

Mechanism for Acquiring Dry Urine-Diverting Toilets by Microcredit in Rural Areas and Determinants of the Reimbursement Rate in West-Central Cote d'Ivoire

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Abstract

Financing sanitation in rural areas through microcredit is an innovation intended to compensate for resource insufficiencies, the viability of which is a guarantee of its sustainability. The aim of this article is first to present the mechanism for acquiring dry urine diversion toilets in rural areas by granting microcredit to households. Then an econometric analysis of the determinants of the microcredit repayment rate for ecological toilets in rural areas in the Bouafle department was carried out on household survey data collected from 2014 to 2017. Our study sample is composed of 133 households. Using a linear regression in STATA, we highlight new results: the use of biofertilizers (sanitized urine and feces) in agriculture, cocoa productivity, the frequency of monitoring as well as strong leadership of the chiefdom favored the reimbursement of the said microcredit.

Keywords

Microcredit, Ecological Toilet, Biofertilizers, Leadership, Reimbursement

1. Introduction

Poverty can be defined as a situation in which individuals do not have the necessary resources to satisfy the basic needs of life. Traditionally, poverty in economics has focused on the material attributes of the individual. This is also justified by the fact that a measurement must relate to quantifiable variables, preferably cardinal

(Magdalou, 2013). However, it is difficult to understand poverty only from this angle. Other intangible and difficult to quantify dimensions such as health, access to basic sanitation services or leisure are also important for understanding social well-being.

The capabilities and functioning approach proposed by Sen (1985) seems to be the theoretical framework for understanding the multidimensional nature of poverty.

Access to water and sanitation is part of the basic functioning or capabilities of a population. It is recognized as a right to human dignity according to a resolution entitled “The human right to water and sanitation”, adopted on July 28, 2010 by the United Nations General Assembly (A/RES/64/292).

As part of continued efforts after the deadline of the Millennium Development Goals, a new set of global goals to eradicate poverty, protect the planet and ensure prosperity for all, was adopted on September 25, 2015 in as part of a new sustainable development program for 2030. In this perspective, 17 sustainable development goals (SDGs) were taken into account, the sixth of which in its target 2 stipulates to ensure access for all, equitable conditions, adequate sanitation and hygiene services and end open defecation, paying particular attention to the needs of women and girls and people in vulnerable situations.

Between 2000 and 2022, global coverage of safely managed sanitation services increased by 8 percentage points, from 49% to 57%: it increased from 36% to 46% in rural areas and to 60% to 65% in urban areas (United Nations Children’s Fund (UNICEF) and World Health Organization (WHO), 2023). Despite the progress made, in 2022, 3.5 billion people still did not have access to safely managed sanitation services. Of these, 1.9 billion people used basic services, 570 million used limited services, 545 million used unimproved sanitation facilities and 419 million practiced open defecation. These limited sanitation services reflect cultural practices as well as socio-economic limitations in areas with high population concentrations.

Sub-Saharan Africa records a reduction in the rate of open defecation from 21% to 17%. In Côte d’Ivoire, despite enormous efforts, access to improved sanitation facilities remains low. Indeed, the coverage of safely managed sanitation services in 2022 is 20% and 14% respectively in urban and rural areas (JMP, *Ibid.*, P2). In 2015 only 30%, 24%, and 22% of the population had access to at least basic, limited (shared), and unimproved sanitation services, respectively (World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF), 2017). The practice of open defecation (OD) stood at 24% in 2015 compared to 59% in 2000 and remained significant in rural areas compared to urban areas with a respective rate of 26% and 4% in 2015 (World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF), 2017). In Central West Côte d’Ivoire, health coverage in hygiene and sanitation was very low with 14.2% of improved toilets, 74.4% of unimproved toilets (DAL, cesspools, open hole, etc.), (Institut National de la Statistique (INS) et ICF International, 2012).

According to the study carried out by the Pan-African Intergovernmental Agency for Water and Sanitation Côte d’Ivoire (EAA-CI) in the Marahoue region for the

implementation of the sanitation component of the Millennium Water and Sanitation Program (PHAM), only 10% of the population used toilets and the other 90% practiced open defecation. [EAA \(2013\)](#), and the risks of contracting fecal hazard diseases and infant mortality are high ([Plan National de Développement, 2012](#)). Poverty, demographic growth, rapid urbanization, reduction in the quality of resources through increased human activities are expected to increase this trend by 2030.

Sanitation is a vital service for humans which has been long considered a public service, therefore free or whose value has been underestimated until now. This has become a rare good in a certain number of countries, including a majority of developing countries. Access to sanitation poses a major problem for some of them in terms of their future economic development. This also implies, from an environmental point of view, that demand management receives due attention and that the costs imposed on third parties are taken into account.

For sanitation to be treated as an economic good, it must be put into a market analysis framework where, on one side, we have the applicants for sanitation services and, on the other side, the providers of this good. Economic instruments must, therefore, be adapted: abstraction taxes, pollution fees and sanitation markets and the costs of non-market uses must be taken into account in environmental management.

Developing and least developed countries experience difficulties in financing sanitation through the “3Ts” (Taxes, transfers and prices/tariffs) due to the low tax revenue inherent to household poverty, the structural weakness of the administration and also the difficulties of integrating a sanitation fee into the water bill in peri-urban and rural areas where water or sanitation networks are non-existent ([Assié, 2013](#)). The sanitation sector in Côte d’Ivoire is no exception to this reality. It benefits from low funding. In fact, the expenditure made over the period from 2009 to 2011 amounts to 0.12% of all expenditure. They have not experienced much progress: they reached respective annual rates of 0.11%, 0.07% and 0.2% respectively in 2009; 2010; 2011 ([Fonds Monétaire International, 2012](#)). In such a context of dwindling public development assistance, it seems necessary that financing sanitation requires recourse to local financial resources, in particular the savings capacity of households.

The scarcity of ordinary financing mobilized for sanitation has led public or associative sanitation promoters to propose programs in favor of sanitation including the use of microcredit. This financing mechanism encourages household demand for sanitation equipment. Its success depends on community mobilization, local authorities, health and hygiene workers, contractors (mason, drainer) and the conditions of execution of this product ([Assié, 2013](#)). Lenders and borrowers effectively engage in a cooperative game when they find a gain according to [Varley’s \(1995\)](#) formula: for lenders success means that revenues are greater than costs, for borrowers that the flow of profits of the investment are higher than the monthly repayment payments.

This article aims to analyze the exogenous factors which influence the reim-

bursement rate of microcredits granted to households for the acquisition of this type of toilet in rural areas in the Department of Bouaflé. The remaining of the study is structured as follows. Section 2 describes the context of this study. Section 3 summarizes the literature review on sanitation financing mechanisms. Section 4 describes the study materials and method. Section 5 presents the results of the study. Section 6 presents the discussions of the results and Section 7 concludes the article.

2. Context of the Study

Coverage of basic sanitation facilities in rural areas in the department of Bouaflé through the implementation of the component of the water supply and sanitation program for the millennium, was achieved through the CLTS-Ecosan approach in 35 localities of the said department (village, camp). This approach combines, on the one hand, the methodology of endogenous community mobilization for collective change towards the eradication of open defecation, then on the other hand, the technology of ecological sanitation through the supply of dry urine diversion toilets (TSDU). To ensure the inclusion of the poor and support household demand for Ecosan latrines, a credit financing mechanism was developed by the Pan-African intergovernmental water and sanitation agency for Africa (EAA) responsible for implementing the PHAM in the Marahoué region. Each beneficiary of the TSDU, represented by the head of household, undertakes to gradually reimburse in the short term the amount of the total cost of the work. Monitoring of these households is ensured by EAA facilitators and village committees in order to enable the proper use of TSDU, the management and agronomic valorization of sanitation by-products (feces and urine), as well as the recovery of the TSDU debt. Three surveys were carried out on these households in order to assess the factors impacting the repayment rate of this type of credit.

3. Literature Review

Issues related to the control of environmental pollution have been the subject of economic studies. Authors such as [Marceau and Migué \(1993\)](#); [Marceau \(1992a\)](#); [Marceau \(1992b\)](#); [Kneese and Schultz \(1975\)](#); [Dorfinan and Snow \(1975\)](#) proposed instruments to regulate pollution. Indeed, through neo-classical theory, we see that different instruments are likely to enable effective pollution control. The most studied are fees, depollution subsidies and tradable emission permits because, it is said, they take into account the fact that the marginal cost of depollution is increasing, that control costs vary between firms and that different technologies can be used to reduce pollution.

Furthermore, the theory of public choice has allowed us to understand the difficulties that we encounter in reality when we seek to implement a control policy using one or other of these instruments. Indeed, by highlighting the interests of the various stakeholders, we understood the logic of their political and strategic positioning. The literature on financing sanitation in rural areas is scant. Our article fills this gap by providing perspectives for innovation in the financing of on-

site sanitation in rural areas through microcredit.

The literature on financing sanitation in rural areas through microcredit is poorly documented. Our article fills this gap by providing perspectives for innovation in the financing of on-site sanitation in rural areas.

The economic literature on sanitation financing indicates that resources traditionally come from taxation (tax), tariffs (prices) and transfers (subsidies). In addition to these resources, there are added revenues from the valorization of sanitation by-products (wastewater, human excreta, etc.), and repayable financing such as loans and micro-credit (Gabert, 2018). In fact, the tariff or fee is the payment made by the user of the service in return for a service or the acquisition of a good. It is local financing to carry out investment or operating expenses. Its determination takes into account economic (principle of efficiency), social (accessibility) and environmental (preservation and sustainable management of natural resources) objectives. Taxes collected by the public authority (the State or the community local) are used to finance investments or the operation of the sanitation service. Subsidies are transfers of funds, such as financial aid from donors or the State, most often one-off to finance an activity of general interest such as sanitation. Revenue from the recovery of sanitation by-products constitutes local funding available when the service is functional and is adapted to cover part of the operating costs of a sanitation service over the long term. Credit and microcredit finance the investment expenditure of households and economic agents in the field of sanitation. They have the advantage of increasing the investment capacity of a household or a sanitation service operator by spreading its investment expenditure over time. We note that there are three main families of microcredit for sanitation, namely loans to households, loans to sanitation professionals, and group loans for the construction of collective facilities (Assié, 2013).

3.1. Microcredit, an Innovative Financial Lever for Access to Sanitation

Indeed, an old practice born from the mismatch of supply and demand on the formal credit market, microcredit was theorized at the end of the 20th century with significant success in the 1990s and 2000s. The 2006 award of the Prize Nobel Peace Prize to the pioneer of microfinance Muhammad Yunus gave a favorable response to the use of this financial tool for the fight against poverty in developing countries.

Microcredit is a local loan adapted to the needs of a small amount, significantly lower than the credit that a business or household can request from a bank (Lelart, 2005). It is a loan for the creation or development of very small income-generating activities to people who do not have access to the traditional financial circuit due to lack of real guarantee. It is also a small amount loan with a short repayment period to the poor who do not have material guarantees to carry out an economic activity. Dedicated in its most common sense to helping to finance income-generating activities, microcredit appears in the field of sanitation as an innovative financing relay, intended to enable the improvement of the sanitation situation.

in regions where limited tax revenues and insufficient subsidies do not yet make it possible to generate the public funds necessary for community sanitation (Assié, 2013). It appears to be a still emerging response to the crucial question of sanitation in developing countries. According to Mehta the potential market for microcredit for sanitation in the years to come will expand. It is with this in mind that public or associative sanitation promoters offer programs in favor of sanitation including the use of microcredit. These microcredit programs, which improve access to sanitation for populations in developing countries, can be grouped into three large families: loans to households, loans to small entrepreneurs and solidarity mechanisms to improve overall sanitation situation, particularly in urban areas (Mehta, 2008).

Indeed, direct loans to households to facilitate access to sanitation are the most developed. This type of credit is better adapted to the current capacities of microfinance institutions (MFIs) and could be subject to the creation of standardized types of products. However, low savings in certain areas can be a limiting factor, or even lead to the need for initial external financing. Additionally, for business loans Mehta sees the potential for lending to small entrepreneurs in the sanitation sector as more limited. Finally, grouped individual loans for access to collective infrastructure take place mainly in urban or peri-urban neighborhoods. The role of an MFI can then be to mobilize the savings of community members, and possibly to provide loans to households with stable incomes but low savings capacity, who build collective latrines together. This type of mechanism leads to a reduction in management costs borne by the MFI (Assié, 2013).

The determinants of microcredit repayment in microfinance.

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

3.2. The Determinants of Microcredit Repayment in Microfinance

The literature on the determinants of repayment performance in a microfinance institution highlights the existence of information asymmetries. Viganò (1993) analyzed the risk factors for repayment default which are the ability to repay, the willingness to repay, the external economic and environmental conditions, the quality of the information which serves as a basis for decision for the granting of loans. credit, the ability of the lender to ensure the goodwill of the borrower through an optimal contract. Boot (2000) notes that the long-term relationship helps to reduce the problems of adverse selection and moral hazard which can result in particular from new borrowers. Guarantees also play an important role in the analysis of a loan repayment default. From a theoretical point of view, guarantees are seen as mitigating elements of the adverse selection problem faced by the lender (Besanko & Thakor, 1987). The guarantees then act as a signal allowing the lender to reduce or eliminate the adverse selection problem caused by the

existence of information asymmetries between lenders and borrowers. However, the nature and evaluation of real guarantees poses a problem, because the evaluation made of guarantees is most often erroneous and lacks objectivity. Using group credit is one solution. Several authors have demonstrated the performance of this type of credit. However, these loans too are prone to problems. [Simtowe and Zeller \(2006\)](#) summarize these problems into four categories and provide theoretical solutions to this type of loan. Firstly, the authors mention that peer selection makes it possible to fight against adverse selection, because members will avoid associating with those whose risk profile they do not know well. This principle allows the formation of homogeneous groups in which all members know perfectly the characteristics of their partners relating to the risk of the project and the level of solvency ([Van Tassel, 1999](#); [Ghatak & Guinnane, 1999](#)). The second category is related to peer monitoring to reduce the choice of a very risky project and the diversion of funds for other purposes. It constitutes an important element enabling the success of group credits ([Stiglitz, 1990](#); [Aghion, 1999](#)). [Wenner \(1995\)](#), however, observes that the group must be small. The third category relates to the failure of the project for exogenous reasons or which are beyond the control of the group member. Intra-group solidarity, however, makes it possible to ensure repayment on time ([Huppi & Feder, 1990](#)). The last category is linked to mutual pressure to avoid default in repayment. This peer pressure makes it possible to reduce moral hazard ex-post and avoid the risk for the group of being deprived of future credit ([Wydick, 1999](#)). However, [Diagne et al. \(2000\)](#) report that pressure can have a negative or weak impact on repayment. Of these four elements, other factors have been mentioned in the literature. These include social capital and external credit options. These arguments therefore make the group with joint guarantee a more efficient instrument than individual credit.

4. Material and Methods

4.1. Study Area

This research took place in the Bouafle department, located in the west center of Côte d'Ivoire in the Marahoue region of which it is the capital, with an area of 4214.5 km² ([Conseil Régional de la Marahoué, 2017](#)). It is located 60 km from the autonomous district of Yamoussoukro, the political and administrative capital and 310 km from Abidjan, the economic capital. Bouafle is limited to the east by Yamoussoukro, to the west by the department of Daloa, to the north by the department of Zuenoula, to the south by the department of Sinfra ([Conseil Régional de la Marahoué, 2017](#)). The relief is composed of low plateaus with some lowlands and hills with an average altitude of 260 meters. The hydrographic network is made up of the Marahoue or Red Bandama River which crosses the department from North to South, rivers and lakes. The climate of Bouafle is Baoulean type. It has two rainy seasons and two dry seasons. The average temperature is 25.30° celsius and precipitation varies from 1800 to 2000 mm ([Conseil Régional de la Marahoué, 2017](#)). The population of the Bouafle department amounts to 300,305

inhabitants including 161,857 men and 138,448 women with an average population density of 71.26 inhabitants/km² (Institut National de la Statistique (INS) et ICF International, 2012).

4.2. Study Population

The study population is all rural households residing in the Bouafle department which benefited from the CLTS-ECOSAN approach of the Millennium Water and Sanitation Program.

Inclusion criteria

- Households residing for at least 6 months in a village where the CLTS-ECOSAN approach took place.
- Household having benefited from microcredit for the acquisition of a TSDU.
- Households having actually used TSDU in the village where the CLTS-ECOSAN approach took place
- Households residing in a village that has achieved ODF status.

Non-inclusion criteria

- Households not benefiting from the CLTS-ECOSAN approach.
- Households that did not give consent for the study.
- Households not residing in a village that has achieved ODF status.

4.3. Type and Duration of the Study

This is a longitudinal study with an analytical aim, which took place over the period from 2014 to 2017. The first pre-project survey took place from January 5 to January 31, 2014. The second took place from January 5 to January 31, 2015, the third survey from January 5 to January 31, 2016. The fourth survey from January 5 to January 31, 2017.

4.4. Sample Size

Let N be the size of the population, with $N = 173$ and n the size of the sample, we set the confidence threshold at 95% with a precision level of $\pm 5\%$.

We therefore write the following formula:

$$n = N / (1 + Ne^2).$$

$n = 173 / (1 + 173 \times 0.05 \times 0.05) = 121$ households receiving microcredit for TSDU endowment.

To avoid data loss, we increased the size of our sample to 10% (that is 12 households), $n = 133$ households receiving TSDU.

4.5. Distribution of the Sample

The 133 households in the sample were distributed proportionally to the respective weight of each locality over all 10 localities by the following formula:

$$n'_i = n * P_i,$$

with:

n : sample size ($n = 133$),

P_i : The weight of locality i in terms of TSDU beneficiary households, with $P_i = n_i/N$,

n_i : the number of households in village i ,

n'_i : the sample size in village i ,

N : total number of households benefiting from TSDU from the study ($N = 173$).

Depending on the inclusion criteria defined, ten localities (village, camp) were targeted as part of our study. Following the population census in these localities, we counted 173 heads of households receiving microcredit for the acquisition of TSDU distributed as follows in **Table 1** below.

Table 1. Distribution of TSDU beneficiary households by locality.

Localities	Beneficiary households (n_i)	Weight of locality (p_i)	Households surveyed (n'_i)
ADAMAKRO	14	0.08	11
BROUKRO	26	0.15	20
ISSAKRO	11	0.06	8
KAYEGUE	14	0.08	11
KONALIYAOKRO	11	0.06	8
KOUAKOUBLEKRO	31	0.18	24
KOUAMEKOUASSIKRO	9	0.05	7
SALIFOUKRO	25	0.14	19
SINFLA	19	0.11	15
YOBOUEKRO	13	0.08	10
TOTAL	173	1	133

Source: Author.

4.6. Data Collection

It concerns data collected from rural households during the implementation of PHAM in Côte d'Ivoire in the department of Bouafle. To collect data, we carried out three household surveys using a questionnaire with heads of households receiving TSDU or representatives in 2015; 2016; 2017.

4.6.1. The Pre-Survey

A pre-survey was carried out on December 12, 2014 with 14 heads of households in the village of Kouakoublekro, in order to test the questionnaire, correct all errors and ambiguities. This pre-survey allowed the investigators to familiarize themselves with the different questions, have a common understanding of the questionnaire and understand the survey methodology.

4.6.2. The Conduct of Investigations

Three household surveys were carried out as part of the analysis of the determinants of microcredit reimbursement intended for the acquisition of TSD.

The first survey took place from January 5 to 31, 2015, the second survey from

January 5 to 31, 2016 and finally the third survey from January 5 to 31, 2017. These surveys covered all ten study locations and only concern heads of households benefiting from TSDU or their representatives. Accompanied by a translator, the information collected concerns the socio-economic characteristics of the households benefiting from TSDU, the cost of production of TSDU, the microcredit mechanism set up by the EAA agency, the monitoring by the village committee, the monitoring carried out by collection agents, production of biofertilizers, reimbursement rate. The interview lasted on average 20 minutes per household and the different responses of the respondents are recorded on the questionnaire form.

4.6.3. Data Processing and Analysis

For data processing we used Excel and STATA 14 software. After a descriptive statistical analysis to study the socio-economic characteristics of TSDU beneficiary households and the repayment performance of the TSDU microcredit, we evaluated the determinants of the repayment rate TSDU microcredit.

1) Econometric Modeling

The endogenous variable is quantitative and the explanatory variables are quantitative and qualitative. We will use linear regression to evaluate the influence of each explanatory factor on the reimbursement rate.

Consider the following model:

$$T_i = \beta_0 + \beta_i X_i + \mu_i. \quad (1)$$

With T_i the endogenous variable “Reimbursement rate of household i ” and X the following exogenous variables:

X_{1i} : Marital status,

X_{2i} : Occupancy,

X_{3i} : Level of education of the head of household,

X_{4i} : Number of workers in the household (Active),

X_{5i} : Number of follow-ups by the PHAM facilitator in the household,

X_{6i} : Number of follow-ups by the village committee in the household,

X_{7i} : Quantity of hygienized urine applied in agriculture,

X_{8i} : Quantity of hygienized feces applied in agriculture,

X_{9i} : Cocoa production per hectare,

X_{10i} : Cocoa production by labor,

X_{11i} : Daily income per capita,

X_{12i} : Leadership of the chieftaincy committee,

X_{13i} : Leadership of the youth committee,

X_{14i} : Leadership women’s committee.

$\beta_0, \beta_1, \dots, \beta_{14}$ are the coefficients of the model to be estimated and μ_i is the error term.

2) Robustness of test

We performed statistical tests to ensure the validity of our multiple linear regression model. The first test evaluates the overall significance of the regression coefficients using the Fisher test. Two hypotheses are formulated. H_0 : the coefficients

are generally insignificant, against the alternative hypothesis H1: the coefficients are generally significant for a P -value less than 0.05.

The second test is that of Breusch-Godfrey, it is used to check the autocorrelation of errors. Two hypotheses are used. We have H0: autocorrelation of errors against H1: the residuals are uncorrelated.

The third test is that of Breusch-Pagen. It is used to check the homoscedasticity of errors with the following hypotheses: H0: the hypothesis of homoscedasticity of errors against the alternative hypothesis H1 of heteroscedasticity of errors.

5. Results

5.1. Household Profile and Performance of TSDU Microcredit

The descriptive analysis of the data to know the profile of households equipped with Ecosan latrines reveals the following results:

The heads of households benefiting from TSDU are almost men (97%) and live as a couple (95%). They are agricultural (98) and more than half are not educated (57%), only a quarter of the heads of household have reached primary school, then the rest have at least secondary level (17%). The characteristics of the housing of TSDU beneficiaries indicate that the housing is largely built with local materials (clay, earth brick). The roofs are mostly made of sheet metal (86%). Many households use lighting sources specific to rural areas, including 47% for solar panels and 41% for other forms (oil, candle, battery). Only 11% of households are connected to the national electricity network (CIE). Regarding sanitation, only a quarter of households practice open defecation and a significant portion of the population has an improved latrine (83%). As part of the agronomic valorization of sanitation by-products by households, we note an increase in the use of biofertilizers (sanitized urine and feces) by households during the PHAM with a strong application in cocoa cultivation, resulting in an increase in cocoa production yield (see **Tables 2-4**).

Table 2. Average production of biofertilizers and cocoa crop yield in 2014.

Indicators	Obs	Mean	Std. Dev.	Min	Max
Quantity of urine in agriculture (Liter)	133	290.36	439.78	0	2490
Quantity of Feces in agriculture (Kilogram)	133	72.53	169.71	0	960
Quantity of urine in cocoa farming (Liter)	133	256.54	379.68	0	1800
Quantity of feces in cocoa farming (Kilogram)	133	72.53	169.71	0	960
Cocoa production (Kilogram)	133	868.75	590.96	0	3000
Cocoa production per farmer (Kilogram)	133	318.9	255.16	0	1500
Cocoa production per hectare (Kilogram)	133	295.2	250.81	0	1500
Cocoa Income (CFA franc)	133	86875	590960.1	0	3,000,000

Source: Our calculations using STATA.

Table 3. Average production of biofertilizers and cocoa crop yield in 2015.

Indicators	Obs	Mean	Std. Dev.	Min	Max
Quantity of urine in agriculture (Liter)	133	312.83	452.64	0	2490
Quantity of Feces in agriculture (Kilogram)	133	82.16	168.61	0	960
Quantity of urine in cocoa farming (Liter)	133	278.98	394.43	0	1800
Quantity of feces in cocoa farming (Kilogram)	133	82.16	168.61	0	960
Cocoa production (Kilogram)	133	1006.16	646.79	0	3000
Cocoa production per farmer (Kilogram)	133	372.60	283.97	0	1500
Cocoa production per hectare (Kilogram)	133	339.23	276.32	0	1500
Cocoa Income (CFA franc)	133	1006165	646790.7	0	3,000,000

Source: Our calculations using STATA.

Table 4. Average production of biofertilizers and cocoa crop yield in 2016.

Indicators	Obs	Mean	Std. Dev.	Min	Max
Quantity of urine in agriculture (Liter)	133	510.56	643.26	0	2940
Quantity of Feces in agriculture (Kilogram)	133	504.66	496.30	0	2520
Quantity of urine in cocoa farming (Liter)	133	473.12	558.29	0	2600
Quantity of feces in cocoa farming (Kilogram)	133	504.65	496.30	0	2520
Cocoa production (Kilogram)	133	1481.16	1035.55	0	6700
Cocoa production per farmer (Kilogram)	133	488.96	391.45	0	2500
Cocoa production per hectare (Kilogram)	133	533.85	404.53	0	2000
Cocoa Income (CFA franc)	133	1629282	1139101	0	7,370,000

Source: Our calculations using STATA.

In terms of household resources, we note on average an increase and stability respectively in income and consumption per capita during the implementation of PHAM (see **Tables 5-7** below). Only a quarter of TSDU beneficiaries have a daily per capita income of more than 737 CFA franc. The analysis of household debt relating to the granting of microcredits for the acquisition of TSDU reveals a low level of repayment of TSDU beneficiaries although the overall repayment rate is 24.84%.

Table 5. Return on TSDU microcredit repayment and income per capita in 2014.

Indicators	Obs	Mean	Std. Dev.	Min	Max
PHAM's Agent monitoring frequency	133	1.49	0.79	0	4
Village committee's monitoring frequency	133	1.53	0.86	0	4
TSDU debt (CFA franc)	133	54631.58	3947.52	42,000	57,000
Reimbursement rate (%)	133	0.91	1.55	0	5.26
Income per capita (CFA franc)	133	564.25	529.81	106.16	2719.18
Expenditure per capita (CFA franc)	133	319.54	230.67	65.75	1720.89

Source: Our calculations using STATA.

Table 6. Return on TSDU microcredit repayment and income per capita in 2015.

Indicators	Obs	Mean	Std. Dev.	Min	Max
PHAM's Agent monitoring frequency	133	3.25	2.03	0	12
Village committee's monitoring frequency	133	3.25	1.89	0	8
TSDU debt (CFA franc)	133	46605.26	10141.06	0	57,000
Reimbursement rate (%)	133	15.47	17.22	0	100
Income per capita (CFA franc)	133	626.01	560.11	106.16	3027.40
Expenditure per capita (CFA franc)	133	327.85	236.07	65.07	1751.71

Source: Our calculations using STATA.

Table 7. Return on TSDU microcredit repayment and income per capita in 2016.

Indicators	Obs	Mean	Std. Dev.	Min	Max
PHAM's Agent monitoring frequency	133	4.96	3.66	2	18
Village committee's monitoring frequency	133	4.08	2.76	2	12
TSDU debt (CFA franc)	133	41755.64	15918.07	0	57,000
Reimbursement rate (%)	133	11.83	26.68	0	100
Income per capita (CFA franc)	133	838.30	686.95	84.42	4321.23
Expenditure per capita (CFA franc)	133	342.83	226.04	79.23	1404.37

Source: Our calculations using STATA.

The stratification of the TSDU debt indicates that half of the households have liabilities of more than 45,000 FCFA, representing more than three quarters (3/4) of the cost of the TSDU (57,000 CFA franc) and only 5% of households were able to pay off their debt. TSDU debt.

5.2. Diagnosis of Multicollinearity

We use the Variance Inflation Factor test at the threshold of 10 or tolerance 0.1.

The Variance Inflation Factor (VIF) test indicates values less than 10, so there is an absence of multicollinearity of the independent variables (see **Table 8**).

Table 8. Multicollinearity test (variance inflation factor).

Variable	VIF	1/VIF
Youth leadership	5.66	0.176684
Village chief's leadership	5.40	0.185196
Agent monitoring	4.48	0.223172
Village committee monitoring	4.00	0.249804
Cocoa production per farmer	2.86	0.349574
Quantity of urine in agriculture	2.49	0.401779
Daily income per capita	2.23	0.448503
Quantity of feces in agriculture (Kilogram)	2.05	0.487636

Continued

Cocoa production per hectare (Kilogram)	2.05	0.488790
Worker	1.46	0.686155
Women's leadership	1.36	0.734649
Occupation	1.28	0.778316
Level of study	1.26	0.794760
Marital status	1.19	0.838403
Mean VIF	2.70	

Source: Our calculations using STATA.

5.3. Estimation of Regression Coefficients and Interpretation

To estimate the vector of parameters β we will use the ordinary least squares (OLS) method. The estimation results are reported in **Table 9**.

Table 9. Determinants of the TSDU reimbursement rate.

Reimbursement rate	Coef.	Std. Err.	t	<i>P</i> > t	[95% Conf. Interval]	
Marital status	2.859737	3.488811	0.82	0.414	-4.049059	9.768533
Occupation	7.466056	7.443414	1.00	0.318	-7.27393	22.20604
Level of study	-1.375694	1.446163	-0.95	0.343	-4.23949	1.488101
Worker	-0.2370471	0.6762086	-0.35	0.727	-1.576124	1.10203
Agent monitoring	3.091685	0.5659726	5.46	0.000***	1.970906	4.212465
Village committee monitoring	2.025172	0.708906	2.86	0.005***	0.6213452	3.428999
Quantity of urine in agriculture (Leter)	0.0070038	0.0024004	2.92	0.004***	0.0022503	0.0117573
Quantity of Feces in agriculture (Kilogram)	0.0101661	0.0028241	3.60	0.000***	0.0045736	0.0157586
Cocoa production per hectare (Kilogram)	-0.0013409	0.0050732	-0.26	0.792	-0.0113872	0.0087053
Cocoa production per farmer	0.0153856	0.0062973	2.44	0.016**	0.0029152	0.0278561
Daily income per capita	-0.0078426	0.0029756	-2.64	0.010**	-0.0137351	-0.00195
Youth leadership	-1.878328	5.13488	-0.37	0.715	-12.04679	8.290133
Leadership of the chieftaincy committee	16.09655	5.35902	3.00	0.003***	5.48423	26.70887
Women's leadership	5.552365	3.061749	1.81	0.072*	-0.5107319	11.61546
_cons	-18.95664	9.538444	-1.99	0.049**	-37.84536	-0.067923

Source	SS	df	MS	Number of obs = 133 F (14, 118) = 48.90
Model	86574.6616	14	6183.9044	Prob > F = 0.0000
Residual	14920.906	118	126.448356	R-squared = 0.8530 Adj R-squared = 0.8355
Total	101495.568	132	768.905815	Root MSE = 11.245

Source: Our calculations using STATA, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Quality of Adjustment

1) The multiple adjusted determination coefficient \bar{R}^2

$\bar{R}^2 = 0.835$: the multiple adjusted determination coefficient is close to 1 (SEE **Table 9** above), the regression of the endogenous variable (TSDU microcredit repayment rate) on the exogenous variables best explains the variance in the repayment rate TSDU microcredit.

2) Overall significance of the regression coefficients (fisher test)

Let us test the null hypothesis H_0 : the coefficients are globally insignificant, i.e. all the coefficients of our multiple regression are zero, against the alternative hypothesis H_1 : the coefficients are globally significant, i.e. say all the coefficients of our multiple regression are globally different from 0.

We note that the p -value = 0.0000 of the Fischer test is less than 0.05 (see **Table 9** above), therefore we reject H_0 , the coefficients of the multiple regression are overall significant at the 5% threshold.

3) Error autocorrelation test

The Breusch-Godfrey test is used to check the autocorrelation of errors. We formulate the following hypotheses:

H_0 the errors are autocorrelated, against the alternative hypothesis H_1 of absence of autocorrelation of the errors.

The test provides us with a p -value = 0.1658 > 0.05 (see **Table 10** below), we reject hypothesis H_0 of autocorrelation of errors, therefore the residuals are uncorrelated.

Table 10. Error autocorrelation test.

Breusch-Godfrey LM test for autocorrelation			
lags(p)	chi2	df	Prob > chi2
1	1.920	1	0.1658

Source: Our calculations using STATA: p -value = 0.1658 > 0.05 we reject hypothesis H_0 of autocorrelation of errors.

4) Homoscedasticity test

We used the Breusch-Pagen test with the following hypotheses:

H_0 : the hypothesis of homoscedasticity of errors against the alternative hypothesis H_1 of heteroscedasticity of errors. The test indicates a p -value = 0.1158 > 0.05 (see **Table 11** below), we accept the hypothesis H_0 of homoscedasticity of errors.

Table 11. Homoscedasticity test.

Homoscedasticity test						
u2	Coef.	Std. Err.	t	$P > t$	[95% Conf. Interval]	
Marital status	-35.27471	73.55044	-0.48	0.632	-180.9246	110.3752
Occupation	-205.5926	156.9206	-1.31	0.193	-516.3381	105.153
Level of study	29.45643	30.48772	0.97	0.336	-30.91756	89.83041

Continued

Worker	-7.328693	14.2557	-0.51	0.608	-35.55886	20.90147
Agent monitoring	-0.1328991	11.93173	-0.01	0.991	-23.76096	23.49517
Village committee monitoring	4.241968	14.94502	0.28	0.777	-25.35324	33.83718
Quantity of urine in agriculture (Leter)	0.034071	0.0506055	0.67	0.502	-0.0661416	0.1342836
Quantity of Feces in agriculture (Kilogram)	0.0727523	0.0595371	1.22	0.224	-0.0451475	0.190652
Cocoa production per hectare (Kilogram)	0.1293239	0.1069515	1.21	0.229	-0.0824692	0.341117
Cocoa production per farmer	-0.200698	0.132759	-1.51	0.133	-0.4635977	0.0622002
Daily income per capita	0.1194292	0.0627315	1.90	0.059	-0.0047963	0.2436546
Youth leadership	-50.67421	108.2526	-0.47	0.641	-265.0437	163.6953
Village chiefs Leadership	44.39633	112.9778	0.39	0.695	-179.3305	268.1232
Women's Leadership	-59.44386	64.5472	-0.92	0.359	-187.2649	68.37718
_cons	232.0919	201.0876	1.15	0.251	-166.1163	630.3002

Number of observations = 133, $F(14, 118) = 1.52$, $\text{Prob} > F = 0.1158$, $R\text{-squared} = 0.1524$; $\text{Adj } R\text{-squared} = 0.0518$. Source: Our calculations in Stata. $p\text{-value} = 0.1158 > 0.05$, we accept the hypothesis H_0 of homoscedasticity of errors.

Considering the signs and values of the coefficients of the explanatory variables obtained from the linear regression at the 5% threshold, we note that:

The increase in cocoa productivity of one additional unit in the household generates an increase of 0.015 points in the TSDU microcredit repayment rate, all else being equal. An increase of one additional unit in the daily income per capita in the household induces a reduction of 0.008 points in the reimbursement rate of the microcredit granted for the acquisition of the TSDU, all other things being equal. An increase of one unit in the frequency of monitoring by the local (village) committee in the TSDU beneficiary household increases the reimbursement rate of the microcredit granted for the acquisition of the TSDU by 2 points, all other things being equal. A unit increase in the number of follow-ups by the PHAM facilitator in the TSDU beneficiary household increases the reimbursement rate of the microcredit granted for the acquisition of the TSDU by 3 points, all else being equal. An additional unit of liter of hygienized urine applied to crops in the TSDU beneficiary household increases the reimbursement rate of the microcredit granted for the acquisition of the TSDU by 0.007 points, all other things being equal. An additional unit of kg of hygienized feces applied to crops in the TSDU beneficiary household increases the reimbursement rate of the microcredit granted for the acquisition of the TSDU by 0.01 points, all other things being equal. Very active participation of the chieftaincy committee in the implementation of the PHAM leads to an increase of 16 points in the reimbursement rate of the microcredit granted for the acquisition of the TSDU, all other things being equal.

6. Discussions

Seven exogenous variables significantly influence the microcredit reimbursement

rate for Ecosan toilets in rural areas in the Bouafle department as part of our study as illustrated by the results above: the number of follow-ups carried out respectively by the agent of the PHAM and by the village committee, the quantity of hygienized urine and feces applied in agriculture, the productivity of cocoa, the daily income per capita in the household and finally the leadership of the chieftaincy committee. The frequency of monitoring carried out in TSDU beneficiary households respectively by the PHAM facilitator and the village committee for the recovery of the microcredit contributed to increasing the repayment rate of the TSDU microcredit. Indeed, the visits carried out by the village committee and the PHAM facilitator to TSDU beneficiary households make it possible to ensure increased monitoring and capacity building of debtors in terms of commitments relating to TSDU credit (TSDU debt, payment schedules, amount to pay, debt balance), which positively impacts the repayment rate. This result is in the same direction as those of [Stiglitz \(1990\)](#), [Varian \(1990\)](#), [Noglo and Androuais \(2013\)](#) who showed that a increasingly regular control favors reimbursement because there is a reduction in ex ante moral hazard. In addition, the increased use of biofertilizers (sanitized urine and feces) in plantations (cocoa) encourages TSDU beneficiary households to pay their debt in view of the gain obtained in the productivity of speculation. Indeed, a household will be more motivated to repay its TSDU debt when it anticipates an increase in its wealth linked to the increase in its income due to the increase in crop productivity through the increased use of biofertilizers. Therefore, the failure to repay will be less significant for TSDU beneficiary households which use sanitation by-products (sanitized urine and feces) extensively. Also, the increase in cocoa productivity per workforce impacts the repayment of TSDU debt, in fact households which have a more productive workforce generate additional financial resources to meet debt repayment commitments. TSDU. The increase in daily income per capita does not favor the reimbursement of microcredit. This result reflects the idea that households with a high standard of living pay less debt linked to the TSDU grant compared to the poor. The active participation and leadership of the chieftaincy committee increases the repayment of the TSDU debt. Indeed, the chieftaincy committee plays the role of moral guarantor of the locality by establishing the guarantee of reimbursement for households under their authority. As a result, their involvement reduces the moral hazard of a failure to pay the TSDU debt. This monitoring constitutes a form of pressure on non-solvent households and in turn reduces loan repayment defaults. This technique is widely practiced in microcredit institutions in the case of jointly guaranteed loans ([Wydick, 1999](#); [Stiglitz, 1990](#); [Diagne et al., 2000](#); [Wenner, 1995](#)).

7. Conclusion and Political Implications

Repayable financing mechanisms such as loans and micro-credit are of interest to developing countries in order to support the demand for basic sanitation facilities in rural areas. It is for this reason that our article focused on the determinants of

the TSDU microcredit repayment rate. It emerges from our study that the regular monitoring of the village committee, the PHAM facilitator on the beneficiaries of the TSDU microcredit as well as the strong leadership of the chiefdom are a guarantee of reducing the asymmetry of information due to moral hazard ex post, thus promoting an increase in the household repayment rate. Optimizing the repayment of this type of credit also requires the adoption of biofertilizers (sanitized feces and urine) by households, which in turn improves agricultural yield.

It would be interesting to include in the microcredit recovery mechanisms for Ecosan latrines close monitoring of facilitators and peers through the local monitoring committee, the chieftaincy towards households, then also to encourage the population to appropriate sanitation by-products.

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Conflicts of Interest

The authors have no conflicts of interest to declare.

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