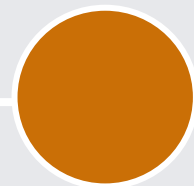


Evaluation of the Potential of Small-scale Irrigation VIVA Bénoué & VIVA Logone



ASA on Governance and Farmer-Led Irrigation in Northern
Cameroon (ID: P173136)

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1. INTRODUCTION

In Cameroon, a country of nearly 24 million inhabitants, poverty affects 60% of the rural population, with significant regional disparities (WFP 2018). This poor population is concentrated in the three northern regions of the country (North, Far North, Adamawa). In these three regions, food security remains precarious because production does not keep up with population growth. All of the rural population and most of the urban populations in the North and Far North depend on local agricultural and livestock production for food, which exposes them to soaring costs of imported products during food shortages.

An overall water deficit exists in almost the entirety of the North and Far North regions, while south of Adamawa is in surplus over the whole year. Chronic drought in the North and Far North, and overabundance of water, on the contrary, during the rainy season in the south of the country are the main climatic limits to agricultural production. The majority of agriculture being rainfed is the primary constraint in northern Cameroon. A diminished rainy season automatically translates into a production deficit and increased food insecurity.

Due to its limited development, irrigated agriculture is of marginal importance despite the many advantages that the country enjoys. Most of the crops still come from rain-fed production, which is highly sensitive to rainfall quantities. It is mainly oriented towards the production of rice, bananas and vegetables. Crop calendars vary from region to region. In the northern regions rice is cultivated twice a year, in the dry season via irrigation and in the rainy season with additional irrigation, if necessary. Vegetable crops (onion, okra, eggplant) are grown in two irrigated campaigns in the off-season (November – January and February – April).

The water used for irrigation comes exclusively from surface water for the supply of large rice-growing areas exploited by entities such as SEMRY in Yagoua and MEADEN in Lagdo, but for off-season vegetable crops in the North and Far North, groundwater is more commonly used. Groundwater resources are abundant in the Bénoué and Logone valleys, with potentially exploitable aquifers of 20 billion m³/year. The country's total withdrawal for the irrigation of agricultural land is only 0.7 billion m³/year from surface water alone. Groundwater is renewed by the Logone and Bénoué rivers, and their tributaries, particularly from stagnant water in the floodplains. Surface aquifers (less than 10m) are very productive and accessible at affordable costs using manual drilling and surface pumps.

Despite this potential, the areas favorable to irrigated agriculture are largely underdeveloped and under exploited. Currently, irrigated land represents less than 9% of irrigable land in Cameroon, and more than 32% of the irrigation potential is located in the North and Far North regions. The state has decided to undertake a far-reaching reform of SEMRY and MEADEN with a transfer of productive, processing and marketing activities to the private sector and a partial transfer of management to Water User Associations (WUAs). However, the high relative investment cost (\$14,000/ha) limits the development of large-scale irrigation systems when compared to cheaper investment costs for small scale irrigation (\$1,000/ha). The strong development potential of small-scale individual irrigation represents a real opportunity for the expansion of irrigated areas in northern Cameroon, where the mobilization of water is affordable and the markets for high value-added crops are accessible.

2. TYPOLOGY OF OPERATION

In the intervention area of the VIVA Bénoué and VIVA Logone programs, farmers individually irrigate small plots of 500 m² to 1 hectare for off-season vegetable production and additional irrigation of rice or corn. The farms are bordering the SEMRY irrigated perimeter or grouped near an urban center as is the case in Garoua in the Bénoué valley.

Figure 1: Cultural Calendar

Month	1	2	3	4	5	6	7	8	9	10	11	12
Individual Small-scale Irrigation												
Off-Season Vegetable Growing	2 nd location									1 st location		
Supplementary Irrigated Rice												
Large Irrigated Area												
Dry-Season Rice												
Rainy-Season Rice												

There are two groups of farmers depending on the type of irrigation practiced:

- Women who manually irrigate from temporary wells or watercourses areas rarely exceeding 500 m², due to the arduousness of the dewatering and the application of water to the plot. The combination and alternation of off-season crops that have different growing cycles generates continuous income to meet the daily expenses of the household and the production costs of the farm. The income from this activity is insufficient to be reinvested in improving the production tools or for the purchase of a motor pump or completing manual drilling to increase the irrigated area. Access to land ownership is governed by customary law and does not constitute an obstacle to the development of small-scale irrigation.
- The second group of farmers is much less numerous than the previous one. A motor pump irrigates from a watercourse, perimeter canal, well, or via manual drilling with an average area of 0.5 hectare, but which may exceed 1 hectare. Men are the most numerous although several women were met on the left bank of the Bénoué valley near Garoua. Access to a permanent water point that is easily mobilized (depth less than 5m) and capable of supplying water in quantity (at least 15 m³/h), increases the surface area and the productivity of market-oriented gardening activities and the search for profit, part of which can be reinvested in the production tool.

For the 2 groups of farmers, the off-season market gardening activity is complementary to that exercised on the irrigated perimeter of SEMRY for the cultivation of rice, because it exploits plots of at least 0.5 ha.

The lack of technical and financial support makes it difficult for farmers practicing manual irrigation to improve and expand small-scale irrigation. Those already engaged in motorized

irrigation have an investment capacity of 100,000 FCFA to 150,000 FCFA, for a profitable activity whose operating profit is close to 2 million FCFA.

Figure 2: Simplified small irrigation operating account in FCFA

Water production costs (lubricant fuel, repair)	129 200
Depreciation (drilling, motor pump)	16 000
Production costs (inputs)	84 500
Total Charges	229 700
Okra and onion product (turnover)	2 100 000
Net Margin	1 938 000

Market gardening in Yagoua of 0.5 ha, 2 market gardening campaigns without taking into account the rainy-season rice campaign with additional irrigation, family labor not counted.

3. ACCESS TO WATER

Hydrogeology – The surface aquifer of the Bénoué valley (from Lagdo to the border of Nigeria) consists of unconsolidated sedimentary formations of fluvial alluvium with a width of 5 to 15 km, which is very productive and whose volume of water does not vary during the year.

The groundwater mobilization potential in the Logone valley from Yagoua to Kousséri, and especially in the immediate vicinity of the SMERY perimeters of Maga and Yagoua, is very significant due to the presence of a generalized aquifer not exceeding 10 meters deep and made up of sandy-clayey (quaternary) sedimentary formations, up to 50 meters thick.

In the two valleys the production flow of the aquifer authorizes motorized pumping which rarely exceeds more than 15m³/h, hand of water controllable by the farmer. Also, the depth of the static level less than 4m is compatible with the 8m depth limit for motorized surface pumping. The two maps below represent the zones that are favorable to the exploitation of groundwater for small-scale irrigation: water depth less than 10m and hydrogeology favorable for manual drilling.

Figure 3: Hydrogeology favorable to small-scale irrigation in the Bénoué valley

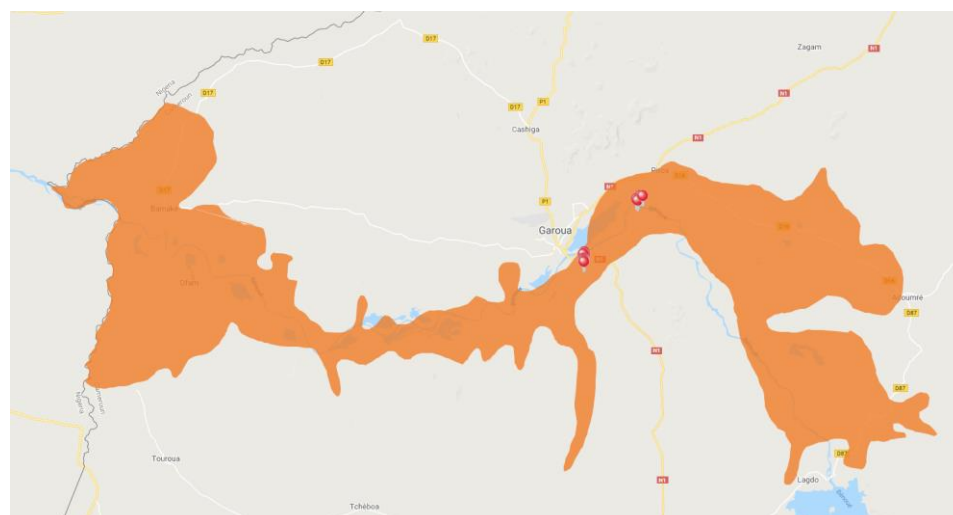
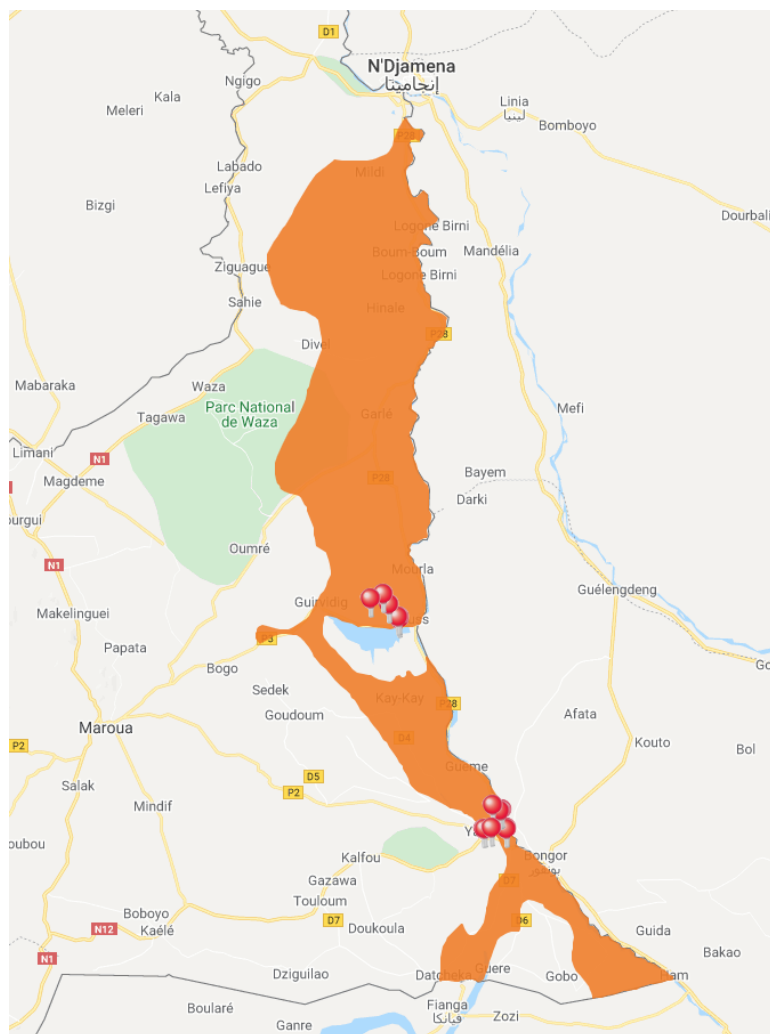


Figure 4: Hydrogeology favorable to small-scale irrigation in the Logone Valley



Groundwater abstraction – The boom in off-season market gardening in the Bénoué valley is catalyzed by demand from the nearby Garoua market. However, this boom could not have happened without the recent introduction of manual drilling less than a decade ago, which led to the rapid expansion of small-scale irrigation that was previously limited to the immediate vicinity of the Bénoué and its tributaries with a direct catchment in the river. On the left bank, the introduction of manual drilling associated with motorized pumping increased the areas that were formerly manually irrigated from temporary sumps by 5 to 10 times.

Manual drilling is less developed in the Logone valley, no doubt due to the presence of the SEMRY rice perimeter, which has stood out for 4 decades as a model of agricultural diversification and total control of irrigation.

Two different manual drilling methods are known and practiced in the North and Far North regions:

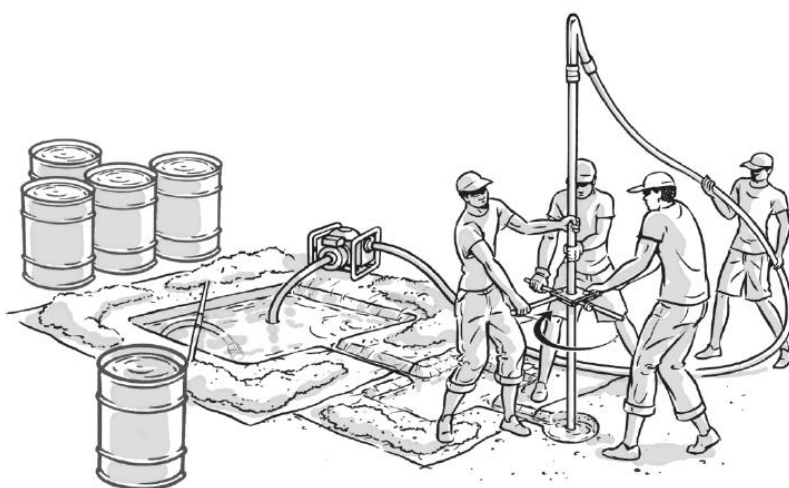
- Rapid well jetting¹ (water launch), originating in northern Nigeria (Fadama region) where since the 1990s tens of thousands of boreholes have been drilled for small-scale irrigation. This technique, practiced by small private operators in Garoua and Pitoa, most often working in the informal sector, makes it possible to drill 7 m deep (diameter 50 to 63 mm) in less than an hour at a cost not exceeding 35,000 FCFA. However, this method does not penetrate clay with a thickness of more than 2 meters and makes it difficult to carry out drilling beyond a depth of 7 meters, a situation encountered on the right bank near Garoua.

Figure 5: Rapid well jetting



- Fewer than a dozen small private operators that are located in Maga and Yagoua use the manual rotary technique, originating in Chad, which is capable of reaching a depth of 15 m (diameter 63 mm) in less than a day, regardless of the thickness of the unconsolidated sedimentary layers (clay and sand). The cost of a borehole is greatly variable since it depends on the standard of equipment proposed according to the use of water. For drinking water, the cost can reach 300,000 FCFA for a 110 mm diameter borehole (pipe thickness of 4 mm) at a depth of 20 m. For irrigation it costs 100,000 FCFA for a 63 mm diameter bore (pipe thickness 2 mm) at a depth of 10 m. The difference in cost and technique with that encountered at Garoua is an additional factor which explains the slower spread of manual drilling in the Logone valley.

Figure 6: Manual Rotary Drilling



Unlined wells are also used in Yagoua for manual irrigation, but their production flow is not compatible with motorized pumping which would dry out the well in a few minutes, hence the need for manual drilling. The submerged walls of the well are maintained with a circular

¹ Manuel technique <https://www.practica.org/publications/forage-manuel-lancage-a-leau/>

braiding of branches and the depth does not exceed 4 m. They are renewed each year at the start of the off-season.

Surface water – There are two types:

- Farmers outside the perimeter illegally pump water into the supply or drainage canals bordering their farms. When water is used by gravity without pumping, certain channels are cut or obstructed to divert water into rice paddies. Manual drilling is a solution to limit illegal pumping in supply or drainage structures in the SEMRY irrigated perimeter. It also makes irrigation more efficient (less water loss) by bringing the water source (manual drilling) closer to the areas to be irrigated.

Figure 7: Primary Channel Pumping



- The pumping of water in the Logone and its tributaries is limited to the land immediately bordering the watercourse, (a strip with a width of around 200 meters) whose cultivation and irrigation depends on the level of water during the year. During low water periods, the increased pumping distance and/or height makes irrigation more difficult. During the flood period, the land on the banks is flooded, which reduces the number of opportunities for off-season cultivation as well as reducing the irrigated area. The use of manual drilling or buried piping (California network) would reduce the incidence or dependence on water in order to increase the irrigated areas along the rivers.

Figure 8: Pumping in a Bénoué tributary



4. IRRIGATION TECHNIQUES

The small-scale irrigation techniques used depend on the means of dewatering used by farmers

- When dewatering is done manually with a bucket, the irrigation is daily. The arduousness of extracting water and transporting it limits the quantities of water applied, while the retention capacity of the clayey-sandy soil makes it possible to add more water, which would reduce the frequency of irrigation. The farmers, mostly women, irrigate from 6 a.m. to 10 a.m. and from 2 p.m. to 6 p.m., around 8 hours a day for an average area of 500 m².
- Motorized pumping combined with manual drilling is a factor in the expansion of small-scale irrigation. The frequency of watering is weekly (once or twice a week) and the duration of irrigation approximately 8 to 9 hours per day for an average area of 0.5 hectares. The motor pump supply a network of earth channels via gravity which can reach a length of 200 meters to irrigate small basins of approximately 4 to 5 m². The efficiency of irrigation (transport and application of water) is probably less than 50%, therefore half of the water pumped will not be used by crops. Gravity irrigation is highly dependent on the topography and slopes of the plot to be irrigated, sometimes forcing the farmer to make counter-slope canals with excavated material. This method of irrigation considerably increases the duration of irrigation and the costs of pumping.

Figure 9: Manual drilling and motor pump - Earth channel in backfill with counter-slope



The technique of supplying water by the "California network" widely used in several countries in West Africa, would reduce by 30 to 40% the time spent on irrigation with an affordable investment cost by farmers, about 200,000 FCFA at 300,000 FCFA / hectare in rural areas. It is a network of buried PVC pipes (diameter 50 to 63 mm) supplied by a motor pump with several outlets (5 to 10 outlets per hectare depending on the topography). This modular and simple technique of installation by a plumber adapts to the farming practices in place. Irrigation is carried out from an outlet located as close as possible to the area of the garden to be irrigated.

Figure 10 : Example of a “California network” in Mauritania



In the Garoua, Maga, and Yagoua markets, there are sellers of low-power gasoline pumps (3 to 5 horsepower) with a diameter of 50 mm (~2 inches) to 80 mm (~3 inches). Motor pumps come from Nigeria (made in China) and their price ranges from 75,000 FCFA to 120,000 FCFA, depending on the power and quality. This varied offer gives each farmer the option of acquiring a motor pump suitable for his needs via his own funds. The estimated lifespan is between 2 and 5 years, but in reality, the lifespan is governed by the number of hours of operation, and the adequacy of maintenance. Despite the cost of fuel (400 to 500 FCFA/liter), which can reach 40% of the total expenditure, this model of small-scale irrigation is profitable and progresses without any external financial support.

5. EXPANSION POTENTIAL OF SMALL-SCALE IRRIGATION

Highly Irrigable Area - The potential for irrigable land via small-scale irrigation is located on the banks of the Bénoué and Logone rivers and more widely in areas where the shallow aquifer consists of unconsolidated sedimentary formations with a water depth of less than 10 m, **easily mobilized with manual drilling** and motorized surface pumping.

The estimated surface of irrigable land in small-scale irrigation located near the irrigated perimeters of Lagdo and SEMRY (Yagoua and Maga) is 5560 hectares, but undoubtedly much higher beyond the rice perimeters in the extension of the two valleys (see Figure 11).

Proximity to Irrigated Perimeter	Irrigable Area (ha)
Lagdo	1560
Maga	1700
Yagoua (pump station P2)	2300

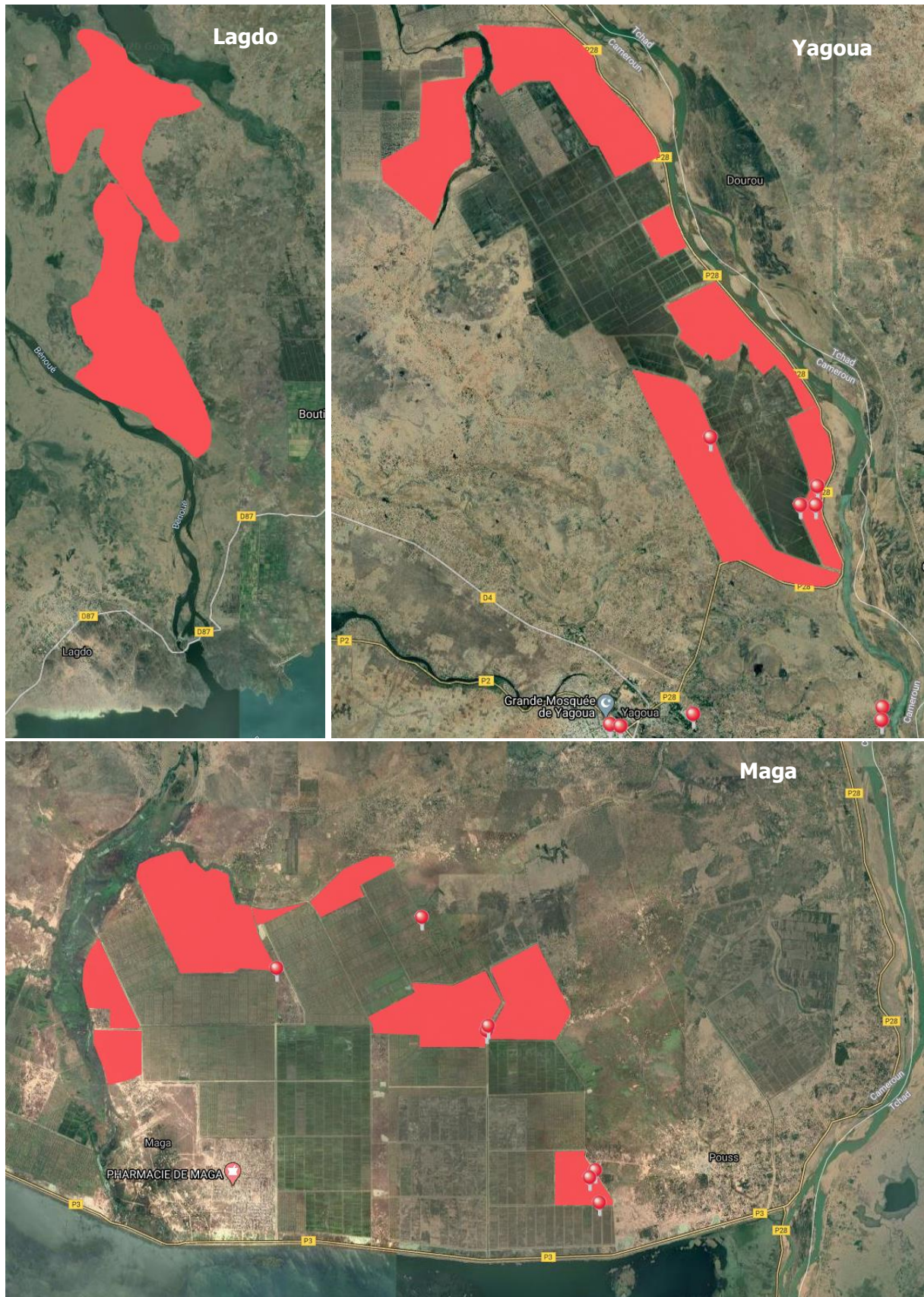
Individual Irrigation – Small-scale irrigation is well-suited to the numerous farmers who are near rice fields, including women. SEMRY accounts for more than **23,000 households** working on 11,500 ha of developed land, and MEADEN accounts for approximately 2,600 additional households on the Lagdo perimeter, which is the same number of households for small-scale irrigation. The off-season irrigation of vegetable crops and the complementary irrigation of rain-fed rice are complementary activities to off-season rice production on collective irrigated areas. This activity contributes to the diversification of agricultural production and income. There is no management problem since the systems are individual. Access to land is not usually a constraint because it is governed by customary law.

Reduced Investment Cost – The investment cost of a small irrigation model composed of manual drilling, a low-power motor pump and an efficient distribution of water like the “California network” is around **500,000 FCFA/ha** if low-cost, locally available technologies are used. In this case, the profitability is very high and can reach more than **4 million FCFA/ha** for 2 off-season campaigns of vegetable crops with high added value.

Existence of a Local Private Sector – The equipment (motor pumps, spare parts, pipes) and services (plumbers, manual drillers, mechanics) to support the development of small-scale irrigation is provided by several small local private operators from Garoua, Maga, and Yagoua. The quality and cost of the services provided are appropriate to the economic context of small farmers who have low investment capacity.

Uneconomical Practices – The low productivity of water and the low overall efficiency of irrigation slows the expansion of irrigable areas and keeps the cost of producing water (fuel, lubricant) high. Efficient water distribution using low cost pipes, such as the “California network”, would have a rapid impact on reducing water losses, reducing the duration of irrigation and the costs of producing water, and the increase in irrigated areas.

Figure 11: Areas Favorable to Small-scale Irrigation: Lagdo, Yagoua, Maga



6. CONCLUSION

The development and improvement of small-scale irrigation offers a real opportunity to expand irrigated areas from shallow groundwater, less than 10 m away, in the Bénoué and Logone valleys.

The “matching grant” provided for the VIVA Benoué and VIVA Logone projects is an appropriate financial instrument, in particular to support small-scale irrigation micro-projects, generally less than 0.5 hectares with the use of affordable equipment's to mobilize water with manual drilling, motorized surface pump and efficient distribution of water by low pressure pipe , such caliifornia network).

It is expected that this irrigation model will increase irrigable areas in the immediate vicinity of the large perimeter of Lagdo, up to approximately 1600 hectares. Irrigable areas may increase by 10 for the whole valley and its tributaries. This model is also expected to improve the efficiency of irrigation in plots used by small-scale farmers along the Benoué river and on the outskirts of Garoua. Saving water with the use of a California-style pipeline improves irrigation productivity, which translates into increased production, income and irrigated areas: "more crop per drop".

In the Logone valley, groundwater resources are abundant and easily mobilized with low-cost techniques available locally. However, due to the limited investment capacities of small-scale farmers, small-scale irrigation is struggling to develop. The VIVA Logone project incorporates a matching grant financing mechanism in its design for small-scale irrigation equipment to be used in areas of less than one hectare.

The production of irrigated off-season vegetables is complementary to rice cultivation in the dry season on the SEMRY perimeter, which strengthens the resilience of small-scale farmers to drought and floods, which otherwise have negative impacts on agricultural productivity, food security, and poverty in the region.

The irrigable area for small-scale irrigation exceeds 4000 hectares in the immediate vicinity of the irrigated perimeter of Maga and Yagoua, and probably 20 times more in the entire Logone valley. This private initiative has high development potential and low investment cost, and provides a potential solution to the region's high and sustained population growth, and to the demand for agricultural products.

Annex 1. Mission Notes

The link below allows you to view the locations visited during the mission.

https://drive.google.com/open?id=1N8Jjge-rtSud3Is7p6mw7z_nge7vKjDU&usp=sharing

By clicking on a site (red pin) you will be able to view the field notes and the photos taken during the visit. You can also access it from the drop-down menus on the left.

Id	GPS	Field Notes
G1	9.29749, 13.425	Left Bank. Mr. Salé Mamoudou. 0.5ha, landowner according to customary law. 2 manual drilling diameters 50 & 63mm (2014), PVC evacuation, prof 7m, level stat 4m, price 33000CFA (25000CFA driller + 8000CFA pipes). Driller Mr. Abakar Oumarou tel 668074357. GMP petrol GX160 of 5.5HP, diam 75mm (3"), bought in Garoua, price 150,000 CFA, flow measured 14m ³ / h, emptying once / week, consumption 0.8 liters/h (+ / - 8 liters / day), fuel price 400CFA / liter. Flexible delivery hose diam 80mm (800 CFA/m) of 4 m for channel feeding in gravity soil and watering by basin. Irrigation frequency 2x / week (March-April) and 1x / week (Oct-Dec). 2 people for irrigation. Non-stop irrigation from 7h to 17h to irrigate 0.5h. Irrigated season: Tomato (Oct-Dec), onion (Sept-Dec), eggplant & vegetables (Oct-June), maize (April-June) Rainy season: Maize. Sale of products on the local market or in the fields, no marketing problem. Before manual drilling, there were no irrigated vegetable crops, only rain production. Equity investment, no technical support / supervision, private no GIC.
G2	9.2951, 13.42533	Left Bank. Manual drilling diameter 63mm, stat level 3.1m
G3	9.29551, 13.42409	Left Bank. Mr Sanda Aron 0.25ha, landowner according to customary law. 1 manual drilling diam 63mm (2019), PVC evacuation, prof 7m, Nstat 2,4m, price 18000CFA (10000CFA driller + 8000CFA pipes). GMP petrol 5,5CV, diam 75 mm (3 "), lifespan 3 to 5 years. Gravity irrigation by earth channel and basin. Irrigation frequency 1x / week. 4 hour irrigation for 0.25m ² . Okra irrigated season (Dec-April) & vegetables (Nov-April). Rice rainy season. Land ownership granted by the Lawan (customary authorities). Equity investment, no technical support / supervision, private no GIC.
G4	9.29059, 13.42383	Left Bank. Mr. Paul Djongo (seasonal worker). 0,75ha. 2 manual drilling diam 63mm, prof 7m, Nstat 2,5m. GMP petrol of 5hp, 75mm (3 "). Season irrigated 0.5ha onion and 0.25ha vegetables
G5	9.28947, 13.42471	Left Bank. Ms. Aaitou Martine. 0.5 ha farmer for 10 years, landowner according to customary law. 1 manual drilling diam 63mm (evacuation). GMP petrol 5CV, 75mm (3 "), price 70000CFA in Garoua, lifespan 5 years. Water transport by gravity channel in soil and gravity irrigation by basin (+/- 2m) Irrigated season: okra (0.25ha) & onion (0.25 ha). Irrigation frequency 1 to 2 times / week, 2 hours to irrigate 0.25 ha. Equity investment, no technical support / supervision, private no GIC.
G6	9.2878, 13.42455	Left Bank. Ms. Didja. 0.25 ha farmer for 4 years, landowner according to customary law. Before catching water from an earth sump and pumping out / watering by hand - 500m ² operated with watering every day. Today, 1 manual drilling diam 63mm (evacuation), price 28000CFA (15000CFA driller + 13000CFA pipes). GMP petrol 5CV, 75mm (3 "), price 60000CFA in Garoua, lifespan 2 years, 3 liters of fuel at 350CFA for 0.25ha, transport of the motor pump with motorbike. Flow test at pump outlet 15m ³ / h. Water transport by gravity channel in soil and gravity irrigation by basin (+/- 2m). Irrigation frequency 1 to 2 times / week, 3 hours to irrigate 0.125ha. Equity investment, no technical support / supervision, private no from GIC.

Id	GPS	Field Notes
G7	9.28722, 13.42473	Left Bank. Manual drilling diameter 63mm, stat level 2.6m
G8	9.35705, 13.48757	Right bank. Mr Koda David. 2ha available but 1.25ha irrigated, owner with land title. Pumping in a temporary tributary of the Bénoué which dries up in March. Manual drilling of 50 mm (2"), price 20000CFA, depth 6m, carried out in the bed of the watercourse and used when the surface water of the watercourse dries up. Discharge height of about 4 m up to in the garden. GMP 5CV, diam 75mm (3"). Water transport by gravity channel in soil and gravity irrigation by basin (+/- 2m). Irrigation 1X / week, 4 hours of pumping for 0.25ha. Fuel price 450 to 500 CFA. Equity investment, no technical support / supervision, private no GIC.
G9	9.35682, 13.48517	Right bank. Manual drilling diameter 63, stat level 2.5m, depth 18.4m.
G10	9.35237, 13.48311	Panoramic from the exposed area and view towards the flooded area below (difference of +/- 5 m)
G11	9.35142, 13.48251	Right bank in flooded area from June to Oct / Nov. Mr Adamou Sarki, 075 ha irrigated. Manual drilling PVC diam 50 to mm, driller Mr Dibi Diop in Pitoua. GMP petrol 5CV 75mm (3"), price 120,000 CFA, 4 liters of fuel for 0.25ha, petrol price 400 to 500 CFA / liter, lifespan at least 5 years. Water transport by gravity channel in soil and gravity irrigation per basin (+/- 2.5m). Irrigated season: onion 0.25ha (Dec to March), tomato 0.25ha (Dec to March), okra 0.25ha, leaf vegetable & eggplant (March to June) Irrigation 1x / week, from 7h to 12h for 0.25ha. Sale of 50 to 60 bags (+/- 60kg) of onions at the price of around 50,000CFA. Agricultural advice brought to input shops in Pitoua.
G12	9.35377, 13.48112	Right bank. Mr. Manou Fadanka. Manual drilling PVC diam 63mm, stat level 3,9m, depth (at least 10m because it could not be measured)
G13	9.35226, 13.4824	Right bank. Channel length in primary gravity land measured at 120, canal supply with motor pump from the tributary of the Bénoué.
M2	10.84103, 15.02648	Mr. Aboubakar Adigi M'Bamb (Tel 697966337), 1.5 ha, landowner according to customary law, predominantly clay soil. Manual drilling PVC diam 63mm, depth 22m (depending on producer), carried out 12 years ago, driller Mr Guilvidig in the locality of Pouss, manual drilling not widely used, price 250000CFA. Plot located on the edge of a drain that operates intermittently from January to April. GMP petrol 5,5CV, diam 75mm (3"), price 120000CFA, possibility to change only the motor and keep the pump part at the price of 70000CFA at a mechanic, GMP available in shops in Pouss, emptying after 4 days of pumping (0.5 liters of oil at 500CFA), flow rate measured at the pump outlet 16m ³ / h, fuel consumption from 3.5 to 5 liters / day at 500CFA / liter. Water transport by gravity channel in soil and gravity irrigation per basin (+/- 2.5m), price for a length of hose (4m) PVC drainage 63mm diameter 2500CFA Irrigated season: tomato 0.25ha (Oct-Jan), chilli 0.25ha (Oct- Jan), watermelon 1ha (Oct-Jan), watermelon 1.5ha (Jan-March) Rice in the rainy season with additional irrigation (April - Oct). Irrigation every 4 to 7 days depending on the season. ha from 7h to 16h.
M3	10.84778, 15.02572	Main drain
M4	10.84627, 15.02453	Mr. Issa Boubakar Minsing, 2ha but only 1ha irrigated, sandy clay soil, landowner according to customary law. Brick well diameter 0.7m, stat level 2.3m, depth 6.8m, price 110000CFA, no drying up of the well or drop in level. GMP petrol 5,5CV, diam 75mm (3"), price 75000CFA, bought in Pouss (origin Nigeria), lifespan 5 years, 2 liters of fuel (500CFA / liter) for irrigation of 0.25ha, price suction hose ringed diam 80mm 5000CFA / meter, price flat discharge pipe diam 80mm 3000CFA / meter, price PVC evacuation pipes 63mm 12000CFA (length 6 m), price evacuation pipe 50mm 6000CFA (length 6 m). Water transport by gravity channel in soil and gravity irrigation per basin (+/- 2.5m), irrigation 2 to 3 times / week.
M5	10.87674, 15.00269	Beginning of direct pumping in the primary canal to irrigate plots outside the irrigated perimeter.

Id	GPS	Field Notes
M6	10.87781, 15.00307	Mr. Haman Seni. 2ha and 1ha irrigated, sandy clay soil. Pumping from the primary channel with crossing of the track. GMP petrol 5,5CV, diam 75mm (3"), price 70000CFA but can reach 95000CFA, 6 liters of fuel / day (500CFA / liter) for irrigation of 0.25ha, drain 1x / week 0.5 liter (500CFA), lifespan of 2 years Transport of water by gravity channel in earth in embankments (more than 160 m in length) and gravity irrigation by large basin, irrigation of the same basin every 3 days, 1 day to irrigate 0.25ha, 3 days to irrigate 1 ha. Cassava cultivation irrigated Oct to April, 80 bags / ha, bag 25,000 to 30,000 CFA
M7	10.90041, 14.98901	Production area excluding rain rice paddy of 500 ha. Gravity feeding from the drain, the level of which is regulated (drain blocking) to feed the perimeter with upstream impact on the drainage of the plots of the SEMRY perimeter => impact on the harvest because the perimeters without locker have a different cultivation calendar with the locker. Additional irrigation from the irrigating channel (destruction of the rider and creation of a channel cutting the access track) when the water level in the drain is insufficient.
M8	10.88984, 14.95816	Manual irrigation for market gardening from the drain, the supply of which is not permanent. Irrigated production cycle against season January to May
Y1	10.34751, 15.28551	Dam cooperative, rice cultivation in the rainy season, 70ha. Channel for bringing water from an arm of the Logone with a regulating structure for the gravity supply of the primary canal financed by PULSI, including the secondary canal. Also pumping from the channel when the water level in the low water season is too low. The perimeter would also have several manual boreholes (information not verified)
Y2	10.34498, 15.2855	Mrs. Doumassa Marceline (widow with 8 dependent children), approximately 500m2 of irrigated land, an innodable area outside the dyke protection area. Landowner by customary law (land of his stepfather). Irrigation from a dead arm of the Logone feeding the perimeter of the Dam Dam cooperative, non-permanent water. Manual irrigation with bucket. More than 10 years of market gardening practice. Irrigation EVERY DAY, except Sunday, from 5 a.m. to 9 a.m. and 3 p.m. to 5 p.m. (7 hours). Irrigation season: start December / January, okra, eggplant tomato. Production over approximately 500m2: okra (2 bags X 8000CFA = 16000CFA), tomato (5 bowls X 2500CFA = 12500CFA), eggplant (3 bags X 6000CFA = 18000CFA). Charges: fertilizer (20000CFA), phytosanitary product (14000CFA). Family labor. Operator of rice plots on SEMRY perimeter (0.5 ha) + Dam Dam cooperative perimeter (0.5 ha). Also operates another irrigated plot for watermelon production (200000CFA turnover, approximately 100,000CFA charge) with rented motor pump 40000CFA / campaign, 3 liters of fuel / day, fuel price 600CFA / liter, irrigation 3 days / week. Collection of the cost of a motor pump 300,000CFA, ready to pay 100,000CFA for the purchase of a motor pump which would allow it to increase the surface of its garden up to 0.5ha.
Y3	10.39116, 15.2725	Ms. Firissou Kateyssou. Plot of +/- 700m2. 2 wall wells covered with branches on the submerged part, diameter 0.7m, depth 4.2m, static level 2.2m, temporary well rebuilt each year. Irrigation every day from 6 a.m. to 10 a.m. and 1 p.m. to 6 p.m. (9 a.m.). Irrigation season from September to February. Main crops: eggplant, okra, pepper, watermelon. Other small area crops: tomato, pepper, leaf vegetable. Products: eggplant (40 bags X 7000CFA = 280000CFA), okra (40 bags X 10000CFA = 400000CFA), other crops (watermelon 30000CFA + tomato 10000CFA + leaf vegetable 8500CFA). Charges: NPK (1 bag X 20000CFA = 20000CFA) + urea (3 bags X 18000CFA = 54000 CFA) + phytosanitary products (30000CFA) + seeds (4000CFA). Family labor. Rice plot on SEMRY perimeter (0.5 ha). Off-season market gardening provides daily subsistence and income for the family.
Y4	10.38739, 15.27217	2 wall wells covered with branches on the submerged part, diameter 0.7m, depth 4m, static level 2.4m, temporary well rebuilt every year
Y5	10.38728, 15.26915	Irrigant used as a source of water for additional irrigation for rain-fed rice by producers outside SEMRY perimeter located along the irrigating canal. Destruction of the irrigator's rider to supply the individual plots without locker, including deterioration of the track for the creation of a supply channel.

Y6	10.346164, 15.247688	Mr. Daniel Siama (Tel 694881993), private operator for manual drilling since 2005, trained in Chad, subcontractor of large companies for manual drilling, legalization process in progress or unfinished business. +/- 10 private manual drilling operators in Yagoua. Manual drilling for drinking water and irrigation, more important for drinking water, around 15 boreholes / year for irrigation, NGOs / municipalities are the main customers. Use of manual technique of manual rotary drilling (jetting) . The whole Logone valley is very favorable (wide alluvial valley), maximum water depth 4m. Cost of manual drilling of diameter 63 mm around 100,000CFA. Kit for manual drilling approximately 150000CFA supplied by two manufacturing workshops based in Maroua, including Mr. Amdou Elhadj.
Y7	10.4007549, 15.2510774	Mr. Djibrissou André (Tel 697377442) about 1 ha but only 0.5 ha irrigated, 7 years of market gardening irrigation. Manual drilling diameter 63mm, static level 3.3m, depth 8.4m, cost 62000CFA, manual drilling operator Mr. Janvier in Yagoua. GMP petrol diam 50mm (2"), 3CV, cost 85000CFA bought in Yagoua, 5 liters of fuel / day (550 to 650 CFA / liter), oil change 1X / week (0.5 liter X 900CFA), life span 2 to 3 years. Water transport by gravity channel in earth (embankments) and gravity irrigation by basin. Irrigation every 5 days from 6h to 18h. Okra irrigation season 0.5ha (Oct to Dec), onion 0.5ha (Rainy season millet (June to Sept.) Products: okra (40 bags X 10000CFA = 400000CFA), onion (20 bags X 25000CFA + 20 bags X 60000CFA = 1.7 million CFA). Charges: NPK (2 bag X 18000CFA = 32000CFA) + urea (1 bag X 18500CFA = 18500 CFA) + phytosanitary products (20 sachets X 1200CFA = 24000CFA). Family labor. Rice plot on SEMRY perimeter (1.5 ha). More profitable market gardening than the cultivation of irrigated rice => less production load.
Y8	10.344127, 15.230931	Mr Seydou Bouba (Tel 699728058), supplier of PVC pipes. PVC evacuation pipes 4 m (thickness 1mm) 2500CFA (dia50), 3000CFA (dia63), tee / elbow / plug 1000CFA (dia50), 1500CFA (dia63). PVC pressure hoses 6m 6000CFA (dia50), 12500CFA (dia63), tee / elbow 1000CFA (dia50), 2500CFA (dia63), union fitting 1500CFA (dia50), 7000CFA (dia63). Glue 5000CFA (1kg). Drilling pipes (blue) dia 110mm length 3m, 10500CFA (Nigeria), 8500CFA (chad), 9500CFA (Nigeria), full pipe or strainer same price.
Y9	10.34375, 15.23301	Mr. Aminou Toukour (Tel 695186160), motor pump supplier and also operator for manual drilling. GMP petrol 50mm (2") from 75000CFA to 100000CFA, 80mm (3") 85000CFA to 120000CFA => price variable according to quality. Motor pumps made in China from Nigeria. Supplier for more than 10 years. Corrugated suction hoses 2 "2500CFA / m, 3" 3500CFA / m. Flat discharge hose 2 "600CFA / m, 3" 800CFA / m. Annual sales volume of 50 GMP local customers but also from Chad. Main client project, gradual increase in sales volume over the years, 2 GMP suppliers in Yagoua. Company legalized for remission of manual drilling, mainly subcontracting large companies based in Yaoundé. Price of a 110mm drill (blue drill pipe) around 250000CFA. performs more than 100 manual drilling / year with the main client municipalities, projects and individuals. Confirmation of the feasibility of manual drilling in the Logone valley from Yagoua to Kousseri.