Functional Analysis of *Moringa oleifera* Lam. Agroforestry Systems in the Valleys of the Niger River and Goulbi of Maradi (Niger)

Rabo Younoussou[1*] ; Lawali Sitou[1] ; Morou Boubé[1] and Mahamane Ali [2]

[1]Dan DickoDankoulodo, University of Maradi
P.O Box 465 Maradi, Niger;

[2]University of Diffa
P.O Box 78 Diffa, Niger

[*]*Corresponding author's email: raboyounoussou [AT] gmail.com*

ABSTRACT--- ***The study was conducted in Niger in the valleys of the Niger River and Goulbi of Maradi. On these sites operators combine the vegetable cropsand M. oleifera forming true agroforestry systems with M. oleifera. The operation of these systems has never been a comprehensive study even though these systems provide most of the farmers' subsistence on these sites. Thus, this study aims to analyze agroforestry systems with M. oleifera of the NigerRiver valley and Goulbi of Maradi. The analysis concerned the management and productivity of these systems. A monitoring form was developed and introduced in the near operators. This regularly informed and allowed us to identify the vegetable crops associated with M. oleifera on each site. Thus, eight (8) vegetable crops were identified as associated with M. oleifera in the NigerRiver valley and five (5) in the Goulbi of Maradi. The study took into account only the fixed and extrinsic factors to the family and thereby outputs considered for these systems are fertilizer, fuel, seed and pesticides. Using these factors is done without respect scientific recommendations as operators are not trained or supervised. The inputs of these systems, both in the NigerRiver valleythan in the Goulbi of Maradi are the fresh leaves of Moringa oleifera and vegetable crops products that are associated with it. Indeed, the study showed that the systems that create most value are those that include cucumber, sorrel and eggplant in the Niger River valley and onion in Goulbi of Maradi. The average net income generated by agroforestry systems with M. oleifera are 3586314 ± 10544665FCFA / ha and 1357004 ± 1963429 FCFA / ha respectively in the Niger River valley and Goulbi of Maradi although these means are not statistically different (p = 0, 31).***

These results show the important role that these systems can play in securing and improving the living standards of farmers of sites and that they should be accompanied from production to marketing the products of these systems.

Keywords--- Functional analysis, agroforestry systems, *M. oleifera*, Vegetable crops.

1. INTRODUCTION

Niger is a sahelian country whose economic and social sustainable development is based on the revitalization of the primary sector. A landlocked country, it has a climate marked by low and erratic rainfall.

Furthermore, the continued deterioration of natural resources poses a threat to the livelihoods of the rural population[9]. However, the food and feed depend almost entirely on rain-fed agriculture. This food insecurity is particularly fragile, because of climatic conditions and high population pressure who make exercise overexploitation on exploitable land. Added to this is the lack of support to producers lack adequate structures for the promotion of cash crops policy.

Today the environmental protection and the fight for the preservation of biodiversity is an urgent need. Agroforestry was already practice in various forms in most regions, but its potential and its contribution to the economy, management of the environment is still largely untapped [3]. Indeed, the producers of the Sahel have developed land use strategies that integrate trees and shrubs in their farming systems. The most preferred and useful species are kept in association with crops.

In addition producers are planting trees to provide some food needs and generate income. This is the case for example of some producers in Niger who plant *Moringa oleifera* for its leaves used largely in the diets. Indeed, nutritional analysis showed that leaves of*Moringa oleifera* are rich in vitamins, minerals and protein than most vegetables [6]. They contain twice as much protein and calcium than milk, as much potassium as bananas, as much vitamin A than carrots, as much iron as beef or lentils and twice the vitamin C than orange.

Also, different parts of the plant such as leaves, roots, seeds, bark, fruits, flowers and immature pods act as cardiac and circulatory stimulants, possess antitumor, antipyretic, anti-epileptic, anti-inflammatory, anti-ulcer, antispasmodic, diuretic, antihypertensive, cholesterol lowering, antioxidant, antidiabetic, hepatoprotective, antibacterial and antifungal activities, and are used in the treatment of various diseases by the system of indigenous medicine, particularly in South Asia [4]. According [13] the reasons for the consumption of *M. oleifera* leaves fall broadly into three factors: food tradition of the household, the leaves organoleptic (taste), and nutritional benefits associated with them. Several authors like[16]. [13]and[14] showed how the interest is accorded by the people in the production of *M. oleifera* leaves.

Thus, the integration of *M. oleifera* in land use systems date from 1983 to 1984 years in the Niger River valley and more than fifty (50) years in the Goulbi of Maradi [18].

According [8] these sites are the main producing areas of *M. oleifera* leaves in Niger. Originally *M. oleifera* was introduced in orchards in Maradi before being introduced gradually into the shallows dedicated to the production of Maize and Sorghum [18]. By then it was integrated in the irrigated perimeter of Djirataoua bordering parcels to be associated with vegetable crops. In the Niger River valley, the *M. oleifera* has integrated cereals cropping systems and eventually supplanting them since its introduction in the area [18].

M. oleifera was especially introduced in the orchards of the Niger River valley considering its socio-economic importance. Today, both in the Niger River valley than in the Goulbi of Maradi, there has been an upsurge in land use systems integrating concomitantly or sequentially *M. oleifera* and crop vegetables, main activity of some operators. These systems are increasingly threatened. This is in order to remedy the problems that beset the lives of rural people who live from this activity that it is incumbent to this study to do a thorough analysis of management and productivity of these systems in order to offer improving tracks and help the decision support.

2. MATERIALS AND METHODS

➢ *Study Sites*

The study was conducted in Niger, two sites located respectively at the Niger River Valley in the region of Niamey and at the Goulbi of Maradi in the region of Maradi in south-east of the country. At each site, two villages were selected on the basis of the representativeness of agroforestry systems of *Moringa oleifera*. The villages of Saguia and Saga Fondo in the Niger River valley and villages of Djirataoua and Tibiri in Goulbi of Maradi were selected (Figure 1)

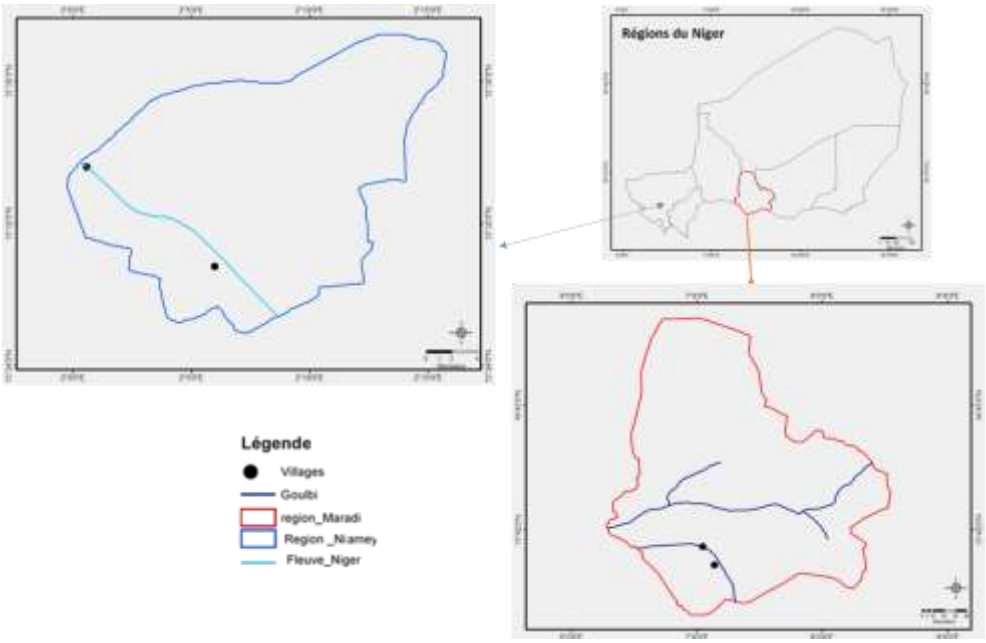

Figure 1: Location of study sites

➢ *Sampling*

The villages were selected in the base of following criteria: existence of gardener site, practice of association*Moringa oleifera*and vegetable crops, long experience of farmers in agroforestry. Note also that the two sites differ in the nature of rivers: the Goulbi of Maradi is a valley that is active only during the rainy season and the Niger River which is a perennial stream. On these sites practice vegetable crops and production of *Moringa oleifera* that lasts all year.

- ***Data collection***

Data were collected through surveys and monitoring of farms. At each site, an exploratory study was conducted to determine the different agroforestry systems of *M. oleifera*. Note that the analysis of the management of an agroforestry system returns to assess the patterns of use of inputs and outputs including labor, land, work equipment, seeds, pesticides, fuel and fertilizers (organic and inorganic). Also the study was interested in assessing the technical productivity which includes the yield of *Moringa oleifera*fresh leaves and products of vegetable crops associated. Finally, an economic evaluation was carried out taking into account the production costs. This assessment highlights economic performance indicators [9] including the ratio benefit / cost (B / C ratio), net income (Revnet) and the internal rate of return (IRR) [15]. Thus, net income (Revnet) and ratio benefit/cost (B / C ratio) were used as economic criteria to study the profitability of systems [19] and[11]. In this study, only the net income was retained as economic evaluation criterion.

- ***Data Analysis***

The information collected was codified with the IBM SPSS Statistics Version 20 and then processed with statistical software Excel and Minitab. Since the data do not follow the normal distribution, the nonparametric Kruskal-Wallis test was used for comparison of means. When data is expressed as a percentage, the comparison is made by the chi-square test of Pearson. In all cases of comparison a value of $p < 0.05$ was considered statistically significant.

3. RESULTS

- ***M. oleifera cropping systems***

The results of this study allowed us to identify the inputs and outputs of agroforestry systems of*M. oleifera*. To carry out this study, we had to first develop a typology of agroforestry systems incorporating *M. oleifera*. On the study sites, there are three (3) types of systems incorporating the *M. oleifera*.

The system of pure culture of *Moringa oleifera*, which is a model of intensification of *Moringa oleifera*leaves production. This system met both in the river valley than in the Goulbi Maradi with distances varying from 0.7mx0.7m to 1m x 1m.

The intercropping system where the *M. oleifera* is associated with fruit trees (photo 1) is the most ancient practice but very little seen nowadays on the sites studied.

Cropping systems combining the *M. oleifera* vegetable crops (photo 2). Here, the *M. oleifera* covers almost the entire operation. These systems considering many benefits that theygive to operators undergo an increasingly extension more growing. Combined with vegetables *M. oleifera*benefits with treatments (irrigation, fertilizers, tillage) and pest treatment provided to crops. On both sites *M. oleifera* has cut health and improvement for the sole purpose of improving production in leaf biomass. It is these systems that were the subject of our study.

Photo 1: *M. oleifera* associated with fruit trees

Photo 2: *M. oleifera* associated with lettuce

- ***Establishment of Moringa oleifera plantation***

The establishment of *M. oleifera* plantation requires preliminary worksystematically clearing land often followed by plowing. In the valley of the Niger River as in the Goulbi of Maradi, depressions soils are most coveted by operators; rarely dune soils are used. Sowing is done in the dry season because according to the surveyed farmers in the rainy season there is a risk of suffocation seedlings or rotting of grains sown by waterlogging. The establishment of culture is by direct seeding in two (2) to three (3) seeds per hill and to a depth of about two centimeters. Germination is effective over a period of ten to fourteen days.

- ***Density of M. oleifera plants on sites***

At both sites, the *M. oleifera* tree density is highly variable. These densities are only 500 to 10,000 plants / ha in the Niger River valley as they can go from 10,000 to 90,000 plants / ha in Goulbi Maradi (Table 1). Average densities are 54583 ± 32701 plants / ha and 5450 ± 3445 plants / ha respectively in Goulbi Maradi and the river valley. The difference between the average density is significant ($p < 0.0001$)

Table 1: Densities of *Moringa oleifera* on sites

Operating sites	Densities of *M. oleifera*/ha								Total
	500	2500	5000	10000	40000	60000	80000	90000	
Niger River valley	15	15	40	30	0	0	0	0	100
Goulbi of Maradi	0	0	0	25	25	4	17	29	100

- ***The Vegetable crops associated with M. oleifera***

In the NigerRiver valley eight vegetable crops have been listed as cultures associated with *M. oleifera* while in the Maradi of Goulbi only five vegetable crops have been identified. The results show that the most dominant crop in the Goulbi Maradi is tomato with a proportion of 50% followed by lettuce (23%) while in the Niger River valley eggplant dominates crops with 24% followed by sorrel, tomato and onion in equal proportion of 16% (Table 2).

Table 3 shows the average of densities of the vegetable crop associated with *M. oleifera*. It appears from these results that cultures are conducted with widely varying densities. Tomato for example is conducted at densities of 6 ± 3 plants / m² and 11 ± 3 plants / m² respectively in the Niger River valley and Goulbi Maradi. The Kruskal-Wallis test shows that these averages are significantly different ($p = 0.01$). As against the average densities of chili in the valleys of the Niger River and Goulbi of Maradi were not significantly different ($p = 0.65$). It is the same with average densities of onion ($p = 0.19$)

Table 2: Representativeness (%) of vegetablecrops associated with *M. oleifera*

Scientifics names	Names in English	Representativitie s (%) Niger River valley	Representativities (%) Goulbi of Maradi
*Lycopersiconlycopersicum*L.	Tomato	16	50
Solanummelongena	eggplant	24	0
*Brassica oleracea*L.	Cabbage	13	0
Cucurbitamoschata	Squash	11	0
*Allium cepa*Lin	Onion	16	23
Capsicum annuum	Chili pepper	2	12
*Cucumissativus*Lin.	Cuncumber	2	0
Hibiscus sabdariffa	Sorrel	16	0
ZeaMays L	Maize	0	4
Lactuvasativa	Lettuce	0	11
Total		100%	100%

Table 3: average densities of vegetable crops associated with *M. oleifera* in agroforestry systems of sites

Niger River valley		Goulbi of Maradi	
Vegetable crops associatedwith*M. oleifera*	Densities (numberof plants/m²)	Vegetable crops associatedwith*M. oleifera*	Densities (number of plants/m²)
Tomato	6 ± 3	Tomato	11 ± 3
Chili pepper	8 ± 0	Chili pepper	10 ± 6
Onion	40 ± 5	Onion	45 ± 5
Eggplant	4 ±1	Lettuce	21 ± 12
Cabbage	8 ± 3	Maize	4 ± 0
Sorrel	127 ± 12		
Squash	4 ± 0		
Cuncumber	2 ± 0		

- ***Fertilization***

Operators provide mineral fertilizer mainly NPK (15-15-15) and urea and organic manure to optimize production. The application of mineral and organic fertilizer is made on entire plot area to benefit all associated components. The frequency of intake of mineral fertilizers (urea and NPK) is given in Figure 2. From this figure 50% of farmers provide mineral fertilizer to *M. oleifera*agroforestry systems at least once two weeks in Niger River valley while in the Maradi of Goulbi 71% of operators bring mineral fertilizer once by month. Figure 3 gives the proportions of the amounts of fertilizer per hectare brought in agroforestrysystems based on *M. oleifera* in the Niger River valley and in the Goulbi of Maradi. From this figure, 10% of farmers in the river valley do not apply mineral fertilizer to these systems and 35% provide an amount between 200 and 300 kg / ha. In sum 50% of the operators of the Niger River valley bring at least 200 kg of fertilizer / ha. In the Goulbi of Maradi all operators use mineral fertilizers. The minimum amount of fertilizer applied per hectare is 50kg. On this site more than 50% of operators use an amount between 50 and 150 kg / ha and 40% apply amounts between 150 and 300 Kg / ha.

The average amounts of fertilizer are $172{,}55 \pm 147{,}84$ kg/ha and $156{,}25 \pm 76$ kg/harespectively in the Niger River valley and in the Goulbi of Maradi. The Kruskal-Wallis nonparametric test shows that these means are not significantly different ($p = 0, 95$).

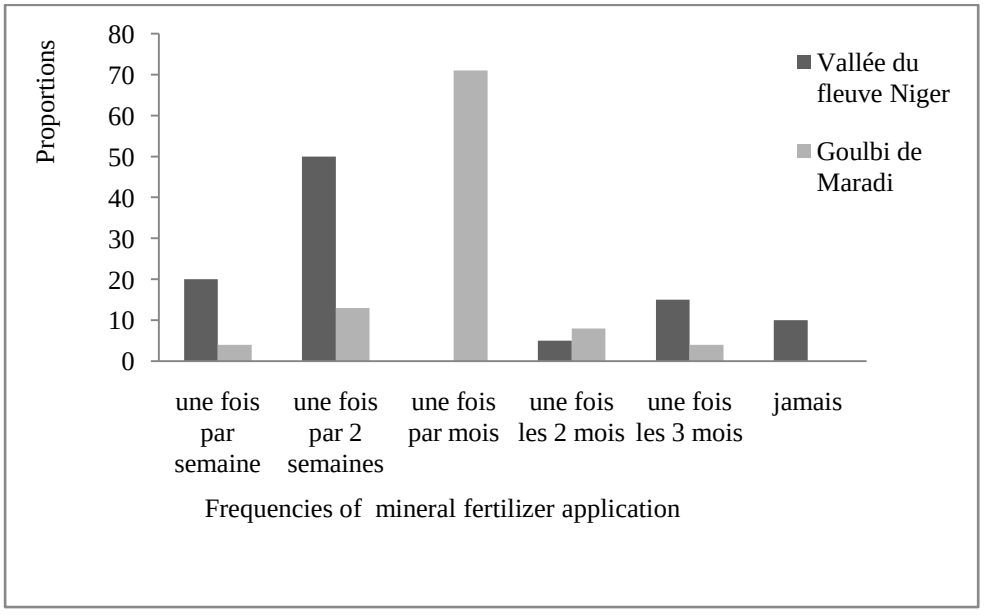

Figure 2: Proportion of contributions frequencies in mineral fertilizers on the sites of study

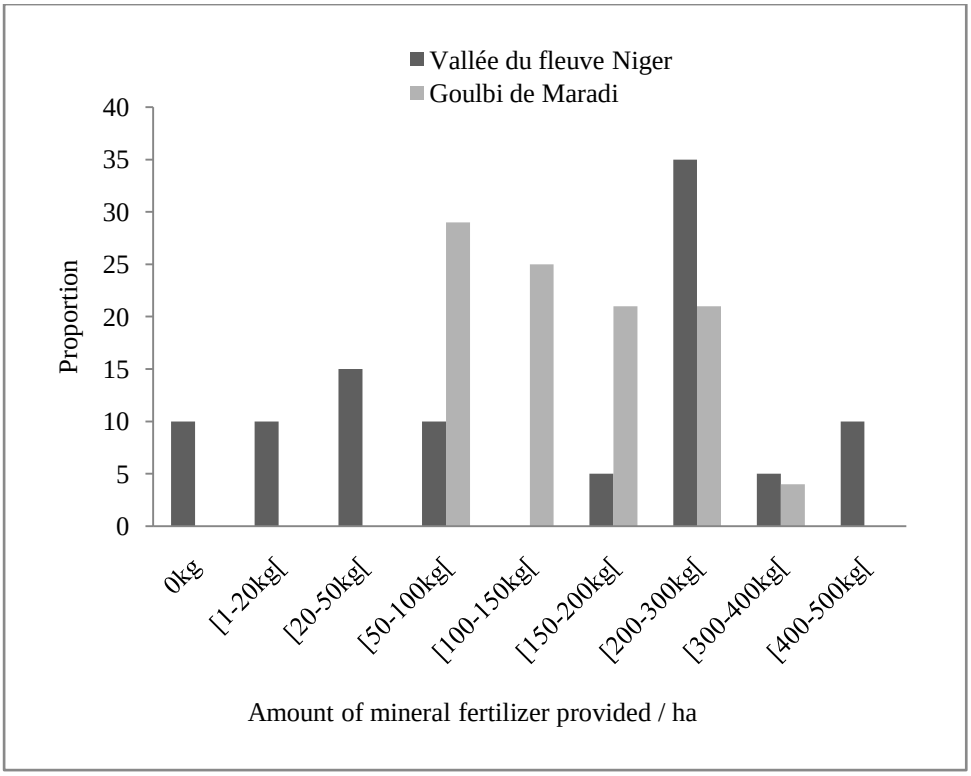

Figure 3: Proportion of mineral fertilizers amounts provided to one ha of agroforestry systems with *M. oleifera* on study sites

- ***Pesticides use***

To fight against insects larvae that are the main enemies of *Moringa oleifera* and vegetable crops associated with it, farmers use pesticides. Phytosanitary treatment frequency is given in Figure 4. From this figure 95% of farmers in the Niger River Valley and 88% in the Goulbi ofMaradi treat the *Moringa oleifera* at least once a week.

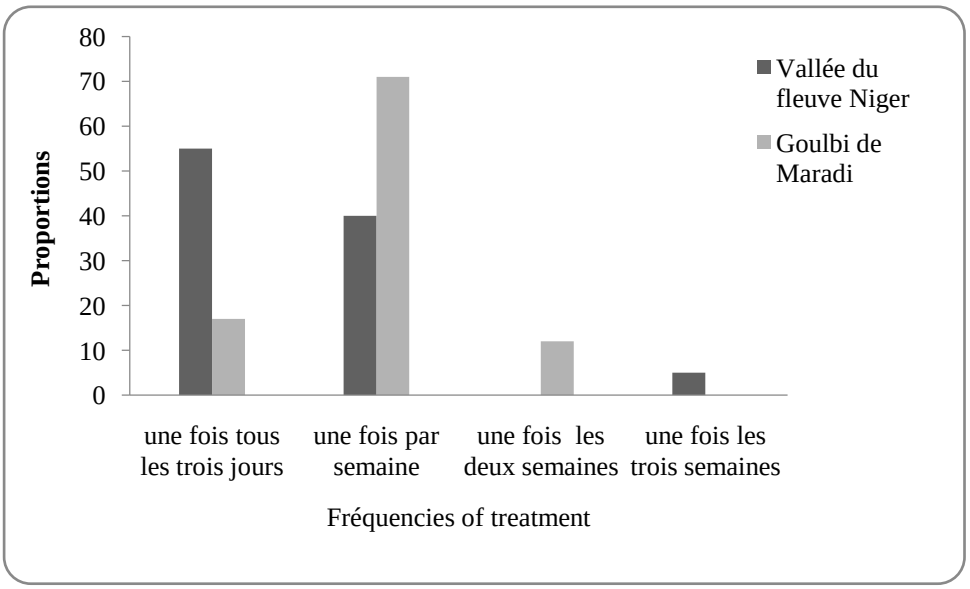

Figure 4: Proportion of quarantine treatment frequencies on the study sites

- ***Coupe of M. oleifera plants***

The coppice is an agroforestry technique that involves cutting trees and shrubs to a height depending on the intended purpose. On the study sites farmers say they have not a fixed level for cut but it should be uniform throughout the plot that is that all subjects are cut at the same level as shown in photo 3.

Photo 3: Coupe of *M. oleifera* plants

Figure 5 shows the proportions of operators performing the cutting levels on the plants of *M. oleifera*. The analysis of this figure points out that the proportion of farmers who have practiced cutting the plants of *M. oleifera* are 60% and 58% respectively in the Niger River valley and the Goulbi of Maradi (Figure 5). Pearson chi-square test shows that these proportions are not significantly different (p = 0.77). Moreover, in the Niger River valley 25% of operators apply the cut between 0 and 20 cm from the ground and 35% apply the cut from 20 to 50 cm from the ground. This means that on this site the cutting level hardly exceeds 50 cm from the ground.

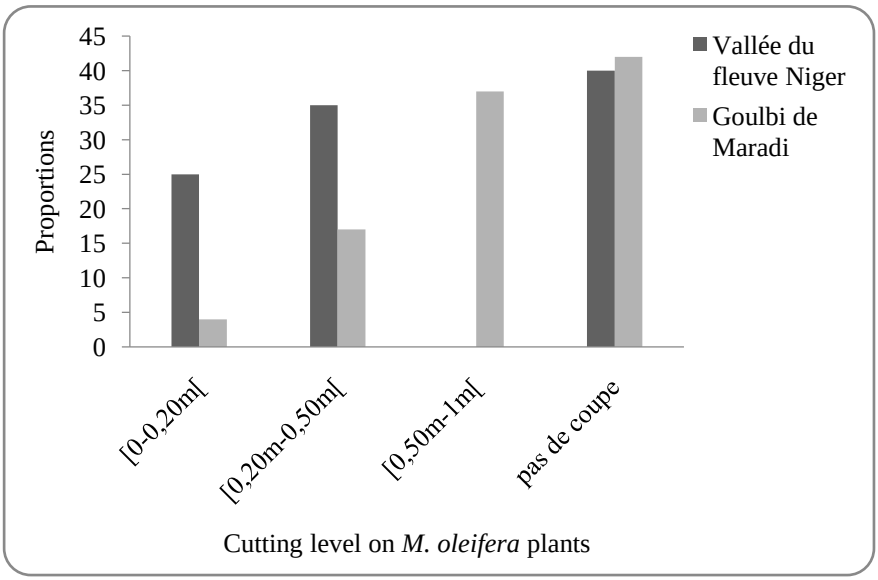

Figure 5: Proportion of cutting levels on *M. oleifera* plants

- ***The costs of farm inputs***

The analysis shows that expenditures in the purchase of fertilizers amounted on average to 153,143 ± 314,832 FCFA / ha and 45463 ± 40046 FCFA / ha respectively in the NigerRiver valley and in the Goulbi of Maradi (Table 4). The nonparametric Kruskal-Wallis shows that these averages are no significantly different (p = 0.70).

Average spending on the purchase of pesticides caused by systems including vegetable crops and *M. oleifera* are reported in Table 5. The systems which entail more expenses in the purchase of pesticides are those that include eggplant in Niger River valley and onion in Goulbi of Maradi.

Average spending on the purchase of plant protection products (Table 5) are 51486 ± 155 358 FCFA / ha and 22524 ± 17026 FCFA / ha respectively in the Niger River valley and Goulbi Maradi. These averages are significantly different (p = 0.57).

It appears from this study that the motorized irrigation is the main water supply operation of the plots. Thus, the average spending for the purchase of fuel for an average amount of 394,926 ± 1119181FCFA / ha and 78205 ± 37830 FCFA / ha respectively in the river valley and the Goulbi Maradi. In summary, the average expense amounted to ± 2075464 5919261 FCFA / ha and 395,590 ± 156,572 FCFA / ha respectively in the Niger River valley and Goulbi of Maradi. These averages are statistically different (p = 0.038).

Table 4:Average costs of production factors in FCFA / ha on the study sites

	Fertilizers	Fuel	pesticides	Seeds
Niger River valley	153143 ± 314832	394926 ± 1119181	51486 ± 155358	1475909 ± 5192457
Goulbi of Maradi	45463 ± 40046	78205 ± 37830	22524 ± 17026	249398 ± 79176

Table 5: Average costs of factors of production per crop per hectare on the study sites

Crop vegetables assoiated with *M. oleifera*	Fertilizers		Fuel		Pesticides		Seeds	
	Niger River valley	Goulbi of Maradi	Niger River valley	Goulbi of Maradi	Niger River valley e	Goulbi of Maradi	Niger River valley	Goulbi of Maradi
Eggplant	347122 ± 577359	-	202264 ± 175107	-	127500 ± 308990	-	3924749 ± 10203619	-
Cabbage	56700 ± 79672	-	131307 ± 104469	-	10000 ± 8165	-	250007 ± 136586	-
Cuncumber	81000 ± 0	-	240000 ± 0	-	80000 ± 0	-	441000 ± 0	-
Squash	252063 ± 153786	-	314550 ± 86777	-	65625 ± 42543	-	644529 ± 260254	-
Onion	128738 ± 185732	101333 ± 47089	1352990 ± 2741018	131778 ± 71200	65625 ± 42543	50000 ± 16667	1739189 ± 3306421	388667 ± 101832
Sorrel	11417 ± 13396	-	134167 ± 145265	-	7083 ± 6987	-	172250 ± 155880	-
Chili pepper	150000 ± 0	27917 ± 11342	270000 ± 0	50889 ± 13989	50000 ± 0	23889 ± 21495	490000	194917 ± 35941
Tomato	35700 ± 48119	40967 ± 38724	288840 ± 312595	78359 ± 29510	34500 ± 44875	17083 ± 12829	611620 ± 707879	253333 ± 51954
Lettuce	-	41746 ± 33470	-	65278 ± 24231	-	22083 ± 13882	-	203274 ± 63436
Maize	-	11250 ± 0	-	75000 ± 0	-	9375 ± 0	-	220625 ± 0

Note that the technical productivity of agroforestry systems *M. oleifera* in the Niger River valley and Goulbi of Maradi is assessed by measuring in the*M. oleifera* leaves biomass yields and products of intercropping.

Thus, the average production of fresh leaves is 1925 ± 3190 kg / ha and 5594 ± 3605 kg / ha respectively in the NigerRiver valley and Goulbi of Maradi. The Kruskal-Wallis test shows that the average of fresh leaves of *Moringa oleifera* is more important in the Goulbi Maradi (p = 0.01). The average production in fresh leaves of Mo*ringa oleifera* varies by cropping in valleys of Goulbi of Maradi and Niger River.

The average yield of onion is 17127 ± 27771 kg / ha and 13417 ± 13553kg / ha respectively in the Niger River valley and Goulbi of Maradi. These averages are not significantly different (p = 0.74) at the 5% threshold. Also, average yields of tomato 2782 ± 3691 kg / ha and 2164 ± 4061 kg / ha respectively in the river valley and Goulbi Maradi are not significantly different (p = 0, 65). It is the same with the average yields of Chili pepper (p = 0.18).

- ***Analysis of revenue and profitability of M. oleifera agroforestry system***

The financial analysis of agroforestry systems show that the system including the onion in *M. oleifera*agroforestry systems has the best productivity in the Niger River valley and those system including lettuce in Goulbi of Maradi. The associations that provide on average less revenue from the sale of fresh leaves of *Moringa oleifera* are associations *M. oleifera* / Chili pepper in the Niger River valley and *M. oleifera* / maize in Goulbi of Maradi. Average revenue generated by the sale of fresh leaves of *Moringa oleifera* by *M. oleifera*agroforestry systems are 442,966 ± 367,361 FCFA / ha and 577,159 ± 270,171 FCFA / ha respectively in the Niger River valley and Goulbi of Maradi. However, systems of the Niger River valley do not generate more revenue than those of Goulbi of Maradi (p = 0.09).

Table 6: Technical and financial productivities of agroforestry systems based on M. oleifera sites

Crop vegetables associated	**average technical productivity (kg/ha)**				**average financial productivity (FCFA/ha)**			
	Cultures		*M. oleifera*		Cultures		*M. oleifera*	
	Niger River valley	Goulbi of Maradi	Niger River valley	Goulbi of Maradi	Niger River valley	Goulbi of Maradi	Niger River valley	Goulbi of Maradi
Eggplant	18700 ± 28238	-	4668 ± 4947	-	9456111 ± 11167000	-	490972 ± 363103	-
Cabbage	14933 ± 13160	-	3758 ± 2917	-	2310000 ± 1966723	-	452067 ± 332383	-
Cuncumber	2000 ± 0	-	5060,0 ± 0	-	10941667 ± 0	-	790000 ±	-
Squash	8610 ± 2964	-	2090 ± 1980	-	1057083 ± 368029	-	188750 ± 229724	-
Onion	17127 ± 27771	13417 ± 13553	12559 ± 10561	6987 ± 1755	2580000 ± 1150722	4222222 ± 4264757	656167 ± 469762	666667 ±122202
Sarrel	4444 ± 5343	-	5744 ± 5958	-	10327778 ± 11486817	-	553056 ± 379635	-
Chili pepper	750,00 ± 0	2740 ± 1377	1100,0 ± 0	5280 ± 3352	456250 ± 0	921528 ± 568014	155000 ± 0	496000 ± 283069
Tomato	2782 ± 3691	2164 ± 4061	6380 ± 7169	4049 1774	673625 ± 674734	3145574 ± 131053	151067 ± 176701	470128 ±222780
Lettuce	-	23243 ± 18030	-	8969 ± 3015	-	1801563 1410354	-	804722 ± 327320
Maize	-	1250,0 ± 0	-	3712,5 ± 0	-	231250 ± 0	-	578125± 0

The revenue mobilized by ha, by selling the production of vegetable crops is 5218812 ±8013815 FCFA / ha and 1175436 ± 1877158 FCFA / ha respectively in the Niger River valley and Goulbi of Maradi. The systems of the NigerRiver valley on average provide more income for producers in the river valley as the Goulbi Maradi ($p < 0.01$). Analysis of Table 6 shows that systems including cucumber in the Niger River valley and onion in Goulbi Maradi are in averagethe most productives.

Average revenue generated by the systems are 56617178± 8183431 FCFA / ha and 1752595 ± 156572 FCFA / ha respectively in the Niger River valley and Goulbi of Maradi. The systems of the Niger River valley generate more revenue than those of Goulbi of Maradi ($p = 0.003$). Average revenue generated by *M. oleifera* agroforestry systems are illustrated in Table 7. The analysis of this table shows that the most productive systems on average are those that include cucumber in the river valley and the Goulbi onion in Maradi. As against systems that include chili pepper in the Niger River valley than those including tomato in Goulbi of Maradi are less profitable on average.

Table 7: Average revenue generated in FCFA / ha by agroforestry systems M. oleifera based on intercropping

Vegetable crops associated	Niger River valley	Goulbi of Maradi
Eggplant	9947083 ± 11326813	-
Cabbage	2762067 ± 1683739	-
Cuncumber	11731667 ± 0	-
Squash	1245833 ± 350369	-
Onion	3236167 ± 1475069	4888889 ± 4156116
Sorrel	10880833 ± 11803297	-
Chili pepper	611250 ± 0	1417528 ± 781581
Tomato	824692 ± 694273	784702 ± 302630
Lettuce	-	2606285 ± 1450479
Maize	-	809375 ±0

In summary, the economic evaluation of net income shows that the profitability of the system is also linked to the vegetable crops associated with *M. oleifera*(Table 8). The analysis of this table shows that among the eight (8) vegetable crops of the valley of the Niger river alone systems that include eggplant, cucumber and Guinea sorrel have positive net income while in the Goulbi of Maradi all systems have positive net income.

Systems that generate most value are those that include cucumber, sorrel and eggplant in the Niger River valley and onion in Goulbi Maradi. Average revenue generated by *M. oleifera*agroforestry systems are3586314 ± 10544665 FCFA / ha and 1357004 ± 1963429 FCFA / ha respectively in the valleys of the Niger River and Goulbi of Maradi although these means are not statistically different ($p = 0, 31$).

Table 8: Average net income in FCFA / ha of agroforestry systems of *M. oleifera* in the valleys of the Niger River and Goulbi of Maradi

Vegetable crops associated	Niger River valley	Goulbi of Maradi
Eggplant	9224668 ± 11023989	-
Cabbage	-935168 ± 6479622	-
Cuncumber	10648667 ± 0	-
Squash	628146 ± 770941	-
Onion	-3387828 ± 14153924	4591278 ± 4192172
Sorrel	10532695 ± 11938272	
Chili pepper	-953150 ± 0	1087350 ± 599392
Tomato	-145968 ± 668542	394960 ± 272307
Lettuce	-	2106021 ±1539138
Maize	-	475625 ± 0

4. DISCUSSION

- ***Types of systems incorporating the M. oleifera***

The existence of three cultivation methods of *M. oleifera* is consecutive to the aspirations of operators. Indeed, some farmers say they never associate the *M. oleifera* to vegetable crops because for them, *M. oleifera* is sufficient in itself to support the operation and the social problems that they face.

Indeed, those who practice the association think making efficient space management stating win twice during the period of association. Revenues of the association are the fresh leaves of *Moringa oleifera* and products of vegetable crops. Moreover, the two study sites, farms planted with fruit trees have reached a level that theycannotbe destroyespecially to make *M. oleifera* almost they are also profitable. That is why we meet this form of association of *M. oleifera* and fruit trees. Similar results were reported by [7]. This author said that systems of planting and cultivationof *M. oleifera*are varied from intercropping associated to intensive industrial production,from semi-direct to cuttings. [8]distinguished four incorporating of*M. oleifera* cultivation systems in agrarian systems: pure plantations of *Moringa oleifera* (monoculture), *M. oleifera* in association with fruit trees in orchards, *M. oleifera* as hedge long live the sites against last season and *M. oleifera* associated with winter or vegetable crops.

- ***Management of M. oleifera agroforestry systems***

Farms of the Niger River valley are ten times less dense in plants of *M. oleifera*than those of Goulbi Maradi. Because some operators of the river valley associate with *M. oleifera* crops such as squash, eggplant and cabbage that are more demanding in space. Thus, the very high differentials between the densities of *M. oleifera* plants may be due to the nature of the associated crops. A study in the Niger River valley conductedby [17] found a density of *M. oleifera* 7000 plants / ha in monoculture and 5000 plants / ha in intercropping. These results confirm those of the study. However, the same author recommended densities of 2500 plants of *M. oleifera* / ha in intercropping [18].

Moreover, the results showed that only operators of the Niger River valley have brought organic manure to *M. oleifera*agroforestry systems. Even here it is mainly crops such as onion and eggplant, and to a lesser extent the cabbage, squash and tomatoes are those that receive the most organic manure. Hence the rate of 60% observed in the results section. This is also justified by the standard deviation, which far exceeds the average amount of the organic material used. In terms of use of mineral fertilizers, the study showed that there was no significant difference between the two valleys. Indeed, all systems receive mineral fertilizer both in the Niger River valley in than in Goulbiof Maradi. The use of mineral fertilizers is a phenomenon that is gaining momentum in the plant production systems and most often in disregard of the recommendations of the relevant services. The amount of fertilizer used far exceed or do not reach the prescribed doses but no application deadlines or the nature of fertilizer are not respected even as these cultures are associated with *M. oleifera*. It is recommended for example 60kg of nitrogen (N), 75kg Phosphorus (P) and 85kg of Potassium (K) in a hectare of onion planting in 45kg and 50kg Nitrogen and Potassium in bulb-formation is 315kg / ha. This phase shift between fertilizer rates used by operators of the two sites and those prescribed could be due to lack of financial resources but also technical support.

On another level, densities of crops associated with*M. oleifera* are not regulatory. Tomato for example, in monoculture, must have a density of 20000-35000 plants / ha. In this study average densities of 6 plants / m² or 60000plants / ha and 11 plants / m² or 110,000 plants / ha respectively in the Niger River valley and Goulbi Maradi were obtained. Yet we can easily notice that the recommended density for the tomato is multiplied by two (2) in the Niger River valley and four (4) in the Goulbi of Maradi. But here the tomato is associated with *M. oleifera*, something that would help make it less dense.

M. oleifera as some crops have many pests. Their production requires therefore phytosanitary treatment. Only plant protection products as well as the doses are generally left to the discretion of the operator. It is not rare to see an operator use an insecticide to treat fungus or mites. The results of the study showed that all farmers use pesticides with very high processing frequencies in the Niger River valley. Yet the recommended frequency for products used is usually once a week.

Before the establishment of intercropping, farmers conduct a plant cutting of *M. oleifera*. This cut has a double advantage. First, it is primarily for sanitary allowing the operator to rid the plants of certain diseases. As a result, it allows not only to obtain improved yields in fresh leaves, but also a system of intercropping. It should however be noted that even if there's clearcuts they intervene after the rainy season it to avoid the cut plants are not subject to clogging during regeneration, clogging that can cause rotting of plants and consequently their death . After size, only one month is required before harvesting again. The resulting rods Size operations are used as fences or plantations is used as construction material or enclosure houses or animals.

- ***productivity of agroforestry systems of M. oleifera in the valleys of the Niger river and Goulbi of Maradi***

The average yield of fresh leaves of *Moringa oleifera* is more important in the Goulbi of Maradi. This could be due to the high density of plants of *M. oleifera* on this site over the Niger River valley. Yet even here the production is lower than expected. Indeed, cohabitation tree / crops can have negative effects on at least two components. Which could significantly reduce the yield of fresh leaves of *Moringa oleifera*. Furthermore, the use of inappropriate pesticides to treat pests *M. oleifera* is ineffective and does not allow for improved yields. Using non mastered and insufficient amounts of the mineral and organic manure does not allow higher yields in fresh leaves of *Moringa oleifera*. Moreover the production of *M. oleifera*is optimal during the winter season while the study was conducted in the dry season.

The average yields of vegetable crops associated with *M. oleifera* are not statistically different between the two valleys but still remain below the amounts prescribed by the literature. This level of production is due to non-compliance with requirements of crops. Indeed, operators provide quantities of fertilizers that cannot satisfy it remains that culture. However, crops being associated with the *M. oleifera*, needs of agroforestry systems must take into account the requirements of both components to achieve optimal performance for each. This loss of performance is not attributable to *M. oleifera* because according [17] young deciduous trees typically cause a loss of crop productivity negligible, their impact can even be beneficial in some cases. Another factor contributing to lower yields of some crops is their high densities. A study by [20] showed that the combination of the layout and spacing the plants of *M. oleifera* had no effect on the yield of cabbage.

- ***ProfitabilityofM. oleifera agroforestry systems on the study sites***

The systems of Goulbi of Maradi have been individually more profitable than those of the Niger River valley. This is explained partly by the fact that operators of Goulbi are spending less compared to those of the Niger River valley. Yet the production is not the best because there is no statistically significant difference between average yields of crops and fresh leaves of *Moringa oleifera*. Another parameter that may help explaining the gap between the profitability of the Niger River valley and that of Goulbi of Maradi is the price of products on the market. Indeed, the operators of the Niger River valley sell their products on the markets of the city of Niamey. During this period the products of vegetable crops are so abundant in the markets that their prices are the lowest of the year. These data are somewhat questionable because due to their novelty, there is little data on the actual profitability of intercropping systems. Nevertheless it is clear from various economic studies (including using simulations) that intercropping systems compare favorably with monocultures and conventional plantations (Graves et al., 2007).

The most profitable Niger River valley systems are those that include sorrel, eggplant, squash and cucumber. Indeed, the operators of the river valley are spending less in systems that include sorrel and onions. As for systems that include eggplant, they hold their profitability eggplant is a culture whose harvest is several months. Indeed Rivest et al. (2010) argue that the choice of intercropping, however, has a large influence on the profitability of intercropping systems.

5. CONCLUSION

Functional analysis of*M. oleifera*agroforestry systems revealed that these systems include eight (8) and five (5) vegetables respectively in the Niger River valley and the Goulbi of Maradi. The study showed that the inputs of these systems are fertilizer, fuel, seed and pesticides and their outputs consist of the fresh leaves of *Moringa oleifera*and products of crops that are associated with it. Moreover, neither the quantities of inputs, nor their method of application are respected by operators. This has consequences for low yields unsatisfactory profitability of these systems. However all of systems of Goulbi of Maradi have proven profitable in contrast to those of the Niger River valley where only systems including sorrel, squash, eggplant and cucumber were profitable. For the sustainability of these systems must be put in place structures that will support the training and technical support operators. It also there's place to choose the most profitable vegetables for these systems.

6. BIBLIOGRAPHIE

[1] ANAFE-RAFT Sahel, 2006. Manuel d'agroforesterie à l'intention des établissements supérieurs du sahel. Bamako-Mali 70p.
[2] Clarke,W. et Thaman.R. 1993. Agroforestery in the pacific Islands: systems for sustainability. United Nations Universitypress, Tokyo: 54p.
[3] De Baets N., Gariépy S. et Vézina A., 2007. Le portrait de l'agroforestérie au Quebec, le centre d'expertise sur les produits agroforesriers, Canada., 15p.
[4] Farooq A., Sajid L., Muhammad A. and Anwarul H. G., 2006. *Moringa oleifera*: A Food Plant with Multiple Medicinal Uses.*Wiley InterScience*21 : 17–25
[5] Foidl N., Makkar H.P.S. et Becker K., 2001. Potentiel de Moringa oleifera en agricultureet dans l'industrie. Actes du séminaire sur *Moringa oleifera* du 29 octobre au 2 novembre2001, Dar es Salaam, Tanzanie. 57 p.
[6] Fuglie L.J**.,** 2002. The Tree of Life, Dakar, Senegal, Western Africa: Church World services, pp 40-60

[7] Gamatié M., 2006. Feuilles de Moringa et autres végétaux à forts potentiel nutritionnel: stratégies, normes et marchés pour un meilleur impact sur la nutrition en Afrique. Atelier international Accra, Ghana. 10p.

[8] Gamatié M. et Saint Sauveur (de) A., 2005. Fiche technico-économique sur les conditions de production et commercialisation de feuilles fraîches de Moringa au NIGER. CTA. 7p.

[9] Godsey L. D., 2000. Economie budgeting for agroforestry practics. Agroforestry in Action. University of Missouri Center for Agroforestry 3:1-9

[10] Graves, A.R., Burgess, P.J., Palma, J.H.N., Herzog, F., Moreno, G., Bertomeu, M., Dupraz, C., Liagre, F., Keesman, K., van der Werf, W., Koeffeman de Nooy, A., van den Briel, J.P. 2007. Development and application of bio-economic modelling to compare silvoarable, arable, and forestry systems in three European countries. Ecological Engineering 29: 434-449.

[11] Ibro G., Moussa M. B., Akamay M. ET Nouhoheflin M. T., 2002. Analyse Coût- bénéfice des Technologies du Niébé : Une Application de la Matrice d'Analyse des Politiques (MAP). Niger, p20

[12] Jhon, C-W. 2009. Programme de renforcement des stratégies de subsistances à travers une utilisation et une gestion améliorée de parcs agroforestiers au Sahel, 52p.

[13] Mawouma S., Mbofung C. M., 2014. Usages alimentaires de *Moringa oleifera* dans la région de l'Extrême-NordCameroun. *J. Biol. Chem. Sci.* 8(4):1847-1852

[14] Njehoya C. A., Sali B., KoAwono P.M.D, Hamadou B., 2014. Évaluation du potentiel de germination de Moringa oleifera dans la zone soudano-guinéenne du Cameroun. *Journal of Applied Biosciences*74 :6141-6148

[15] Olschewski, R., Tscharntke, T., Benıtez, P.C., Schwarze, S., Klein, A.M., 2006. Economic evaluation of pollination services comparing coffee landscapes in Ecuador and Indonesia. Ecology and Society 11 (1), 7p.

[16] Quashie A. M., etTchezoum Y. A., 2009. Étude de la germination de *Moringa oleifera*, *Afrique Science*, 5 (3) : 169-180

[17] Rivest D., Olivier A. et Gordon A. M., 2010. Les systèmes de cultures intercalaires avec arbres feuillus. Jumeler production de bois et production agricole tout en protégeant l'environnement. Université Laval. University of Guelph. 12p

[18] Saint Sauveur (de) A. 1997. Le *Moringa oleifera* au Niger et en Inde, ou quand les agriculteurs préfèrent planter les arbres, Le Flamboyant, Silva 43 : de 16 à 23.

[19] Yamada M. and Gholz H. L., 2002. An evaluation of agroforestry Systems as a rural development option for the Brazilian Amazon. *Agroforestry Systems* 55 (1): 81-87

[20] Rabo Y., Laouali A., Moussa B. et Mahamane A., 2015. Effect of the combination of the layout and the cutting level of Moringa oleifera plants on the yield in apple of *Brassica oleracea* (cabbage, variety Oxylus). *Int.J.Curr.Microbiol.App.Sci* 4(11): 800-807