Asian Journal of Environment & Ecology

13(4): 68-76, 2020; Article no.AJEE.63351
ISSN: 2456-690X

Dynamics of Approaches to Disseminate Measures for Sustainable Land Management and Adaptation to Climate Change within Agricultural Holdings in the Zou Department

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Authors' contributions

This work was carried out in collaboration among all authors. Authors EY, JA and FKA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors LA and RLM managed the analyses of the study. Authors LA, RLM, FA, MD and TG managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJEE/2020/v13i430192
Editor(s):
(1) Prof. Daniele De Wrachien, University of Milan, Italy.
Reviewers:
(1) Isaac Sarfo, Nanjing University of Information Science and Technology, China.
(2) Moudingo E. J-Hude, University of Douala, Cameroon.
Complete Peer review History: http://www.sdiarticle4.com/review-history/63351

Original Research Article

Received 28 September 2020
Accepted 02 December 2020
Published 16 December 2020

ABSTRACT

The restoration and preservation of terrestrial ecosystems are important challenges for human beings and are subject of many initiatives and intervention approaches. The present paper focuses on the dissemination approaches of sustainable land management and climate change adaptation (SLM/ CCA) measures implemented under the Soil Protection and Rehabilitation for Food Security Project. The influence of changes in these dissemination approaches on the adoption of SLM/ CCA by farmers in the department of Zou were analyzed. A survey was conducted on 150 farmers who

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are adopters and non-adopters of the targeted measures. These farmers were randomly selected in nine villages in the department of Zou. Interviews were carried out with the team of the project. As methodological approach, 150 farmers were randomly sampled in nine villages of the department of Zou. In addition, interviews were carried out with the project team. Data analysis was performed using descriptive statistics, as well as Chi-square and Pearson's correlation tests. The results showed that the dynamics noted in the dissemination approaches influence the adoption of sustainable land management and climate change adaptation measures, depending on the main activity and the farm total area of the farmers. In addition, adopters of SLM/CCA measures are more affected by the "SOL-Mobil" (98.0%) and "ProSOL Technician" (85.1%) approaches. They are less affected by the "Relay producer" (41.8%) and "Radio broadcast" (4.4%) approaches. Non-adopters are affected by the "ProSOL Technician" (63%) and "Relay Producer" (33.3%) approaches. However, they are less aware of the "Radio broadcast" approach (33.3%) and not affected by the "SOL-Mobil" approach. It is therefore important to take into account the diversity of farmers when implementing these approaches.

Keywords: ProSOL; SLM / CCA measures; dissemination approaches; dynamics; Zou department.

1. INTRODUCTION

Agriculture constitutes the main economic activity in Benin and employs at least 70% of the working population in small farms [1]. However, agriculture in Benin is characterized by deforestation, land over-exploitation and some non-sustainable agricultural practices. As a result, most of soils in Benin are currently degraded [2]. The southern region of Benin is particularly concerned where over-growing population increased land pressure. [3] have shown negative balances of 14 and 5 kg / ha respectively for nitrogen and potassium. The consequence is the decline of crop yields [4-5]. Being the major crops for the local populations, cereal crops, including maize are the most affected.

Faced with this situation, several Sustainable Land Management and Climate Change Adaptation (SLM / CCA) technologies are being tested to ensure the restoration of soil fertility. There are: i) traditional technologies, ii) fertilizer technologies based on mineral fertilizers, iii) fertility maintenance technologies based on herbaceous legumes, iv) agroforestry technologies based on woody legumes, v) conservation techniques of water in the soil and vi) technologies based on composting and manure use [6]. According to [7], the relevance of all of these technologies to the real concerns of farmers is not always established.

ProSOL is one of the projects of the special initiative "ONE WORLD without Hunger" (SEWoH) of the German Federal Ministry for Economic Cooperation and Development (BMZ). In Benin, since 2015, this project has been operating in 18 districts in the departments of Borgou, Alibori, Zou and Collines. It aims to implement sustainable and high-impact approaches to promote soil protection and the rehabilitation of degraded soils. To achieve this objective, the project promotes sustainable land management and climate change adaptation measures (SLM / CCA) classified into six categories: Integrated Soil Fertility Management (GIFS), Conservation Agriculture (CA), Water and Soil Conservation (CES), Agriculture and Livestock Integration, Agroforestry (IAEA), and Climate Change Adaptation (CCA) [1].

According to [8], a total of 34,000 farmers were trained in SLM from 2016 to 2018. Then, from 2016 to 2018, 82,000 ha of land were rehabilitated. To achieve these results, different dissemination approaches are adopted by ProSOL and have undergone changes over time. There are mainly: ProSOL Technician, Radio Broadcast, SOL-Mobil and Relay farmers. These changes in dissemination approaches were made in order to have a lasting impact on the project intervention communities. In such a context, it is necessary to analyze these changes and provide empirical evidence as to their link with the cultivation practices of the target farmers. This is the interest of this study, which aimed at assessing the influence of changes in dissemination approaches on the adoption of sustainable land management and adaptation to climate change (SLM / CCA) measures in the Zou department in Benin.

2. MATERIALS AND METHODS

2.1 Data Collection Methods and Tools

The data collection used for the present study went through 3 main phases: A documentary

research phase, an exploration phase and an in-depth investigation phase.

Following a documentary review, four focus groups were carried out with the key actors in the implementation of ProSOL (technical advisers, farmer's organizations, farmers and ProSOL technicians). To be representative of the study area, 150 farmers were randomly selected in six villages three different districts in the department of Zou. The selected villages are those with the most important adopters of sustainable land management and adaptation to climate change (SLM / CCA) measures in the Zou department. Interview guides were to collect qualitative information that allowed us to formulate our research hypotheses. Questionnaires were used for the survey phase.

With farmers and the farmer's organizations, discussions focused on the SLM / CCA measures adopted by them, the reasons for their choices, the channels of access to knowledge of these measures, the dissemination approaches of those measures, times of adoption of SLM / CCA measures, stages of implementation of techniques for disseminating measures, etc.

With regard to ProSOL supervisors and technicians, the topics covered revolve around the number of target farmers, as well as their distribution in the districts and the villages of Zou, the dissemination approaches developed by the project, the description of each technique. (stages, actors involved and the levels of responsibility of each type of actor ...), the chronology of these approaches, the spatial coverage of each dissemination technique, explanatory elements of the evolution of the dissemination techniques of SLM / CCA, the effects on the dissemination of measures for sustainable land management and adaptation to climate change (SLM / CCA), the increase in adoption rates of SLM measures over time, general information on the department of Zou, etc.

As for the technical advisers, it was at their level to collect information on the intervention villages of ProSOL, the farmers benefiting from the project (adopters and non-adopters), the approaches adopted by ProSOL for the dissemination of SLM / CCA measures, as well as general information on the study area.

The in-depth investigation allowed to collect important individual information enabling the different production systems to be characterized. These cross-sectional data are collected by means of semi-structured individual interviews with the sampled farms. The questionnaire developed is constituted of both opened and close ended questions and mainly addressed: (i)- the socio-economic characteristics of the household head; (ii)- the major crops; (iii)- SLM/CCA measures adopted by farmers and their descriptions; (iv)- the reasons these techniques adoption and their impacts on crops yield; (v)- the channels through which farmers are informed about these measures; (vi)- the techniques by which farmers are trained on the implementation of these measures; (vii)- farmers' perception of the approaches to disseminating SLM/CCA measures.

2.2 Methods and Tools for Data Analysis

Collected data were firstly entered into the Excel software (Version 2016). Then, the quantitative data are compiled and exported to the SPSS Statistics software (Version 20). The statistical analyzes made of the quantitative data are descriptive statistics, Pearson's correlation test and chi-square test. The Chi-square test allowed to characterize the two categories of identified farmers. The Pearson correlation test was used to assess the correlation between the two categories of farmers identified and the dissemination approaches implemented by the project. A cross-analysis of the results of these two tests made it possible to assess the effects of the dynamics of the dissemination approaches adopted on the categories of farmers.

Regarding descriptive statistics, the means and frequencies are the calculated parameters. For the second analysis, the Pearson correlation coefficient is estimated and noted rxy. It is a parametric coefficient which gives a measure of the degree of linear connection between two quantitative variables X and Y normally distributed. It is given by the ratio between their covariance and the non-zero product of their standard deviations. Thus, it standardizes the covariance and corrects it for the influence of the units of measure of the variables. Formally, the rxy is given by the formula:

rxy= cov (X, Y) XY

rxy= in (Xi-X) (Yi-Y) in (Xi-X)2* in (Yi-Y)2 [9]

With X the explanatory variable, Y the explained variable, X and Y the respective means of the variables X and Y.

Then, the value of p is estimated to assess the significance of the correlation between these two variables. The interpreting work of a linear correlation coefficient is always done in two stages: an interpretation in relation to the sign / direction of the connection and an interpretation in relation to the degree of dependence.

With respect to the sign:

- if rxy>0, X and Y are positively correlated (the linear relation between X and Y is positive).
- rxy <0, X and Y are negatively correlated (the linear relationship between X and Y is negative).
- if rxy = 1, X and Y are uncorrelated (no linear link, but possibility of a link of another type).

The interpretation with respect to the correlation intensity will be done by following the value of p and the following rules:

p≤ .01 the coefficient is significant at the 1% threshold or the coefficient is different from 0 with a probability of 99%

p≤ .05 the coefficient is significant at the 5% threshold = the coefficient is different from 0 with a probability of 95%

p≤ .10 the coefficient is significant at the 10% threshold = the coefficient is different from 0 with a probability of 90%

p> .10 the coefficient is not significant

In this study, the significance level of 5% is used, a threshold generally accepted in the social sciences.

Chi-square test which is done when it comes to comparing two groups of variables and the dependent variable is qualitative. Before proceeding with this test, the statistical hypotheses must be formulated: the null hypothesis H0 and the alternative hypothesis H1. H0 postulates that there is no difference between the frequencies of the two groups while H1 postulates that there is a difference between the frequencies of the two groups, a difference that is not due to chance. The existence of this difference allows us to state that a variable Y depends on another variable X, and therefore to infer that X is indeed the cause of Y.

The interpretation is mainly done with respect to the p-value. This p-value makes it possible to confirm or refute the hypothesis H1 and hence the research hypothesis. The decision rules are the same as for the previous test. As part of this research, this test makes it possible to compare the groups of farmers (adopters and non-adopters) identified during the investigation phase. It is also retained 5% as the materiality threshold.

Regarding the data collected from the interview guide, synchronic and diachronic analyzes are made. First, an interview-by-interview analysis was carried out to reflect the main points of the speeches of the various stakeholders in the project. Then, the thematic analysis is carried out and made it possible to trace the evolution of the dissemination approaches adopted by ProSOL, as well as the different perceptions of stakeholders on the approaches.

3. RESULTS

3.1 Socio-Demographic Characteristics of The Types of Farmers and the Factors Determining the Adoption of SLM / ACC Measures

The results of the Chi-square test are summarized in Table 1. The statistical assumptions of this test were as follows:

H0: There is no difference between the frequencies of the two types of farmers;

H1: There is a difference between the frequencies of the two types of farmers.

Table 1. Chi-square test results

Socio-demographic characteristics	Sex	Age	Household size	Education level	Main activity	Land tenure status	Farm total area
Value of Chi-square test	0.348	1.146	1.229	4.746	15.205	0.367	11.881
Degree of freedom	1	2	4	2	2	1	2
p-values	0.55	0.56	0.87	0.09	0.0001	0.54	0.003

Source: Based on test results, 2019

From the analysis of Table 1, it emerges that only the main activity of the farmer and the exploitation area registered statistically significant difference between the two types of farmers (adopters and non-adopters) at the 5% threshold. Indeed, their respective *P* values are 0.0001 and 0.003.

On the other hand, the p-values associated with socio-demographic characteristics, sex (*P* = 0.55), age (*P* = 0.564), household size (*P* = 0.87), education level (*P* = 0.09) and land tenure status (*P* = 0.54) all show statistically a non-significant difference between the two types of farmers at the 5% level. Then, the statistical hypothesis H0 is accepted at the 5% threshold for the characteristics of sex, age, household size, level of education and land status, but rejected for the characteristics of the main activities of the farmer and the total area of the exploitation.

We retain that at the 5% threshold, only the main activity of the producer and the total area of his farm discriminate against the surveyed farmers. Those two variables that have been found to be relevant are investigated. Figs. 1 and 2 show the difference observed between the two types of farmers in terms of these variables (main activity and the total area of their farm).

The analysis of Fig. 1 shows that adopters of SLM / CCA measures are strongly dominated by farmers with agriculture (83.9%) and trade (83.3%) as main activities, against respectively 16.1 and 16.7% at the level of non-adopters. On the other hand, farmers with crafts as their main activity less adopted SLM / CCA measures, with an adoption rate of 28%.

Fig. 2 shows that farmers whose farms' areas vary from 2.5 to 5 hectares and from 5 to 7.5 hectares are strongly represented in the group of adopters (respectively 93.5 and 94.4%) compared to respectively, 6.5 and 5.6% at the level of non-adopters. However, it is noted among adopters of sustainable land management measures and adaptation to climate change (SLM / CCA) a non-negligible presence (56.6%) of farmers with areas between 0.01 and 2.5 hectares.

We concluded that the adopters of the measures are mainly farmers with agriculture and trade as their main activities, and large areas of exploitation, while the non-adopters are mainly made up of small farmers with crafts as their main activity.

3.2 Influence of Changes in Measures Dissemination Approaches (GDT / ACC) on Categories of Farmers

This influence is understood through the Pearson correlation test, the results of which are shown in Table 2. These results show that the correlation coefficient between the types of farmers and the diffusion approaches gives rxy = 0.222 > 0. Moreover, we note that the value of P (Sig. (2-tailed)) associated with this correlation coefficient is P = .006. So, the correlation coefficient obtained is significant at the 5% level. It is concluded that the types of farmers and the dissemination approaches of sustainable land management and adaptation to climate change (SLM / CCA) measures are positively correlated or that there is a strong positive link between these two variables.

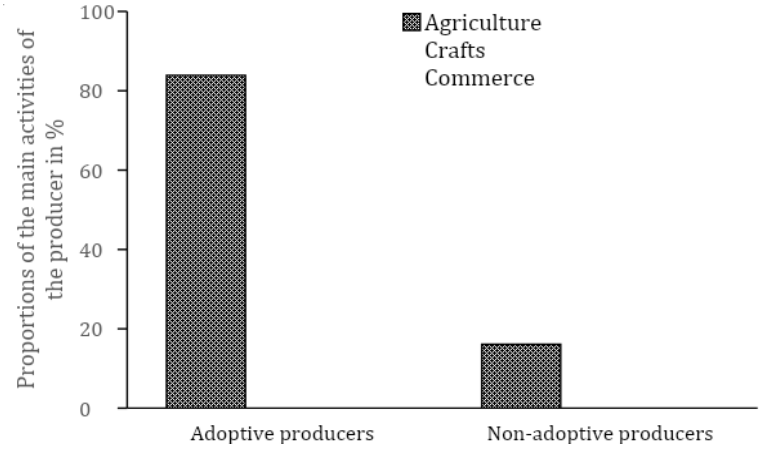

Fig. 1. Breakdown by main activity of the producer
Source: Based on our surveys' results, 2019

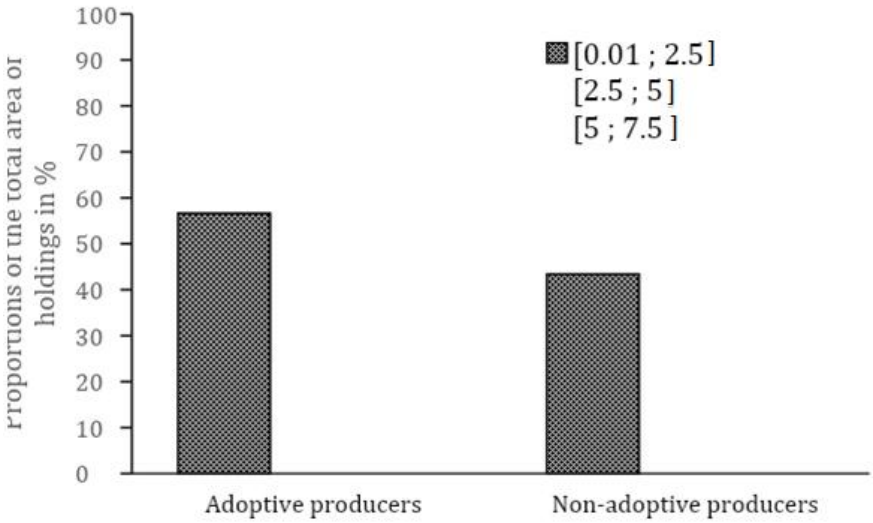

Fig. 2. Breakdown by total area of the holding
Source: Based on our survey results, 2019

Table 2. Summary statistics of the correlation test

	Parameters	Types of farmers	Approaches to disseminating SLM/CCA
Types of farmers	Pearson Correlation	1	.22
	Sig. (2-tailed)	-	.006
Approaches to disseminating SLM/CCA	Pearson Correlation	.22	1
	Sig. (2-tailed)	.006	-

Source: From test results (2019)

Fig. 3 shows the repartition of the types of farmers (adopters and non-adopters) according to the channel of information receiving on measures for sustainable land management and adaptation to climate change (SLM / CCA). Adopters of SLM / CCA measures were mostly farmers sensitized by the “Technician ProSOL” and “SOL-Mobil” approaches, while the non-adopters were more affected by the “Radio Show” and “Relay Producer” approaches. Fig. 3 show that for adopters of SLM / CCA measures, the approaches most shared by farmers are: the "technician ProSOL” (85.1%) and SOL-Mobil (98.0%), and the least shared are the “Radio program” (16.3%) and the “Relay producer” (41.8%). For non-adopters, the approaches most shared by farmers are: “Radio broadcast” (83.7%) and “Relay producer” (58.3%), as opposed to “Technician” approaches: ProSOL” (15.2%) and “SOL-Mobil” (2.0%) which are the least to affect farmers.

As shown above, the adopters of SLM / CCA measures were mostly farmers with agriculture and trade as their main activities, and large areas, unlike non-adopters who were essentially made up of small farmers whose main activity is craftsmanship.

By crossing this observation with the conclusions of the analysis of Figs. 1, 2 and 3, we can conclude that farmers with large operating areas, as well as agriculture and trade as main activities are the most "affected" by the “Technician ProSOL” and “SOL-Mobil” approaches. While small farmers whose main activity is handicrafts are sensitized on measures for sustainable land management and adaptation to climate change (SLM / CCA) through the "Radio broadcast" and "Relay producer" broadcasting approaches.

4. DISCUSSION

The results of our study revealed that the main activity of the producer and the farm area discriminate between the two types of farmers (adopters and non-adopters).

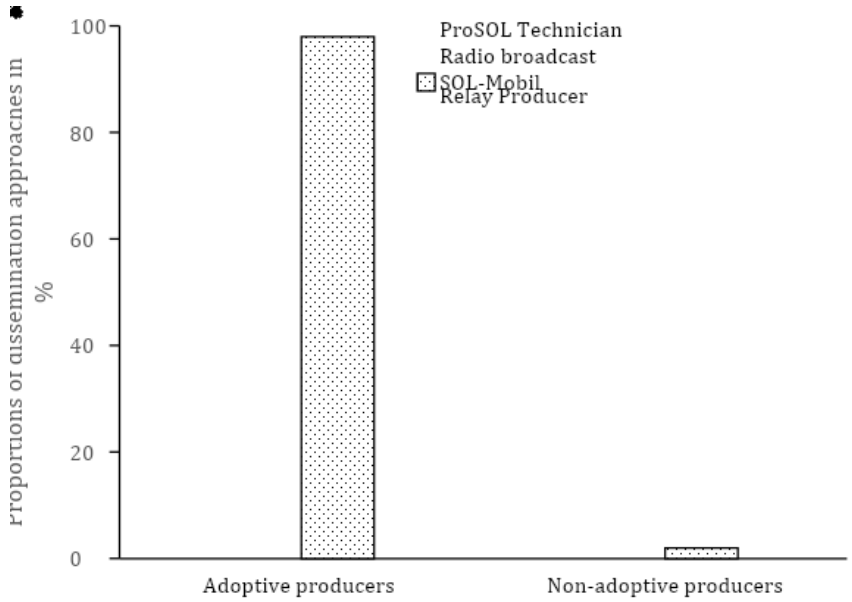

Fig. 3. Distribution of farmers according to dissemination approaches
Source: Based on our survey results, 2019

Regarding the main activity of the farmer, the result is consistent with the findings of certain previous studies [10-11] which have shown that the participation of the producer in non-agricultural activities influence the adoption of new technology. [12] agrees and goes further by showing that in the event that the new technology requires more labor mobilization, households participating in non-agricultural activities will have to make a trade-off between the time to devote to non-agricultural activities and that to agricultural activities, depending on whether he considers one or the other as main.

Concerning the farm's area, farmers with large cultivable land are most adopters of SLM/CCA measures. The reason is that those with a large area are more able to allocate a portion of land for SLM / CCA measures without significantly impacting their current production and this while waiting to be definitively convinced of the scope of these. Indeed, smallholders that [13] qualify as "risky phobic" are less more willing to adopt SLM / CCA measures, unlike those with large cultivable area. To guard against the risk, they prefer to wait and see what the SLM / CCA measures give as results for neighboring farmers before making the decision to adopt them. In addition, the fear of installing SLM / CCA measures on the little land they have and of not having the expected results explains their reluctance, which is not necessarily the case among large farmers who would be less vulnerable in the event of a possible risk. If this result confirms the observation of [14] according to which the area exploited by the farmer positively influences the adoption of a new technology by the producer, [15] find on the other hand that the area has a negative influence on technology adoption.

In the present study, sex, age, household size, education level, and land tenure were not discriminate between the surveyed types of farmers (adopters and non-adopters). This observation is opposed to the results of [16-17] who state that gender, age, education level and land status are determining factors in the adoption of soil fertility management technologies and soil erosion control practices adoption in Benin. It should be noted that the positive relationship between the adoption of technologies and age is also observed in other situations in Cameroon [18]. In addition, the study showed that the adopters of measures for sustainable land management and adaptation to climate change (SLM / CCA) are mainly farmers sensitized by the "Technician ProSOL" and "SOL-Mobil" approaches, while that non-adopters are more affected by the "Radio broadcast" and "Relay producer" approaches. This analysis suggests a relative effectiveness, in terms of effect, of the "Technician ProSOL" and "SOL-Mobil" approaches.

Moreover, several previous studies [14,19,20] concluded that regular contact with an agricultural extension agent positively influences the adoption of a technology by the producer. This positive relationship can be explained by the fact that, as noted in previous studies [21,22] regular contact with agricultural extension agents ("Technician ProSOL" and "SOL-Mobil in the case of this study) allows farmers to be better informed about new technologies available and their nature, which in turn influences the adoption decision.

5. CONCLUSION AND RECOMMENDATIONS

This study examined, in both a synchronic and diachronic approach, the approaches to disseminate measures for sustainable land management and adaptation to climate change (SLM / CCA) by agricultural holdings in the districts of Zou department. The Chi-square and Pearson correlation test results revealed that farmers with large operating areas, as well as agriculture and trade as their main activities are the most "affected" by the "Technician ProSOL" approaches. "And" SOL-Mobil". While small farmers whose main activity is handicrafts are made aware of measures for SLM / CCA through the "Radio broadcast" and "Relay producer" approaches. This suggests a relative effectiveness, in terms of effect, of the "ProSOL Technician" and "SOL-Mobil" approaches among farmers with large farm areas, as well as agriculture and commerce as their main activities. In view of these results, the diversity of dissemination approaches is beneficial for the adoption of measures for SLM / CCA and should be encouraged. Because this makes it possible to take into account the specificity of farmers and therefore improve the rate of adoption of measures for SLM / CCA. However, the project must place more emphasis on securing the measures for SLM / CCA, increase the SOL-Mobil team, make projections by hamlets and no longer by village as it was done, create more synergy between the different dissemination approaches in order to make them more effective, set up incentives to encourage relay farmers, ensure the full-time availability and in sufficient quantity of SLM / CCA inputs, increase awareness of the popularization of documents on land neutrality in the Republic of Benin, initiate research on the possibility to produce biofertilizers from the *Mucuna sp* plant, initiate research on the edibility of the plant of *Mucuna sp*.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

ACKNOWLEDGEMENTS

We present our sincere thanks to the entire GIZ team who fully funded this research through the Soil Protection and Rehabilitation to Improve Food Security in Benin (ProSOL) project in partnership with the Faculty of Agronomic Sciences (FSA) of the University of Abomey-Calavi (UAC).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/63351