni hydro-agricultural development, including the dams and irrigation canals, was constructed within the Maggia Valley watershed. Initially, the perimeter was designed to provide supplemental irrigation across the entire irrigated area during the rainy season (July to October) and to ensure full irrigation of approximately 1200 hectares during the dry season. The 2019 census estimated the number of farmers at 4832, of whom less than 5% are women.

The Konni irrigation scheme is supplied by the seasonal waters of the Maggia River via the two earthen dams mentioned above: the Zongo and Mozagué dams. Their waters are brought in by a 15 km long canal and then stored in the Tchérasa buffer reservoir before being distributed through a system of canals, along with a drainage system, access roads, and protective dikes.

The irrigation infrastructure of the Konni scheme includes:

- **The Mozagué dam**, located approximately 30 km from the service area of the

scheme, has an initial water storage capacity of 30 million m³ (**Figure 1**) and is equipped with a 60 m long concrete spillway. The maximum height of the dam is 9.85 m above the foundation. Its total length is approximately 653 m.

- **The Zongo dam** has an initial capacity of 12 million m³ (**Figure 2**). It is equipped with a 50-meter-long spillway. The maximum height of the dam is 7.45 meters above the foundation. Its total length is approximately 392 meters.
- **The Tchérassa buffer reservoir**, with a storage capacity of 2.5 million cubic meters (**Figure 3**), is located downstream of the Zongo dam at the head of the main canal.



Source: Dr. Abdoukarimou S, 2024.

Figure 1. Mozagué Dam.



Source: Dr. Abdoukarimou S, 2024.

Figure 2. Zongo Dam.



Source: Dr. Abdoukarimou S, 2024.

Figure 3. Inlet Canal.

The irrigation system is gravity-fed. Rainwater is stored in the Mozagué dam during the rainy season. In September, it is released into the Zongo dam, where it is stored before being conveyed through a 15 km supply canal to the Tchérassa reservoir. The Konni hydro-agricultural development is supplied from this reservoir. Irrigation of the plots begins in November.

Within the development, the irrigation network consists of:

- 1 main canal (head end) at the outlet of the Tchérassa regulating reservoir;
- 4 trapezoidal reinforced concrete primary canals with a total length of 25,115 linear meters (m);
- 23 trapezoidal reinforced concrete secondary canals with a total length of 26,660 m;
- 159 trapezoidal reinforced concrete tertiary channels with a total length of 69,370 meters and 79 rectangular reinforced concrete tertiary channels with a total length of 113,000 meters;
- 1 drainage network consisting of: 40,000 meters of primary drains; 27,000 meters of secondary drains.

Figure 4 below illustrates the main infrastructure of the Konni hydro-agricultural development (dams and irrigated area).



Source: MCA, APD/EIES Studies, 2018.

Figure 4. Map of the hydro-agricultural development and irrigation infrastructure.

The Maggia watershed, which feeds the dams of the Konni hydro-agricultural development, covers an area of approximately 4138 km², of which 2119 km² are located in Niger and 2019 km² in Nigeria as shown in **Figure 5**. The Maggia is a semi-permanent river that originates about 100 km northeast of Konni in the plateaus of the Bouza department, then flows through the Madaoua department further south, and heads west into the Malbaza (rural communes of Doguéraoua and

Malbaza) and Konni (rural commune of Tsernaoua and urban commune of Konni) departments, where it disappears completely into marshy depressions, the main one being Lake Kalmalo in Nigeria. Its general direction is northeast-south-west.

The Maggia River's flow regime is of the tropical Sahelian type, characterized by intermittent flow from July to September, with the possibility of flooding in June or early October, and virtually no flow for the rest of the year. The construction of the Mozagué Dam and the Tchérassa reservoir has significantly reduced the duration of its flow in the Konni sub-basin.

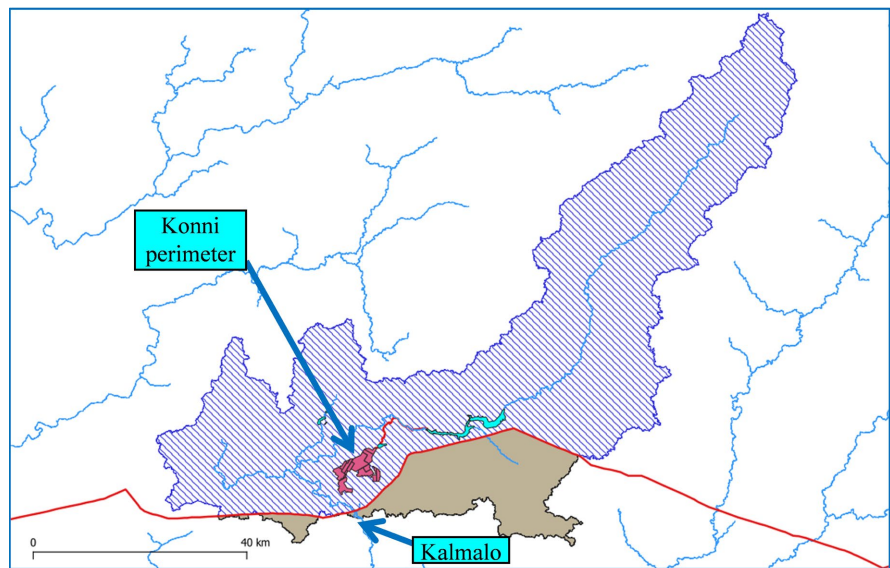


Figure 5. Overview of the Maggia watershed in Niger (CACG, 2021).

The study area, covering the municipalities of Konni and Tsernaoua, is located in the Maggia Valley. The approximately twenty villages included in the study are situated around the dams, along the supply canals, and around the irrigated perimeter. They extend over 35 km from Mozagué to the outskirts of Konni, in the direction of Niamey. Water is withdrawn from the dams by non-residential operators in three ways:

- ✓ Withdrawal from the two dams (Mozagué and Zongo);
- ✓ Withdrawal from the supply canal;
- ✓ And withdrawal from the aquifer, which is largely replenished by water infiltration from the Tchérassa reservoir.

In the study area, two irrigated production systems coexist: semi-intensive and intensive. The semi-intensive system, using traditional irrigation and/or recession agriculture, focuses on the cultivation of onions, cowpeas, peas, and maize. This system has long existed along the banks of the Maggia River and its tributaries. The more intensive system has been established in irrigated areas developed downstream from dams or, more recently, through the proliferation of surface wells and small, affordable motor pumps. In addition to the areas influenced by

the Mozagué Dam, the entire Maggia Valley is being cultivated as the water recedes; cowpeas, peas, and maize are sown there during the recession period. These three crops do not require irrigation; they complete their growing cycle thanks to the capillary action of the reservoir water. However, onion cultivation, the most important crop, followed by tomato cultivation, both grown on the same site, are irrigated.

Beyond the town of Konni and the villages cultivating the scheme, the hydro-agricultural infrastructure of the three-reservoir system (Mozagué, Zongo, and Tchérassa) has given rise to an ecosystem of flooded areas and recession-cultivated land; this fosters groundwater recharge and supports irrigation outside the scheme downstream of Tchérassa (**Figure 6**) using shallow wells. In the upstream area, the villages and their associated hamlets that cultivate the Mozagué lowland after the dam's waters have drained number 18, with a total population of 22,912 inhabitants.

Figure 6 and **Figure 7** show plots irrigated from the supply canal by irrigators located outside the formal irrigation scheme.



Figure 6. Irrigated crops outside the perimeter downstream of Tchérassa.



Figure 7. Recession crops in the Mozagué dam bed.

3. Data and Methods

To conduct this study, we opted for a participatory and inclusive approach. A par-

ticipatory approach is understood as a process that involves all stakeholders concerned by the subject. It is also based on data triangulation before validation.

Secondary data were collected from the Millennium Challenge Account Niger (MCA-Niger), projects funded by MCA-Niger (GDSI, SAA, Land), the General Directorate of ONAHA, the ONAHA office in Konni, and the decentralized technical services of the Konni department (agriculture, water resources, environment, community development).

Primary quantitative and qualitative data were collected through questionnaires and interview guides administered to individual stakeholders or through focus groups with people directly or indirectly involved in the management of the Konni AHA and water withdrawals from irrigation infrastructure. More specifically, the surveys were conducted with civil society actors, administrative (Prefect) and customary (Canton Chief) authorities, municipal authorities (mayors and deputies), decentralized technical services (Onaha, agriculture, hydraulics, rural engineering, environment, community development), and with operators from villages in the non-development zone.

The collected data were processed using SPSS software for analysis and graphical representation in Excel.

The surveys were conducted using several complementary methods:

The first method involved interviewing heads of households selected at random from eight villages, comprising either farmers working on the Konni hydro-agricultural scheme or producers operating outside the scheme. **Table 2** below presents the sampling results.

The second method involved organizing village-level meetings using focus groups comprising men, women, and young people. **Table 3** details the distribution of focus groups by village.

Table 2. Results of the sampling conducted as part of the study on water piracy.

Year	Village population in 2012		Parent population in 2024		Number of surveyed household heads (AUEI members)	Number of surveyed household heads (non-AUEI members)	Total sample per village
Villages	Number of inhabitants	Number of households	Number of inhabitants	Number of households			
Dagarka	1930	311	2758	444	20	30	50
Tchéraça Mangou	1945	314	2785	450	25	30	55
Tchéraça Gouné	3695	595	5291	852	40	45	85
Tamaka	2044	329	2920	470	22	26	46
Tounga	245	39	341	54	3	4	7
Guidan Godia	1806	291	2586	417	20	22	42
Kaoura	800	139	1148	199	9	11	20
Dibissou	5030	810	7202	1160	55	65	120

Table 3. Distribution of focus groups by village.

Villages	Focus group with operators who are AUEI members	Focus group with operators outside the development area	Total focus groups conducted
Dagarka	1 (FGH)	2 (FGH, FGF)	3
Tchérassa Mangou	2 (FGH, FGF)	2 (FGH, FGF)	4
Tchérassa Gouné	2 (FGF, FGJ)	2 (FGH, FGF)	4
Tamaka	-	2 (FGF, FGJ)	2
Tounga	-	1 (FGF)	1
Dibissou	1 (FGF)	1 (FGJ)	2
Total focus group	6	10	16

Note: FGH (men's focus group), FGF (women's focus group), FGJ (youth focus group).

To understand the various perceptions held by the operators, we organized three types of focus groups: men (adults), women (adults), and young people. A total of 16 focus groups were held in the villages: 6 with operators who were members of the AUEI and 13 with operators outside the scheme.

The third method involved individual interviews, using a specific interview guide for each stakeholder. **Table 4** below lists the stakeholders interviewed.

Table 4. Stakeholders surveyed.

Stakeholders	Interviewees
Administrative, municipal, and customary authorities	Mayor of Konni; Canton Chief of Konni; Village chiefs of Dibissou, Tounga, and Guidan Godia
Departmental technical services	Departmental Director of Agriculture; Departmental Director of Water Resources; Permanent Secretary of the Departmental Land Commission
Representatives of bodies directly involved in development management	President of the Konni AUEI (Water Users' Association); President of the Konni Cooperative; Head of the Konni ONAHA branch

In terms of the sample, out of the 11 villages and neighborhoods utilizing the Konni irrigation scheme, we selected the four largest villages: Tchérassa Gouné and Tchérassa Mangou, which have a large number of female farmers; Dibissou, where a large number of male farmers are located; and Dagarka, which has a sig-

nificant number of young male farmers.

Regarding the area outside the irrigation scheme, we targeted women, men, and young people from the village of Tchérassa Gouné who live alongside farmers benefiting from the AHA (Areas of Abundance for Water), from the villages of Tamaka and Toungan Gouga located along the intake canal west of Tsernaoua (the area of major water withdrawals from the canal), and from the villages of Guidan Godia and Kaoura, where there are also farmers cultivating plots outside the irrigation scheme. To estimate the cultivated areas using irrigation water from the dams, we conducted a comprehensive survey of users outside the designated irrigation perimeter who directly impact the operation of the AHA (Agricultural Housing Authority), from the upstream storage dams to the downstream end of the irrigated area. For plots located in the eastern and northern parts of the Konni perimeter, which primarily use groundwater, we analyzed a satellite image.

To assess agricultural profitability and the losses incurred by farmers and the AUEI (Agricultural Housing Authority) due to water theft, we evaluated the operating accounts of a few randomly selected farmers. The calculation of the AUEI's financial losses due to water theft was based on the water rights fee. This fee was calculated using the farmers' operating accounts, which provided the AUEI with an indication of the producers' ability to pay.

4. Results and Analysis

Within the Konni perimeter, the 0.75 ha plot unit is fully cultivated during the wet season (WS), but this is reduced by half during the dry season due to insufficient water, amounting to 0.375 ha per farmer. **Table 5** below shows the evolution of cultivated areas and development rates over the eleven years prior to the rehabilitation of the irrigation system.

Table 5. Evolution of cultivated areas during the wet and dry seasons over the eleven years prior to the rehabilitation of the irrigation system.

Années	SSH	Percentage SH	SSS	Percentage SS
2017	2270	92.58	208.59	8.51
2016	2145	87.48	567.12	23.13
2015	2065	84.22	600.57	24.49
2014	2294	93.56	602.69	24.58
2013	2233	91.07	194.3	7.92
2012	2017.01	82.26	524.02	21.37
2011	2245.4	91.57	450.75	18.38
2010	1982	80.83	488.7	19.93
2009	2170	88.5	320.78	13.08
2008	1803	73.53	437.87	17.86
2007	2156.7	87.96	442.4	18.04
Moyenne	2125.56	86.69	439.8	17.94

SSH: Wet season area; SSS: Dry season area.

It should be noted that the rehabilitation of irrigation infrastructure and equipment for the Konni AHA, which began in 2018, was completed in early 2022. Testing of the irrigation canals continued until the end of 2023. Production and irrigation activities using the rehabilitated facilities did not truly begin until 2024. During that year, 2,452 hectares—the entire perimeter—were cultivated during the rainy season, while 520 hectares were farmed during the dry season. The management of the irrigation infrastructure and equipment was handled by the AUEI.

Figure 8 illustrates the evolution of cultivated areas and the land utilization rate within the Konni scheme during the eleven years prior to rehabilitation (see also **Table 5**).

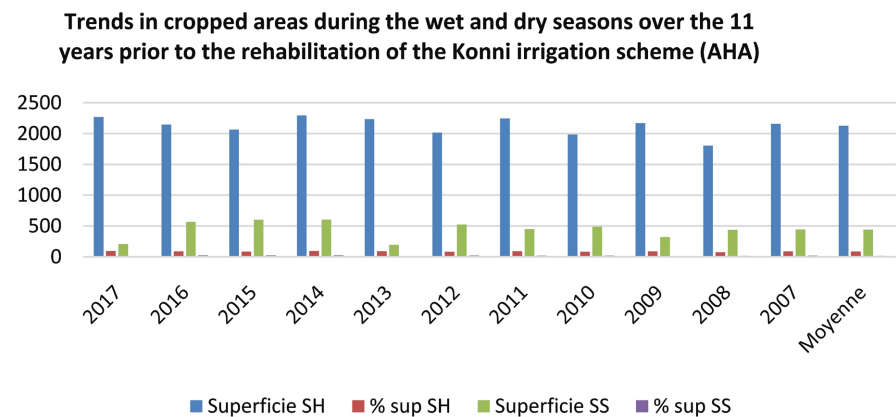


Figure 8. Evolution of cultivated areas and development rate in the Konni Perimeter.

Analysis of the table shows a general trend towards decreasing cultivated areas in both sub-sector (SS) and sub-sector (SH) areas. Similarly, cultivated areas are small in SS compared to sub-sector (SH) areas, where water is not a limiting factor. This area fluctuates around 500 hectares per year and has tended to decrease over the last five years. Cultivation rates are higher in SH areas, ranging between 80% and 90%, while they are very low in SS areas, ranging from 8% to a maximum of 25%. For a total net area of 2452 hectares in the Konni hydro-agricultural development, the average agricultural development rates are 87% in SH areas compared to 18% in SS areas. Water is the limiting factor for the development of the Konni project.

The retrospective study of the annual evolution of these areas up to 2017 carried out by the Studi firm showed that the area cultivated in the rainy season was invariably respected while that of the dry season was variable and recorded an average of 555 Ha with a peak in 1995 of 737 Ha, and this is a corollary of the lack of water availability but also of the pronounced degradation of irrigation infrastructure.

Table 6 below presents the cropping calendar followed by producers in Konni.

4.1. Relationship between Rainfall and Cultivated Area

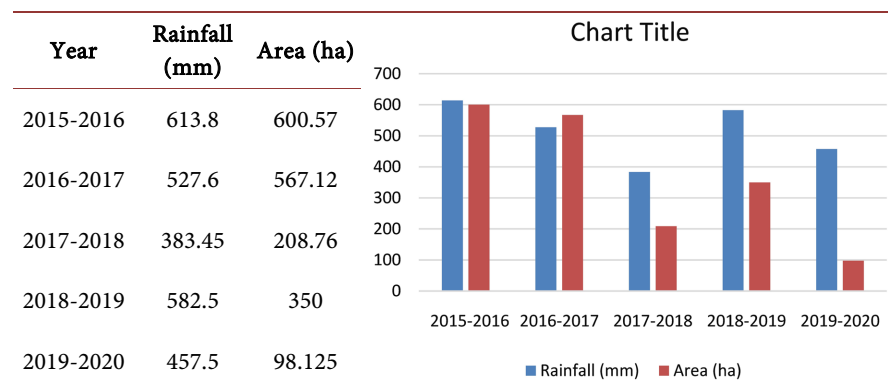
Field surveys have shown a clear correlation between the amount of rainfall recorded in the area each year and the cultivated area. As **Table 7** below shows, with a few exceptions, from 2015 to 2020, the more abundant the rainfall, the larger the

cultivated area within the Konni irrigation scheme. The year 2020 is the only exception, where the cultivated area decreased despite increased rainfall. This is explained by the closure of the irrigation scheme to agricultural activities due to perimeter rehabilitation work.

Table 6. Cropping calendar for the konni hydro-agricultural development area.

Agricultural campaigns	Start date	End Date	Main Crops	Irrigation
SSS	November 15	March 31	Corn, wheat, sorghum, anise, onion, tomato	Pre-irrigation of 10 days followed by irrigation of 3 days per week.
SSH	April 15	October 31	Millet, sorghum, cowpeas, peanuts	The elimination of supplementary irrigation was due to the abandonment of cotton cultivation, but also because of the scarcity of water resources.

Table 7. Relationship between rainfall and cultivated area during the dry season in the Konni development area from 2015 to 2020.



It should be noted that during the perimeter rehabilitation periods (2018–2022) and the irrigation canal testing phases (2022–2023), there was no correlation between cultivated area and rainfall—unlike in previous years. This is because farmers were prohibited from cultivating plots located in areas undergoing rehabilitation. Instead, they received financial compensation from the Project. Overall, all farmers within the Konni AHA were compensated for the non-cultivation of their plots during the rehabilitation period.

4.2. Economic Profitability of Agricultural Activities in the Konni Development Area

Based on the analysis of the operating accounts of several producers, it was possible to obtain data on the profitability of different crops during the dry and wet seasons. The total value of production and the costs associated with cultivating a 0.375 ha plot were assessed for different groups of producers across various crops during focus group interviews (**Table 8**).

Table 8. Production costs per crop for the dry and cool seasons.

Speculation	Total load (FCFA/ha)	Product/Recipe (FCFA/ha)
Oignon	762,500	1,500,000
Blé	427,500	600,000
Maïs	296,000	315,000
Tomate	845,000	2,000,000
Chou	803,000	900,000
Sorgho	287,500	305,000

FCFA: CFA francs; Ha: Hectare.

Onion and tomato crops are more profitable than dune crops. Approximately 2,000,000 CFA francs can be earned from one hectare cultivated with onions and/or tomatoes, with an investment of around 750,000 CFA francs for labor, inputs, treatments, a motor pump, and fuel for irrigation; this is simply not possible with a hectare of dune crops, regardless of the specific crop.

During the rainy season, the average profit margin calculated from a sample of farmers is approximately 100,000 to 120,000 CFA francs per 0.75-hectare plot (total sales + self-consumption – total production costs). This relatively low margin can be explained by several factors:

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

During the dry season, the average profit margin is much higher: from 400,000 to 500,000 FCFA per 0.75 ha plot. This is mainly due to:

- Cash crops that generate more revenue;
- Lower overall production but higher demand, driving up prices.

Thus, even though yields are generally very good, off-season crops generate higher gross margins than rainfed crops; hence the need for the rehabilitation and maintenance of the AHA's infrastructure and equipment to reclaim uncultivated plots.

Irrigation during the dry season is very profitable. It allows producers to benefit from substantial income in order to meet the needs for food, clothing, and all social expenses of the household.

Illegal Water Withdrawals from Dams and the Financial Consequences for the Konni Irrigation System (AUEI)

As a reminder, the two dams, Mozagué and Zongo, were built in the minor bed of the fossil valley of the Maggia River to supply the Konni hydro-agricultural development. Originally, water withdrawals from the dams were authorized for all uses except agriculture due to the significant quantities of water required for this activity.

To assess the quantities of water withdrawn that constitute losses for the Konni development, we used several sources:

- Surveys conducted along the intake canal based on direct observations;
- The use of results from work carried out by the CACG Consultant within the framework of the Sustainable Irrigation System Management (CACG) Project, funded by MCA Niger. The CACG used satellite imagery to estimate the areas irrigated from wells and boreholes located near the Tchérassa reservoir.

Water is drawn from the dams in several ways:

- Directly from the reservoirs for various uses (human and animal consumption, agriculture);
- From the water table. Water from the two dams seeps into the Tchérassa storage reservoir. Studies have shown that during the rehabilitation of the area where dam water is not released into the Tchérassa buffer reservoir, wells in the surrounding area dry up;
- Along the supply canal that crosses seven administrative villages in the municipality of Tsernaoua. The inhabitants of these villages draw water from the dams to irrigate their gardens and farms during the dry season.

The aim of the investigations into water theft from the Konni hydro-agricultural development is not to provide an exhaustive and highly precise estimate of the quantities of water withdrawn, but rather to assess, based on observations and other means including satellite imagery, the areas cultivated by farmers outside the development zone. All illegally withdrawn water obviously represents a loss of income for the farmers and the Konni Irrigation Water Users Association (AUEI). While farmers lose hundreds of hectares of land that could be cultivated, the AUEI suffers a significant loss of revenue from the water rights fees, which are the association's primary means of survival and the only means of maintaining and ensuring the long-term viability of irrigation equipment and infrastructure.

Based on work carried out by the CACG Consultant as part of the GDSI Project implementation, the areas irrigated by farmers outside the development using water from the two dams were estimated using satellite imagery.

As shown in **Figure 9**, the areas farmed by farmers located on the periphery and outside the Konni hydro-agricultural development were estimated at 860 hectares in 2020.

The 860 hectares are distributed as follows:

- 44 hectares irrigated by direct withdrawal from the intake canal;
- 760 hectares cultivated in the immediate vicinity of the development using groundwater;
- 56 hectares irrigated using a combination of groundwater and canal.

Regarding the 760-hectare estimate, it is difficult to separate the water that comes naturally from rainfall from the water that infiltrates from the Tchérassa storage reservoir. However, studies conducted by CACG have estimated, in a conservative scenario, that the Konni hydro-agricultural development loses an average of 200 hectares of usable farmland due to water theft. A more conservative scenario estimates the lost land for each dry season at over 300 hectares.

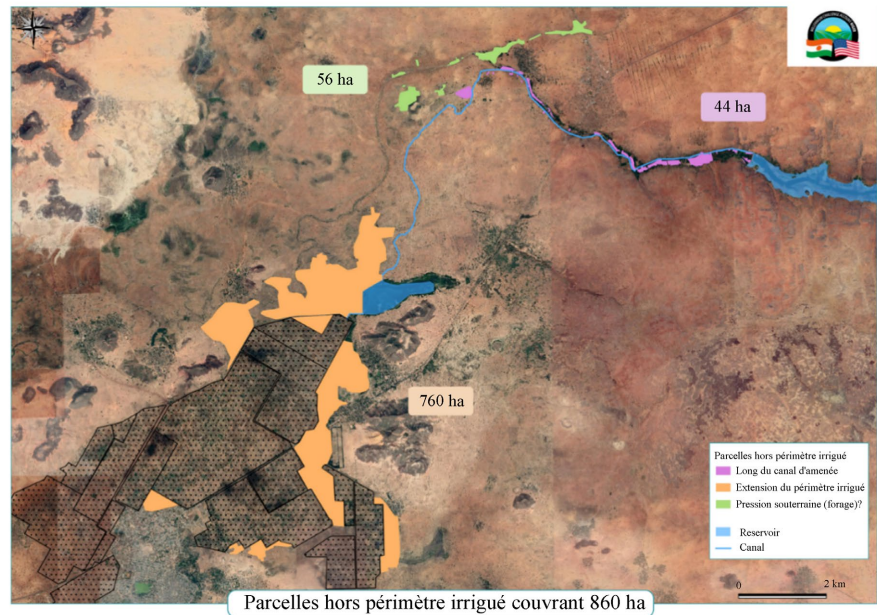


Figure 9. Areas estimated from the analysis of satellite images.

Direct water abstraction from the supply canal running through the seven villages of the Tsernaoua municipality allows farmers located outside the formal irrigation scheme to irrigate their crops during the dry season, as shown in **Figure 10** (see also the onion plots in **Figure 11**).



Figure 10. Irrigation of a plot from the supply canal by an operator outside the development scheme.

Figure 10 and **Figure 11**: Pumping of water from the canal by non-development operators.



Figure 11. Onion plot belonging to a farmer outside the irrigation scheme, using water from the supply canal.

The water rights collected by the AUEI are estimated at an average of 20,000 CFA francs per 0.75 hectares. Based on the low and high scenarios respectively, the net financial losses for the AUEI are 5,333,333 CFA francs for 200 hectares and 8,000,000 CFA francs for 300 hectares.

The resources generated from water rights were intended to finance the association's operations, organize water management, ensure the maintenance of infrastructure and the renewal of hydromechanical equipment, as well as the preservation of the agricultural heritage within the development area, in order to contribute to sustainable agricultural practices and the food security objectives of the association's members.

If solutions are not found in the short and medium term, the illegal upstream water withdrawals from the dams will constitute a bottleneck for the success of the Konni AUEI's operation.

The unauthorized abstraction of water from the Konni irrigation scheme has been discussed at various AUEI general assemblies, yet no definitive solution has been found (**Figure 12**: Holding of the association's ordinary general meeting).

4.3. Stakeholder Perceptions Regarding Water Withdrawal from Dams

This section addresses the opinions expressed by stakeholders regarding the issue of water theft from the irrigated area by farmers operating outside the designated areas.

4.3.1. Opinions of Administrative, Municipal, and Traditional Authorities

According to the various authorities, it is possible to minimize water withdrawal from the irrigated area by farmers operating outside the designated areas by providing them with wells, boreholes, and motor pumps. However, they believe that

these farmers will continue to withdraw water from the irrigated area's infrastructure because it is easily accessible. Nevertheless, the authorities believe that by implementing effective water policing, withdrawals can be stopped.



Figure 12. Holding of a General Meeting of the Konni AUEI, September 12, 2024.

Some believe that this withdrawal should be stopped by establishing water monitoring committees for the irrigated area. Others believe that since borehole water is better for crops, drilling boreholes with PVC piping would significantly reduce water withdrawals.

Most authorities see Integrated Water Resources Management (IWRM) as an opportunity to unite the efforts of different users, strengthen community cohesion, and mobilize more financial resources for the benefit of the two (2) municipalities concerned (now led by newly elected mayors). They support the establishment of a consultation framework on this matter and are committed to contributing to its success by supporting the mobilization of technical services and communities through awareness campaigns to encourage their participation in the process.

4.3.2. Opinions of Departmental Technical Services [5]

According to the majority of departmental technical service managers interviewed, water withdrawals outside the Konni Watershed Area (AHA) perimeter can only be minimized through agreements and negotiations between the various users and by drilling boreholes for the benefit of those operating outside the perimeter. Some believe that withdrawals outside the perimeter could even be eliminated by drilling two deep boreholes to pump water directly into the canals, or by drilling deep boreholes and canals for those operating outside the perimeter [5].

4.3.3. Opinions of Representatives and Managers of Structures Directly Involved in the Management and Supervision of the AHA

Some officials believe that water withdrawals from the AHA (Aqueduct of the Aq-

ueduct of the Aqueduct) by outside operators can be reduced by providing them with wells and boreholes. However, the ultimate solution remains the construction of a control road along the canal and the deployment of water monitoring agents. For some, the enthusiasm of outside users for AHA water remains very strong despite the extreme penalties (confiscation of water pumps and detention). To resolve this problem, it is necessary to increase outreach, organize meetings with them, and gradually identify, organize, and equip them with appropriate infrastructure. For others, the withdrawals will never stop. The solution is to allow them access to water within the designated area by paying fees. For some, the implementation of an integrated water resources management framework is a good opportunity to settle once and for all the controversy surrounding the use of water intended for the AHA, to achieve consensual management of water in the sub-watershed by users and to have a framework for consultation and communication between users.

4.3.4. Opinions of Farmers Operating outside the Designated Area

The opinions of farmers operating outside the designated area were gathered through focus groups with women, men, and young people. Following these discussions, some women indicated that water withdrawals outside the designated area could be minimized by providing them with equipped wells and/or boreholes, but that at certain times of the year, they would still use water from the AHA (Area of Water and Sanitation), which would remain much more accessible than well water. Others, however, believe that water belongs to everyone and they do not understand why they should not have the same right to use it as the farmers operating within the AHA. For the latter, the land through which the water from the development flows belongs to their ancestors. It is therefore unacceptable that they be prohibited from using this natural resource for agricultural purposes [5].

For farmers operating outside the designated area, these withdrawals can be minimized if they have wells and/or boreholes, or even eliminated if they have similar infrastructure to that of farmers within the designated area. For others, diversions must be planned, subject to payment of fees, for plots located along the supply canal.

As for young people, water withdrawals are due to insufficient and difficult access to well water during certain periods of the year. They believe these withdrawals can be reduced by providing them with boreholes shared by groups of three farmers or one well per farmer. They can also be eliminated by drilling deep boreholes or creating ponds [5].

4.3.5. Opinions of AHA Operators

Just as with operators outside the designated area, the opinions of operators within the irrigated area were gathered through focus groups with women, men, and young people.

The women operators believe that water withdrawals can be minimized by drilling boreholes for the benefit of operators outside the designated area.

For the AHA operators, if drastic measures are not taken by the authorities against those withdrawing water outside the designated area, the Konni AHA will one day disappear. The Konni Water Users' Association (AUEI) will never be able to fulfill its mission of sustainable water and irrigation infrastructure management. As for the young people, they believe that these withdrawals can be reduced by providing boreholes to operators outside the designated area.

To summarize the stakeholders' perceptions regarding water piracy, the following opinions emerged:

- ✓ The majority of those interviewed believe that drilling boreholes or wells will stop illegal water extraction;
- ✓ Some authorities believe that the phenomenon can only be eradicated through the establishment of a highly effective water police force;
- ✓ Some believe that even drilling boreholes and wells will continue to divert water from the Konni development because the supply canal is not sealed and is therefore easily accessible.

5. Discussion

In their [6], book entitled "Informal Irrigation in West Africa: A Solution or a Problem?", Jean Payen and Virginie Gillet address the issue of informal water management for agricultural purposes. According to these authors, in West Africa, only a very small number of farmers have actually benefited from state-funded irrigation reforms, while many others have resorted to parallel initiatives—often grouped under the term "informal" irrigation. Lacking proper guidance, this spontaneous phenomenon, whose extent is poorly understood but which appears to be accelerating, risks undermining the growing awareness of the need for "integrated" water resource [7] management, thereby weakening the agricultural sector—by far the largest consumer of this resource. This reflection aligns with analyses of the water management situation in the Konni irrigation scheme.

The findings of this study on the illegal extraction of irrigation water by some non-compliant operators could jeopardize this major reform undertaken by the State. Indeed, the successful operationalization of the Konni Irrigation Water Users Association (AUEI) hinges on resolving the issue of illegal water withdrawal upstream of the service area. Despite the significant sums invested under the Niger Compact Program, the lack of effective water management remains a major obstacle to the success of the AUEI's interventions.

The illegal extraction of water from dams by unauthorized operators is the primary cause of the reduced capacity to reach the development's service area, and if no management measures are taken, this could lead to premature degradation of the irrigation infrastructure. These findings are confirmed ([8], p. 2) through a forecast, based on the linear extrapolation of sediment inputs, which shows that the accelerated rate of siltation of the Ouled Mellouk dam and the reduction of its capacity could damage the development process if measures are not taken. This also corroborates the analyzes conducted in 2010 by [9], who concluded, after

studying the Galmi irrigation scheme in Niger, that due to a lack of enforcement of regulations, anarchy reigns, with a non-functional Water Users Association office ([8], p. 2).

The study showed that onion and tomato crops contribute very effectively to increasing farmers' incomes, surpassing dune crops. These results also align with those gathered from populations in Benin, where ([10], p. 13); [11] (p. 174) state that in a cultivated field, one can find the following intercropping systems: maize and tomatoes, among others. That is to say, one or the other of the chosen crops has the potential to survive in the event of delayed or interrupted rainfall, or excessive rainfall ([10], p. 13; [11], p. 174).

For the past five years, development partners have been funding the Konni AHA (Agricultural Housing Area) through rehabilitation work and capacity building for producers. This funding was designed to ensure good agricultural production through complete water management. The current state of the Konni development does not allow farmers to capitalize on their achievements, as no succession plan is in place. This aligns with the research findings of FAO [2] who believe that organizations working in their respective areas must consider the realities of these areas to avoid failing to deliver successful activities from the outset.

Finally, as indicated in the Food Sovereignty Summary Bulletin, issue 22, November 2016 [12], the increasing water needs for various uses and climate change are expected to exacerbate tensions among producers. Under these conditions, improved governance of water resources and local regulations will be essential. This perspective is well-suited to the realities of hydro-agricultural development in Konni [12].

6. Conclusions

The Konni irrigation scheme comprises two perimeters, developed in 1979 and 1982 respectively. They are irrigated using water from the Mozagué and Zongo dams, which are conveyed through a 15 km long supply canal. The water is stored in the Tchérassa buffer reservoir before being distributed to the canals (primary, secondary, and tertiary) and the plots within the scheme. Before reaching the Konni service area, the water flows through the farms of seven administrative villages. The inhabitants of these villages pump water from the dams for various uses, the most significant of which is agriculture, despite this being prohibited.

As part of the reform of the management of facilities, an association of irrigation water users whose main mission is to sustainably manage and maintain the water and irrigation infrastructure of the Konni AHA was created on March 14, 2020. To access irrigation water, the members of this association pay a water fee which is used for the operation of the association and the maintenance of the irrigation infrastructure.

Water piracy from dams poses a significant challenge to the operationalization of this fledgling association. The consequences of illegal water use are substantial for the Konni Water Users' Association (WUA). Even under the baseline scenario,

financial losses for the WUA are estimated at over 5,000,000 CFA francs per year for an area of 200 hectares.

The Millennium Challenge Corporation has invested over 30 billion CFA francs to rehabilitate irrigation infrastructure and equipment, strengthen the cooperative's capacity, and support the establishment, training, and equipping of the WUA.

If sustainable solutions to this water piracy problem are not found, the investments made by the Niger Compact Program will not be sustainable. Opinions and perceptions among stakeholders regarding the resolution of this problem remain divergent and are not unanimous. However, it is urgent that the administrative and traditional authorities of the Konni and Tsernaoua communes find a lasting solution to this long-standing problem. The State of Niger must take responsibility by ensuring that the Konni Water Users' Association (AUEI) has sufficient water to irrigate the area, not only by preserving the quantities supplied by existing irrigation infrastructure but also by drilling deep boreholes to permanently address the water scarcity constraint in the area.

Author Contributions

Saidou Abdoukarimou—S.A., Illou Mahamadou—I.M., and Saley Makama Mahaman Sani—S.M.M.S.: Conceptualization, S.A.; methodology, S.A.; software, S.A. and S.M.M.S.; validation, S.A., I.M., and S.M.M.S.; formal analysis, S.A. and S.M.M.S.; investigation, S.A., I.M., and S.M.M.S.; resources, S.A., I.M., and S.M.M.S.; data curation, S.A. and S.M.M.S.; writing—original draft preparation, S.A. and S.M.M.S.; writing—review and editing, S.A., I.M., and S.M.M.S.; visualization, S.A. and S.M.M.S.; supervision, S.A. and I.M.; project administration, S.A.; funding acquisition, S.A., I.M., and S.M.M.S. All authors have read and approved the published version of the manuscript.

Conflicts of Interest

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

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