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# Endogenous Strategies to Face Climate Change and Maintains Ecosystem Resilience in Forest of Three Rivers in the North of Benin

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***Abstract* – The lands bordering of the three rivers forest (FC3R) in northeastern Benin are continually subjected to anthropogenic pressures which affect the renewal of biological resources and the ecosystem resilience. These pressures are aggravated by climate change that threatens food security and biodiversity. Faced this situation, different practices and adaptation measures developed locally that shown several level of acceptability and efficiency. Hence, the actual study proposes to evaluate the endogenous adaptation strategies in the land bordering the forest of the three rivers in order to point up the most effective. Thus, in the purpose to analyze those endogenous adaptation strategies, a survey was carried out among 301 farmers in the riparian villages of FC3R. Data were processed in order to point up the socio-economic effectiveness of those strategies. Thus, the methodology of the matrix approach of risks developed by World Bank was used for social acceptability evaluation. The econometric analysis was carried out using parameters: gross margin (GM), profit/cost (P/C) and man/day ratio (M/D). Tests like Kruskal wallis non parametric test and Pairwise.wilcox.test were also performed. Results showed 12 endogenous strategies developed against climate change were identified, described and prioritized. The Agroforestry, the large ridge perpendicular to the slope, the small ridge and the flat plowing are the most effective strategies. Econometric analyses of these most adopted strategies reveal that large ridges yield the highest GM (144113 XOF) and the highest P/C ratio (0.99) and also have the advantage of requiring less effort (24.57 H/J). It was followed by small ridges with GM = 144113 XOF, P/C = 0.99 and M/D = 25.76. Compared to the less effective strategies, flat plowing provides a higher GM (117167 XOF) than agroforestry (GM=102994 XOF). However, the P/C ratio shows that flat tillage (0.80) is less beneficial and required more effort than agroforestry (B/C = 0.92). Thus, the best endogenous strategies or practices to face the climate change and maintaining ecosystem resilience in the FC3R are water and soil conservation strategies.**

***Keywords* – Benin, Climate Change, Ecosystem Resilience, Endogenous Adaptation Strategies, Three Rivers Classified Forest.**

## I. Introduction

The ecosystems degradation in the world is linked to anthropogenic factors, including agricultural activities [7]. The populations of the planet are dependent on intact ecosystems and the services they provide, such as soil fertility, clean water and food [18]. Over the past decades, we assisted on a widespread degradation of natural ecosystems, aggravated by unfavorable socio-economic and pedoclimatic contexts [5]. This degradation is characterized by a significant decrease in plant formations and a considerable reduction in wood resources (fire wood and service wood). This phenomenon of degradation of natural resources poses a threat to humanity and has become a fundamental concern since the Rio Conference in 1992 [1]. Benin suffers from the effects of climate change, which limit its development, resulting in global warming, and decreasing variability in rainfall, droughts and occasional floods [6]. Indeed, production becomes more and more unpredictable with climate change, which often creates confusion in agricultural planning [14]. Faced with this situation, adaptation measures, adopted by the riparian's populations, range from traditional or endogenous practices to improved endogenous practices that also differ from one agro-climatic region to another but can be adapted for transfer to enhance adaptation [3]. Hence the relevance of a new adaptation approach that involves sustainable management, conservation and restoration of ecosystems to provide services that enable people to adapt to the adverse effects of climate change [11]. Across the globe, initiatives have been established to assist communities in implementing approaches to adapt to and mitigate climate change; the Ecosystem Based Adaptation (EBA) approach to ecosystem Adaptation [12]. It is therefore an emergent anthropocentric approach put in place as part of a global adaptation strategy to help people adapt to the adverse effects of climate change while preserving biodiversity and ecosystem services [16]. The influence of human activities on the classified forest of the three rivers is very important, threatening the sustainability of the peripheral agricultural and pastoral systems and degrading this protected area [20]. For example, any study that aims to contribute to better management of the soil bordering the classified forest of the three rivers is timely and is part of this adaptation approach based on the sustainable management of ecosystems. Hence the present that will evaluate and analyze the adoption and the effectiveness of endogenous adaptation strategies around the FC3R towards it ecosystem resilience. This study aims is to evaluate the endogenous adaptation strategies around the forest of the three rivers in order to see the most effective by prioritizing them and analyzing their effectiveness.

*Study Area*

The FC3R is one of the largest forests in Benin and is located in the northern part of the country between parallels 10° 18' and 18° 48' north latitude and meridians 2° 46' and 3° 35' of longitude east (Figure 1) [15].

It straddles the departments of Borgou and Alibori and is limited:

- in the north-west by the municipality of Gogounou,
- in the south - west by the municipality of Bembèrèkè,
- in the Northeast by the municipality of Ségbana and
- in the south - east by the commune of Kalalé.

It currently covers a total area of 259,600 ha for all four riparian municipalities [22].

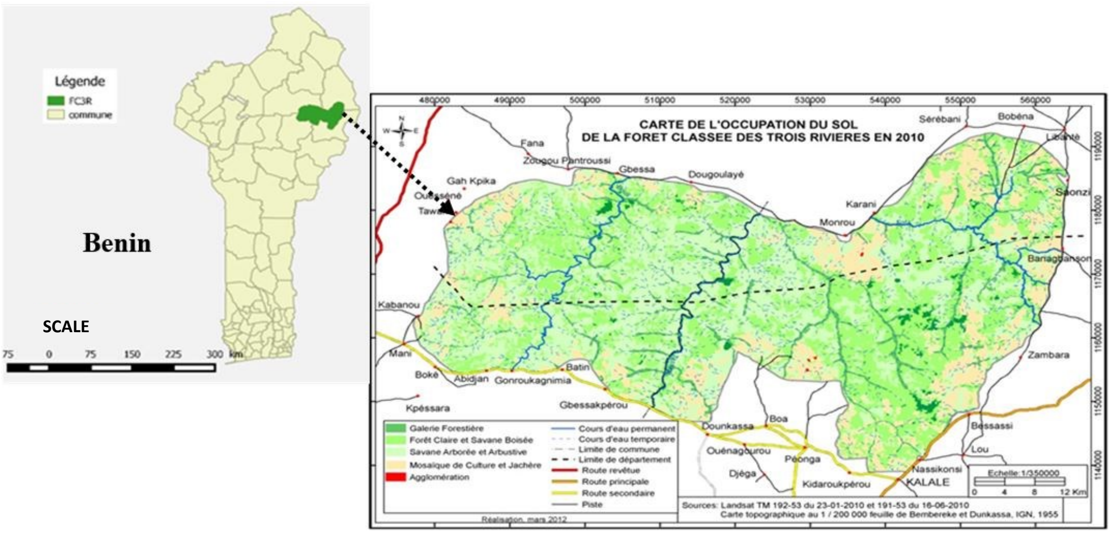


Fig. 1. Location map of the three rivers classified forest (FC3R)
Source: DGFRN (2010)

## II. Methodology

### *A. Sampling and Data Collection*

- In the present study, a 5 km zoning around the forest boundary was made to study the actual impact of anthropogenic activities on the classified forest of the three rivers. Villages in this area were systematically selected. Thus, the number of villages per municipality varies from one to another. Thus, there are 04 villages in the municipality of Bembèrèkè, 06 in Gogounou, 05 in Ségbana and 11 in Kalalé.

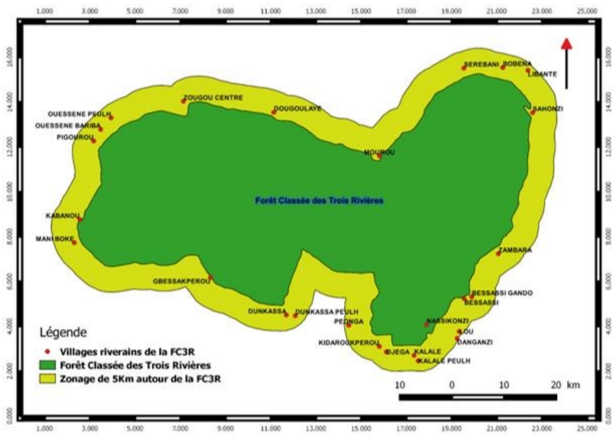


Fig. 2. Delimitation of the study area around the Three Rivers Classified Forest *Source: Lokossou, 2016.*

- The surveys were carried out in the bordering municipality of the classified forest of the three rivers (Kalalé, Bembèrèkè, Gogounou and Ségbana). Sampling has been particularly relevant to the whole population that is actively engaged in agricultural activities. The methodology used in the data collection took into account the actors involved in agricultural operations that are affected by climate change. The sampling is random according to the agricultural assets in the concerned villages. Strategies for conservation and adaptation to climate change, sociocultural and demographic characteristics (age, ethnicity, sector of activity, religion, etc.) of local residents and their perception of each strategy (description, advantages, disadvantages, Recommendations) were collected. Previously, the proportion of agricultural households in the four municipalities was determined by the data from the monographs [12]; which was updated by the discount rate of the General Population Census of 2013 [16]. The average of these proportions gave 73.25%. The sample size was determined by the formula of [4]

$$n = \frac{P(1-P)U^2_{1-\alpha/2}}{d^2}$$

N = sample size;
U = confidence level according to the normal centered reduced law (for a confidence level of 95%, U1-α / 2 = 1.96);
P = proportion of farmers;
D = tolerated margin of error (5% close)

Thus, 301persons belonging to the riparian lands of the FC3R were subjected to the questionnaire of the investigations.

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The number of respondents was calculated per village by the following formula:

$$Q = n / E \times 100$$

With n = number of respondents;

Q = the proportion to be applied to the population of a given village to have the number of respondents in that village;

E = total person for a 5-km around the forest.

*B. Method of Data Processing and Analysis*

*- Description of Endogenous Adaptation Strategies*

The data collected about the adaptation strategies identified were addressed. These strategies were listed and then briefly described according to local practices. In addition, the main advantages and disadvantages of each strategy were highlighted. The percentage adoption was also calculated to assess the degree of adoption of these strategies.

*- Prioritization of Endogenous Adaptation Strategies*

The effectiveness analysis of the adaptation strategies used the methodology of the World Bank's Institute risk matrix approach, based on six feasibility criteria: cost, easiness, effectiveness, rapidity, capacity and acceptability. Two steps were followed: II.

- The first step was to list the recorded strategies through the surveys with the farmers;
- The second stage consisted of prioritizing and classifying proposed adaptation strategies based on cost, easiness, effectiveness, rapidity, capacity and acceptability (see Table 2). Criteria ranges are low, medium, high. The criterion favors the achievement of the strategy. A strategy that costs a low cost for the criteria"cost" is a strategy that does not require new needs for capacity building or technology transfer for its implementation at a high cost as regards the criterion" capacity".

Thus, any strategy totaling a score lower than 12 is not retained. Strategies were prioritized based on total scores. This prioritization reflected the level of effectiveness of each endogenous adaptation strategy.

*- Analysis of the Socioeconomic Effectiveness of Endogenous Adaptation Strategies*

The effectiveness analysis focused on endogenous strategies to improve maize yield, which is the basic crop for food security around the three rivers' classified forest. The best strategies obtained from the prioritization were subjected to econometric analysis in order to determine the most effective. During the inventory of these strategies, the econometric parameters such as cost of realization, gross margin, ratio man/day of each strategy were estimated. The most effective strategies for improving farmers' incomes were determined by taking into account the priority strategies, the econometric parameters mentioned above, using the Kruskal Wallis test followed by the Pairwise.wilcox.test to compare the mean of these parameters for each chosen strategy. The boxplots were also performed for analysis for analysis of means, medians and deviations.

## III. Results

*A. Adoption of Endogenous Adaptation Strategies*

*- List of Endogenous Adaptation Strategies*

The preliminary study carried out in the riparian lands of the FC3R identified sixteen (16) of the most used strategies for adapting to climate change. Among them, farmers are familiar with and practice 12 such as agroforestry, crop diversification, crop density adjustment, water and soil conservation techniques such as the large ridge perpendicular to the slope, small ridge perpendicular to the slope and flat plowing, fertilization technique, use of resistant varieties, use of early varieties, support for agro-meteorological monitoring, reforestation and direct seedling. Table 1 presents the description, advantages and disadvantages of each strategy.

Table 1. Description, advantages and disadvantages of the most used climate change adaptation strategies

| Strategies | Description | Advantages | Inconveniences |
|---|---|---|---|
| AF | Association of trees with crops | • Shade for farmers<br>• Fruit marketing for fruit trees<br>• Use of trees for medicinal purposes<br>• High organic matter<br>• Brakes the wind speed<br>• Conserves moisture<br>• Reduces water erosion<br>• Not require many upkeep | Hands raised for initial planting and upkeep |
| CD | Crop rotation, crop association | • Restoration of soil fertility<br>• Sustainable land management<br>• Romps the life cycle of pests for crops | • Requires greater technical experiences<br>• Secondary crops may not be favored |
| CDA | Reseeding or density adjustment of young plant | • Fight against the phenomenon of lodging<br>• Adjustment of crop density<br>• Increased harvest quantity | • Destruction of seedlings by pests<br>• Vulnerability of youngest plants<br>• Requires more monitoring and complementary work |
| GB | Large ridge of 80-100 cm in thickness and 30-50 cm in height, perpendicular to the slope | • Increased crop density<br>• Good soil loosening<br>• Reduced number of ridges<br>• Increased number of pockets per line<br>• Easy and inexpensive installation<br>• Fight against erosion<br>• Maintains moisture in the soil<br>• Good burial of the roots of the plants | • Undersaving trees during soil preparation<br>• Little vital space between the two parallel sowing lines of the same ridge<br>• Requires a little more physical effort |

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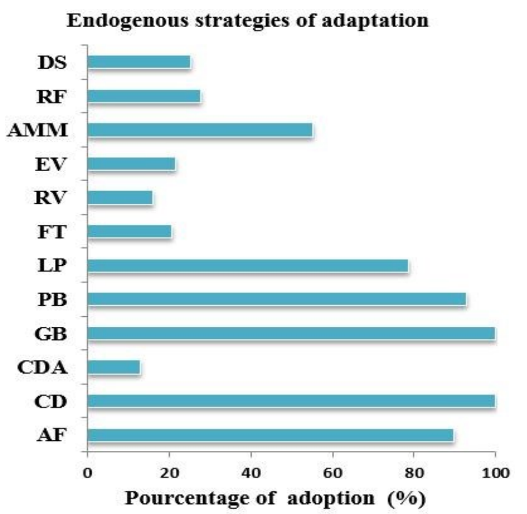
| Strategies | Description | Advantages | Inconveniences |
|---|---|---|---|
| | | • Promotes water infiltration on steep soils | |
| PB | Small ridge of 40-60 cm thick and 30-40 cm height, Perpendicular to the slope | • Easy and inexpensive installation • Fight against erosion • Maintains moisture in the soil • Promotes water infiltration on steep soils • Aeration of plants | • Undersaving trees during soil preparation • Requires a significant amount of ridge per hectare |
| LP | The mouldboard (plow or hoe) shed the ground always on the same side of the plow | • Easy to implement • Possibility of choosing plant layout • Good loosening of topsoil • Good performance | • Difficult to achieve over a large area • Requires trip of physical effort • Difficulty in obtaining sowing lines |
| FT | Use of crop residues, livestock manure | • Cheap • Moisture conservation • Protects the soil from high sunstroke in the dry season • Bury organic matter under the ridges | • Availability of animal feces in sufficient quantities |
| RV | Use of mutant or resistant varieties | • Resistance to climate change stress • Strong adaptation to the effects of climate change | • High cost • Difficult access to resistant varieties • Failure to select mutant varieties • Dependence of seed production firms |
| EV | Use of short-cycle varieties | • Good performance in case of shortening of the seasons | • Harvest period gag • Varieties often not too popular by populations • Dependence of seed production firms |
| AMM | Forecast of agricultural seasons and their duration | • Sowing on a good date • Normal application of fertilizer • Accuracy in agricultural planning | • Scheduling Dates • Predictions are not always accurate |
| RF | Trees plantation | • Soil enrichment in organic matter • Fighting against erosion • Shade developed for habitats • Mitigation of climate change impacts | • High cost • Depletion of genetic diversity |
| DS | Direct seedling without plowing | • Fast and easy to implement • Does not require technical knowledge | • High risk of loss of seedlings • Difficulty of sowing on-line • Little aeration in the soil • Soil easily exposed to erosion |

AF: agroforestry; CD: crop diversification; CDA: crop density adjustment; GB: large ridge perpendicular to the slope; PB: small ridge perpendicular to the slope; LP: flat plowing; FT: fertilization technique; RV: use of resistant varieties; EV: use of early varieties; AMM: support for agro-meteorological monitoring; RF: reforestation; DS: direct seeding

- *Degree of Adoption of Endogenous Strategies of Adaptation*

Fig. 3 shows the percentage of adoption of endogenous strategies around the FC3R.




AF: agroforestry; CD: crop diversification; CDA: crop density adjustment; GB: large ridge perpendicular to the slope; PB: small ridge perpendicular to the slope; LP: flat plowing; FT: fertilization technique; RV: use of resistant varieties; EV: use of early varieties; AMM: support for agro-meteorological monitoring; RB: reforestation; SD: direct seeding

*Fig. 3. Percentage of Adoption of Endogenous Strategies for Adaptation to Climate Change*

Figure 3 shows that adaptation strategies adopted by more than 60% of the populations of the the Three Rivieres classified forest are: crop diversification (CD), agroforestry (AF), Large plowing Ridge perpendicular to the slope (GB), small ridge perpendicular to the slope (PB), flat plowing (LP) and finally support to agro-meteorological follow-up (AMM). Of all these strategies, note that the GB and CD followed by the PB, LP and AF are the most widespread because of their effectiveness according to the remarks of the local populations.

*B. Prioritization and Social Acceptability of Endogenous Adaptation Strategies to Climate Change*

Prioritization of adaptation strategies showed that the large ridge perpendicular to the slope, the small ridge perpendicular to the slope, flat plowing and agroforestry are the strategies that have a score greater than or equal to 12 according to the method of The World Bank's risk matrix approach (Table 2). Thus we have according to these criteria:

- The large ridge perpendicular to the slope, which is one of the anti-erosion techniques, is the most effective strategy. It is relatively cheaper, easy to implement, effective in erosion control and retains much moisture. It is, moreover, very quick to implement and adopted by the majority of farmers because of its high acceptability on all the riparian lands (see Table 2).
- The small ridge perpendicular to the slope is the second most effective strategy. It costs relatively cheaper, easy to execute, effective in erosion control and retains much moisture. It is also less quick to execute than the large ridge. The peasants have the capacity to carry it out and it is widely accepted by local residents (see Table 2).
- Flat Plowing is the third most effective strategy. It is relatively cheaper and faster, more or less easy to implement, and performs well. It is less acceptable than the previous ones by the farmers because of the difficulties in choosing the sowing lines (see Table 2).
- Agroforestry ranks fourth and ranks as the most effective climate change strategies. It costs more or less expensive, it is more or less easy to execute, very efficient, more or less rapid to achieve, moderately acceptable by farmers because of the constraint in the hands of works raised for the initial planting and maintenance in Start of installation (see Table 2).

Table 2. Prioritization of endogenous strategies for adapting to climate change according to World Bank criteria

| STRATEGIES | COST | EASINESS | EFFECTIVENESS | RAPIDITY | CAPACITY | ACCEPTANCE | TOTAL | RANK |
|---|---|---|---|---|---|---|---|---|
| AF | 2 | 2 | 3 | 2 | 1 | 2 | 12 | 4 |
| DC | 1 | 1 | 1 | 1 | 2 | 1 | 7 | 5 |
| AC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| SC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 |
| APP | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 13 |
| GB | 2 | 3 | 2 | 3 | 3 | 3 | 16 | 1 |
| PB | 3 | 2 | 2 | 2 | 3 | 2 | 15 | 2 |
| LP | 2 | 2 | 3 | 2 | 3 | 2 | 14 | 3 |
| TF | 0 | 0 | 0 | 1 | 1 | 0 | 3 | 11 |
| SE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| VR | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 |
| VP | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 6 |
| EBP | 1 | 1 | 1 | 0 | 1 | 0 | 4 | 10 |
| AGM | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 9 |
| RB | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 6 |
| SD | 1 | 1 | 1 | 1 | 2 | 1 | 5 | 6 |

1 = low; 2 = medium; 3 = high;

AF: agroforestry; CD: crop diversification; CDA: crop density adjustment; GB: large ridge perpendicular to the slope; PB: small ridge perpendicular to the slope; LP: flat plowing; FT: fertilization technique; RV: use of resistant varieties; EV: use of early varieties; AMM: support for agro-meteorological monitoring; RB: reforestation; SD: direct seeding

### *C. Economic Efficiency of Endogenous Strategies*

The results revealed a very significant difference between the different adaptation strategies (Table 3, 4, 5 and Figures 4, 5, 6). The Pairwise.wilcox.test test showed that the large ridges followed by small ridges have the highest gross margins and profit ratios; while agroforestry totaled the lowest values for these parameters. For example, the large ridges yield the highest gross margin (144113 XOF) and the highest P/C ratio (0.99) and also have the advantage of requiring less physical effort (24.57 H/J). The small ridges are the best effective after the large ridges with the following values: gross margin (144113 XOF), P/C ratio (0.99) and H/J ratio (25.76). Compared to the last two strategies, Flat plowing provides a higher gross margin (117167 XOF) than agroforestry (102994 XOF). However, the P/C ratio shows that Flat plowing (0.80) is less beneficial and more labor intensive than agroforestry which requires labor and a B/C ratio of 0.92.

Thus, the large perpendicular ridge and the small ridges are the most effective strategies used by local population of the FC3R, which justifies its level of adoption by the farmers.

Table 3. Synthesis of the socio-economic parameters of the most used types of plowing

| OPERATIONS | TYPES OF PLOWING | | | | | |
|---|---|---|---|---|---|---|
| | LARGE RIDGE PLOWING | | FLAT PLOWING | | SMALL RIDGE PLOWING | |
| | Mean | CV (%) | Mean | CV (%) | Mean | CV (%) |
| Field preparation | 26494 | 21.54 | 27596 | 29.50 | 27409 | 15.55 |
| plowing | 30469 | 5.14 | 27442 | 10.15 | 27681 | 11.80 |
| seedling | 6077 | 11.43 | 6596 | 20.65 | 6332 | 35.55 |
| First Clearing | 12298 | 14.07 | 12058 | 4.88 | 11919 | 6.65 |
| Second Clearing | 12395 | 14.69 | 12019 | 4.92 | 12037 | 4.70 |
| Third Clearing | 12114 | 5.55 | 11942 | 4.01 | 12080 | 3.88 |
| Herbicide | 7624 | 8.42 | 7510 | 1.31 | 7500 | 0.00 |
| Fertiliser | 38090 | 15.08 | 38712 | 12.62 | 36693 | 7.71 |
| Seeds | 2504 | 1.82 | 2500 | 0.00 | 2500 | 0.00 |
| COST | 149527 | 8.86 | 146433 | 7.13 | 143935 | 4.45 |
| RETURNS | 292224 | 15.51 | 263604 | 13.79 | 277034 | 11.89 |
| GROSS MARGIN | 144113 | 31.25 | 117167 | 30.08 | 134387 | 24.86 |
| BENEFIT/COST (B/C) | 0.99 | 32.38 | 0.80 | 31.17 | 0.94 | 26.74 |
| MEN/DAY (M/D) | 24.57 | 10.75 | 26.51 | 10.52 | 25.76 | 10.53 |

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Table 4. Syntheses of socio-economic parameters in Agroforestry Systems

| OPERATIONS | AGROFORESTERY Mean | CV (%) |
|---|---|---|
| Field preparation | 26877 | 15.78 |
| Planting | 61197 | 12.91 |
| Keeping | 25154 | 17.93 |
| COST | 113313 | 9.82 |
| RETURNS | 216307 | 14.79 |
| GROSS MARGIN | 102994 | 28.28 |
| PROFIT/COST (B/C) | 0.92 | 29.53 |
| MEN/DAY (M/D) | 28.08 | 15.61 |

Table 5. Gross margin, Man/day ratio and Profit/cost ratio of the most adaptated strategies: Results of the Kruskal Wallis test followed by Pairwise.wilcox.test (P value adjustment method: holm).

| Stratégies d'adaptation | Gross margin (XOF) | | Man / Day (H/J) | | Profit/Cost (P/C) | |
|---|---|---|---|---|---|---|
| | M | CV (%) | M | CV(%) | M | CV(%) |
| Large ridge plowing (GB) | 144113$^{a}$ | 31.25 | 24.57$^{a}$ | 10.75 | 0.99$^{a}$ | 32.38 |
| Small ridge plowing (PB) | 134387$^{b}$ | 24.86 | 25.76$^{a}$ | 10.53 | 0.94$^{b}$ | 26.74 |
| Flat Plowing (LP) | 117167$^{c}$ | 30.08 | 26.51$^{b}$ | 10.52 | 0.80$^{c}$ | 31.17 |
| Agroforestery (AG) | 102994$^{d}$ | 28.28 | 28.08$^{a}$ | 15.61 | 0.92$^{d}$ | 29.53 |
| Kruskal-Wallis rank sum test | 0,000 | - | 0,000 | | 0,000 | - |

Means with different letters (a, b, c and d) are significantly different according to the test of Pairwise.wilcox.test M= mean; cv = coefficient of variation

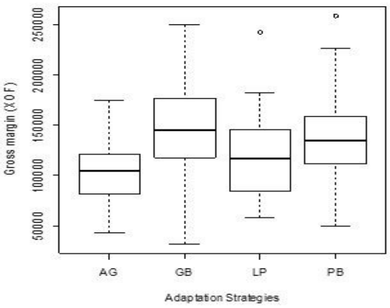


Fig. 6. Boxplot of adaptation strategies for Goss margin

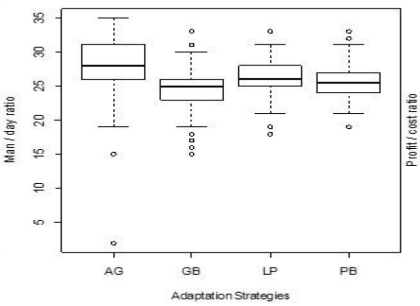


Fig. 5. Boxplot of adaptation strategies for Man / Day ratio

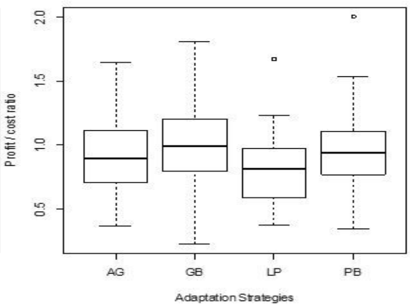


Fig. 4. Boxplot of adaptation strategies for Profit / Cost ratio

## IV. Discussion

The analysis of the effectiveness of adaptation strategies used the World Bank's risk matrix approach based on six feasibility criteria previously cited. It emerges that endogenous adaptation strategies to climate change have several levels of effectiveness according to the farmers. Of the strategies developed or implemented, only four (Agroforestry, large ridges, short ridges and flat plowing) are effective because they score are ≥12.

The econometric analysis allowed concluding that large ridges and small ridges are more economical, easy to implement than flat plowing and agroforestry. Furthermore, those strategies ensure the ecosystem sustainability and thus fit with the principle of Ecosystems Based Adaptation (EBA). The socio-economic performance of these different plows is mainly related to their ease implementation and their ability to control erosion and conserve soil moisture. Which characteristics are related to their architectural structure as confirmed by [21] who states that the difference in efficiency between soil and water conservation technics is due to the difference in architecture between the types of barriers that constitute them when he comparing stony ropes with grass strips. Plowing increases the roughness of the soil and limits the rate of runoff of the first rains and this effect is even more remarkable when plowing is done in ridges perpendicular to the slope [13]. These strategies contribute, therefore, the most in the resilience of the FC3R ecosystem resilience.

It should be noted that most of the strategies that are widely adopted and most effective, according to local population, are water and soil conservation strategies or anti-erosion strategies. That is confirmed by [19] according to which integrated water and soil management could be determinative in food safety achieving [19]. [18], [19], [17] go further by asserting that water and soil conservation is the real problem of agricultural development in several tropical countries, including Benin. That is then the reason why local residents prefer to prioritize endogenous strategies for water and soil conservation to adapt to climate change.

For most other strategies, farmers face enormous difficulties in their implementation. These include the high cost of reforestation, for example, and the difficulty of access to seeds for the use of resistant varieties and the high need of physical effort. This is in harmony with the [2] study findings, which states that smallholder farmers are more vulnerable because low-resource countries are gradually trying to adapt to the climate change effects by implementing strategies and techniques of their own or with the help of the monitory services. Although many farmers are already adapting to climatic variations, weather becomes less predictable and some of the farmers' strategies may no longer be effective [13]. However progressive adaptation to change is therefore not a sustainable solution and farmers will have to prepare in advance for radical changes [17]. Adaptation cannot therefore be uniform or homogeneous, but rather a diversity of mutually beneficial approaches, knowledge and know-how [11].

## V. Conclusion

This study, which examined the endogenous adaptation strategies around the FC3R, allowed to see the best performers in social and economic plan in this context of climate change. Thus, only four of the developed and implemented strategies (Agroforestry, large ridges, small ridges and flat tillage) are socially most acceptable and economically profitable for local population. Findings also reveal that the most effectiveness and largely adopted strategies implemented by local residents against climate change around the FC3R are water and soil conservation technologies. Those technologies allow them to achieve food safety by enhancing their incomes and maintain ecosystem resilience of this forest reserve according to Ecosystem Based adaptation approach.

## VI. Acknowledgments

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**First A. Author**

**Mr Romaric Serge Lokossou**, was born at Cotonou the 19th January 1986 in Benin. He obtained the last degree of secondary school in 2005, the degree of Agricultural Engineer in 2011 at the Faculty of Agronomy of University of Parakou and the Master of Science degree in 2013 at the same University. Actually he is a PhD student at the Faculty of Agronomy of the University of Abomey-Calavi since 2016.

He had worked as Research Assistant from 2011 to 2014 within the Unit of Soil Physics and Environmental Hydraulics (PSHE) of the University of Parakou, Benin Republic. From the 2015 to 2017, he worked as Research Assistant in the Biodiversity Unit of Centre of Forest Studies, Research and Training of Environment Ministry of Benin. During his performed works and studies where he addressed several topics such as: Sustainable conservation of Forest ecosystem; Water and soil management for the sustainable production and food security in semi-arid area; Agro climatology, climate change.

**Second B. Author**

**Dr Sèhounkpindo Gaston AKOUEHOU**, at Dassa-Zoumé the 24th April 1961 in Benin. During his academic cursus, he obtained several degrees as: degree of Agricultural school (Lycée Agricole Mêdji de Sékou (LAMS)) in 1986; degree of Agricultural Engineer at" Ecole Nationale de Génie Rural et des Eaux et Forêts Montpellier" in 1997 (France); Master of Science at the "Ecole Nationale de Formation Agronomique (ENFA)/Université Mirail de Toulouse in 1998 (France) and PhD degree at the" Institut National Polytechnique de Toulouse INP-Ecole Nationale de Formation Agronomique de Toulouse" in 2002 (France).

From 2003 to 2017: Researcher at the Environment Ministry of Benin. From 2014-2016: General Director of Centre of Forest Studies, Research and Trainings where he have conducted research activities on any subject related to environmental protection and conservation. He also conducted training for environmental Department staff. His research and studies was focused on following topic: Sustainable conservation of Forest ecosystem; Rural Forestry, sylviculture, and socioéconomie.