INTRODUCTION

Land degradation affects 1.5 billion people and 74% of the world's poor (Economics of Land Degradation: 3). It prevents agricultural production and increases poverty and vulnerability. It affects 33% of the world's land surface, affecting more than 2.6 billion people in over 100 countries. The financial and economic costs of land degradation at the global level are between 3 and 5% of agricultural GDP for US$ 42 billion per year and a loss of ecosystem services in the order of US$ 43,400 to US$ 72,000 per km² and between US$ 870 and US$ 1450 per person per year 4. At the level of the African continent, these costs vary from 4 to 12% of GDP, 85% of which results from soil erosion, nutrient loss and crop changes 5.

In Benin, the economic and financial costs of land degradation range from 8,100 to 14,100 billion CFA francs and 3 to 5% of Gross Domestic Product (GDP) 6. The Adja Plateau is one of the main agricultural production areas in southern Benin with more than 90% of its population engaged in agriculture. Unfortunately, this area of very high land pressure suffers, contrary to the theory of Boserup, 7 the persistence of mining agriculture and the pronounced degradation of the cultural environment. With a surface area of 944 km², the Adja Plateau, located in the Couffo department in south-western Benin, is also characterized by strong land pressure and worsening degradation of the cultural environment. In fact, despite this land pressure, the agricultural practice of the farmers of the Adja Plateau remains essentially extractive; an agriculture without concern for restoring the soil's fertility potential, i.e. mining agriculture. This state of affairs is contrary to the theory of Boserup, 7 which states that population density is a positive factor in increasing agricultural production. In other words, the demographic pressure that this area is experiencing should favour the intensification of the production system, the increase in land productivity and, ultimately, the technical change towards agricultural practices that conserve and improve yields. This is not the case. To this end, Houngbo and al., revealed that the poorer the producer in this area, the less he implements land conservation farming (LCA) practices such as natural fallow and improved fallow technologies based on Mucuna pruriens and Acacia auriculiformis.

Thus, when water and wind action, reinforced by human activities, can have negative impacts on the soil, there are elements of appreciation and mechanisms for its repair or restoration in a context of budgetary constraints. This is the

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main objective we are pursuing. The associated research question is: what factors determine the willingness of producers to pay for the adoption of soil conservation techniques? This main question gives rise to a series of secondary questions. Do the economic factors of the producer determine his or her attitude to financing the mitigation of land degradation effects? Do the social characteristics of the producer influence his willingness to pay for soil conservation? This research will therefore help to mobilize funding for the land degradation control programme on the Adja Plateau in Benin.

EXPERIMENTAL SECTION

The study environment

The study area identified for this research is the Adja Plateau, which includes the municipalities of Aplahoué, Djakotomey, Dogbo, Klouékannay, Lalo and Toviklin, and is located in agro-ecological zones VI and VII of Benin. Indeed, according to FAO, an agro-ecological zone is a cartographic unit of land resources, defined in terms of climate, geomorphology and soils, and/or vegetation cover and possessing a specific range of potentials and constraints for land use. Agro ecological Zone VI includes the municipalities of Djakotomey, Dogbo, Klouékannay and Toviklin in addition to other municipalities and is characterized because of its soil characteristics as a "clayey land" zone. The climate is marked by two (02) rainy seasons (March-July; October-November) and two (02) dry seasons (December-February; August). Rainfall varies from 1000 to 1400 mm. As for Agro-Ecological Zone VII, it includes the municipalities of Lalo and several other municipalities. It is called depression zone. It is the smallest of the eight (08) agro-ecological zones in terms of surface area. On the climatic level, it is quite comparable to the bar land zone with, however, a high relative humidity. In the two agro-ecological zones, maize, cassava, cowpea, groundnuts, peanuts, pepper and tomatoes are grown.

The study population: sampling

The field approach enabled information to be collected from farm house holds. Thus, on the basis of rigorous criteria, random sampling by municipality will be carried out. Data from the National Institute of Statistics and Economic Analysis helped to discriminate between villages. With regard to the target groups, the methodology used and the phenomena to be studied, only the heads of households were interviewed. The formula of \(^{10}\)

\[
n = \frac{t^2 \times p \times (1-p)}{E^2}, \text{ where}
\]

\[
n = \text{sample size}
\]

\[
t = 95\% \text{ confidence level (typical value of 1, 96)}
\]

\[
p = \text{estimate of the proportion of the specific population concerned by the study. Where it is not defined, it is equal to 50%).}
\]

\[
E = \text{margin of error tolerated: up to 6%}. \text{ Thus:}
\]

\[
n = \frac{1.96^2 \times 0.5 \times (1 - 0.5)}{0.00^2}, \text{ and: } n = 267
\]

### Table 1 Household sample structure by sex

<table>
<thead>
<tr>
<th>Municipalities</th>
<th>Total population (RGPH)</th>
<th>Number of households</th>
<th>Household size</th>
<th>Number of households who by municipality</th>
<th>Sex</th>
</tr>
</thead>
<tbody>
<tr>
<td>APLAHOUÉ</td>
<td>171 109</td>
<td>35 101</td>
<td>5.2</td>
<td>67 (25%)</td>
<td>38</td>
</tr>
<tr>
<td>DJAKOTOMEY</td>
<td>134 028</td>
<td>25 106</td>
<td>5.3</td>
<td>48 (18%)</td>
<td>42</td>
</tr>
<tr>
<td>DOGBO</td>
<td>103 057</td>
<td>21 199</td>
<td>4.9</td>
<td>40 (15%)</td>
<td>35 (15%)</td>
</tr>
<tr>
<td>KLOUKANMEY</td>
<td>128 97</td>
<td>25 251</td>
<td>5.0</td>
<td>48 (18%)</td>
<td>62</td>
</tr>
<tr>
<td>LALO</td>
<td>119 926</td>
<td>17 133</td>
<td>6.8</td>
<td>32 (12%)</td>
<td>28</td>
</tr>
<tr>
<td>TOVIKLIN</td>
<td>88 611</td>
<td>17 773</td>
<td>6.0</td>
<td>32 (12%)</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td>745 328</td>
<td>140 444</td>
<td>5.5</td>
<td>267 (100%)</td>
<td>233</td>
</tr>
</tbody>
</table>

Source: Calculated from INSAE statistics (2015)

### The model of study

The data collection tool is the contingent questionnaire. The Contingent Assessment Method (CAM) empirically obtained the willingness to pay (WTP) of beneficiary households to avoid land degradation. By estimating the average WTP using the probit model, the tobit model (Tobin, 1958) istested by the two-step method of Heckman (1979) to control for selection bias in the sample of 267 households. Two (02) situations S1 and S2 are proposed to the respondents:

- S1: Keep the current land degradation situation. This situation does not entail any financial burden on the households, but they will continue to suffer the nuisances related to the current degradation and infertility of the agricultural soils in their municipality.
- S2: To participate financially in the soil quality improvement programme. This entails a financial cost for households, but allows them to avoid the decline in soil fertility they are currently experiencing.

In a first step, the individual decides whether or not to pay for soil conservation techniques (SCTs). This decision can be represented by a dichotomous qualitative model based on a certain criterion 

\[
y^*_i, \text{ if } y^*_i < 0, \text{ individual i decides not to pay}
\]

\[
y^*_i > 0, \text{ individual i decides to pay}
\]

In a second step, the individual decides how much he or she is going to spend on SCTs, after deciding to pay. We then have a model of censored data since, if we note y2,i the actual payment for household i, this is defined by with i = 1, 2, ..., N :

\[
y^*_i \leq y^*_i \leq y^*_i^{*}\text{, if } y^*_i \leq 0
\]

\[
y^*_i > y^*_i \text{, if } y^*_i > 0
\]

The econometric model used to estimate the WTP of respondents falls within the domain of qualitative variables, more specifically selection models. Indeed, the variables we are trying to explain are the WTP amounts declared by households to contribute to the improvement of soil quality on the Adja Plateau. However, it is certain that this information is only available for households that have opted for S2. This is a two-stage model. In the first stage, the household chooses whether to participate in the programme or not, and then they
decides how much to pay. Using the method of Heckman (1979), our model can be formalized mathematically as follows for each household i:

**Selection equation:** to participate in the soil quality improvement program. Let \( Z \) be the quality variable, such that \( Z = 1 \) if household \( i \) participates in the program and 0 otherwise:

\[
Z = w\beta + \mu_i e_i \quad \text{follows a normal law of parameters N(0,1). (4)}
\]

- **Substantial equation:** estimated willingness to pay (PAC) (observable only if \( Z = 1 \)):

\[
Y = x_i \gamma_i + \epsilon_i \quad \text{follows a normal law of parameters N(0,1). (5)}
\]

The \( w_i \) and \( x_i \) are observable socio-economic variables. Assuming a normal distribution N(0, 1), the error terms of the two equations (selection and substantial) are there fore absolutely continuous and assume for density \( f(x) \), suchthat:

\[
f(x) = \frac{1}{\sqrt{2\pi}} e^{-x^2/2}, \quad \text{avec } x = \mu_i e_i. \quad (6)
\]

**RESULTS AND DISCUSSION**

The results of the survey on the Plateau ADJA, present 80 heads of households, i.e. 30% who chose S1 \((y_{1,i}^* > 0)\), thus having a CAP = 0, and 70% who made the S2 option \((y_{1,i}^* > 0)\), i.e. who accepted the programme to combat agricultural soil degradation, thus representing 117 households that actually agreed to invest in soil conservation. Thus, of the 117 households, 80 agree to pay 1500 FCFA, while 55 households agree to pay 2500 FCFA. There are 36 agricultural households that agree to pay 3000 FCFA and 14 households that agree to pay 3500 FCFA. The last category of households that agreed to invest 4000 FCFA in soil conservation techniques on the Plateau ADJA, comprises only2 households and is located in the commune of APLAHOUÉ. The average CAPs for the six (06) communes of Plateau ADJA that accepted the program (S2) and for the entire sample of 267 households (S1+S2) are presented in Table 2.

**Table 2** Determination of the average WTP of the 6 municipalities of the Plateau ADJA

<table>
<thead>
<tr>
<th>Variables</th>
<th>WTP (S1+S2)</th>
<th>WTP (S1)</th>
<th>WTP (S2)</th>
<th>WTP (S1+S2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>APLAHOUÉ</td>
<td>67</td>
<td>20</td>
<td>0</td>
<td>47</td>
</tr>
<tr>
<td>DJAKOTOMEY</td>
<td>48</td>
<td>14</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>DOGBO</td>
<td>40</td>
<td>12</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>KLOUKANMEY</td>
<td>48</td>
<td>14</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>LALO</td>
<td>32</td>
<td>10</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>TOVIKLIN</td>
<td>32</td>
<td>10</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>267</td>
<td>80</td>
<td>-</td>
<td>187</td>
</tr>
</tbody>
</table>

**Source:** Auteur, 2020

The average WTP of the six (06) communes for S2 is then equal to 2225.34 FCFA and for (S1+S2) it is equal to 1556.47 FCFA. For the first stage, the estimation of the selection equation is carried out on all the observations that responded to the quota scenario, i.e. on a sample of 267 farm households. For the second step relating to the substantial equation, STATA uses the observations of S2, those who decided to pay. This estimate is based on 187 observations. Based on the model studied, the coefficients of the selection equation are interpreted as those of the probit model. The coefficients of the substantive equation represent the influence of the explanatory variable on the explained variable. This is ordinary least squares (OLS). Figure 1 shows the average willingness to pay of the entire sample of 267 heads of households in the ADJA Plateau.

**Figure 1** Les consentements à payer moyen de l'échantillon

**Source:** Auteur, 2020

The survey of the Adja Plateau allowed us to categorize six (06) variables from the selection equation and four (04) variables from the substantive equation (Table 3).

**Table 3** Variables in the selection and substantive equations of the model

<table>
<thead>
<tr>
<th>Variables of the selection equation</th>
<th>Variables of the substantial equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farming income (REVENU)</td>
<td>Age of the peasant (AGE)</td>
</tr>
<tr>
<td>Non farming income (NONAG)</td>
<td>Size of the house hold (TM)</td>
</tr>
<tr>
<td>Household size (TM)</td>
<td>Access to market (ACCMAR)</td>
</tr>
<tr>
<td>Age of the peasant (AGE)</td>
<td>Farming income (REVENU)</td>
</tr>
<tr>
<td>Level of instruction (EDU)</td>
<td>Access to market (ACCMAR)</td>
</tr>
</tbody>
</table>

**Source:** Auteur, 2020

For the significance of the coefficients of the variables in the selection and substantive equations of the model, it should be noted that for the selection model (first step), the coefficients of the variables market access (ACCMAR) and farmer age (AGE) are not significant. As for the substantial equation (second step), the age of the farmer has no influence on the amount of willingness to pay. On the other hand, the coefficients of the variables "household size" (HS) and "Farming income (FI) are significant at 1% in both the first and second steps. Furthermore, the two-stage model of Heckman (1979) estimates the inverse of the Mills ratio. Since the inverse of the Mills ratio is not significant, there is therefore no selection bias. The results of the two-stage estimation by Heckman (1979) are presented in Table 4.
The average WTP for households that agree to participate in the land degradation programme is equal to 1556.47 FCFA/month/hectare for the entire sample. The total areas (ST) sown during the 2018 and 2019 periods being respectively equal to 167,396 hectares and 201,739 hectares, this results in a total WTP (TWTW) of 3,127,626,864 FCFA/year in 2018 and 3,769,291,476 FCFA/year for 2019 over the entire ADJA Plateau. Details of average communal WTP for the 2018 and 2019 periods are presented in Table 5.

Table 5 Determination of annual municipal WTP and totals

<table>
<thead>
<tr>
<th>WTP municipal annual resources</th>
<th>Total area sown(hectare)</th>
<th>Totals WTP(FCFA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2018</td>
<td>2019</td>
</tr>
<tr>
<td>Aphonhoue</td>
<td>19 788</td>
<td>50 056</td>
</tr>
<tr>
<td>Djakotomey</td>
<td>21 000</td>
<td>35 101</td>
</tr>
<tr>
<td>Dogbo</td>
<td>19 656</td>
<td>14 750</td>
</tr>
<tr>
<td>Klouekammy</td>
<td>18 624</td>
<td>34 487</td>
</tr>
<tr>
<td>Lalo</td>
<td>17 436</td>
<td>18 330</td>
</tr>
<tr>
<td>Toviklin</td>
<td>15 564</td>
<td>14 672</td>
</tr>
<tr>
<td>Plateau Adja</td>
<td>18 684</td>
<td>167 396</td>
</tr>
</tbody>
</table>

Source: Based on statistics from the Departmental Directorate of Agriculture, livestock’s and fisheries of Couffo (DDAEF, 2020)

Table 5 shows that total AACs are an increasing function of the total area sown. In other words, the greater the area sown, the greater the total WTP.

CONCLUSION

The survey work on the ADJA Plateau led to two (02) categories of results; descriptive result from the survey on the determinants of willingness to pay (WTP) and econometric results from Heckman’s (1979) 2-stage estimation. This work made it possible to express in monetary terms what farm-households in the six (06) communes on the ADJA Plateau are willing to pay for an improvement in the quality of their soils in order to avoid fertility losses, which can lead to risks of food insecurity and poverty. The results obtained made it possible to draw methodological, analytical and practical conclusions. It was found that farming households in the ADJA Plateau attach importance to improving the quality of their soils and are willing to contribute financially to this effort. The study also revealed the significant influence of socioeconomic variables on the decision of farmers to pay for improving the quality of their soils. The calculated values will constitute basic references for future research aimed at understanding the economic value of agricultural soils in general and will help to inform public decision-makers in agricultural policy in Benin.

Bibliographic References