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**Impact of Climate Change on Rice Farmer  
Income in Togo**

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## **Summary**

Developing countries such as Togo, whose economy is mainly based on the agricultural sector, remain highly vulnerable to the effects of climate change. Faced with this situation, field surveys were carried out with 602 rice farmers, overall of the rice production areas of Togo, to measure the effect of these climatic changes on the income of rice growers. The results showed that rice practice has a positive profit margin for producers. The poor distribution of rains, floods, the lengthening of the drought, the emergence of new diseases etc., are among others the perceptions of the producers on the climatic effects. The econometric analysis of the data from the Ricardian approach has shown that socio-economic variables have different significant effects on income overall. On the other hand, the incidence of the temperature and the rainfall turned out not significant on the income. However, the excess or decrease in temperature or rainfall would help reduce the income level of rice farmers following the signs observed.

## **Key words:**

Income, climate change, rice growing, Togo

## **Introduction**

Togo, like most African countries south of the Sahara, has been hit hard by the global economic crisis of recent years. This crisis, marked among other things by the soaring prices of basic commodities such as foodstuffs, has affected more economically-oriented countries that are heavily importing foodstuffs, but without significant financial resources. Among the agricultural products most affected by the price increase, the situation of rice is very worrying in view of the persistent decline in global rice stocks and therefore the reduction of supply in the face of the ever-increasing demand from developing countries. Development. To reverse the trend and so little curb the crisis, each country has undertaken urgent action to promote and support local production of consumer crops like rice. In addition to these crises, there is climate change. Indeed, it is now accepted that global warming is unequivocal (GIEC, 2001; GIEC, 2007) and will undoubtedly have impacts on agriculture. However, these impacts, according to the same authors, may be more pronounced in some areas than others, because of the great variability of the climate in space and socio-economic development. Togo, whose economy is essentially based on agriculture (48% of GDP (World Bank, 2014)), may be particularly affected by climate change. Indeed, the performance of the country's economy is closely linked to that of the agricultural sector, which, moreover, depends on the climate. The future climate projection scenarios show a decrease in rainfall of 3% and 8%, respectively for the years 2050 and 2100, in the southern part of the country. While the opposite scenario could occur in the northern part with an increase of 2% and 5% of rainfall over the same period. Temperatures, meanwhile, will increase throughout the territory but to varying degrees depending on whether we are north or south. With regard to all these observations,, various initiatives (program, policy, strategy) have been put in place in order to boost the national rice value chain, through sustained and sustainable production and an acceptable quality of milled rice that attracts farmers consumers always demanding.

This report presents the results of data collection in order to make available the information needed to make decisions for the well-being of people.

## **Objective**

This study aims, in a global way, the improvement of the income of rice growers to contribute sustainably to food security. Specifically, it is:

1. Highlight producers' perceptions of climate change;
2. Evaluate the effect of climate change on rice farmers' incomes;
3. Suggest solutions for improving production.

## **Methodology**

### **Presentation of the study area**

The study took place in four regions of Togo namely the Maritime, Plateaux, Kara and Savanes regions.

The Maritime Region is between the meridians 0 ° 40 'and 1 ° 50' of east longitude and parallel 6 ° and 6 ° 50 north latitude (MERF, 2014). It covers an area of 6397 km<sup>2</sup>, or about 11% of the

national territory according to the statistics of the Directorate General of Statistics and National Accounts (DGSCN) 2011. The Maritime region represents nearly 42% of the national population in 2011. It is a cultural brewing area where we find almost all ethnic groups: Ewe, Ouatchi, Mina, Kabyè, Losso, Kotokoli, etc. The climate is Equatorial Guinean with alternating rainy seasons and dry seasons. Rainfall is characterized by poor distribution throughout the year. The total annual rainfall varies between 1000 and 1200 mm. The study was carried out on the rice development poles of Mission-Tové and Agome-Glozou located respectively in the valleys of Zio and Mono about 35 km and 90 km respectively from Lomé. The rice-growing areas of Mission-Tové and Agome-Glozou are the two largest irrigated rice production areas in Togo. On these perimeters, the irrigation system is of gravity type and the irrigated areas are currently 360 ha for Mission-Tové and 20 ha for Agome-Glozou. Irrigable areas are, however, 660 ha at Mission-Tové and 60 ha at Agome-Glozou. These two perimeters currently benefit from redevelopment and extension actions through the Project Tové Agricultural Land Development and Rehabilitation Project (PARTAM) and the Lower Mono Valley Hydropower Project (PBVM). Rice dehulling units are located near these rice-growing areas.

In the Plateaux region, the study took place in the lowland rice pole located on the Kpalimé-Atakpamé road and extends over the prefectures of Kpélé and Amou. Rain heights vary between 1300 and 1600 per year with 2 to 3 months of dry season. The dominant vegetation is the wooded savannah. The population density of the area is quite high with a high proportion of ethnic Kabyè ethnic minorities. The dominant ethnic groups are Ewe and Akposso. The population is predominantly rural. Lowland rice cultivation is important. The lowlands are rich in silt and flood quickly enough. In this zone, the exposed land is used for cash crops (coffee, cocoa), forcing farmers to develop the lowlands (FAO, 2005). Access to lowland lands is through inheritance, loan or rental for indigenous male and female , by purchase or lease for non-indigenous people. The lowlands are exploited more than 80% of the available land and mostly by female (FAO, 2005). Local people have a long tradition of rice growing and rice is a basic food.

In the Kara region, the activities of the study were carried out in Dankpen prefecture located about 90 km from Kara. It covers an area of about 20.5% of the national area with an estimated population of 769,940 inhabitants (RGPH4, 2010). The dominant ethnic groups are Konkomba, Bassar and Lamba. The climate is Sudanese semi-arid where there are only two seasons: a rainy season between May and October, and a dry season between November and April. Temperatures and rainfall vary more: between 18 ° C and 40 ° C and between 100 and 900 mm / year. During the rainy seasons, the monsoon winds coming from the South-West progress towards the North bringing a little freshness. Between December and February, the harmattan, wind from the Sahara also refreshes the temperatures. The air is then more dusty and dry. In addition, this season also corresponds to the time of burning in preparation for planting, which increases the quantity of particles in the air. In this zone, rice production is done only in the lowlands in a traditional way. There are, however, some rice farmers who have received training on the Rice Intensive System (SRI). The total area of the lowlands is about 3500 ha, of which about 800 are exploited in rice production.

The Savannah Region covers an area of 8,470 km<sup>2</sup> with a population of 828,224 inhabitants according to data from the Directorate General of Statistics and National Accounts

(2011). According to these data, the population of Savannah represents 13.4% of the total population of Togo with a density of 96 inhabitants / km<sup>2</sup>. There are ethnic groups such as Moba, Tchokossi, Gourma, N'gangam, Mossi, Fulani, etc. The Savannah region has seven prefectures and its capital is Dapaong. The region is characterized by a Sudano-Guinean climate with two annual seasons, a dry season (November-May) and a rainy season (May-October) with rainfall between 1000-1100 mm. The economy of this region is mainly based on the agricultural sector which occupies 80% of the total labor force. Although the region is full of enormous potential, agricultural practice (field work and family farming) is characterized by the extensive degradation of soil in the western zone of the region, erratic rains and very infertile land. Among the main crops grown, rice and maize occupy a prominent place in both production and food. The activities took place in four townships in three prefectures in the Savannah region namely: Dapaong township in Tone prefecture, Nano township in Tandjoaré prefecture, Mango township and Sadori township in the prefecture of Oti. In these townships, there is an irrigated area, Tantigou in Dapaong, or a planned agricultural development zone (ZAAP), Sadori, Mango and Nano.

### Choice of villages

The sampling frame used for first-degree sampling consists of all the villages surveyed in the study areas. A total of 45 villages were randomly selected for the entire study area.

### Choice of producers

In each village the producers were chosen at random. 652 rice producers were therefore the subject of this study. Table 1 gives a special breakdown of the sample size.

**Table1: Distribution of producers by region**

Region				
Maritime	Plateaux	Kara	Savannah	Total
150	200	150	152	652

### Data collection and analysis

The study took into account two types of data: secondary and primary data.

Secondary data was collected at the regional level. These are climate data (monthly average temperatures and monthly total rainfall). They come from the main synoptic stations of the Meteorology Department of Togo and cover various periods. Primary data were obtained from a survey of the sample of farms selected. They concerned the socio-economic characteristics of the farms (age, level of education, main activity of the head of household, size of the household, area of the farm, etc.), factors of production (agricultural inputs, equipment, type of soil, and labor used), the socio-institutional environment of the farms (access to credit, access to the extension service, etc.). To better appreciate the effect of climate on income, climatic parameters were broken down according to the production seasons prevailing in each region. The data were processed and analyzed from descriptive statistics and econometric modelling using the SPSS 20 and STATA 13 software. Starting from

the evidence of the results obtained by Mendelsohn et al. (1994) in their study and taking into account the characteristics of the climate of the regions, we retained the following functional form:

$$\begin{aligned}
 RN_{ha} = & \beta_0 plui gsp + \beta_1 plui gsp^2 + \beta_2 plui psp + \beta_3 plui psp^2 + \beta_4 plui gss \\
 & + \beta_5 plui gss^2 + \beta_6 plui pss + \beta_7 plui pss^2 + \beta_8 temp gsp + \beta_9 temp gsp^2 \\
 & + \beta_{10} temp psp + \beta_{11} temp psp^2 + \beta_{12} temp gss + \beta_{13} temp gss^2 + \beta_{14} temp pss \\
 & + \beta_{15} temp pss^2 + \sum_j^m \mu_j Z_j + C^{te}
 \end{aligned}$$

Where:

Pluigsp and pluipsp represent the average total rainfall of the large and small wet seasons respectively;

Tempgsp and temp psp, are the average temperature respectively of the large and the small wet season;

Pluigss and pluipss represent the average total rainfall respectively of the high season and the small dry season;

tempgss and temp pss are respectively the average temperature respectively of the large and small dry season.

Z<sub>j</sub> = is the set of characteristics of the farms;

J, μ<sub>j</sub> = are coefficients of the variables and

C<sup>te</sup> = is a constant.

Independent variables include linear and quadratic terms of temperature, rainfall, and only linear terms of soils and farm characteristics. It must be remembered that the number of variables resulting from climatic parameters vary according to the seasons.

## Results and Discussion

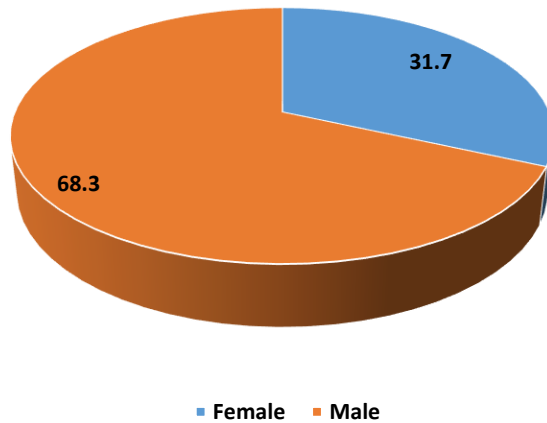
The results are presented by region.

### Maritime Region

#### Sociodemographic characteristics of rice farmers

The survey results reveal that the majority of rice farmers in the study area (68.3%) are male while female make up 31.7% of the sample (Figure 1). This low proportion of female to male can be explained by the fact that rice growing is a demanding activity requiring a lot of physical effort.

## Sales



**Figure 1: Distribution of Rice Farmers by Gender in Maritime region**

Overall, the average age of rice farmers is 43 years with a standard deviation of 9.9 years. There is a higher age for male (45) than for female (38). The average household size is estimated at 8 persons with a standard deviation of 3.4 persons (Table 2).

**Table 2: Distribution of Producers by Gender, Age and Size of Households in Maritime Region**

Sex	Age	Size of Household
Male	45 (10,7)	8,4 (3,8)
female	38 (5,4)	7,5 (3,8)
Set	43 (9,9)	8,1 (3,4)

Parentheses contain standard deviations

Table 3 shows that most respondents live in unions (77%), compared to 11% of single and 8% who lost their spouse. This same table shows that the overall level of education in the area is 84%.15% of rice farmers are uneducated. About 22% of respondents are educated through informal education (literacy), 36% attended primary school, 25% attended college (Table 3). From a gender perspective, and female are less educated than male. In fact, 11% of female have no education compared to 4% of male. Likewise, only 7% have reached primary school and almost none at the secondary or high school level.

**Table 3: Distribution of rice farmers by sex, marital status and educational attainment in Maritime**

Characteristics	Sex		Total	
	Male	Female	Number	%
Married	80	35	115	77,0%



<b>Marital status</b>	Divorced	6	0	6	4,0%
	Widower/widow	5	7	12	8,0%
	Single	12	5	17	11,0%
	free Union	0	0	0	0,0%
	Other	0	0	0	0,0%
<b>Instruction Level</b>	None	7	17	24	15,9%
	Primary	44	11	55	36,6%
	Secondary	38	0	38	25,6%
	University	0	0	0	0,0%
	Koranic School	0	0	0	0,0%
	litaracy	13	20	33	22,0%
	Other	0	0	0	0,0%

### Characteristics of rice farms

Agriculture is the main activity of respondents, 81% of cases. Regarding experience in rice production, the average duration is 10, 18 years with an average of 11 years for male and 9 years for female. In the exercise of their activity, 79% of rice farmers say they use agricultural credit. In addition, all respondents said combined both family and wage labor. The use of chemical fertilizers and pesticides is commonplace on the perimeter.

Access to land on the irrigated perimeters of the Zio Valley and Agome-Glozou is characterized by two major modes: land ownership and tenancy. Thus, out of the 150 rice farmers surveyed, the majority answered to be land tenants (83%) compared to 8% who acquired land by inheritance and 7% per purchase (Table 4).

**Table 4: Distribution of rice farmers by sex, main activity and mode of access to land in Maritime**

Characteristics	Sex						
	Female		Male		Total		
	Number	%	Number	%	Number	%	
Main Activity	None	4	2,6%	2	1,2%	6	2,4%
	Agriculture	43	29,3%	97	65,9%	140	95,1%
	Breeding	2	1,2%	2	1,2%	4	2,4%
	Student	0	0,0%	0	0,0%	0	0,0%
Mode of access to the land	Heritage	3	2,0%	9	6,0%	12	8,0%
	Purchase	6	4,0%	5	3,0%	11	7,3%
	Charity	0	0,0%	0	0,0%	0	0,0%
	leasing	53	35,0%	72	48,0%	125	83,3%
	Other	1	0,6%	1	0,6%	2	1,3%

### Area harvested and distribution of producers by farm size

The average area per rice farmer is 1.25 ha. There is very little disparity in access to land by gender. Male use an average of 1.45 ha and female 1.15 ha (Table 5). The smallest area encountered was 0.18 ha and the largest was 4 ha. The average production of white rice for the entire sample is 2.13 tonnes or 3.6 tonnes of paddy. This observed production gives an average yield of 2.5 tons / ha of paddy rice with a distribution of 1.5 tons / ha for female and 2.2 tons / ha for male.

**Table 5: Area of rice harvested, and production obtained by sex in ha in the Maritime**

Sex	Area		Production	
	Average	Standard deviation	Average	Standard deviation
Male	1,42	0,9	1,18	2,7
Female	1,15	0,6	2,07	3,4
<b>Set</b>	<b>1,26</b>	<b>0,7</b>	<b>2,13</b>	<b>3,3</b>

### Rice farmers' perceptions on the climate change

The information in the survey cards shows that rice farmers have noticed a certain disruption in the normal course of the climate. The main changes perceived by the producers concern: the bad distribution of the rains, the shortening of the duration of the big and small rainy season, the reduction of the number of rainy days, the more frequent pockets of drought, the very strong and violent rains and the lengthening of the drought. All these findings are confirmed by the studies on the Second National Communication (MERF, 2010) which, on projection models, show decreases in rainfall over the coming years. This means that changes in climatic parameters are very real and pose a threat to agriculture in general and rice, although the rice system is irrigated. The difficulties will be even more serious on the Agome-Glozou perimeter where the Mono River dries up some years. Also, the pumping system being defective, the availability of water throughout the year remains problematic. During the surveys, there was an increased lack of water on the perimeter forcing several producers to abandon their rice Farm in favor of other activities.

### Income from farming activity

Rice production activities provide a positive gain for farmers. Of the 100 rice farmers surveyed, the average income amounts to 182,064 CFA francs per hectare. In a detailed way, 28% of respondents have an income of less than 100,000 CFA francs. The majority, 37%, have an agricultural income between 100,000 and 200,000 CFA francs. There is still a proportion of 4% of rice farmers who have a higher income of 500,000 CFA (Table 6).

**Table.6: Distribution of rice farmers by sex and income class / ha (%)**

Gross Farm Income Class	Sex		Total
	Male	Female	
> 100000	18	10	28
100000-200000	18	19	37
200000-300000	8	7	15
300000-400000	10	3	13
400000-500000	1	2	3
>500000	4	0	4
<b>Total</b>	<b>59</b>	<b>41</b>	<b>100</b>

### **Econometric analysis of climate change on rice farmers income**

Table 7 gives the results of the regression. The Fisher-Snedcor test shows that the model is globally significant. The coefficient of determination ( $R^2$ ) of the model is 0.3615. These results compared to those of Gbetibouo and Hassan (2005), Kurukulasuriya et al. (2006), remain satisfactory.

The Student's test shows that some linear and quadratic terms of temperature, as well as rainfall are not significant. However, they have expected effects as to their sign. Indeed, the signs of the linear and quadratic terms are opposite. This can be explained by the fact that it is an irrigated rice system whose main source of water is the watercourse. Nevertheless, these rivers benefit from rainwater which, when it becomes excessive or rare, causes floods or droughts. This is shown by other climatic parameters of the model. In the dry season, rains remain crucial in the supply of canals. The results of the estimation show that rainfall during the short season positively affects rice farmers' income to a point where they become harmful to production. This is shown by the quadratic term of the amount of rain in the short rainy season. The rains of the small rainy season remain, with regard to the very determining results for the income of the rice farmers. However, their effect is limited to a certain threshold beyond which they no longer contribute to increasing income but reducing it. With regard to temperatures, the results show that an increase in the quadratic terms of temperature in the short rainy season and the long dry season results in a decline in rice farmers' income. Just like the rains of the small rainy season, the temperatures of this season also remain crucial in the income aggregate. The level of education is negatively correlated with the income of rice farmers. This means that the more educated the rice farmer, the less is his income from this activity. This can be explained by the fact that educated producers are more likely to engage in other activities and make rice production a secondary activity to which little care is given. The sign of the size of the household is negative. This assumes that the number of farm workers at the household level negatively affects income. The more this number increases, so is the income the producer earns. This can be explained by the fact that most of the respondents' households are not active and therefore do not constitute a qualified family workforce, that is, that the members are active but are more engaged in school studies than country activities.

Access to credit from microfinance institutions is significant and has a positive effect on income. This means that most rice farmers who benefit from these credits actually use them for agricultural investment purposes.

The number of years of experience in rice farming on farm income has a positive and significant effect. This means that the most experienced producers are those who get a better income or the probability of getting a good income increases with the number of years experienced.

**Table 7: Estimation Model Results (Dependent Variable = Net Farm Income) in Maritime**

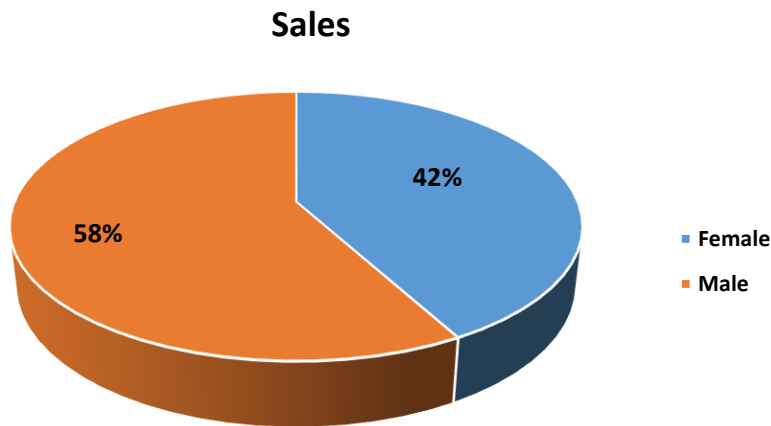
<b>Income by Hectar</b>	<b>Coef.</b>	<b>Std. Err.</b>	<b>t</b>	<b>P&gt;t</b>
Sex	-39614.42	33116.96	-1.19	0.235
Instruction level	-11371.49	5574.25	-2.04	0.027**
Agricultural credit	45307.81	19362.31	2.34	0.021**
Area of exploited rice	-31.52228	11219.38	-0.00	0.998
Soil type	50662.33	42921.66	1.18	0.242
Ln (SIZE OF HOUSEHOLD)	-7482.101	1953.553	-3.83	0.001***
Age	22647.58	73933.58	0.31	0.76
Year of experience	20485.35	8906.673	2.3	0.03**
Rain large season wet	1377.659	1176.152	1.17	0.245
Rain large season humid square	-2.672521	3.026203	-0.88	0.38
Rain small wet saison	1654.632	769.8987	2.15	0.035**
Rain small season humid square	-7.129852	2.914316	-2.45	0.017**
Rain large season	3145.787	1784.285	1.76	0.082*
Rain large season dry square	-18.34224	15.05449	-1.22	0.227
Little small season	557.4787	865.0307	0.64	0.521
Rain small season dry square	-0.8472913	3.172478	-0.27	0.79
Temperature large season wet	1553116	4228315	0.37	0.714
Temperature large season humid square	-26929.6	74657.44	-0.36	0.719
Temperature small season wet	1.31E+07	5608182	2.33	0.022**
Temperature small season humid square	-236338.9	101963.8	-2.32	0.023**
Temperature large season	9298100	3740091	2.49	0.015**
Temperature large season dry square	-162578	64930.41	-2.50	0.014**
Temperature small season	6722663	7268528	0.92	0.358
Temperature small season dry square	-126497.6	137658.2	-0.92	0.361
_CONS	2.03E+08	1.02e+08	1.99	0.049**
Number of obs		150		
F		1.77		
Prob > F		0.0325		
R-squared		0.3615		

Significant difference at the 1% threshold (\*\*\*), 5% (\*\*), 10% (\*)

## Plateaux Region

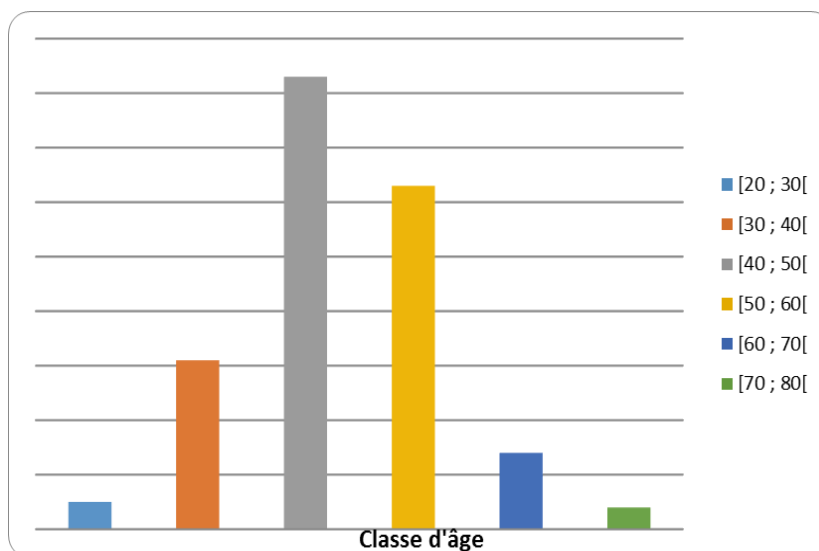
### Sociodemographic characteristics of surveys

The gender distribution shows that 58% of rice farmers are male and 42% are female as shown in Figure 2. This representativeness of female in rice production indicates its importance for food security and income of local populations.



**Figure 2: Distribution of respondents by gender in the Plateaux**

The average age of rice farmers is 48 years with a standard deviation of 5 years, which reflects a low dispersion of the age population around the average. This age is an asset for rice farmers in the conduct of their production activities. In general, rice farmers surveyed have an age ranging from 20 to 80 years as shown in Figure 3.



**Figure 3: Distribution of rice farmers by age group in Plateaux region**

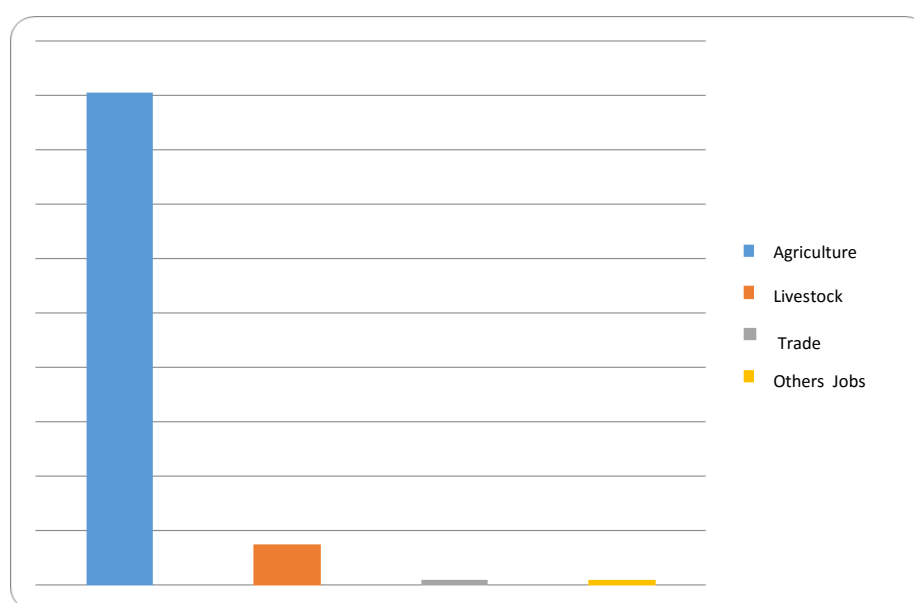
The distribution of rice farmers by age group (Figure 3) a large number of respondents aged between [40; 50 [with a percentage of the workforce of 41.5%. The average experience in rice cultivation is 12 years with the sample studied. The distribution of rice farmers by marital

status and by level of education is presented in Table 8. It shows that a significant number of rice farmers (85%) are married persons and 68% have a secondary level of education. Of the 200 rice farmers surveyed, 169 (84.5%) are married; 15 (7.5%) are single; 8 (4%) are widowed as well as 8 (4%) divorced. The average size of a rice-growing household is seven people.

**Table 8: Distribution of Rice Farmers by Marital Status and Education Level in the Plateaux**

		Number	Percentage
<b>marital Status</b>	Married	169	84,5 %
	Divorced	8	4 %
	Widower/Widow	8	4 %
	Single	15	7,5 %
<b>Instruction Level</b>	None	10	5 %
	Primary	45	22,5 %
	Secondary	135	67,5 %
	University	1	0,5 %
	literacy	9	4,5 %

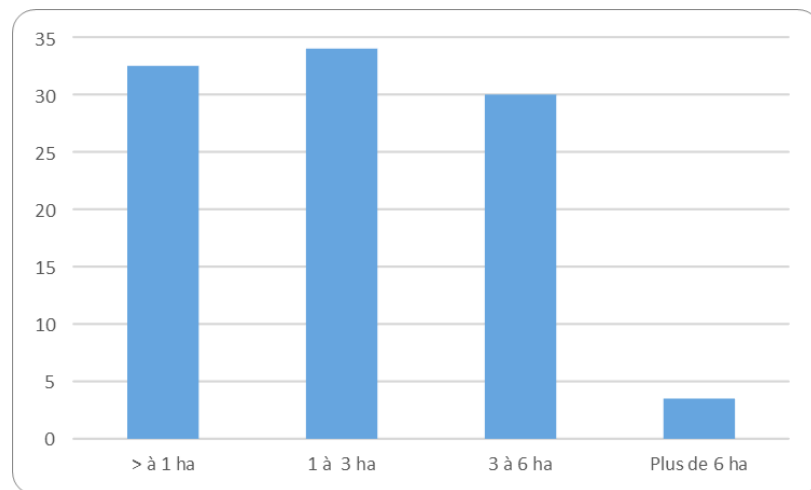
According to the level of education (Table 8), 135 of the 200 rice farmers surveyed (67.5%) have secondary education; 45 (22.5%) have primary level; 10 (5%) have no level of education; 9 (4.5%) are literate and only one person is 0.5% at the university level. The distribution of rice farmers according to their main occupation highlights agriculture as the main activity of rice farmers surveyed (Figure 4). In fact, 90.5% of these rice growers are mainly engaged in agriculture; 7.5% have livestock as the main activity and only 1% of the respondents practice the trade. Trade is practiced mainly by female The other main occupations of rice growers are hairstyling and sewing, which are practiced by 1% of respondents. Moreover, for these rice farmers, livestock farming is the most popular secondary activity, ie 72% of respondents.



**Figure 4: Distribution of rice farmers by main occupation in the Plateaux**

In fact, 90.5% of these rice growers are mainly engaged in agriculture; 7.5% have livestock as the main activity, only 1% of respondents practice the trade. Trade is practiced mainly by female (Figure 4). The other main occupations of rice growers are hairstyling and sewing, which are practiced by 1% of respondents. Among rice farmers whose main activity is agriculture, 81% of them belong to a peasant organization, particularly a cooperative. For these rice farmers, breeding is the most popular secondary activity, ie 72% of respondents. Regarding the distribution of respondents by household size, the modal class is class [5; 7 [with 31% of rice farmers. Then the class [3; 5 [with 23% of respondents, class [7; 9 [with 13% and class [11; 13 [with 12% of respondents as shown in Figure 3.2.4.

These rice farmers have an average rice area of 2.47 ha (Figure 5). The distribution of rice farmers by rice area is shown in Figure 5.



**Figure 5: Distribution of Rice Farmers by Size of Rice Area**

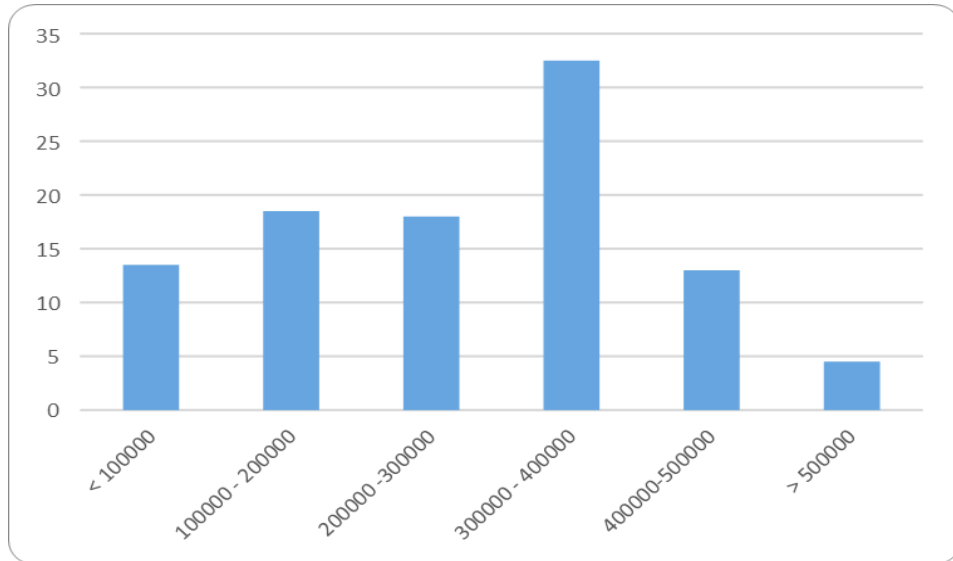
This distribution shows that 34% of rice farmers have an area of between 1 and 3 ha, 32.5% an area less than one hectare, 30% an area ranging from 3 to 6 ha and only 3.5% an area greater than 6 Ha.

#### **Rice farmers perceptions of climate change**

One hundred percent (100%) of the respondents felt that they were experiencing a change in the elements of the climate, especially for rainfall. Thus, 100% of respondents mentioned the poor distribution of rainfall and prolonged drought as a manifestation of climate change. Other observations made by rice growers are the disappearance of certain plant species and the appearance of new diseases on crops as a manifestation of changes in their environment.

#### **Income from rice activity**

The net income from rice cultivation is generally positive with an average income of 346,296 CFA per hectare. The net income of 300,000 to 400,000 CFA francs is the most represented with 32.5% of rice farmers as shown in Figure 6



**Figure 6: Distribution of Net Income of Rice Farmers in Plateaux Region**

Eighteen-point five percent (18.5%) of rice farmers have an income of 100,000 to 200,000 CFA francs, 18% have an income of 200,000 to 300,000 FCFA, 13.5% have an income of less than 100,000 F CFA, 13% have an income of 400 000 to 500 000 CFA francs and only 4.5% have an income higher than 500 000 FCFA.

#### **Econometric analysis of climate change on rice farmers' income**

The Fisher-Snedcor test shows in Table 9 that the model is globally significant. The coefficient of determination ( $R^2$ ) of the model is 0.4111. The income from rice production is explained at 41.11% by the variables of the model.

The Student's test shows that the linear and quadratic terms of the temperature, as well as the pluviometries are not significant. However, they have expected effects as to their sign. Indeed, the signs of the linear and quadratic terms are opposite. What can be explained in the climatic data of the seasons of the practice of the rice appear sufficient to provide good returns to the producer if the latter respects the cultural calendar. However, when they become excessive or rare, they cause floods or droughts. This is shown by the quadratic parameters of the model.

Most socio-economic variables do not significantly affect the income of rice producers. Only the age, the year of experience and the area exploited are at the 5% threshold. Indeed, the older the producer, the less his income will be. This can be explained by the fact that rice growing is an activity that requires enough physical strength. But older people often do not have enough strength to cope with different rice activities. Also, as labor becomes increasingly scarce in the area, these people are, in some cases, forced to exploit small areas according to their physical strength.

The number of years of experience in rice cultivation has a positive and significant effect on farm income. This means that the most experienced producers are those who get a better income or the probability of getting a good income increases with experience.

The increase in areas planted contributes to increase the income of rice farmers. Indeed, Togolese agriculture as a whole is of extensive type. Land therefore remains the first factor



explaining the agricultural production observed. To hope to have large production, producers are required to expand their area.

**Table 9: Estimation Model Results (Dependent Variable = Net Farm Income) in Plateaux Region**

Income by hectar	Coef.	Std. Err.	t	P>t
Sex	-2825.794	32605.36	-0.09	0.931
Level of instruction	4171.846	18658.61	0.22	0.823
Agricultural credit	56813	34539.9	1.64	0.102
Age	-4108.324	1951.854	-2.10	0.037**
Ln (HOUSEHOLD SIZE)	4269.506	4856.981	0.88	0.381
Year of experience	8514.999	3207.74	2.65	0.009**
Soil type	61583.2	48207.58	1.28	0.203
Surface area of exploited rice	225444.8	52674.01	4.28	0.000**
Rain large season wet	316.0326	885.6165	0.36	0.722
Rain large season himide square	-.4485436	.6370563	-0.70	0.482
Rain small season wet	645.0032	1105.013	0.58	0.560
Rain small season humid square	-1.053366	1.437331	-0.73	0.465
Temperature large season wet	57960.76	60363.47	0.96	0.338
Temperature large season humid square	-961.4408	1452.577	-0.66	0.509
Temperature small season wet	-13709.02	73038.14	-0.19	0.851
Temperature small season humid square	1685.427	1800.026	0.94	0.350
_CONS	-1281669	1305337	-0.98	0.327
Number of obs	200			
F	2.64			
Prob > F	0.0218			
R-squared	0.4111			

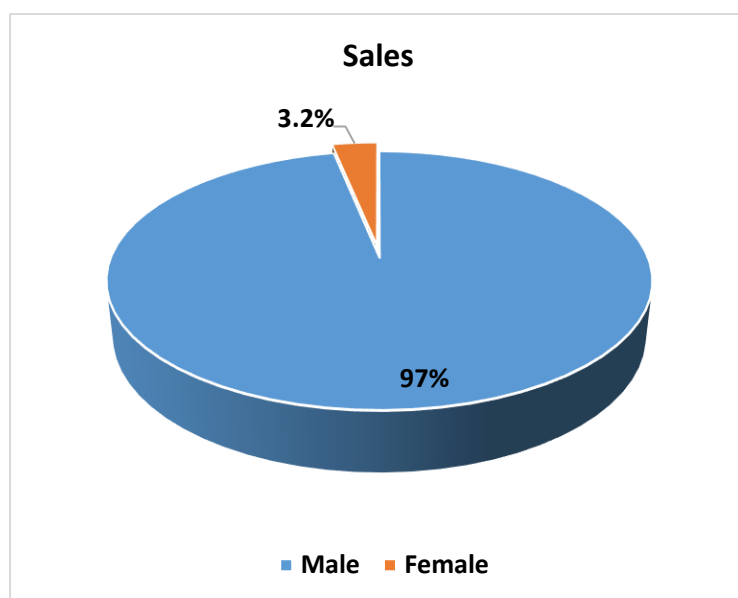
\*\* Significant difference at threshold 5%

## Kara Region

### Sociodemographic characteristics of rice farmers

The survey results reveal that the majority of rice farmers in the study area (93%) are male while female make up 7% of the sample (Figure 7).

This low proportion of female compared to male can be explained by the fact that in these localities rice cultivation is considered as a human activity because of the strength to be exercised in order to develop the lowlands.



**Figure 7: Distribution of Rice Farmers by Gender in Kara**

Overall, the average age of rice farmers is 37 years old. Male are slightly older than female. The average household size is estimated at 9 people (Table 10).

**Table 10: Distribution of Producers by Gender, Age and Household Size in Kara**

Sex	Age	Household size
Man	38	10
Woman	36	8
<b>Set</b>	<b>37</b>	<b>9</b>

Rice farmers in the study area have a good average experience of 9 years for male and 3 years on average for female. But everything is done almost traditionally.

Most of the respondents are married, in 94% of the cases. It is also observed that nearly 35% of the producers surveyed have primary education and 27% secondary education. But it also shows that 34% of them had no formal or informal education (Table 11).

**Table 11: Distribution of rice farmers by sex, marital status and educational attainment in Kara**

Characteristics	Sex		Total		
	Male	Female	Number	%	
<b>Marital status</b>	Married	93	1	94	94,0%
	Divorced	0	0	0	0%
	Widower/Widow	0	0	0	0%
	Single	6	0	6	6,0%
	Free union	0	0	0	0,0%
	Other	0	0	0	0,0%
<b>Instruction Level</b>	None	55	2	57	57%
	Primary	20	0	20	20%
	Secondary	19	0	19	19%
	University	4	0	0	4%
	Koranic School	0	0	0	0,0%
	Literacy	0	0	0	0,0%
	Other	0	0	0	0,0%

#### **Occupations of rice farmers in the study area.**

The main economic activity of the study area is agriculture. All respondents (100%) have as their main activity, agriculture. Most rice farmers (70.21%) belong to a group while 29.78% are individual producers. With regard to credit, most producers are not informed of an opportunity to access credit, which means that only 32% of respondents said they had access to credit while 68% of respondents said they had access to credit (20%) have not had information and 48% say they have not had the financial means to open an account or the distance from their place of residence to the bank is large. Extension work is very important in rural areas, but it should be noted that 72.34% of rice farmers state that they do not have access to extension services, compared to 27.65% who say they have access to extension services. In the area no rice producer uses a tractor. Compared to the total area available to the farmers surveyed (759.75 ha), the area of rice is very small (71.25 ha) or 9.37% of the total area. A good proportion (56%) of rice farmers still use local seeds, only 28% of farmers use improved seeds and 16% both. In the area, 100% of rice farmers make their rice in the bottom. Access to the land is inherited in 93.33% of the cases and the soil is exclusively sandy-clay. More than half of the producers use fertilizers (86%) while only 41% use pesticides.

#### **Area harvested and distribution of producers by farm size**

The average total area per rice farmer is 5.06 ha and that of rice is 0.47 ha. The smallest area of rice is 0.25 ha while the largest is 2 ha (Table 12).

**Table 12: Area of rice harvested by sex in Kara (ha)**

Sex	Average	Minimum	Maximum
Male	0,5	0,25	2
Female	0,5	0,5	0,5

<b>Set</b>	<b>0,5</b>	<b>0,37</b>	<b>1,25</b>
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The average production of paddy rice for the entire sample is 554.46 kg for an average area of 0.47 ha. This observed yield gives an average yield of 1179.70 kg / ha. This yield clearly explains that rice cultivation in the study area is traditional.

### **Rice farmers perceptions of climate change**

The counting of survey forms has identified the finding of the producers on Climate Change. The information in the survey cards shows that rice farmers have noticed a certain disruption in the normal course of the climate. The main changes perceived by the producers concern: the bad distribution of the rains during the rainy season, the prolonged drought, the floods of the lowlands, the new diseases on the cultures, the appearance of new insects, the violent winds and the sudden stops of rain, and scorching heat in the dry season. For this crop year, the lowlands were flooded and the rice washed away by runoff and sandy landings.

### **Income from rice activity**

Rice production provides a positive gain to rice farmers in the area. Of the 150 rice farmers surveyed, the average income amounts to 168,065 CFA francs per hectare. In a detailed way, 13% of the respondents have an income higher than 200 000 F CFA, 7% have an income between 100 000 and 150 000 FCFA. The majority, 80%, have a farm income of less than 100,000 FCFA.

### **Econometric analysis of climate change effect on income**

The regression results of the model are contained in Table 13. The Fisher-Snedcor test shows that the model is globally significant. The coefficient of determination ( $R^2$ ) of the model is 0.6882. The income of rice farmers is explained to 68.82% by the variables dependent on the model.

The Student's test shows that the linear and quadratic terms of the temperature, as well as the pluviometries are not significant. However, they have expected effects as to their sign. Indeed, the signs of the linear and quadratic terms are opposite. What can be explained in the climatic data of the seasons of the practice of the rice appear sufficient to provide good returns to the producer if the latter respects the cultural calendar. However, when they become excessive, they cause floods. This is shown by the quadratic parameters of the model. Most socio-economic variables do not significantly affect the income of rice producers. Only the level of education, the year of experience, access to credit and the area of rice exploited are at the 5% threshold. Indeed, the level of education is positively correlated with the income of rice farmers. This means that the more the rice farmer is educated, the more his income from this activity. This can be explained by the fact that educated producers are sufficiently equipped to apprehend the modern technologies taught to put them into practice.

The number of years of experience in rice cultivation has a positive and significant effect on farm income. This means that the most experienced producers are those who get a better income or the probability of getting a good income increases with experience.

Increasingly large areas contribute to increase the income of rice farmers. Indeed, Togolese agriculture is of extensive type. Land therefore remains the first factor explaining the

agricultural production observed. To hope to have large production, producers are required to expand their area.

Access to credit from microfinance institutions is significant and has a positive effect on income. This means that most rice farmers who benefit from these credits use them for agricultural investment purposes.

**Table 13: Estimation Model Results (Dependent Variable = Net Farm Income) in Kara Region**

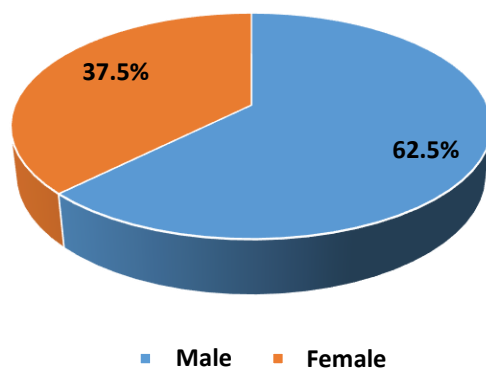
Income per hectare	Coef.	Std. Err.	t	P>t
Sex	70727.22	55889.75	1.27	0.213
Age	1619.028	1179.914	1.37	0.177
Level of instruction	45790.28	18915.78	2.42	0.020**
Year of experience	4267.452	1873.72	2.28	0.028**
Access to credit	84955.55	29023.74	2.93	0.005**
Ln (HOUSEHOLD SIZE)	200.3462	2877.34	0.07	0.945
Operated area	247643.3	34525.77	7.17	0.000**
Rain large season wet	459.3604	871.933	0.53	0.601
Rain large season humid square	-.1771385	.3568197	-0.50	0.622
Temperature large season wet	-1092.885	54173.88	-0.02	0.984
Temperature large season humid square	-1147.201	1320.403	-0.87	0.390
_Cons	318792.3	899004.2	0.35	0.725
Number of obs	150			
F	8.63			
Prob > F	0.000			
R-squared	0.6882			

\*\* Significant difference at the 5% threshold

## Savannah Region

### Sociodemographic characteristics of rice farmers

The survey results reveal that the majority of rice farmers in the study area (62.5%) are male while female make up 37.5% of the sample (Figure 8).



**Figure 8: Distribution of Rice Farmers by Gender in the Savannahs**

Overall, the average age of surveyed rice farmers is 42 years old with a minimum of 22 years and a maximum of 66 years. The average age per sex is 40 years for female with extremes of 22 and 59 years and then 43 for male with extremes of 28 and 66 years (Table 14). The average household size is 10 with a standard deviation of 6 as shown in the following table.

**Table 14: Distribution of Producers by Sex, Age and Household Size in the Savannah**

Sex	Age	Household Size
Male	43,7 (10)	12 (7)
Female	40,6 (8)	7 (1)
<b>Set</b>	<b>42,6 (10)</b>	<b>10 (6)</b>

Parentheses contain standard deviations

As shown in Table 15, most respondents (89.47%) are married and 10.53% are widowed. Taken by sex, one can observe that the majority as well as female is married.

As for the level of education, the results of the survey reveal in general that the educational level reached by the rice farmers surveyed is between the primary (36.18% of the cases) and the secondary (32.89% of the case). There is also a high rate of out-of-school attendance (20.39%) and three typical cases of female with university level.

**Table 15: Distribution of rice farmers by sex, marital status and educational attainment in the Savannah**

Characteristics	Sex		Total		
	Man	Woman	Number	%	
<b>Marital Status</b>	Married	95	41	136	89,47%
	Divorced	0	0	0	0,0%
	Widower/Widow	0	16	16	10,53%
<b>Instruction Level</b>	None	6	25	31	20,39%
	Primary	46	9	55	36,18%
	Secondary	33	17	50	32,89%
	University	0	3	3	1,97%
	Koranic School	10	3	13	8,55%

### Characteristics of rice farms

The main activity that occupies the rice farmers surveyed is in 95.39% of cases agriculture. These respondents have proven experience in rice farming, 16.47 years on average (18.13 years for male and 13.7 years for female). The exploitation of rice farmers is also characterized by the combined use of family and salaried labor in 98.03% of cases and 1.97% using only family labor. The rate of access to credit is 63.16% among rice farmers surveyed. Regarding the use of fertilizers, it is commonplace (80.26% of producers surveyed) but the recommended doses are not often respected. However, the use of herbicides is very high (77.63% of respondents). There are three types of land tenure in the rice fields surveyed:

36.84% of respondents inherited their land, 40.79% had their land donated and 22.37% rented the land they use (Table 16).

**Table 16: Distribution of Rice Farmers by Sex, Main Activity and Mode of Access to Land in the Savannah**

Characteristics	Sex			Total			
	Male	Female	Total				
<b>Main Activity</b>	Agriculture	88	57,89%	57	37,50%	145	95,39%
	Liberal professions	7	4,60%	0	0,00%	7	4,60%
<b>Mode of access to the land</b>	Heritage	43	28,28%	13	8,55%	56	36,80%
	Gift	33	21,71%	29	19,07%	62	40,78%
	leasing	19	12,50%	15	9,86%	34	22,36%

#### Area harvested and distribution of producers by farm size

The area exploited by rice farmers in the Savannah region is highly variable. The average area revealed by this study is 2.68 ha with a standard deviation of 2.24 which reflects the enormous variability between areas. It should also be noted that the average area exploited by female (1.68 ha) is lower than that of male (3.28 ha).

**Table 17: Area of rice harvested by sex in ha**

Sex	Average	Standard deviation	Minimum	Maximum
Male	3,28	2,57	0,25	12
Female	1,68	0,9	0,25	3
<b>Set</b>	<b>2,68</b>	<b>2,24</b>	<b>0,25</b>	<b>12</b>

The average production of paddy rice for the entire sample is 5,896 tons for an average area of 2.68 ha. This equates to a yield of 2.2 tonnes / ha.

#### Rice farmers' perceptions of climate change

Climate change, which a few years ago was the only place for scientific discussions, is now a phenomenon recognized by the entire community and agricultural producers. The results of the survey reveal that the rice farmers surveyed observe these climatic changes through: the poor distribution of rains; prolonged drought; flooding; the appearance of new diseases on crops; the appearance of new pests; the disappearance of certain tree species and the lack of pasture grasses.

This observation of climate change was made by the totality of rice farmers surveyed but only 41.45% of them claim to use adaptation techniques to this climate change. These techniques

are among others: the use of early varieties and early planting. Despite these means of adapting to climate change, the rice farmers surveyed are all unanimous that a development with irrigation on their production site would be necessary to really cope with climate change.

### **Income from rice activity**

Regarding the rice incomes of the respondents, it appears that rice activity provides positive returns for rice farmers. It should be noted that for all respondents, the average rice income is 167,516 FCFA per hectare of rice grown. Considering income classes, it should be noted that the majority of respondents (65.78%) have a rice income of between 100,000 FCFA and 200,000 FCFA, 13.15% have an income of less than 100,000 FCFA, 17, 76% have an income of between 200,000 FCFA and 300,000 FCFA. It is noted that 3.28% of respondents have an income above 300,000 FCFA (Table 18).

**Table 18: Distribution of rice farmers by sex and income class**

Farm income class	Sex		Total
	Male	Female	
< 100000	6	14	20 (13,15%)
100000-200000	68	32	100 (65,78%)
200000-300000	17	10	27 (17,76%)
>300000	4	1	5 (3,28%)
<b>Total</b>	<b>95</b>	<b>57</b>	<b>152</b>

### **Econometric analysis of climate change on rice farmers' income**

The results of the model regression are shown in Table 3.4.19. The Fisher-Snedcor test shows that the model is globally significant. The coefficient of determination ( $R^2$ ) of the model is 0.3942. Dependent variables account for 39.42% of income from rice production. Student test shows that the terms linear and quadratic temperature, as well as rainfall are not significant. However, they have expected effects as to their sign. Indeed, the signs of the linear and quadratic terms are opposite. This can be explained by the fact that the quantities of water that have fallen seem to be sufficient to provide the farmer with a good return if he respects the crop calendar. However, when they become excessive, they cause floods. This is shown by the quadratic parameters of the model. Most socio-economic variables do not significantly affect the income of rice producers. Only the age, the year of experience, access to credit and the area exploited are significant. In fact, the number of years of experience in rice cultivation has a positive and significant effect on agricultural income. This means that the most experienced producers are those who get a better income or the probability of getting a good income increases with experience. The experiences acquired allow producers to obtain good yields despite the difficulty of the activity. However, under the influence of age, production tends to fall. Indeed, experience is acquired over time. But when age advances and reaches a certain level, this experience has a negative effect on production since the producer, certainly



experienced, becomes less efficient given the demanding nature of rice farming in physical effort. Efficiency then decreases with experience from this threshold age. This shows the negative and significant effect of age on income.

Increasingly large areas contribute to increase the income of rice farmers. Indeed, Togolese agriculture as a whole is of extensive type. Land therefore remains the first factor explaining the agricultural production observed. To hope to have large production, producers are required to expand their area. Access to credit from microfinance institutions is significant and has a positive effect on income. This means that most rice farmers who benefit from these credits actually use them for agricultural investment purposes. In fact, as the family labor force is less and less in demand, rice farmers resort only to the wage labor force. Obtaining agricultural credit would not only allow producers to obtain agricultural inputs but also to solicit salaried Work force.

**Table 19: Estimation Model Results (Dependent Variable = Net Farm Income) in Savannah**

Income	Coef.	Std. Err.	t	P>t
Sex	11653.61	13165.06	-0.89	0.378
Age	-85.17767	40.36856	-2.11	0.032**
Level of education	-1624.555	5152.853	-0.32	0.753
Year of experience	294.5423	125.33714	2.35	0.028**
Agricultural credit	4508.541	2532.8882	1.76	0.072*
Ln (MENAG SIZE)	193.7597	867.9379	0.22	0.824
Rice surface	1256.652	519.2776	2.42	0.026**
Soil type	2780.812	7226.342	0.38	0.701
Rain season wet	107.8437	302.2164	0.36	0.722
Rain season humid square	-0.051795	-0.1839098	-0.28	0.779
Temperature wet season	-6929.806	18427.94	-0.38	0.707
Temperature season humid square	-76.0439	344.6236	-0.22	0.826
_Cons	458582.7	330142.3	1.39	0.167
Number of obs	152			
F	3.62			
Prob > F	0.009			
R-squared	0.3942			

Significant difference at threshold 5% (\*\*), 10% (\*)

## Conclusion and Recommendations

This study measured the impact of climate change on rice farmers incomes in the rice production area. It showed that rice cultivation is mainly held by male whose main activity is agriculture. The level of schooling is generally acceptable. The rice production activity is an activity that offers a positive gain to farmers and largely covers the expenses incurred in production. In most cases, the effects of climate parameters on income do not have a significant impact on income across regions. However, they have expected effects as to their

sign. The greater quantity of rainfall, the less the income obtained by producers. Also, high temperature negatively affects rice production and thus the income of rice farmers. In terms of socio-economic variables, these also have different effects on income across regions. Rice growers are no stranger to the findings made on climate change. The main changes perceived by the producers concern: the poor distribution of the rains, the shortening of the duration of certain seasons, the reduction of the number of rainy days, the more frequent pockets of drought, the floods and the lengthening of the duration of the drought. As a result, the study identified some production issues. These difficulties are related to the non-respect of the calendars of cultivation and water distribution, the low flow of water in the dry season, the leak of water on the distribution channels, the lack of maintenance of the channels, the system pumping not adapted to the topography of the environment, dewatering of the Mono River, the low use of good practices, the name management of the lowlands, the low use of improved seeds, weak technical support, the siltation of the dam, etc.

In view of the difficulties, it is important to:

- Rehabilitate tertiary channels on irrigated areas
- To make available to producers early, extra-early varieties, and improved seeds
- Introduce floating varieties of rice and good farming practices in the lowlands of the Kara area
- Train producers on basement lowland development systems
- Introduce small mechanization into production systems
- Strengthen technical support to producers

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