INTERNATIONAL SOLAR ALLIANCE

République du Niger

MINISTÈRE DE L'ÉNERGIE

Study on the development potential of solar irrigation in the Maradi region - Niger

Final report

PRACTICA

September 2024

TABLE OF CONTENTS

List of figures

ACRONYMS AND ABBREVIATIONS

BAGRI: Niger Agricultural Bank (Banque agricole du Niger)

CH : Continental Hamadien

CRA: Regional Chamber of Agriculture (Chambre d'agriculture Régionale)

EPTIN: Evaluation of the irrigable land potential in Niger (Evaluation du Potentiel des Terres Irrigables au Niger)

FISAN: Investment Fund for Food and Nutritional Security (Fonds d'Investissement pour la Sécurité Alimentaire et Nutritionnelle)

MFI: Micro finance institution

Nigelec: Niger Electricity Company (Société nigérienne d'électricité)

ONAHA: National Office for Hydro-Agricultural Development (Office national des Aménagement Hydro agricoles)

OP: Producer Organisation (Organisation de producteurs)

PARIIS: Regional Support Project for the Sahel Irrigation Initiative (Projet d'Appui Régional à l'Initiative pour l'Irrigation au Sahel)

PASEC: Support project for climate-sensitive agriculture (Projet d'Appui à l'agriculture SEnsible aux risques Climatiques)

PUSADER: Emergency project to support food security and rural development (Projet d'Urgence pour l'Appui à la Sécurité Alimentaire et le DÉveloppement Rural)

RUWAMU: Small-scale irrigation project (Projet De Petite Irrigation Ruwanmu)

SPIN: Strategy for Small-Scale Irrigation in Niger (Stratégie de la Petite Irrigation du Niger)

TDH: Total Dynamic Head

EXECUTIVE SUMMARY

This report presents Practica's study of the Djirataoua I irrigation scheme to assess the relevance and feasibility of implementing solar-powered irrigation.

The Maradi region is densely populated (5.25 million inhabitants) and predominantly rural (85%), and is considered the economic capital of Niger. The region is an important agricultural zone, particularly for food production during the winter months, but in recent years it has suffered a rainfall deficit of around 200 mm per year, due to climate change. The region nevertheless has irrigable land in the Maradi and N'Kaba goulbi, notably in the commune of Djirataoua (7,552ha). However, this potential is threatened by a decline in the water table.

The report presents the characteristics of the available solar energy, with average radiation reaching 7.1 kWh/m2/day when irrigation water requirements are at their highest in April, making the Maradi region particularly favourable for the use of solar-powered irrigation.

The Djirataoua I scheme covers a net developed area of 791 ha, 144 ha of which is non-functional, subdivided into several plots and managed by 7 cooperatives (4,433 farmers) divided into 65 producer groups:

- Djirataoua Nord with 7 producer groups totaling 90 ha
- Djirataoua Sud with 12 groups totaling 155 ha
- Radi Aderaoua with 9 groups totaling 120 ha
- Kodéraoua Maradou with 13 groups totaling 141 ha, and a non-functional extension with 6 GMPs covering 69ha
- CPR Djirataoua with 9 groups totaling 106 ha
- Bakawa with 3 groups totaling 31 ha
- Kegel with 6 groupss totaling 75 ha, non-functional.

Each producer group manages a perimeter with an irrigation infrastructure that consists of a borehole, a submersible pump powered by the electricity grid (Nigelec), open reinforced concrete canals and/or a Californian PVC network.

Focus group disucssions with the cooperatives and ONAHA, as well as the use of existing documentation, showed that the area under development has decreased (580.5 ha), mainly due to i) the reduction in flow rates from certain boreholes, which are no longer able to cover water requirements, ii) hydraulic infrastructures (pumps, distribution networks) in poor condition, with significant water losses, considerably reducing irrigation efficiency. Under these conditions, longer pumping times are needed to cover losses, resulting in very high water production costs (electricity bills and pump maintenance) borne by farmers.

In order to maintain the production potential and reduce farmers' costs, Practica recommends in this report that old pumps be replaced by hybrid electric pumps powered by solar panels (7 hours a day), and by the electricity grid outside sunshine hours.

This proposal initially concerns the 44 operational boreholes that are able to irrigate the developed areas (498ha). The characteristics and sizing of the equipment for each cooperative are presented, together with the budget for its purchase and installation. The cost of switching to solar energy would be about USD 2,853,000.

The business plan presented in the report covers equipment depreciation, the typical crop rotation encountered on the AHA, and operating expenses and income by production season. The annual

financial gain for the farms (average area 0.16ha) with the switch to solar energy is $43, and the annual income is estimated at $706.

In the case of faulty perimeters (11 boreholes with insufficient water) or non-functional perimeters (12 boreholes), the first step will be to carry out pumping tests on the boreholes to determine the actual capacity of the water resource. The characteristics of the boreholes should be used to size the pumps and determine the irrigable surface areas.

The study also shows the length of canals and PVC pipes used to transport water, and provides an estimate for the rehabilitation of the distribution network. This rehabilitation would make irrigation more efficient and thus reduce water production costs, but a more detailed study is needed for its sizing and budgeting.

The study notes that Niger has embarked on a vast program to develop large-scale irrigation and small-scale irrigation through public policies (Initiative 3N, SPIN...) implemented by the ministries and numerous development projects that also rely on solar energy. The private sector is dynamic in this field, with financial institutions involved, solar equipment suppliers and installers, and skills that can be mobilized for equipment maintenance and repair (ONAHA, pump and distribution network repairers).

The report highlights both the strong points and points of attention for the implementation of solar irrigation in the Djirataoua I AHA, along with a roadmap of actions to be carried out. It is recommended that an Environmental and Social Impact Assessment (ESIA) is carried out prior to implementing the roadmap, in order to assess the effects of irrigation on the water table and to prevent potential conflicts with the usage of drinking water.

1. INTRODUCTION

The International Solar Alliance (ISA) has commissioned Practica to carry out a study on solar powered irrigation in the Maradi region of Niger.

The objectives of the study are as follows:

- Carry out an assessment of 6 irrigated perimeters identified by ISA, and the non-functional Keguel perimeter. Propose a functional irrigation solution for each site and draw up a business case for each solution.
- In the Maradi region, develop an overall inventory of the solar irrigation sector: identify the available resources, the involved stakeholders, the opportunities and constraints, etc.

The expected outcome of the study is a feasibility report on solar irrigation in the Maradi region.

The methodology used by Practica includes a field mission to collect data on the six identified irrigation perimeters (IP), as well as that of Keguel, which together make up the Djirataoua I irrigation scheme. Interviews were conducted with different stakeholders in the irrigation ecosystem:

- Representatives of producer cooperatives from the 7 sites
- ONAHA officials managing the Djirataoua I irrigation scheme
- The Departments of Agriculture and Rural Engineering, and Hydraulics in the Maradi region
- Agricultural equipment suppliers in Maradi and Niamey.

The mission took place from 27 May to 03 June 2024 and was led by:

- Mr Ali Hamadou, an irrigation expert who has been working with Practica for over 25 years
- Mr Abdou Zakari, ISA focal point at Niger's Ministry of Energy in Niamey
- Ms Djahara Hassaye, Regional Energy Director for Maradi
- Mr Saadou Salifou, Regional Director of Rural Engineering in Maradi
- Ms Hama Hadjara, perimeter manager at ONAHA.

This field mission, which was very short for a study of an irrigation scheme as vast as Djirataoua I, was supplemented by a literature review. The main documents used are presented in Appendix 7.

All the stakeholders we met (appendix 1) were very forthcoming and collaborative. However, due to the frequent replacement of ONAHA technical staff, a great deal of data was unavailable, including the development plan, data on current flow rates from boreholes, and specifications of submersible pumps.

The focus group discussions with the agricultural cooperatives were very valuable, and demonstrated the capacity of the cooperative representatives in terms of their knowledge of the facilities, the existing problems and the cultivation practices of the farmers. Nevertheless, the collected data was based on oral accounts and not on any registered data, hence we were unable to validate its reliability.

Our study focused on the technical aspects of the facilities, and more specifically on the pumping systems. A number of subjects need to be looked at in greater depth:

- The condition and lengths of the irrigation canals and, more generally, the water distribution system, in order to determine what rehabilitation work needs to be carried out.
- the socio-organisational aspects were not addressed and must be taken into account before any decision is taken to rehabilitate or extend the irrigated perimeter, especially for the Keguel perimeter where there was a land dispute.

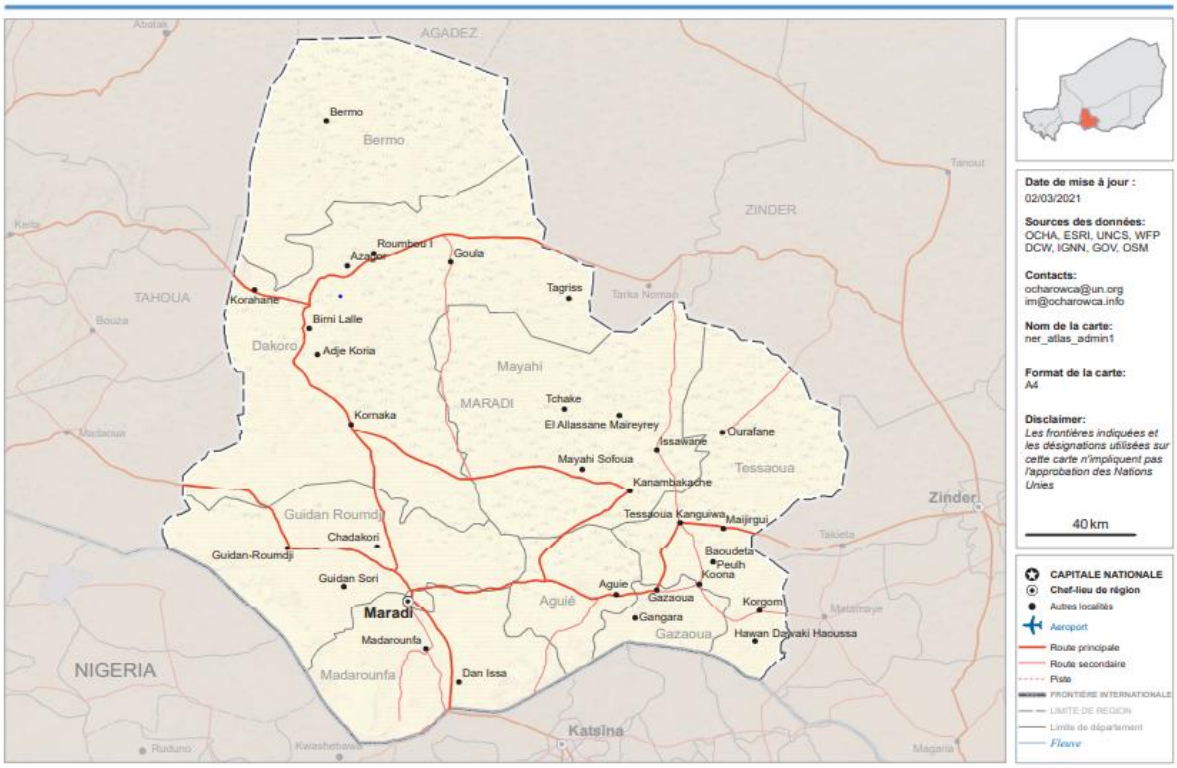
2. GENERAL INFORMATION ON THE MARADI REGION

Covering an area of 41,796 km^2, the Maradi region is located in south-central Niger, around 700 km east of the capital Niamey. It is bordered to the east by the Zinder region, to the west by the Tahoua region, to the north by the Agadez region and to the south by Nigeria.

The population of the Maradi region is estimated at 5.25 million, 50.8% of whom are women (INS Niger 2024). It has a population density of 126 inhabitants/km2, compared with 13.5 inhabitants/km2 for the country as a whole. The majority of the population live in rural areas (85%). The population of the Maradi region is particularly young (49% under the age of 15) and is growing at a high rate (3.9%).

The Maradi region is considered to be the economic capital of Niger thanks to its commercial dynamics. After agriculture and livestock breeding, trade is the main activity of the region's population. Informal trade is predominant, playing a transversal role in all economic activities. Over 74% of the population is involved in trade and business.

Figure 1: Administrative map of the Maradi region



Agricultural land covers 72% of the territory (27,600 km²), pastoral land 25% (9,600 km²) and forest land 3%.

The Maradi region has a number of assets, including the dynamic economic operators, the potential of available land and irrigable area (480,998 ha, EPTIN, 2019, the existence of major commercial activity with its proximity to Nigeria, and the human resource capacity inherited from the various programmes and projects carried out in the region.

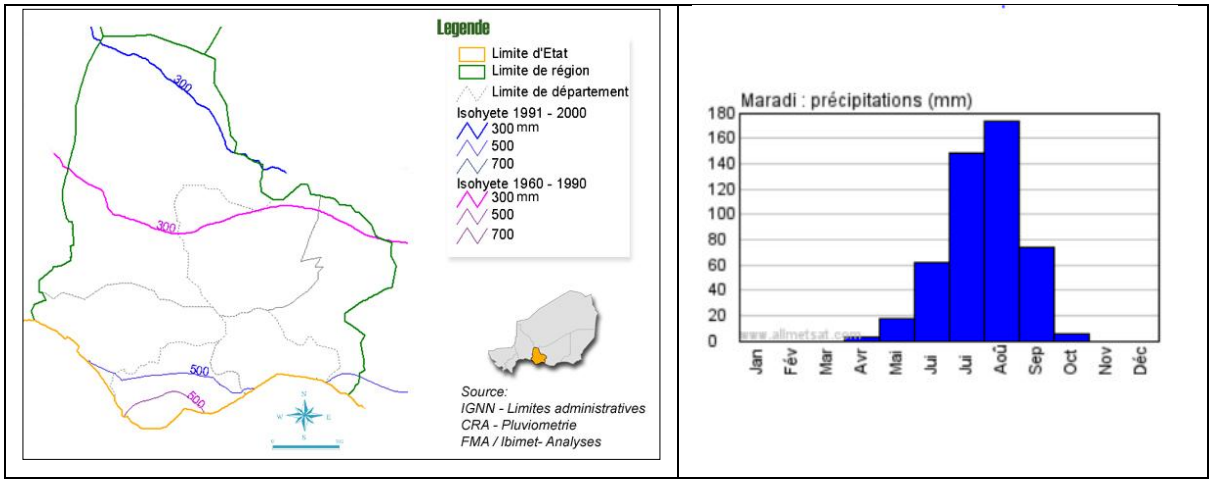
The main constraints of the region are the irregularity and poor distribution of rainfall in time and space, strong land pressure, insufficient use of irrigable land (35%), competition and juxtaposition of livestock farming with agricultural activities as there is a source of conflict between farmers and livestock farmers, the accelerated silting up of water bodies and particularly Lake Madarounfa, rapid population growth resulting in additional food requirements, and environmental degradation.

The Maradi region has a semi-arid Sahelian climate. It is characterised by three distinct seasons:

- a dry, cold season from November to February, with average lows generally below 15°C
- a hot dry season from March to May, with high temperatures between April and May of up to 40°C and the effects of the harmattan dry continental tropical winds
- a rainy season from June to October. Rainfall is generally short-lived and very intense.

The Maradi region shows a north-south rainfall gradient: the Madarounfa and Maradi stations have an average of **around 513 mm/year**, while Mayahi has an average of 400 mm and Dakoro 300 mm. Rainfall increases from north to south, but over the last three decades the region has experienced a rainfall deficit of around 200 mm. In the southern part, annual rainfall rarely exceeds 700 mm.

Figure 2: Map of isohyets in the Maradi region



Source: Niger water resources master plan, and annual rainfall distribution (Maradi aerodrome)

Average solar radiation is 6.5 kWh/m^2 /day. It is **7.1 kWh/m2/day** when the need for irrigation water is highest (April), with evapotranspiration reaching 7.6 mm.

	Jan	Feb	Mar	**Apr**	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Avg
Rainfall (mm)	0	0	0	4	20	66	154	184	77	8	0	0	513
Radiation (kWh/m2/d)	6,4	7,1	7,3	**7,1**	6,6	6,3	5,8	5,6	6,1	6,5	6,7	6,2	6,5
Evapotranspiration (mm)	5,7	6,7	7,3	**7,6**	7,5	6,6	5,5	4,8	5,3	5,7	5,9	5,6	6,2

Sources: Aquastat climate information tool

3. AGRICULTURAL ACTIVITIES

Agriculture is the main activity in the Maradi Region, employing over 95% of the rural population. Around **85% of the region's total population** depends on this activity.

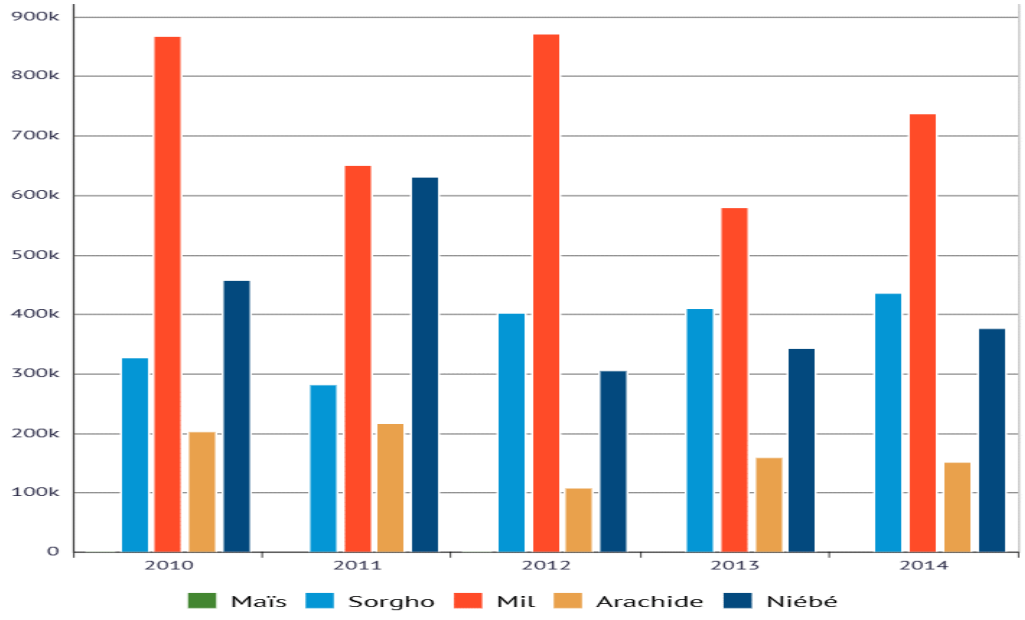
Arable land resources are estimated at 2,476,680 hectares. Fallow land has almost disappeared from the production systems, especially in the south where the land occupation rate exceeds 80%.

Livestock farming is the second most important economic activity in the region. It is practised by over 90% of the population and provides them with a substantial income. Both men and women are involved in this activity. It is a means of combating poverty, a form of savings and also contributes to the financial empowerment of women.

According to the INS Niger figures for 2020 ('le Niger en chiffres', 2020), Niger's livestock population is estimated at around 52,700,000 head, 16% of which comes from Maradi. Livestock consists mainly of cattle, sheep, goats, camels, donkeys, horses and poultry, in particular the Maradi red goat and the Balami breed of sheep, which are highly prized for their productive qualities.

The Maradi region is an important agricultural area, particularly for the production of cereals (millet, sorghum), groundnuts and cowpeas. The region produces around a quarter of the country's cereal output. It is the leading producer of millet (22.7% of national production), cowpeas (37.5% of national production) and souchet (60% of national production). It ranks second for sorghum and cowpea production. Maradi is also known for its sesame and vegetable production.

Figure 3. Annual production of the main food crops (INS Niger 2014)

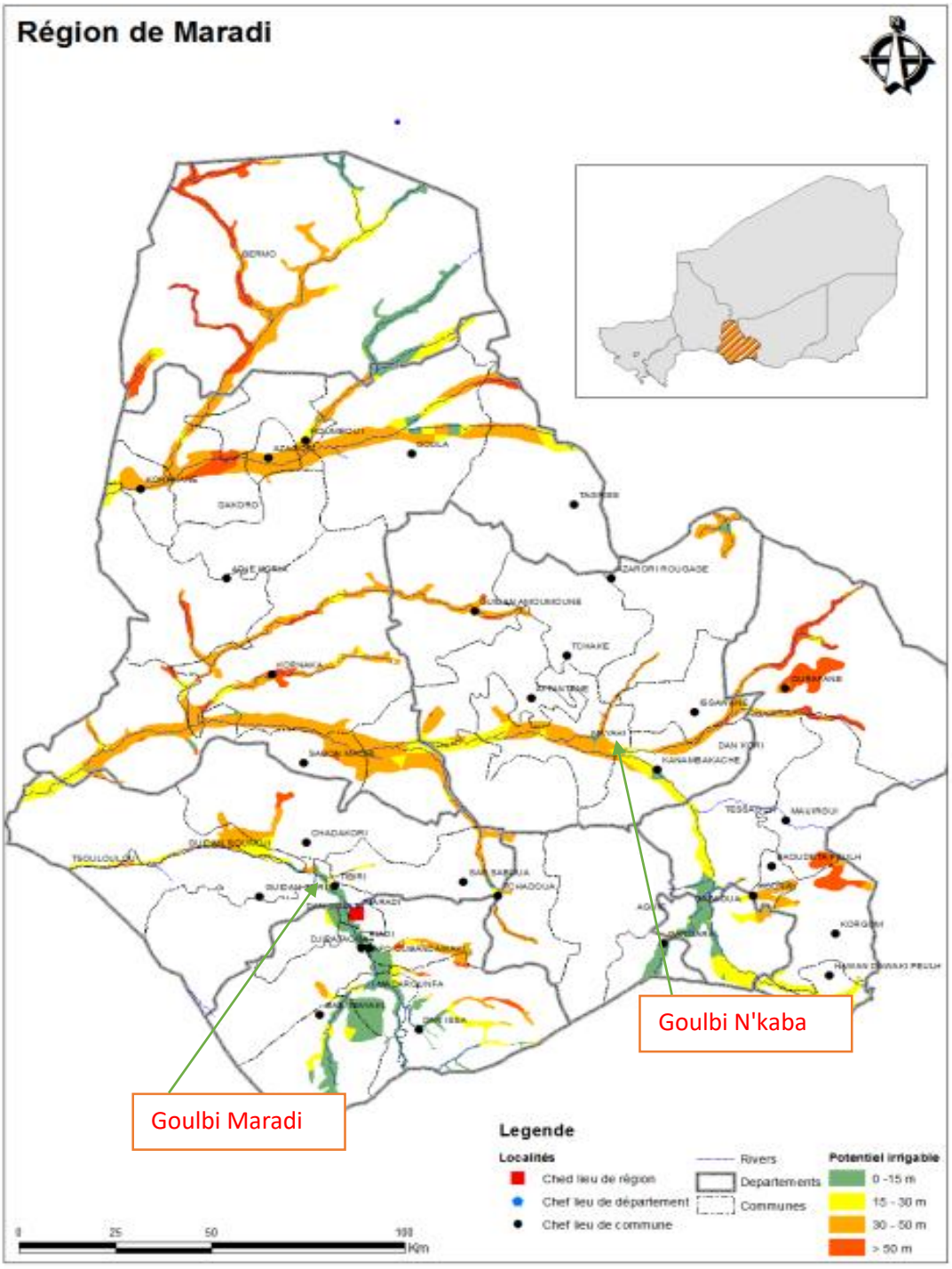


4. IRRIGATED AGRICULTURE

The agro-climatic zones that are favourable to the development of irrigated agriculture are the Maradi and N'Kaba goulbi valleys.

The goulbis are generally shallow valleys, 2 to 5 kilometres wide, surrounded by plains. The terrain is relatively flat, and crops are often flooded during the winter months. As a result, they form long alluvial floodplains.

Figure 4: Map of irrigable potential in the Maradi region



The Maradi goulbi, which is the most developed one, forms a 150-kilometre loop from Tsouloulou to the south of Madarounfa. It is an area of diverse agricultural activities. The valley is famous for its irrigated cereals, horticulture, tobacco, moringa and fruit trees. The Maradi goulbi feeds Lake Madarounfa, the largest body of water (800 ha) in the region.

The Maradi goulbi is the main river in the region. It has its source in Nigeria and joins the Rima river in Nigeria, which is a tributary of the Niger river. The construction of upstream dams in Nigeria has led to **a significant reduction in flow**, which is becoming increasingly unpredictable. Since 1988, there has been no flooding, while this used to be described as an annual event in the area around the town of Maradi.

The N'Kaba gully crosses the region from east to west over a length of 170 km, with a width varying between 200 m and 5 km. The trend is towards fossilisation on the Niger side, with virtually no run-off. The Goulbi N'Kaba is a huge agroforestry park planted with doum palm (Hyphaenethebaica) covering 31,500 ha, mainly in the Mayahi department.

Goulbi soils are hydromorphic soils characterised by temporary (pseudo-Gley) or permanent (Gley) waterlogging of all or part of the soil. The soil structures are of the clay-loam type.

According to the evaluation report of Niger's irrigable land potential carried out by the Direction Générale du Génie Rural in December 2014, the irrigable land potential of the Maradi goulbi as an agroecological zone was estimated at 81,418ha, and that of the N'Kaba goulbi was estimated at 137,896ha. In particular, the irrigable land potential in the commune of **Djirataoua is estimated at 7,552ha.**

The two goulbis account for a total of **19,350 ha of small-scale irrigated areas**, and around 1,000 ha of irrigated areas with total water control in the Maradi goulbi valley: these are irrigation schemes managed by ONAHA, which includes the sites covered by this study.

Figure 5: Distribution of irrigable potential by administrative level and depth of water table (Madarounfa district)

	0 - 15 m	15 - 30 m	30 - 50 m	> 50 m	Grand Total
MADAROUNFA	**38 364**	**9 421**	**6 765**	**2 306**	**56 856**
DAN ISSA	4 794	3 879	2 736	1 788	13 197
DJIRATAOUA	3 087	851	3 096	518	7 552
GABI	12 454	2 837			15 291
MADAROUNFA	11 547	1 081			12 628
MARADI	1 763				1 763
SAFO	3 346	346	933		4 625
SERKIN YAMMA	1 373	427			1 800

Water resources

The crystalline basement, made up of granite, gneiss and shale, occupies a narrow strip of 10 to 15 km wide along the Nigerian border; it goes down northwards at a gradient of around 1% under an overburden of fine to coarse sandstones, mottled with kaolin cement, corresponding to the CH (Farak sandstone facies).

The basement formations contain a fissured water table flowing northwards with a strong gradient. Water levels are close to the surface.

The CH contains a hydraulic system that can be likened to a continuous water table flowing north-westwards along the course of the Goulbi, with an average gradient of 1/1000. At the level of the dry wedge, the sterile sandstone overburden can be up to 40 m thick. The depth of the water level under the plateaux can exceed 50 m.

The ancient and recent alluvial deposits of the Goulbi Maradi and its left bank tributary, the Goulbi N'Gabi, contain a water table belonging to the same aquifer system as the CH. This is the aquifer exploited by the Djirataoua irrigation scheme. The water table contained in the recent alluvium is the one with the best characteristics, and is continuous with that of the CH sandstones that border the Goulbi. There are permanent exchanges between the two aquifers. The alluvium can be up to 30 m thick. The most productive sandy-gravelly level is 10 m thick or more in the upstream sector (Djibia - Madarounfa) and around 5 m thick in the downstream sector (Djirataoua - Tibiri).

Figure 6. Characteristics of sedimentary aquifers in the Maradi region

Aquifer	Location	Type	Static water level (m)	Drilling depth (m)	Flow rate (m3/h)	Water quality	Renewal rate	Sensitivity
Alluvial deposits	Goulbis Valleys	Clayey sands, gravels (max. thickness = 40 m)	1-10	30 - 50	Up to 150	good	high	Pollution and climate: very high

5. DJIRATAOUA I IRRIGATION SCHEME DEVELOPMENT

History and description of the scheme

Situated along the right bank of the Maradi goulbi, some ten kilometres south of Maradi, the Djirataoua I irrigation scheme is located in the commune of Djirataoua, Madarounfa department (N= 13°22'49.2'', E= 007°09'05.7'').

The irrigation scheme was established in 1982 by the Maradi rural development project funded by the World Bank. In 2005, it was partially rehabilitated by the Projet de Réhabilitation de l'Aménagement Hydro-Agricole de Djirataoua et de Protection du Lac de Madarounfa, then extended in 2008 by the Projet Spécial Présidentiel (under the Initiative in support of Heavily Indebted Poor Countries - HIPC). Its main objective is to improve the living conditions of farmers by increasing productivity while maintaining the natural potential (water, soil) through its preservation and restoration (ANID, 2010).

At the start of its operation, cotton was the predominant crop, with the KANYACI cotton company buying the cotton produced in the perimeter. Later, wheat production was developed with the "Moulin du Sahel" company. The irrigation perimeter cooperative collected the produce and deducted the water charges from the harvest value.

In 1999, the Moulin du Sahel closed and producers lost their buyer, which led to the gradual abandonment of wheat production in favour of moringa, and "Yajin yawo°" anice, which is a horticultural cash crop (ONAHA Maradi Regional Office).

The Djirataoua I perimeter covers **a net developed area of 791 ha, 144 ha of which is non-functional**, divided into plots of very different sizes ranging from 0.04 to 0.64 ha, while **the most common plots are 0.16 ha**. The perimeter is subdivided into multiple plots and managed by 7 cooperatives divided into 65 Producer Groups (Groupes Mutualistes de Producteurs), which are :

- Djirataoua North with 7 producer groups totalling 90 ha;
- Djirataoua Sud with 12 groups totalling 155 ha;
- Radi Adéraoua with 9 groups totalling 120 ha;
- Kodéraoua Maradou with 13 groups totalling 141 ha, and a non-functional extension with 6 groups covering 69 ha;
- CPR Djirataoua with 9 groups totalling 106 ha;
- Bakawa with 3 groups totalling 31 ha;
- Kegel with 6 groups totalling 75 ha, not operational.

Appendix 2 provides a description of each of these areas.

Each producer group forms an independent hydraulic unit around a borehole. The producer group are grouped into sectors by the power line that supplies electricity to the submersible electric pumps.

Figure 7. Satellite image of the Djirataoua I perimeter

Two irrigation periods are used in the Djirataoua I perimeter:

- Winter: from May to October with irrigation to supplement rainfall for moringa, maize, sorghum, cassava and banana crops.

- Off-season: from November to March only irrigated production, of aniseed, moringa, chilli, maize and banana crops.

Institutional and land framework

In general, the land, equipment and infrastructure on the irrigation schemes are owned by the State and administered by the Office National des Aménagements Hydro-Agricoles (ONAHA), a Public Industrial and Commercial Establishment (EPIC) with legal personality and financial autonomy.

ONAHA is placed under the supervision of the Ministry of Agriculture and Livestock. Its missions include:

- To delegate project management for public amenities;
- To monitor developments on the basis of a regularly updated inventory;
- To provide support services for the operation and maintenance of the facilities;
- To act as a technology reference, promote innovation and act as a link between agricultural research, extension services, irrigators and players in the agricultural sectors;
- Carrying out extension work and providing agricultural advisory services on demand for hydro-agricultural schemes.

ONAHA manages **1,450 ha exploited in the goulbis of the Maradi region** (ONAHA, 2015), including the Djirataoua I perimeter.

Due to a lack of financial resources, ONAHA has difficulties to carry out effective maintenance work on the hydraulic installations, and to supervise and provide agricultural advice to producers in order to develop the perimeter.

In the Djirataoua area, the farmers own their plots and are responsible for renewing the equipment.

Management of irrigated areas

Crops are irrigated by controlled submersion through **inland ditches**. Irrigation frequency varies widely. It ranges from 7 to 10 days for wells that are still efficient. For very low-flow boreholes, the frequency can be as high as 25 days (ANID, 2010).

In a monitoring report dated January 2024, the ONAHA states:

- Daily duration of irrigations: 24 hours
- Duration per shift: 10 days
- Irrigation time per unit plot: 2.5 hours/0.16 ha.

Water distribution on the plots is characterised by **low efficiency, estimated at 40%**. In most of the cases studied, farmers did not respect the water turns. Irrigation is carried out on demand rather than by water turn.

On a monthly basis or on request, the farmers meet in a general assembly at the level of each cooperative to set the water charges in order to cover the running costs of water production: electricity costs (invoice sent by Nigelec), plumbers to maintain the Californian network, local masons to repair water leaks in the reinforced concrete canals.

Marketing of horticultural products

Farm produce is sold daily by each farmer on the market located near the irrigation scheme and on the markets in Maradi, Madarounfa, Dan Issa and neighbouring Nigeria (anise). The market is held daily.

Diagnosis of existing irrigation infrastructure and equipment

Irrigation infrastructure

Boreholes:

- 67 boreholes with a diameter of 200 mm were drilled to depths ranging from 22 m to 80 m, **44** of which were **operational and 17 faulty**:
  - A **drop in operating flow** was observed at 11 boreholes (Djirataoua North: 4; Djirataoua South: 4; Radi Adéraoua: 3).
  - Six boreholes in Koderawa Maradou were realised through poor workmanship
  - Six boreholes in Keguel are not in use.
- Flow rates vary from **94 to 55 m3/h** for functional boreholes (data from GR Maradi 2014).
- The dynamic level of the boreholes varies from **23.8 to 40 metres**.

Pumping:

- The boreholes are equipped with submersible pumps powered by the electricity grid (Nigelec).
- The submersible pumps in the Kegel perimeter and 6 pumps in the Kodéraoua Maradou perimeter have broken down and are unable to irrigate the perimeters.
- 7 buffer basins fed by pumps distribute water to 7 producer groups of 4 cooperatives.

The distribution of water to the crops:

- The boreholes supply water to open reinforced concrete channels (primary and secondary pipes) and/or by the Californian PVC network (built in 2007); with the exception of 7 boreholes where the water feeds into retention basins and then flows by gravity into the channels.
- Water distribution in the CPR, Bakwa and Keguel areas is provided solely by a Californian network.
- 59 kilometres of concrete canals
- 46.8 kilometres of Californian-style pipework
- The plots are irrigated by siphoning water from the canals.

Figure 8. Irrigation infrastructure in the Djirataoua I irrigation scheme

COOPERATIVES	NUMBER OF BOREHOLES	NUMBER OF ELECTRIC PUMPS	NUMBER OF RETENTION BASINS	CONCRETE CHANNELS (ml)	CALIFORNIAN NETWORKS
DJIRATAOUA NORTH	7	7	1	6 490	0
DJIRATAOUA SOUTH	12	12	2	20 620	0
RADI ADERAWA	11	11	1	18 490	0
KODERAWA MARADOU	19	13	3	14 180	0
CPR DJIRATAOUA	9	9	0	0	x
BAKAWA	3	3	0	0	x
KEGUEL	6	5	0	0	x
TOTAL	**67**	**60**	**7**	**59 780**	**46 815**

Borehole and valve

Water retention reservoir

Canal derivation in reinforced concrete (primary and secondary canal)

Cultivated areas

The cultivated areas by each of the cooperatives are shown in the table below:

Figure 9. Summary of the situation of each cooperative in the Djirataoua I irrigation scheme

COOPERATIVES	Number of producers	Area initially cultivated[1] in ha	Area irrigated in 2023 (ha)	Number of boreholes	Concrete channels (ml)
Djirataoua North					
Functional perimeters	400	28,65	29,65	3	6 490
Partially functional perimeters		48,21	29,71	4	
Non-functional perimeters					
T1	**400**	**76,86**	**59,36**	**7**	**6 490**
Djirataoua South					
Functional perimeters	1200	101,55	101,09	8	20 620
Partially functional perimeters		49,04	40,56	4	
Non-functional perimeters					
T2	**1200**	**150,59**	**141,65**	**12**	**20 620**
Radi Aderawa					
Functional perimeters	520	85	85	8	14 180
Partially functional perimeters		33	12	3	
Non-functional perimeters					
T3	**520**	**118**	**97**	**11**	**14 180**
Kodarawa Maradou					
Functional perimeters	726	145,38	145,38	13	18 490
Partially functional perimeters					
Non-functional perimeters		69	0	6	
T4	**0**	**214,38**	**145,38**	**19**	**18 490**
CPR Djirataoua					
Functional perimeters	737	106	106	9	
Partially functional perimeters					
Non-functional perimeters					

[1] There are slight differences between the areas initially developed and the areas initially cultivated as reported by the representatives of the cooperatives. We have taken their statements into account here.

	Number of producers	Area initially cultivated (ha)	Area irrigated in 2023 (ha)	Number of boreholes	Concrete channels
TOTAL DJIRATAOUA I irrigation scheme					
Functional perimeters	4433	498	498	44	59780
Partially functional perimeters		130	82	11	
Non-functional perimeters		144	0	12	
T5	**737**	**106**	**106**	**9**	**0**
Bakawa					
Functional perimeters	450	31,13	31,13	3	
Partially functional perimeters					
Non-functional perimeters					
T6	**450**	**31,13**	**31,13**	**3**	**0**
Keguel					
Functional perimeters	400		0		
Partially functional perimeters			0		
Non-functional perimeters		75	0	6	
T7	**0**	**75**	**0**	**6**	**0**

Over the entire irrigation scheme, 580.5 ha are developed by **4,033 producers** from 53 producer groups (55 boreholes):

- **Functional perimeters**: 42 producer groups (managing 44 boreholes) declare that they exploit the entire developed area (around 498 ha)
- **Partially functional perimeters**: 11 producer groups from 3 cooperatives (Djirataoua North, Djirataoua South, Radi Adouraoua) are experiencing problems with water resources and reduced operating flows and are no longer able to irrigate the developed area: the area under cultivation has been reduced from 130 to 82ha (-38%).
- **Non-functional perimeters**: the extension to the Kodarawa Maradou perimeter (69ha) and the Keguel perimeter (75ha) are not functional and are not exploited (12 producer groups).

The main irrigation constraints in Djirataoua I

Reducing the flow of boreholes

The data from the piezometers installed in the area by the hydraulic services have shown that the water level in these structures has fallen by an average of 1.50 m (Source: ANID 2010 diagnosis). This lowering can influence the installation characteristics of submersible pumps. There are many causes for the lowering of the water level:

- Overexploitation of the water table for irrigation and supplying drinking water to the ever-growing population.
- The impact of climate change on aquifer recharge, particularly variations in the frequency and volume of rainfall.
- The poor regulation of water volumes in the Goulbi at the Djibya dam in Nigeria.

The consequences for irrigation are a drop in the operating flow from the boreholes: intermittent pumping due to the drop in the dynamic level. The boreholes are no longer able to cover water requirements, and the area under cultivation has fallen by between 4% and 71% (-38% on average for the 11 boreholes concerned in the 3 cooperatives).

In its 2010 report, ANID recorded flow rates of between **2.5 l/s and 13 l/s** for a sample of 10 boreholes**, compared with 12 to 30 l/s** when they were first drilled.

In addition, poor irrigation management and inefficient infrastructure mean that pumping times are increasing, accentuating the over-exploitation of the aquifer.

Degradation of the infrastructure:

The hydraulic infrastructure (pumps, distribution networks, dykes, etc.) is in a poor condition in most areas. In theory, ONAHA is responsible for major repairs (pumps, canals), while farmers are responsible for weeding the main drains and doing routine maintenance (cleaning irrigation canals, weeding sprinklers and plot drains).

In practice, the cooperatives replace and maintain pumps, clean irrigation canals and conveyance channels, and carry out minor repairs to canals and PVC pipes.

In addition, the Keguel perimeter and the extension to the Kodarawa Maradou perimeter are not operational because the equipment has broken down. There are also land disputes that could affect operations.

The distribution network (canals, pipes) is in poor condition, with significant water losses, considerably reducing irrigation efficiency, estimated at 40%. Under these conditions, you have to pump for longer periods to cover the losses.

Energy and maintenance costs

The average daily pumping time is **16 to 24 hours, 7 days a week** (ONAHA monitoring sheet; 2024), due to the reduced operating flow rate from boreholes, poor water management and the absence of water towers, the bad state of the distribution network and the quality of electrical equipment.

The cost of producing water (electricity bill and pump maintenance) averages 300,000 CFA/ha/year.

Figure 10. Annual electricity and maintenance costs for the irrigation system (pump and distribution) (source: Practica 2024 survey)

Cooperatives	Irrigated area (ha)	Electricity costs (FCFA)	Pump maintenance costs (FCFA)	Network maintenance costs (FCFA)	Cost/ha/year (FCFA)	Cost / ha/ year ($)	Cost/ 0.16ha / year ($)
Djirataoua North	59,36	24 000 000	2 000 000	600 000	448 113	735	118
Djirataoua South	141,65	22 500 000	3 600 000	1 200 000	192 729	316	51
Radi Aderawa	97	23 000 000	1 000 000	500 000	252 577	414	66
Koderaoua Maradou	145,38	21 000 000	3 000 000	1 200 000	173 339	284	45
CPR Djirataoua	106	23 000 000	2 000 000	1 000 000	245 283	402	64
Bakawa	31,13	15 700 000	1 000 000	200 000	542 885	890	142
Keguel	0	-	-	-	-		-
Average		89.8%	7.6%	2.6%	309 000	507	81

Water production costs represent around 30% of the total operational costs. **90% of water production costs concerns electricity consumption**.

6. PROPOSAL FOR THE DEVELOPMENT OF SOLAR IRRIGATION IN THE DJIRATAOUA I IRRIGATION SCHEME

We propose to treat functional perimeters separately from faulty and non-functional perimeters.

Functional areas

For these areas, we are proposing to replace the existing electric pumps connected to the Nigelec electricity grid with new electric pumps powered by solar panels.

Niger and the Maradi region are particularly favourable for energy use, with solar radiation of 7.1kWh/m^2 /day at the irrigation peak (April).

Irrigation using solar energy allows farmers to produce all year round while reducing production costs. This source of energy is free, and generates no greenhouse gas emissions.

This proposal concerns **44 boreholes covering an area of 498 ha and grouping together 6 cooperatives**:

Figure 11. Number of pumps to be replaced for cooperatives in functional areas

COOPERATIVES	BOREHOLE NUMBER	IRRIGATED AREA IN HA	NUMBER OF SOLAR PUMPS TO BE INSTALLED
Djirataoua North GN	4, 8, 9	29,65	3
Djirataoua Sud GS	1, 5, 6, 7, 9, 10, 11, 12	101,09	8
Radi Aderawa RA	4, 5, 6, 7A, 7B, 8A, 8B, 9	85	8
Kodarawa Maradou KM	1 à 13	145,38	13
CPR Djirataoua	11, 12A, 12B, 13 to 17	106	9
Bakawa	1 à 3	31,13	3
TOTAL		**498,25**	**44**

This proposal will enable the renewal of the pumping equipment and a reduction of operating costs.

The solar-powered hybrid pumping systems will run directly on solar energy without energy storage for around 7 hours a day, while the rest of the day electricity supplied by the grid is required.

The pumps will be sized in a way to cover irrigation needs during the peak water requirement month (April) in order to deal with more frequent temperature peaks as a result of climate change.

The solar pump design assumptions are as follows:

- Crop: horticulture
- Gross peak water requirement for plants: 80 m3/ha/d
- Pumping time: 7 h/day
- Radiation: 7.1 kW/m2/d
- Efficiency of the distribution network: 70% for the Californian network; 45% for the concrete canal and Californian network
- Pump unit efficiency: 60%.
- Panel yield: 50% (dusty environment)
- Borehole flow rates are the oral accounts of operating flow rates.

Figure 12. Pump and solar panel power and irrigated area per borehole

For 1 borehole in the perimeter of:	Average area / borehole (ha)	Flow (m3/h) / TDH[2] average (m)	Pump power (kW)	Solar panel power (kWp)	Area irrigated by solar energy (ha)	Area to be irrigated by Nigelec network (ha)
Djirataoua North GN	9,9	75/40	20,2	27,3	4,22	5,68
Djirataoua Sud GS	12,6	83/40	22,3	30,2	4,67	7,93
Radi Aderawa RA	10,6	94/50	31,6	42,7	5,29	5,31
Kodarawa Maradou KM	11,2	94/50	31,6	42,7	5,29	5,91
CPR Djirataoua	11,8	74/41	20,4	27,6	6,48	5,33
Bakawa	10,4	74/41	20,4	27,6	6,48	3,93

The hybrid operating time of the solar pumping system and the electricity grid can be broken down as follows:

- 7-hour solar pumping

- Average power supply 7.7 hours, ranging from 4.5 hours (Bakawa) to 12 hours (Djirataoua Sud)

This model has been designed for the most restrictive conditions (peak water demand and 100% coverage of the irrigated area). During the other periods of the year, we can expect less pumping time using the electricity network.

It is worth noting the influence of irrigation efficiency on pumping time. If the water distribution network in the Djirataoua Sud perimeter were upgraded to a fully Californian network, the pumping time on the Nigelec network would be reduced from 12 hours to 5 hours.

Fixed solar panel installations must be secured to prevent the risk of theft or vandalism:

- Mesh fencing around the pumping station and photovoltaic panel installation;
- Use 50 mm heavy angle bars welded together for the edge of solar panels;
- 24-hour security guarding either by members of the cooperative or salaried employees.

[2] TDH: total dynamic head (m)

Faulty and non-functional perimeters

As regards the 11 boreholes whose exploited surface areas have been reduced due to water shortages, and the 12 boreholes in the extension of the Kodarawa Maradou perimeter and the Keguel perimeter that are not operational, we propose first of all to carry out pumping tests on the boreholes in order to determine their exploitation rate.

Calculating the dimensions of the solar equipment would be too theoretical and risky when the flow rates from the boreholes no longer cover the water needs of the developed areas (faulty perimeters) or when these boreholes have not been used for several years.

Yield tests on these boreholes will make it possible to size the pumps according to the capacity of the water resource and to determine the irrigable areas.

There are two reasons why it does not make sense to blow out the boreholes in operation, as recommended in several reports:

- The main cause of the drop in yield from boreholes seems to be overexploitation of the aquifer, which results in a drop in the dynamic level of exploitation of the water table; if this is the case, blowing will have no impact.

- Blowing is particularly effective in calcareous sedimentary strata (clogging of the well screens by calcification) or in aquifers with low transmissivity (fine clays clog the well screens). In our situation, the alluvial aquifer (sandy) is characterised by high transmissivity and a high operating flow rate.

Figure 13. Boreholes in areas that have failed or are non-functional

COOPERATIVES	BOREHOLE NUMBER	POTENTIAL AREAS IN HA	NUMBER OF BOREHOLES TO BE TESTED
Djirataoua North GN	3, 5, 6, 7	48,21	4
Djirataoua Sud GS	2, 3, 4, 8	49,04	4
Radi Aderawa RA	1, 2, 3	33	3
Kodarawa Maradou KM	14 à 19	69	6
CPR Djirataoua	-	-	-
Bakawa	-	-	-
Keguel	1 à 6	75	6
TOTAL		**274,25**	**23**

In the case of Keguel, before starting any intervention it is recommended to assess the potential land disputes through discussions with ONAHA, the Maradi DRGR and local authorities, in order to secure the necessary commitments from the farmers related to the use of the land.

Investment budget for pump renewal

The investments considered in this study relate solely to the replacement of existing pumps with a solar pumping system, as described below:

Solar pump

- supply and installation of hybrid pumps (solar/grid electricity) with an output of 20 to 32 kW
- electrical control and protection accessories, wiring
- Cost = 8,500,000 FCFA per unit

Solar panels

- supply and installation of solar generator from 27 to 43 kWp
- electrical control and protection accessories, wiring, panel support
- Cost: 866,000 FCFA / kWp

Protective fencing:

- 60 linear metre mesh fence around each pumping unit (borehole and solar panels)
- Cost: 9,000 FCFA/ml.

Investments to replace the pumps in the functional perimeters are as follows[3] :

Figure 14. Investment in solar irrigation of functional perimeters

COOPERATIVES	Number of boreholes	Fencing cost	Pump cost	Solar panel cost	Total cost
Djirataoua North GN	3	1 620 000	25 500 000	70 795 500	97 915 500
Djirataoua Sud GS	8	4 320 000	68 000 000	208 925 387	281 245 387
Radi Aderawa RA	8	4 320 000	68 000 000	295 767 867	368 087 867
Kodarawa Maradou KM	13	7 020 000	110 500 000	480 622 783	598 142 783
CPR Djirataoua	9	4 860 000	76 500 000	214 793 547	296 153 547
Bakawa	3	1 620 000	25 500 000	71 597 849	98 717 849
TOTAL CFA	44	23 760 000	374 000 000	1 342 502 933	1 740 262 933
TOTAL USD		**$ 38 950**	**$ 613 115**	**$ 2 200 825**	**$ 2 852 890**

The investment required to switch to solar energy for the 44 boreholes in the operational areas would be USD 2,853,000.

For faulty and non-functional perimeters, it is recommended that flow tests be carried out before sizing the equipment.

The average cost of equipping each borehole with solar power is USD 62,000 per borehole. The investment budget required for the 23 additional potential boreholes (faulty or non-functional perimeters) can be estimated at **USD 1.43 million** (excluding flow tests).

[3] For this estimate, we assumed that all the boreholes in the same cooperative had the same flow rate-TDH

The business plan

Depreciation of equipment

The lifespan of solar equipment:

- 7 to 10 years for the solar pump
- 15 to 20 years for solar panels

Figure 15. Annual depreciation costs per borehole

Description		Cost (FCFA)	Service life	Annual depreciation charge (FCFA)
Fencing of pumping stations		540 000	10	54 000
Electric pump		8 500 000	7	1 214 286
Solar panels and accessories / drilling	Djirataoua North GN	23 598 500	20	1 179 925
	Djirataoua Sud GS	26 115 673	20	1 305 784
	Radi Aderawa RA	36 970 983	20	1 848 549
	Kodarawa Maradou KM	36 970 983	20	1 848 549
	CPR Djirataoua	23 865 950	20	1 193 297
	Bakawa	23 865 950	20	1 193 297

The depreciation charges to be considered for the renewal of equipment and infrastructure per perimeter and per hectare are as follows:

Figure 16. Annual depreciation costs per borehole and per hectare

Annual depreciation charge / producer group borehole	Average area/producer group borehole	Fencing (FCFA)	Pump (FCFA)	Solar panels (FCFA)	Annual cost / ha (FCFA)	Annual cost / 0.16ha (FCFA)
Djirataoua North GN	9,9	54 000	1 214 286	1 179 925	247 294	39 567
Djirataoua Sud GS	12,6	54 000	1 214 286	1 305 784	204 291	32 686
Radi Aderawa RA	10,6	54 000	1 214 286	1 848 549	294 041	47 046
Kodarawa Maradou KM	11,2	54 000	1 214 286	1 848 549	278 288	44 526
CPR Djirataoua	11,8	54 000	1 214 286	1 193 297	208 608	33 377
Bakawa	10,4	54 000	1 214 286	1 193 297	236 690	37 870
Average annual depreciation cost (FCFA) (/ ha and / unit 0.16ha)					244 869	39 179
Average annual depreciation cost (USD) (/ ha and / unit 0.16ha)					$ 401	$ 64

The fee for the farmers' contribution to the pumping equipment renewal fund can be defined on the basis of this amount: **245,000 FCFA per** ha/year or for each farm (0.16ha): 39,000 FCFA / year ($64).

Production costs and revenues

We have considered that the Djirataoua I irrigation scheme is used all year round during two seasons: from May to November for the winter season and from December to March for the off-season.

In winter, the main crops grown are moringa, maize, sorghum, cassava and bananas.

In the off-season, the main crops are anise, moringa, chillies, maize and bananas.

Crop rotation varies between areas and farms. However, based on focus group discussions with farmers, we have identified the main crops grown and assessed their importance. We estimated that a typical plot of 0.16 ha is cultivated as follows:

Figure 17. Crop rotation according to season

Winter season		Dry season	
Moringa	20%	Moringa	20%
Maize	30%	Maize	30%
Sorghum	15%	Anise	30%
Cassava	30%	Chilli	15%
Banana	5%	Banana	5%
	100%		100%

Typical operating accounts for each of these crops have been produced taking into account the statements made by farmers at focus group meetings in each of the cooperatives, see also appendix 4.

Figure 18 summarises the results of the production costs and revenue.

Figure 18. Production costs and revenue per ha

Winter season			Dry season		
	Production costs (FCFA)	Revenue (FCFA)		Production costs (FCFA)	Revenue (FCFA)
Moringa	139 208	537 756	**Moringa**	139 208	537 756
Maize	205 177	331 120	**Maize**	205 177	331 120
Sorghum	938	70 609	**Anice**	254 787	734 892
Cassava	107 313	344 556	**Chilli**	261 563	1 200 000
Banana	74 859	300 000	**Banana**	74 859	300 000
Total	527 494	1 584 042	**Total**	935 594	3 103 768

Annual income per hectare is estimated at around 2,692,000 FCFA, **or $4,413.**

Annual income per farm (0.16ha) is estimated at $706, which is higher than the average annual income of $610 in Niger (World Bank 2022).

Figure 19. Income per year and **per ha** for functional perimeters

	Annual production costs (FCFA)	Annual revenue (FCFA)	Electricity costs (FCFA)	Network maintenance costs (FCFA)	Security[4]	Depreciation fees	Net margin/ha
Djirataoua North	1 532 760	4 720 326	232 020	60 606	50 909	247 294	2 596 736
Djirataoua South	1 532 760	4 720 326	99 986	95 238	40 000	204 291	2 748 051
Radi Aderawa	1 532 760	4 720 326	118 836	47 170	47 547	294 041	2 679 971
Koderaoua Maradou	1 532 760	4 720 326	76 255	107 143	45 000	278 289	2 680 879
CPR Djirataoua	1 532 760	4 720 326	97 917	84 746	42 712	208 609	2 753 582
Bakawa	1 532 760	4 720 326	190 339	19 231	48 462	236 691	2 692 844
Average FCFA/ha	1 532 760	4 720 326	135 892	69 022	45 772	244 869	2 692 011
Average USD/ha	**$ 2 512,7**	**$ 7 738,2**	**$ 222,8**	**$ 113,2**	**$ 75,0**	**$ 401,4**	**$ 4 413,1**
Average USD /0.16ha	$ 402	$ 1 238	$ 36	$ 18	$ 12	$ 64	$ 706

Banana, cassava and moringa in May 2024

Maize in May 2024

Return on investment

The financial impact per producer group is as follows:

- Reduction of pump operation and maintenance cost per ha: 300,000- 137,000 = 163,000 FCFA
- Surveillance cost per ha: CFAF 45,800

For the 44 producer groups concerned, this represents around **CFA 82 million per year (USD 134,000).** The annual electricity cost savings amount 268 USD/ha (excluding the cost of safeguarding), or 43 USD per plot (0.16 ha).

However, the return on investment period is long, if no improvements are made to water transport and distribution:

- 29 years including surveillance costs
- 21 years if the surveillance is organised on a voluntarily basis by the farmers.

[4] Surveillance is considered a salary expense of 42,000 FCFA/month/borehole. It could be reduced if the night guard covers several boreholes and if guarding is provided on a voluntary basis by members.

Rehabilitation of distribution networks

The rehabilitation of the water distribution networks was not the subject of this study. This would require a more detailed study of all the irrigation scheme's equipment: retention basin, concrete channels, PVC pipes and small civil engineering works.

To improve the efficiency of water transport, it is recommended to replace the open canals with PVC pipes (Californian network).

As an indication, the replacement of 59.7 kilometres of concrete canals in the Djirataoua I irrigation scheme is estimated at 720 million FCFA, or 1,180,000 USD.

Drip irrigation would make it possible to improve the efficiency of applying water to plots, using solar surface pumps that pump water from buffer basins which are filled by the submersible pump installed in the borehole.

Drip irrigation involves distributing water through a network of low-pressure tubes, bringing the water to the immediate vicinity of the cultivated plants:

Benefits and positive impacts	The limits of technology
Precise watering	
Reduced evaporation losses	
Network efficiency	Relatively difficult to install
Weed control	Costly to invest
Integrated application of water and nutrients - fertigation	Risks of clogging emitters
	Accumulation of salt on the surface of the soil
Self-sufficiency	Exposure of pipes and drippers to damage (animals)
No interference with other farming activities	
Insensitive to wind	Negligible influence on the microclimate
No leaf scorch	Limitation of root volume
Water-saving system	
Low labour requirements	

However, drip irrigation is an expensive investment, **costing** around **$10,000 per hectare**.

Extension of irrigated areas

During the focus group meetings, we asked participants about the availability of land to consider extending the perimeters. It emerged from these discussions that the Djirataoua I irrigation scheme could be extended by 543 ha as follows:

Figure 20: Extension of surface areas on existing perimeters and Californian sizing

COOPERATIVES	Potential in AREA (ha)	Number of BOREHOLES	Main pipelines (ml)	Secondary pipes (ml)	Intake structures (NB)	Block valves (NB)
Djirataoua North GN	10	1	300	600	40	80
Djirataoua Sud GS	100	8	2 400	4 800	320	640
Radi Aderawa RA	81	6	1 800	3 600	240	480
Kodarawa Maradou KM	192	16	4 800	9 600	640	1 280
CPR Djirataoua	50	4	1 200	2 400	160	320
Bakawa	10	1	900	1 800	120	240
Keguel	100	8	1 800	3 600	240	480
TOTAL	**543**	**44**	**13 200**	**26 400**	**1 760**	**3 520**

As mentioned in Chapter 3, the groundwater is available at depths between 30 and 50 metres. An extension will increase the negative water balance (withdrawals greater than replenishment) of the aquifer, which is already overexploited, and could jeopardise existing irrigated areas with a further fall in the dynamic water level (a phenomenon already observed), resulting in a reduction in the irrigated area.

7. ENVIRONMENT FOR THE DEVELOPMENT OF SOLAR IRRIGATION

Public policy

Droughts resulting from insufficient rainfall accompanied by significant cereal deficits were the main reason why leaders and donors became aware of the need to develop irrigation in Niger. After the 1984 drought, Niger embarked on a vast programme to develop large-scale irrigation and small-scale irrigation known as "off-season crops", with the construction of several tens of thousands of hectares of irrigated land.

The 3N initiative *"Les Nigériens Nourrissent les Nigériens" ("Nigeriens Feed Nigeriens") was* intended to be the food security and sustainable agricultural development component of the Sustainable Development and Inclusive Growth Strategy (SDDCI)-Niger 2035. It was also part of the process of implementing the Comprehensive Africa Agriculture Development Plan (CAADP), the ECOWAS Common Agricultural Policy (ECOWAP) and the WAEMU Agricultural Policy (WAAP).

The aim of the 3N Initiative was to protect the people of Niger from famine and to guarantee the conditions for their full participation in national food production and the improvement of their income, by strengthening their food production and supply capacities and their resilience in the face of crises and disasters, based on the principles of concentrating actions and using communes (municipalities) as entry points.

The 3N initiative was replaced in 2024 by the Resilience Programme to Safeguard the Nation (PRSP - Programme de Résilience pour la Sauvegarde de la Patrie) aligned with the ambitions of full national sovereignty led by the National Council for Safeguarding the Nation and Government (Conseil National pour la Sauvegarde de la Patrie et le Gouvernement). The promotion of irrigated agricultural production has been defined as a key challenge in agricultural development.

To boost the agricultural sector and the economy of Niger, the development of irrigated crops is a realistic and sustainable pathway to enable the country to improve its food security and guarantee income for its population.

Irrigation is a key factor in agricultural development. Given the importance of agriculture and the high cost of food, the search for suitable land and water resources for irrigation, and good natural resource management will remain a constant endeavour for the State's technical services.

The development of irrigated agriculture, involving both public and private investment and varying degrees of water control and productivity, is based on two main axes:

- Maintenance, restoration and extension of medium and large-scale public irrigation schemes with total water control, which is a prioritised in the frame of the PRSP.

- Small-scale private irrigation, carried out by farmers and supported by the State through the Stratégie de la Petite Irrigation du Niger (SPIN) adopted in 2015.

The irrigation schemes are implemented by the State, which retains ownership of them, but their management has been transferred to the cooperatives, along with the responsibility for all operating costs. The irrigation schemes mainly concern rice production for family consumption and the local market.

SPIN aims to support autonomous irrigated farms of controlled size (generally between 0.5 and 15 ha), whether private or community-based, that are economically viable and ecologically sustainable, and that are developed using technologies adapted to local know-how. Small-scale irrigation (Petite irrigation) is geared more towards the production of a wide range of horticultural products for local and export markets.

The SPIN action plan provides for the construction of 5,600 ha and the rehabilitation of 1,600 ha of small-scale irrigation areal per year (source: SPIN action plan).

The major constraint to the development of small-scale irrigation is the financing of private investments (borehole drilling, water conveyance, distribution), the cost of which is unbearable for vulnerable households. SPIN proposes to support a policy of shared costs between the farmer, FISAN[5] and banking institutions.

The Djirataoua I irrigation scheme is **a public irrigation scheme, but the land is owned by the farmers**, and the extensions could come under support for small-scale irrigation, in order to give greater responsibility to the farmers, who would own the land and equipment.

Niger has also set up a National Action Plan for Integrated Water Resources Management (PANGIRE): this defines the national framework for water resources management and is the operational tool for implementing Niger's National Water Policy (Integrated Water Resources Management - IWRM).

Private sector

The study included visits to suppliers and service providers of pumping and irrigation equipment. The solar pumps available on the Maradi market are of low capacity: 2 to 20 m3/h for 55 m to 150 m TDH. Suppliers consulted in Niamey offer a varied range of AC/DC solar pumps: between 70 and 100 m3/h for TDH between 40 m and 60 m.

The specific costs and characteristics are detailed in Appendix 5.

There are many suppliers of pipes and hydraulic equipment in Maradi and Niamey. We were also able to meet with ACMA, a company that is specialised in manual and mechanised drilling, and offering services for the construction and installation of elevated water storage tanks. ACMA operates in the Maradi region and has been at the forefront of the implementation of irrigation programmes, with proven knowledge of the region's various aquifers.

[5] FISAN: the Fonds d'Investissement pour la Sécurité Alimentaire et Nutritionnelle (Investment Fund for Food and Nutritional Security) aims to combine public and private agricultural financing initiatives with a view to increasing the volume and quality of financing in order to promote the transformation of the agricultural sector and fully ensure its role as an engine of the economy.

Support per sector

Solar powered irrigation is one of the sub-sectors that involves several categories of stakeholders: public, private and farmers' organisations (FOs). Under current legislation, each of these categories plays a specific role. The categories of involved stakeholders include:

- **Public stakeholders**: Ministry of Energy, ministries in the rural development sector, mainly the Ministries of Agriculture and Livestock, Hydraulics, and Environment, which, through their technical services, research institutions and field offices, define development standards and regulate the sub-sector.
- **Private stakeholders**: consultancy service groups/ consultancy firms, businesses and companies, financial institutions and national and international NGOs support public actions and producers' organisations by supplying goods and services and carrying out works;
- **Farmers' Organisations (FOs)** include the CRAs, unions and federations that provide advisory support to producers (associations, cooperative societies, individual producers) with sub-projects.
- **Partner institutions**: implementing agencies, donors, partners for technical and financial support.

In order to support the sector, the Ministries of Energy and Finance have worked on a tax exemption for renewable energy equipment, which is implemented through a joint Act.

The Maradi region has benefited from a number of projects and programmes, including PARIIS, PASEC and many others, all of which have done a great deal of work in the field of solar irrigation:

PARIIS / Maradi

- Training for technical departments and consultancy firms, companies and firms in the sizing and implementation of solar irrigation sub-projects.
- The financing and implementation of **13** solar pumping **sub-projects** totalling **36.34** ha (for a total sum of 157,652,000 FCFA)
- Studies for the construction of sills around which solar-powered irrigation sites will be built.

PASEC/Maradi

Capacity-building for advisory service groups and consultancy firms for the development and implementation of integrated agricultural production sub-projects using water extraction methods adapted to climate change, i.e. solar pumping.

- The financing and implementation of 19 sub-projects for a total subsidy of 142,531,982 FCFA for 365 **beneficiaries**
- Training for producers and advisory service groups on the use and maintenance of solar pumps and panels.

SPIN

- The existence of development models for the Maradi goulbi zone in the SPIN memento.

RUWAMU

- 7 irrigation sites developed in the Madarounfa department.

PUSADER

- 7 irrigation sites developed in the Madarounfa department.

Next to this, there are ongoing discussions and a study realised by kFW to study the scope for constructing a mini solar power plant to cover the electricity needs for the entire Djirataoua I perimeter.

Finally, the PRODEV project supported by ISA could directly contribute to the rehabilitation of the Djirataoua I perimeter.

Financing via banking institutions

The funding of irrigation schemes is the responsibility of the State, which can call on partners to speed up the implementation of irrigation schemes.

The financing of small-scale private or community irrigation is the responsibility of users supported by government and project/programme support, through the use of Matching Grants, taking care not to distort the already very fragile rural financial market, and with a view to setting up a sustainable financing system under the umbrella of the Investment Fund for Food and Nutrition Security (Fonds d'Investissement pour la Sécurité Alimentaire et Nutritionnelle - FISAN). FISAN is piloting the implementation of a system comprising three facilities:

- Facility 1: agricultural credit;
- Facility 2: financing of structural agricultural investments by local and regional authorities;
- Facility 3: setting up a window for targeted subsidies aimed at vulnerable populations.

The funding method and mechanisms recommended as part of the implementation of SPIN aim to support:

- Vulnerable groups, by facilitating their access to collective irrigation facilities (100% subsidy)

- Private and community investment in the development of irrigable land, and the development and marketing of products (standard application with 40% subsidy, 10% personal contribution and 50% credit);

- Investment by local authorities in infrastructure designed to increase production potential and facilitate product marketing (95% subsidy and 5% developer contribution);

- The adoption of innovative technologies that help to protect the environment (100% subsidy).

Several financial institutions are interested in the irrigation sector.

<u>BAGRI in Maradi</u>

It is a state institution that has been operating in Maradi since 2011, and its role is to support producers throughout the agricultural production value chain.

From 2014 to 2024, BAGRI supported Maradi farmers through the PRODAF and PAPI projects in the areas of food security. The PRODAF project provides assistance for the acquisition of solar irrigation kits, irrigation boreholes, Californian network distribution systems and close protection fences, in particular wire fencing, as well as any activity that enters the value chain with funding for micro-businesses. For the PAPI project, these are economic development hubs in the Communes of Djirataoua, Guidanroumji, Tchadoua, Gazaoua, Gourgia and Mayahi.

Customers have two options:

- 1er cases: Direct solicitation between the producer and BAGRI with the following procedures
  - Opening an account
  - Visit to the customer's site
  - Granting of credit up to 1,000,000 FCFA with repayment of capital + interest
- 2ème cases: The producer is supported by a project under FISAN rules, in particular with shared-cost financing:
  - 40% subsidy

- 10% personal contribution
- 50% loan with repayment of capital plus interest ranging from 7 - 10% per annum.

Funding is also provided for the processing of agricultural products, working capital requirements and livestock activities.

The types of loans with credit rates of 7 to 10% per annum are:

- Short-term for 3 years
- Medium-term for 7 years
- Long-term for 15 years.

The required collateral consists of a land title deed, a deed of transfer or a title deed in rural areas.

The repayment schedule depends on production; a 1% penalty is applied in the event of a late payment or non-payment; an application form is required, as well as a residence certificate; data collection is carried out by BAGRI.

YARDA Savings and Credit Union

YARDA is also supporting the PAPI project with Swiss funding, applying the FISAN funding rules; the credit is a condition for the grant; the producer expresses his needs with the following conditions:

- A financial guarantee from the party
- Study costs amounting to 1% of the loan granted, which varies between 1 million and 1.5 million FCFA.
- The annual interest is 21% and is paid on a sliding scale over the remaining capital.

The loan can be up to 20 million FCFA for groups and cooperatives, and 15 million FCFA for individuals. It is important to note that this fund has already worked with certain cooperatives in Djirataoua I to grant loans for the renewal of pumping equipment.

These elements indicate that a producer group wishing to invest, with the support of the ISA, in a new hybrid pump powered by solar panels protected by a fence, could seek an investment loan from BAGRI.

8. ANALYSIS FOR THE DEVELOPMENT OF SOLAR IRRIGATION

The advantages and constraints of developing solar powered irrigation at the Djirataoua I irrigation scheme are presented here:

The advantages

The development of irrigated agriculture is a national priority	Irrigation is strongly supported by the Niger government, which has set up a strategic framework and set objectives for maintaining and developing irrigated areas, both for large-scale irrigation schemes and small-scale private irrigation (SPIN). Any support for preserving, restoring and extending irrigated crop production capacity is perfectly in line with Niger's objectives.
There is considerable potential for developing irrigated agriculture	Niger has available land and significant groundwater resources for the development of irrigation. The area of arable land used for agriculture is estimated at around 15 million hectares. As for irrigable land, the potential is estimated at around 11 million hectares (more than 2/3 of arable land) according to an assessment carried out by the Ministry of Agriculture in 2014. In the Maradi region in particular, the potential irrigable area of Maradi goulbi is 81,000 ha. 580 ha of the Djirataoua I irrigation scheme is exploited; 192 ha is developed but not exploited (reduction in borehole flow rates, technical problems with infrastructure, land disputes) and 543 ha could be extended.
Solar irrigation is adapted to local climatic conditions	Sunshine conditions are ideal for switching to solar pumping, with an average radiation level of 6.5 kWh/m^2/day in the Maradi region. Switching to solar pumping would make irrigation more secure, with an impact on agricultural productivity and a considerable reduction in operating costs. Solar equipment is available in Niger, and experience with solar irrigation has led to the development of proven skills in the maintenance of this equipment. Furthermore, agricultural equipment powered by renewable energy is exempted from taxes and import duties.
Food security and higher incomes	The Djirataoua I irrigation scheme could impact more than 4,400 people. It will contribute to their food security and that of the population of the city of Maradi, estimated at 410,000 people. The income generated by agricultural activities in the Djirataoua I irrigation scheme is substantial: around $706 per year per farmer (0.16ha) if the perimeters are converted to solar irrigation.

Constraints and points to watch out for

Overexploitation of water resources	Solar irrigation opens the way to the exploitation of groundwater, with a local risk of overexploitation of aquifers. Strategies for monitoring water resources and withdrawals need to be put in place in production basins with a high potential for irrigated crop production. -> It will be necessary to carry out an Environmental and Social Impact Assessment (ESIA) and to set up monitoring of water abstraction to assess the effects on groundwater levels and prevent any conflicts of use with drinking water.
Initial cost of equipment too high	The problem with developing solar irrigation is not its profitability, but the ability of producers to raise the initial investment for a new installation, or to finance the replacement of existing installations. The cost of the solar pump is the main obstacle to its purchase. -> Investment in irrigation schemes is the responsibility of the State, which can mobilise resources from its budget or seek external support. -> Financial incentive policies granted to farmers are a major lever for the development of solar pumping. These facilities are provided by the FISAN, which provides a 100% subsidy for vulnerable groups in collective irrigation schemes, and a 40% subsidy for private irrigation.
Land dispute	The extensions to the Koderawa perimeter (75ha) and the Keguel perimeter (69ha) are not being farmed, because of technical problems but possibly also because of reported land disputes. Conflicts between farmers and livestock breeders are numerous in this region and can influence the use of agricultural land. ->An in-depth socio-organisational study of the two areas and the resolution of disputes should precede any intervention; also as a prerequisite for any new extensions (543ha).
Pumping station safety	Although insecurity is declining thanks to government interventions, criminal groups are active on both sides of the nearby Niger-Nigeria border, focusing mainly on cattle rustling. ->Fixed investments such as solar pumping stations need to be protected by fencing (at least wire fencing) and a guard for continuous surveillance.

9. ROADMAP

The detailed roadmap is presented in Appendix 7.

Activities across the whole of the Djirataoua I irrigation scheme are spread over around 30 months, including 24 months for the switch to solar irrigation on functional perimeters.

Below is a summary of the roadmap:

	Activities Quarter	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Estimated budget FCFA/borehole	Responsibility
	Conducting an ESIA study												Rural Engineering and Environment Departments
1.	**Functional areas: 498 ha, 44 boreholes**												
	Technical study and tender preparation												ONAHA, Rural engineering, consultancy firms
	Purchase of equipment											37 890 000	Partner
	Installing and securing equipment												ONAHA-Research office-Cooperatives
	Training for ONAHA and cooperatives												Consultancy firm - supplier
2.	**Partially functional areas: 130.25 ha, 11 boreholes**												
	Preparing and carrying out pumping tests											360 000	Rural Engineering - ONAHA - Consultancy firm
	Technical study and tender preparation												Rural Engineering, ONAHA -– Consultancy firm
	Consultation with cooperatives												Rural Engineering – ONAHA – DRAE - cooperatives
	Purchase of equipment											37 890 000	Partner
	Installing and securing equipment												Rural Engineering - ONAHA- Consultancy firms – DRAE - Cooperatives
	Training for ONAHA and cooperatives												Consultancy firms - supplier

	Activities Quarter	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Estimated budget FCFA/borehole	Responsibility
3.	Non-functional areas: 144 ha, 12 boreholes												
	Consultation with cooperatives on the use of irrigation perimeters												ONAHA - DRAE
	Blowing boreholes											420 000	Drilling company
	Preparing and carrying out pumping tests												Rural Engineering, Drilling company
	Technical study and tender preparation												Rural Engineering - ONAHA - Energie Dpt - Consultancy firms
	Consultation with cooperatives												ONAHA - DRAE
	Purchase of equipment											37 890 000	Partner
	Installing and securing equipment												Rural Engineering - ONAHA- Consultancy firms - Cooperatives
	Training for ONAHA and cooperatives												Consultancy firms - supplier

10. CONCLUSION

The study shows the relevance of supporting agricultural production in the Maradi region:

- This is a densely populated region (5.25 million inhabitants) with a rural majority (85%), considered to be the economic capital of Niger.
- The region is an important agricultural zone, but in recent years has suffered from a rainfall deficit of around 200 mm per year, due to climate change.
- The region offers irrigable land potential in the Maradi and N'Kaba goulbi, particularly in the commune of Djirataoua (7,552ha). However, this potential is threatened by a decline in the water table.

The study shows that the Maradi region is particularly favorable to the use of solar energy, with average solar radiation reaching 7.1 kWh/m2/day when irrigation water requirements are at their peak in April.

The Djirataoua I irrigation scheme covers a net developed area of 791 ha, but developed areas have declined (580.5 ha), mainly due to i) reduced flow rates from certain boreholes, which are no longer able to cover water requirements, ii) hydraulic infrastructures (pumps, distribution networks) in poor condition, with significant water losses, considerably reducing irrigation efficiency, estimated at 40%.

In order to maintain production potential and reduce farmers' costs (especially the cost of electricity to power the existing pumps), we propose to replace the old pumps with hybrid electric pumps powered by solar panels (7 hours a day) and then the electricity grid.

Initially, this proposal concerns 44 boreholes covering a surface area of 498 ha, grouping together 6 cooperatives. The investment required to switch these 44 boreholes to solar power would be about USD 2,853,000 (pumps, solar panels, protective fencing).

In the case of faulty (11 boreholes with insufficient water) or non-functional (12 boreholes in the Kodarawa Maradou and Keguel extension) perimeters, we first recommend to implement pumping tests on the boreholes to determine their operating flow rate. The flow rate tests on these boreholes will make it possible to size the pumps according to the capacity of the water resource and to determine the irrigable surface areas.

This recommendation to renew the pumping systems and switch to solar-powered irrigation is in line with public policy, as Niger has embarked on a vast program to develop large-scale irrigation and small-scale irrigation, implemented by numerous programs that also rely on solar energy.

Investments will have to be supported and at best 100% subsidized, in line with the perimeter framework.

A roadmap with activities to be carried out has been proposed for the implementation of solar irrigation in the Djirataoua I irrigation scheme, which will nevertheless need to be preceded by an Environmental and Social Impact Assessment (ESIA) to assess the effects of irrigation on groundwater levels and prevent potential conflicts of use with drinking water.

LIST OF APPENDICES

Appendix 1: List of people consulted+

LOCATIONS	FULL NAME	STRUCTURES	CONTACTS
NIAMEY	Mr Abdou Zakari	Ministry of Energy	96 49 88 39
	Mr Bassirou Balla Souley		81 76 11 55
MARADI	Ms Djahara Hassaye	Regional Energy Director	99 32 32 35
	Mr Saadou Salifou	Regional Director of Rural Engineering	91 32 96 58/94 50 43 50
	Mr Moustapha Ali	Regional Director of ONAHA	97 27 74 78
	Ms Ramatou	Deputy Regional Director of Hydraulics	96 34 35 36
	Mr Hassane	Hydraulic Database manager	96 80 84 79
	Mr Laouali Ali	SG Djirataoua Town Hall	88 58 04 27
	Mr Salissou Elh Mati	Chairman of the Djirataou Cooperative Union	92 47 76 83/ 96 18 85 08
	Mr Mati Ousseini	Djirataoua Nord cooperative representative	88 50 40 17
	Mr Salissou Elh Mati	Djirataoua Sud cooperative representative	96 18 85 08
	Mr Abdoul Aziz Yahaya	Djirataoua cooperative representative Kouderaoua Marakou	99 90 95 28
	Mr Seydou Harouna	Cooperative representative Djirataoua Radi Aderaoua	95 68 77 17
	Mr Nouhou Kalla	CPR Djirataoua cooperative representative	88 30 22 90
	Mr Tassiou Ali	Bakawa cooperative representative	99 77 44 05
	Mr Rabé	Keguel cooperative representative	98 27 68 71
	Mr Ibrahim Abdoulaye Mohamed	BAGRI Credit Manager	
	Mr Oumarou Adamou Oumarou	Director IMF ACEP	80 07 02 38
	Mr Abdou Maman Assoumane	Director MFI YARDA	96 49 30 67
	Mr Abdourahmane Ibrah	Niger Commerce Representative	98 23 91 17
	Elh Salissou Mahaman	Establishment Elh Salissou Mahaman	96 97 10 07
	Mr Abdoulaye Mamane	Director ACMA	96 96 56 81

Appendix 2: Presentation of the 7 cooperatives of the Djirataoua I irrigation scheme

DJIRATAOUA NORTH

The cooperative has **400** members, **100** of whom are women; the members of the cooperative live less than **500 m from** the perimeter and farm an area of **90 ha**, with an average area of **0.16 ha** per farmer; the soil structure is clay-loam; the development was carried out in 1982 by the Maradi rural development project, financed by the World Bank; the development consisted of drilling seven (7) boreholes to a depth of 60 m; the boreholes are equipped with electric pumps installed by Nigelec ; an invoice is issued by the company after each off-season or wintering campaign. For one borehole, the water is distributed from a reception basin which supplies water by gravity to reinforced concrete channels consisting of a main and secondary pipes; the other six boreholes discharge directly into the concrete channels.
Since 2005, the Project for the Rehabilitation of the Djirataoua Irrigation Development and Protection of Lake Madarounfa has been rehabilitating the irrigation canals, boreholes and submersible pumps, and completing the distribution system with a Californian network at a cost of around 2.5 billion CFA francs. The plots are watered by siphoning from the canals. Close protection of the development is provided by a live bauhinia hedge.
The development of the perimeter is facilitated by advisory support from ONAHA on agricultural production techniques and irrigation management; An electro-mechanic technician can be mobilised by the Cooperatives and paid for by ONAHA for the diagnosis, repair and installation of submersible pumps; the farmers cover the travel costs.

The area is farmed all year round, with the main crops being maize, sorghum, manioc, moringa and beans in the winter and onions, cabbage and squash in the dry season.

Products are sold individually on the market created near the perimeter or in Maradi, Madarounfa and Dan Issa.

The operators are of the 'experienced' type and meet in general assembly every month and every week to set contributions in order to meet the expenses incurred or expected for the operation; in this way they manage to pay for electricity, plumbers for maintenance of the Californian network and local masons for repairs to water leaks in the reinforced concrete canals. A cash book is used to manage the perimeter.

The operating constraints of the perimeter are:

- A drop in the water table in 57% of boreholes (4/7), leading to a drop in borehole flow and a failure to cover the total area planned.
- The sharp rise in electricity bills (8,000,000 FCFA in the off-season, or 24,000,000 FCFA a year)
- Inaccessibility to quality electrical equipment (circuit breakers)
- The continuing deterioration of the reinforced concrete canals installed since 1982.

Summary table of the cooperative:

COOPERATIVE DJIRATAOUA NORD	
Number of operators	400 including 100 women
Type of operator	Experienced
Areas initially farmed	76.86 ha
Areas currently farmed	58.36 ha
Average area per farmer	0.16 ha
Soil type	Clay-loam-sand

Terrain slope characteristics	Flat (Low)
Type of irrigation water catchment	Groundwater
Number of reception facilities	One (1) pool
Type of pumps installed	Electric pumps + transformers
Number of boreholes	07 with a diameter of 200 mm and a depth of 60 m
Reinforced concrete channels	6490 ml
Californian networks	PM

DJIRATAOUA SOUTH

The cooperative has **1,200** members, including **100** women. The members live less than **500 m from** the perimeter and farm an area of **155 ha**, with an average area of **0.16 ha** per farmer, but currently varying from 0.16 to 0.64 ha; the soil structure is clay-loam; the development was carried out in 1982 by the Maradi rural development project financed by the World Bank, then rehabilitated in 2005 by the Djirataoua Hydro-Agricultural Development and Madarounfa Lake Protection Project.

Twelve (12) boreholes were drilled to depths ranging from 22 m to 60 m. The boreholes are equipped with pumps and electric generators installed by Nigelec.

The water is distributed via reinforced concrete canals made up of main and secondary pipes, supplemented in 2005 by a Californian network; the water flows to the irrigators' plots via a siphoning system. 2 retention basins complete the distribution system.

The close protection of the development consists of a live bauhinia hedge.

An electromechanical technician is assigned and paid for by ONAHA to diagnose, repair and install the submersible pumps, and the operators cover the travel costs.

The perimeter is farmed all year round, with the main crops being maize, cassava, moringa, sorghum, aniseed and banana in the winter season and anice, chilli, cabbage and squash in the dry season. The products are sold individually on the market created near the perimeter or in Maradi, Madarounfa and Dan Issa.

The operators are 'experienced' and meet in general assembly every month and every week to fix contributions in order to meet the expenses incurred or expected for the operation; thus they manage to pay the electricity costs, the plumbers for the maintenance of the Californian network and the local masons for the resumption or repair of water leaks in the reinforced concrete canals. A cash book is used to manage the perimeter.

The operating constraints of the perimeter are:

- A drop in the water table in 33% of the boreholes (4/12) drilled, i.e. 8.48 ha whose water needs are not covered out of 150.59 ha developed.
- The sharp rise in electricity bills (20 to 25 million per year)
- Inaccessibility to quality electrical equipment (circuit breakers)
- The continuing deterioration of the reinforced concrete canals installed since 1982

Summary table of the cooperative:

COOPERATIVE DJIRATAOUA NORD	
Number of operators	1,200 farmers, including 100 women
Type of operator	Experienced
Areas initially farmed	150.59 ha
Areas farmed	142 ha
Average area per farmer	0,16 ha
Soil type	Clay-loam-sand
Terrain slope characteristics	Flat (Low)
Type of irrigation water catchment	Groundwater
Number of reception facilities	Two (2) reception basins
Type of pumps installed	Electric pumps + transformers
Number of boreholes	12 boreholes with a diameter of 200 mm and 22-60 meters' depth
Reinforced concrete channels	20,620 ml

KODERAWA MARADOU

The 726 members of the cooperative live less than **500 m from** the perimeter and farm an area of **145.38 ha** with an average area of **0.16 ha** per farmer; the soil structures are of the clay-loam type. The development was carried out in 1982 by the Maradi rural development project funded by the World Bank, then rehabilitated in 2005 by the Djirataoua Hydro-Agricultural Development and Madarounfa Lake Protection Project.

Thirteen (13) boreholes were drilled to depths of up to 80 m; **13** boreholes are operational and equipped with submersible pumps, covering an area of **145.38 ha**. In 2010, as part of the financing of the President's special programme, six other areas were drilled to cover an area of **70 ha, but the 6** boreholes are not operational because they were poorly executed. A water retention basin completes the development of one borehole. The total surface area is therefore **215.38 ha**. An invoice is issued by Nigelec after each off-season or wintering campaign and paid by the cooperative.

The water is distributed via reinforced concrete channels made up of main and secondary pipes; a siphoning system ensures that the water flows to the irrigators' plots. 1 retention basin completes the distribution system. Close protection of the development is provided by a live bauhinia hedge. An electromechanical technician can be mobilised and paid for by ONAHA to diagnose, repair and install the submersible pumps, with the operators covering travel costs.

The area is farmed all year round, with the main crops being maize, cassava, moringa, sorghum in the winter and aniseed, onions, cassava, green chillies and moringa in the dry season. The products are sold individually on the market created near the perimeter or in Maradi, Madarounfa and Dan Issa.

The operators are of the 'experienced' type and meet in general assembly every month and every week to set contributions in order to meet the expenses incurred or expected for the operation; in this way they manage to pay for electricity, plumbers for maintenance of the Californian network and local masons for repairs to water leaks in the reinforced concrete canals. A cash book is used to manage the perimeter.

The operating constraints of the perimeter are:

- Unsuccessful completion of six boreholes, which could increase the area farmed to 215.38 ha
- The sharp rise in electricity bills (9.5 to 11.5 million FCFA per campaign or 21 million per year)
- Inaccessibility to high-quality electrical equipment (circuit breakers)
- The continuing deterioration of the reinforced concrete canals installed since 1982

Summary table of the cooperative:

COOPERATIVE KODERAWA MARADOU	
Number of operators	726 farmers, including 100 women
Type of operator	Experienced
Developed areas	145.38 ha
Areas farmed	145.38 ha
Average area per farmer	0.16 ha
Soil type	Clay-loam-sand
Terrain slope characteristics	Flat (Low)
Type of irrigation water catchment	Groundwater
Number of reception facilities	One (1) reception basin
Type of pumps installed	Electric pumps + transformers
Number of boreholes	19 boreholes with a diameter of 200 mm and a depth of 40 to 80 m, 13 of which are currently operational.
Reinforced concrete channels	18,490 ml

RADI ADERAWA

The cooperative has **520** members, **68** of whom are women; the cooperative members live less than **500 m from** the perimeter and farm an area of **120 ha**, with an average area of **0.16 ha** per farmer; the soil structure is clay-loam; the development was carried out in 1982 by the Maradi rural development project funded by the World Bank, then rehabilitated in 2005 by the Djirataoua Hydro-Agricultural Development and Madarounfa Lake Protection Project.

Eleven (11) boreholes were drilled to depths of up to 80 m; **11** boreholes are operational and equipped with submersible pumps. Invoicing is carried out by the company after each off-season or wintering campaign; water distribution has been ensured by reinforced concrete canals consisting of main and secondary pipes since 1982; a siphoning system ensures that the water flows to the irrigators' plots. 3 water retention basins are installed at 3 boreholes.

The close protection of the development consists of a live bauhinia hedge.

The development of the perimeter is facilitated by advisory support from ONAHA, which also pays for the services of the pump repairer and the farmers cover their travel costs. The area is farmed all year round, mainly growing maize, manioc, moringa, sorghum and green chilli in the winter and aniseed, manioc and moringa in the dry season.

The operators are of the 'experienced' type and meet in general assembly every month and every week to fix contributions to meet the expenses incurred or expected for the operation; in this way they manage to pay the electricity costs, the plumbers for maintenance of the Californian network and the local masons for repairs to the water leaks in the reinforced concrete canals. A cash book is used to manage the perimeter. Products are sold individually on the market created near the perimeter or in Maradi, Madarounfa and Dan Issa.

The operating constraints of the perimeter are:

- A drop in the water table in 17% of boreholes (3/11), i.e. 21 ha, whose water needs are not covered.
- The sharp rise in electricity bills (12 to 13 million per campaign)
- Inaccessibility to high-quality electrical equipment (circuit breakers)
- The continuing deterioration of the reinforced concrete canals installed since 1982.

Summary table of the cooperative:

COOPERATIVE RADI ADERAWA	
Number of operators	520 Farmers, including 68 women
Type of operator	Experienced
Developed areas	120 ha
Areas farmed	99 ha
Average area per farmer	0.16 ha
Soil type	Clay-loam-sand
Terrain slope characteristics	Flat (Low)
Type of irrigation water catchment	Groundwater
Number of reception facilities	Three (3) large reception basins
Type of pumps installed	Electric pumps + transformers
Number of boreholes	11 boreholes with a diameter of 200 mm and a depth of 80 m, 11 of which are currently operational.
Reinforced concrete channels	14,180 ml

CPR DJIRATAOUA

The cooperative has **737** members, **113** of whom are women. The cooperative members live less than **500 m from** the perimeter and farm an area of **106 ha**, with an average area of **0.125-0.25 ha** per farmer.

Nine (9) boreholes have been drilled to depths of up to 70 m; **9** boreholes are operational and equipped with submersible pumps, but operations began in 2016. The company invoices after each off-season or wintering campaign; water is distributed via a Californian network.

The close protection of the development consists of a live bauhinia hedge.

ONAHA monitors the development of the perimeter, and an electro mechanic technician can be mobilised by the cooperative and paid for by ONAHA to diagnose, repair and install the submersible pumps, with the farmers covering the travel costs.

The perimeter is farmed all year round, with the main crops being maize, cassava, moringa, sorghum and banana. Products are sold individually on the market created near the perimeter or in Maradi, Madarounfa and Dan Issa.

The operators are of the 'experienced' type and meet in general assembly every month and every week to set contributions in order to meet the expenses incurred or expected for the operation; in this way they manage to pay for electricity, plumbers for maintenance of the Californian network and local masons for repairs to water leaks in the reinforced concrete canals. A cash book is used to manage the perimeter.

The operating constraints of the perimeter are:

- The sharp rise in electricity bills (21 to 25 million per year)
- Inaccessibility to high-quality electrical equipment (circuit breakers) and other accessories to protect pumps against sudden variations in electrical voltage.

Increasing number of water leaks at joints on the Californian network.

Summary table of the cooperative:

COOPERATIVE CPR DJIRATAOUA	
Number of operators	737 Farmers, including 113 women
Type of operator	Experienced
Developed areas	106 ha
Areas farmed	106 ha
Average area per farmer	0.125-0.25 ha
Soil type	Clay-loam-sand
Terrain slope characteristics	Flat (Low)
Type of irrigation water catchment	Groundwater
Number of reception facilities	Three (3) large reception basins
Type of pumps installed	Electric pumps + transformers
Number of boreholes	9 boreholes with a diameter of 200 mm and a depth of 80 m, all of which are currently exploitable
Californian network	Linear not communicated

BAKAWA

The cooperative has **450** members, including **43** women. The members live less than **500 m from** the perimeter and farm an area of **31 ha**, with an average area of **0.10-0.4 ha** per farmer.

Three (3) boreholes were drilled to depths of up to 50 m. The 3 boreholes are operational and equipped with submersible pumps. Invoicing is carried out by the company after each off-season or wintering campaign; water distribution is ensured by a Californian network; close protection of the development is provided by a bauhinia hedge.

Development of the perimeter with advisory support from ONAHA began in 2019. An electro mechanic technician can be mobilised by the cooperative and paid for by ONAHA to diagnose, repair and install the submersible pumps, with the farmers covering travel costs.

The area is farmed all year round, with the main crops being moringa, manioc, aniseed, maize and onions. The products are sold individually on the market created near the perimeter or in Maradi, Madarounfa and Dan Issa.

The operators are of the 'experienced' type and meet in general assembly every month and every week to fix contributions to meet the expenses incurred or expected for the operation; in this way they manage to pay the electricity costs, the plumbers for maintenance of the Californian network and the local masons for repairs to the water leaks in the reinforced concrete canals. A cash book is used to manage the perimeter.

The operating constraints of the perimeter are:

- The sharp rise in electricity bills (15.7 million a year)
- Frequent replacement of pumps, including one (1) in 2021, two(2) in 2022 and three(3) in 2023
- Increasing number of water leaks at joints on the Californian network.

Summary table of the cooperative :

COOPERATIVE BAKAWA	
Number of operators	450 Farmers, including 43 women
Type of operator	Experienced
Developed areas	31.13 ha
Areas farmed	31.13 ha
Average area per farmer	0.10-0.4 ha
Soil type	Clay-loam-sand
Terrain slope characteristics	Flat (Low)
Type of irrigation water catchment	Groundwater
Number of reception facilities	0 large reception basins
Type of pumps installed	Electric pumps + transformers
Number of boreholes	3 boreholes with a diameter of 200 mm and a depth of 50 m, all of which are currently exploitable
Californian network	Linear not communicated

KEGUEL

The cooperative has **400** members, including **20** women. The members live less than **500 m from** the perimeter, which covers an area of **75 ha**, and the soil structure is clay-loam.

The development was carried out in 2014 as part of a special presidential project (PPTE): The development involved the construction of six (6) boreholes at depths of up to 50 m, 3 of which are equipped with submersible pumps supplied by Nigelec, and a Californian-type distribution network.

Since the boreholes were drilled and the pumps installed, the site has remained unused for various reasons:

- Unresolved land issues
- Unsuitable electrical transformers
- Insufficient number of pumps installed (3 pumps installed for 6 boreholes)
- Orchestrated vandalism on the Californian network due to the lack of human presence on site.

Summary table of the cooperative:

COOPERATIVE KEGUEL	
Number of operators	400 Farmers, including 20 women
Type of operator	Experienced
Developed areas	75 ha
Areas farmed	0 ha
Average area per farmer	0.175 ha
Soil type	Clay-loam-sand
Terrain slope characteristics	Flat (Low)
Type of irrigation water catchment	Groundwater
Number of reception facilities	0 large reception basins
Type of pumps installed	Electric pumps + transformers
Number of boreholes	6 boreholes with a diameter of 200 mm and a depth of 50 m not exploited.
Californian network	Linear not communicated

Appendix 3: Summary table of the Djirataoua I irrigation scheme perimeters

COOPERATIVE	Initial area in ha	Borehole number	Number of boreholes	Channels (ml)	Irrigated area in ha	Depth (ml)	Static level (ml)	Dynamic level (ml)	Pump size in ml	Flow rate (l/s)	Main pipeline (ml)	Secondary pipeline (ml)	Intake structure	Block valve
Djirataoua North GN														
90ha	11	3	7	6 490	7,55	60	12	30	40	23	300	600	40	80
	10,73	4			11,73	60	12	30	40	23	300	600	40	80
	13,42	5			11,23	60	12	30	40	23	300	600	40	80
	11	6			3,19	60	12	30	40	23	300	600	40	80
	12,79	7			7,74	60	12	30	40	23	300	600	40	80
	11,89	8			11,89	50	12,04	28,01	38,5	15,97	300	600	40	80
	6,03	9			6,03	60	11,4	35,28	40	23,88	150	600	40	80
T1	**76,86**		**7**		**59,36**	**410**					**1 950**	**4200**	**280**	**560**
Djirataoua Sud GS														
155 ha	9,45	1	12	20 620	9,45	60	12	30	40	23	500	1000	65	130
	14,2	2			10,1	60	12	30	40	23	500	1000	65	130
	12,06	3			11,58	60	12	30	40	23	500	1000	65	130
	11,21	4			10,48	60	12	30	40	23	500	1000	65	130
	10,72	5			10,72	60	12	30	40	23	500	1000	65	130
	16,98	6			16,98	60	12	30	40	23	700	2200	145	290
	11,72	7			11,72	60	12	30	40	23	500	1000	65	130
	11,57	8			8,4	60	12	30	40	23	500	1000	65	130
	12,02	9			11,56	60	12	30	40	23	500	1000	65	130
	17,07	10			17,07	60	12	30	40	23	800	2200	145	290
	11,59	11			11,59	60	12	30	40	23	500	1000	65	130
	12	12			12	60	12	30	40	23	500	1000	65	130
T2	**150,59**		**12**		**141,65**	**720**					**6 500**	**14 400**	**940**	**1880**

COOPERATIVE	Initial area in ha	Borehole number	Number of boreholes	Channels (ml)	Irrigated area in ha	Depth (ml)	Static level (ml)	Dynamic level (ml)	Pump size in ml	Flow rate (l/s)	Main pipeline (ml)	Secondary pipeline (ml)	Intake structure	Block valve
Radi Aderawa RA														
120 ha	10	1			3	80	12	40	50	26	400	800	53	106
	11	2			4	80	12	40	50	26	400	800	53	106
	12	3			5	80	12	40	50	26	400	800	53	106
	12	4			12	80	12	40	50	26	400	800	53	106
	12	5	**11**	**14 180**	12	80	12	40	50	26	400	800	53	106
	10	6			10	80	12	40	50	26	400	800	53	106
	23	7 A and 7 B			23	80	12	40	50	26	700	1500	100	200
	18	8 A and 8 B			18	80	12	40	50	26	500	1500	100	200
	10	9			10	80	12	40	50	26	400	800	53	106
T3	**118**		**11**		**97**	**720**	**108**	**360**	**450**	**234**	**4 000**	**8 600**	**571**	**1 142**
Kodarawa Maradou KM														
214,38 ha	11,5	1			11,5	80	12	40	50	26	400	700	47	94
	10,04	2			10,04	80	12	40	50	26	400	700	47	94
	12,91	3			12,91	80	12	40	50	26	400	700	47	94
	10,56	4			10,56	80	12	40	50	26	400	700	47	94
	9,86	5			9,86	80	12	40	50	26	400	700	47	94
	13,33	6			13,33	80	12	40	50	26	400	700	47	94
	14,21	7	**13**	**18 490**	14,21	80	12	40	50	26	400	700	47	94
	8,2	8			8,2	80	12	40	50	26	400	700	47	94
	11,7	9			11,7	80	12	40	50	26	400	700	47	94
	13,96	10			13,96	80	12	40	50	26	400	700	47	94
	14,08	11			14,08	80	12	40	50	26	400	700	47	94
	5,27	12			5,27	80	12	40	50	26	400	700	47	94
	9,76	13			9,76	80	12	40	50	26	400	700	47	94
	11,5	14	**6**			0	0	0	0	0	400	700	47	94
	11,5	15				77	11,57	37,36	36,35	25,79	400	700	47	94

	11,5	16				66	10,97	34,62	44,15	23,65	400	700	47	94
	11,5	17				66	10,5	36,08	37,33	25,58	400	700	47	94
	11,5	18				76	10,3	30,24	49,7	19,94	400	700	47	94
	11,5	19				43	NO	PUMP		5,55	400	700	47	94
T4	**145,38**		**19**		**145,38**						**7600**	**13300**	**893**	**1786**

COOPERATIVE	Initial area in ha	Borehole number	Number of boreholes	Channels (ml)	Irrigated area in ha	Depth (ml)	Static level (ml)	Dynamic level (ml)	Pump size in ml	Flow rate (l/s)	Main pipeline (ml)	Secondary pipeline (ml)	Intake structure	Block valve
CPR Djirataoua														
106 ha	14	10			14	69,5	9,1	32,93	33	23,83	300	600	40	80
	13,5	11			13,5	60	9,43	33,65	28	24,22	300	600	40	80
	12	12			12	52	9,9	23,78	33,45	13,88	300	600	40	80
	12	12 bis			12	72	11,95	26,25	49	14,3	300	600	40	80
	11	13	**9**		11	70	10,53	33,78	35	23,25	300	600	40	80
	12	14			12	60	10,99	34,22	37,5	23,23	300	600	40	80
	12,5	15			12,5	60	10,42	34,62	36,47	24,2	300	600	40	80
	12	16			12	60	10,85	33,94	41,32	23,09	300	600	40	80
	7	17			7	60	9,4	25,11	41,5	15,71	300	600	40	80
T5	**106**		**9**		**106**						**2400**	**4800**	**320**	**640**
Bakawa														
31ha	10,64	1			10,64	50	10,2	32,22	41	22,02	300	600	40	80
	11,33	2	**3**		11,33	50	10,4	34,89	40,3	24,49	300	600	40	80
	9,16	3			9,16	50	12,2	27,34	43,5	15,14	300	600	40	80
T6	**31,13**		**3**		**31,13**						**900**	**1800**	**120**	**240**
Keguel														
75ha	12,5	1			0	50	10,2	32,22	41	22,02			40	80
	12,5	2			0	50	10,2	32,22	41	22,02			40	80
	12,5	3	**6**		0	50	10,2	32,22	41	22,02			40	80
	12,5	4			0	50	10,2	32,22	41	22,02			40	80
	12,5	5			0	50	10,2	32,22	41	22,02			40	80

	12,5	6			0	50	10,2	32,22	41	22,02			40	400
T7	**75**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**240**	**800**

COOPERATIVE	Initial area in ha	Borehole number	Number of boreholes	Channels (ml)	Irrigated area in ha	Depth (ml)	Static level (ml)	Dynamic level (ml)	Pump size in ml	Flow rate (l/s)	Main pipeline (ml)	Secondary pipeline (ml)	Intake structure	Block valve
TOTAL (791.4ha)	**702,96**		**67**		**580,52**						**23 350**	**47 100**	**3 364**	**7 048**

Appendix 4: Farm accounts for the main crops

Maize				
Expenses	**Unit**	**Quantity / 0.16ha**	**Unit cost (FCFA)**	**Average cost/ha (FCFA)**
Ploughing and making boards		1	5000 - 12000	53 660
Seeds	Tia	1 - 2	1000 - 4000	15 493
Fertiliser	Bag	1	50000 - 90000	448 381
Pesticide	Sachets	1 - 3	1250 - 4500	24 771
Seasonal workforce	Ploughing	1 - 3	6000 - 19000	94 548
One-off workforce		0 - 1	6000 - 12000	26 442
Packaging	100kg bags	3 - 15	250 - 750	8 636
Transport	1 - 5	1	250 - 4000	11 990
Total charge				683 923
Sale but on 0.16 ha	100 Kg	4 - 8	22000 - 35000	1 103 734
Gross margin excluding electricity and maintenance				**419 811**
				$688

Moringa				
Expenses	**Unit**	**Quantity / 0.16ha**	**Unit cost FCFA**	**Average cost/ha**
Ploughing and making boards		1	6000 - 40000	139 224
Seeds	Tia	3 - 5	1000 - 3000	69 872
Fertiliser	Bag	1 - 2	24000 - 60000	255 665
Pesticide	Sachets	1 - 6	2500 - 7500	44 324
Seasonal workforce	Ploughing	1	4500 - 18000	82 356
One-off workforce		1 - 6	6000 - 7000	60 096
Packaging	100 kg bags	4 - 30	250 - 600	29 119
Transport		0 - 1	0 - 12000	15 385
Total charge				696 040
Moringa for sale	50 Kg	12 - 80	5000 - 20000	2 688 782
Gross margin excluding electricity and maintenance				**1 992 742**
				$3 267

Anice				
Expenses	**Unit**	**Quantity / 0.16ha**	**Unit cost FCFA**	**Average cost/ha**
Ploughing and making boards		1	5000 - 41500	140 084
Seeds	Tia	1 - 3	2000 - 4000	32 933
Fertiliser	Bag	1	60000 - 95000	466 947
Pesticide	bag	1	2500 - 9500	40 925
Seasonal workforce	fertiliser+pesticide	1	3000 - 20000	105 649
One-off workforce		0 - 1	20000	38 462
Packaging	100 kg bags	5 - 10	200 - 450	12 212
Transport		1	1000 - 3000	12 079
Total charge				849 291
Anise sale	100 Kg	4 - 6	50000 - 55000	2 449 639
Gross margin excluding electricity and maintenance				**1 600 349**
				$ 2 624

Cassava				
Expenses	**Unit**	**Quantity / 0.16ha**	**Unit cost FCFA**	**Average cost/ha**
Ploughing and making boards		1	18000 - 24000	134 569
Seeds			0 - 5000	15 788
Fertiliser	Bag	0.5 - 1	60000	121 154
Pesticide	Sachets	0		-
Seasonal workforce	Ploughing	1	0 - 20000	30 769
One-off workforce		0 - 1	7000	10 769
Packaging	100 kg bags	14 - 21	125 - 150	18 074
Transport		1	0 - 10000	26 585
Total charge				357 709
Cassava sales	100 Kg	14 - 21	9000 - 10000	1 148 519
Gross margin excluding electricity and maintenance				**790 811**
				$ 1 296

Sorghum				
Expenses	**Unit**	**Quantity / 0.16ha**	**Unit cost FCFA**	**Average cost/ha**
Ploughing and making boards		1	6000 - 25000	102 083
Seeds	Tia	2 - 3	400 - 800	8 542
Fertiliser	Bag (1 bag urea + 1 bag 15-15 + organic manure)	1	24000 - 60000	241 667
Pesticide	g	0		-
Seasonal workforce	Cutting + harvesting	1	7400 - 20000	82 083
One-off workforce		0 - 1	11000	22 917
Packaging	100 kg bags	4 - 6	200 - 250	7 188
Transport	1	0 - 1	3000	6 250
Total charge				470 729
Sorghum sales	100 Kg	4 - 6	22000	687 500
Gross margin excluding electricity and maintenance				**216 770**
				$ 355

Banana				
Expenses	**Unit**	**Quantity / 0.16ha**	**Unit cost FCFA**	**Average cost/ha**
Ploughing and making boards		1	6000 - 12000	56 250
Seeds	Feet	0 - 90	250	70 313
Fertiliser	organic manure+1 bag NPK*6+1 bag urea		150000	930 000
Pesticide	Sachets		-	-
Seasonal workforce	Pruning+Identification+watering+fertilisation		15000 - 126000	440 625
One-off workforce			-	-
Packaging	100 kg bags		-	-
Transport			-	-
Total charge				1 497 188
Banana sale	Diets(6kg)	240 - 400	3000	6 000 000
Gross margin excluding electricity and maintenance				**4 502 812**
				$ 7 382

Green chilli				
Expenses	**Unit**	**Quantity / 0.16ha**	**Unit cost FCFA**	**Average cost/ha**
Ploughing and making boards		1	6000	37 500
Seeds	boards	2	8000 - 10000	112 500
Fertiliser	organic manure + urea + NPK		20000 - 122000	443 750
Pesticide	8 sachets + handwork	1	10000 - 28000	118 750
Seasonal workforce	1	1 - 8	6000 - 12000	187 500
One-off workforce	1		40000 - 136000	550 000
Packaging	100kg bags	120 - 200	200	200 000
Transport	100kg bags		0 - 30000	93 750
Total charge				1 743 750
Green chilli sale	100 Kg	120 - 200	8000	8 000 000
Gross margin excluding electricity and maintenance				**6 256 250**
				$ 10 256

Appendix 5: Quotes from suppliers

Establishment of 'BKD Electronique' in Maradi :

SOLAR PUMPS		AC/DC SOLAR PUMPS	
TDH= 100 m; Q= 6 m3/h	140 000 FCFA	TDH= 150 m; Q= 14 m3/h	260 000 FCFA
TDH= 80 m; Q= 6 m3/h	100 000 FCFA	TDH= 150 m; Q= 3 m3/h	FCFA 250,000
TDH= 130 m; Q= 10 m3/h	230 000 FCFA	TDH= 150 m; Q= 5 m3/h	FCFA 240,000
		TDH= 80 m; Q= 8 m3/h	FCFA 200,000
		TDH = 65 m; Q= 20 m3/h	FCFA 250,000
Monocrystalline panels			
450 w		90,000 FCFA	
540 W		FCFA 100,000	
350 W		FCFA 65,000	
280 W		FCFA 55,000	
380 W		57,000 FCFA	

Niger commerce' establishment in Maradi:

Description	Unit	Prices
Pvc pressure hoses diam 100	6ml	27,000 FCFA
Pvc pressure hoses diam 110	6ml	36,500 FCFA
Pvc pressure hoses diam 125	6ml	FCFA 40,000
Pvc pressure hoses diam 150	6ml	FCFA 51,500
Pvc pressure hoses diam 160	6ml	FCFA 75,000
Pvc pressure hoses diam 200	6ml	90,000 FCFA

Description	Unit	Prices
Iron E 500 Euro quality: 12 ml		
Diam 8	21 Bars	FCFA 73,000
Diam 10	13 Bars	
Diam 12	9 Bars	
Diam 14	6 Bars	
Diam 16	5 Bars	
Diam 20	3 Bars	

Elhadj Salissou' establishment in Maradi:

Description	Unit	Prices
Pvc pressure hoses diam 110	6ml	FCFA 23,500
Pvc pressure hoses diam 90	6ml	FCFA 17,000
Pvc pressure hoses diam 75	6ml	13,500 FCFA
Pvc pressure hoses diam 63	6ml	FCFA 9,000
Pvc pressure hoses diam 50	6ml	FCFA 6,750
Pvc pressure elbow diam 110	U	FCFA 6,000
Pvc pressure elbow diam 90	U	FCFA 6,000
Pvc pressure elbow diam 110	U	FCFA 4,000
Pvc pressure elbow diam 75	U	3,000 FCFA
Pvc pressure elbow diam 63	U	FCFA 1,750
Pvc pressure elbow diam 50	U	1 000 FCFA

Description	Prices
CIRCUIT BREAKERS / CONTACTORS :	
400 A	90,000 FCFA
300 A	FCFA 75,000
250 A	FCFA 55,000
160 A	CFAF 45,000
ELECTRICAL CABLES: ml	
4x35	13,500 FCFA
4x25	FCFA 11,000
4x16	FCFA 7,000
4x10	FCFA 5,500
4x6	FCFA 3,500
CONVERTERS: TO ORDER	1 300 000 to 1 500 000 FCFA

Consultation Plus' establishment in Niamey:

AC/DC SOLAR PUMPS AND ARRAYS	
TDH= 40 m; Q= 70 m3/h	37 984 800 FCFA
TDH= 40 m; Q= 100 m3/h	48 349 700 FCFA
TDH= 60 m; Q= 70 m3/h	49 236 250 FCFA
TDH= 60 m; Q= 100 m3/h	64 158 850 FCFA

Drilling and steel construction company: 'ACMA' in Maradi

Description	Prices
Diam 63 stainless steel drill head	75 000 FCFA
Stainless steel drill head diam 80 and 90	95 000 FCFA
Diameter 200 borehole at a depth of 40 m	1,500,000 to 2,000,000 FCFA
Diameter 200 borehole at a depth of 60 m	2,000,000 to 3,000,000 FCFA
Diameter 140 borehole at a depth of 40 m	1,500,000 to 1,700,000 FCFA
Diameter 140 borehole at a depth of 60 m	2,000,000 to 2,500,000 FCFA
Diam. 125 borehole at a depth of 40 m	1,500,000 to 1,700,000 FCFA
Diam. 125 borehole at a depth of 60 m	2,000,000 to 2,500,000 FCFA
Blowing	400 000 FCFA
Development	200 000 FCFA
Pumping test	400 000 FCFA
Raised tanks with 6 m high supports :	
- Stainless steel 10 m 3	2 500 000 - 3 000 000 FCFA
- Metal 10 m3	1 700 000 FCFA
- Stainless steel 20 m3	4,500,000 - 5,000,000 FCFA
- Metallic 20 m3	2 500 000 FCFA

Appendix 6: Detailed Roadmap

	Monthly activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	23	24	25	26	27	28	29	30	31
0.	Conducting an ESIA study																														
1.	Functional areas: 498 ha, 44 boreholes																														
1.1	Recruitment of a consultancy firm																														
1.2	Technical sizing																														
1.3	Preparation of the CAD (specifications, etc.)																														
1.4	Consultation procedure																														
1.5	Equipment control																														
1.6	Equipment installation																														
1.7	Securing equipment																														
1.8	Training for ONAHA and cooperatives																														
2.	Defaulting areas: 130.25 ha, 11 boreholes																														
2.1	Preparation of pump test specifications																														
2.2	Consultation of companies for pumping test																														
2.3	Pumping test																														
2.4	Recruitment of a consultancy firm																														
2.5	Technical sizing																														
2.6	Consultation with cooperatives																														
2.7	Preparation of the tender (specifications, etc.)																														
2.8	Consultation procedure																														
2.9	Equipment control																														
2.10	Equipment installation																														
2.11	Securing equipment																														
2.12	Training for ONAHA and cooperatives																														

	Monthly activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	23	24	25	26	27	28	29	30	31
3.	Non-functional areas: 144 ha, 12 boreholes																														
3.1	Consultation with cooperatives on the use of perimeters																														
3.2	Preparation of pump test specifications																														
3.3	Consultation of companies for pumping test																														
3.4	Pumping test																														
3.5	Recruitment of a consultancy firm																														
3.6	Technical sizing																														
3.7	Consultation with cooperatives																														
3.8	Tender preparation (specifications, etc.)																														
3.9	Consultation procedure																														
3.10	Equipment control																														
3.11	Equipment installation																														
3.12	Securing equipment																														
3.13	Training for ONAHA and cooperatives																														

Appendix 7: List of consulted documents

- Rapport de caractérisation des zones agro-climatiques favorables à la petite irrigation; MAE, GIZ ; 2017
- Rapport de Diagnostic participatif rapide et planification des actions du périmètre de Djirataoua ; ANID ; 2010
- Rapport 'Développement de l'irrigation au Niger : diagnostic et options stratégiques' ; Banque mondiale AFTAR ; 2009
- Note sur les expériences d'irrigation solaire pour le maraichage dans la commune de Safo ; CRA Maradi ; janvier 2019
- Rapport d'Evaluation du potentiel en terres irrigables du Niger ; MAE, SPIN ; 2021
- Dépliant démographique de la Région de Maradi ; INS Niger ; édition 2024
- Diagnostic institutionnel spécifique de l'ONAHA ; COSTEA ; 2015
- Guide de diagnostic rapide des périmètres, Djiarataoua I ; MAE, Direction Générale du Génie rural ; janvier 2024
- Rapport ' projets et programmes de développement de l'irrigation au Niger (1966-2010) : éléments pour un bilan' ; CEIPI ; août 2011

Consultation of websites:

- INSTAT Niger data portal : Données Agricoles - Niger - Niger Data Portal (opendataforafrica.org)
- FAO : FAO Climate Info Tool
- SPIN : Présentation – STRATEGIE DE LA PETITE IRRIGATION AU NIGER (SPIN) (spin-niger.ne)
- FISAN : fisan.ne
- Inter réseaux : L'or jaune de Djirataoua (Niger) – Inter-réseaux (inter-reseaux.org)

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