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Green Microfinance and Ecosystem Services A quantitative study on outcomes and effectiveness

Davide Forcella and Frédéric Huybrechs

There has been growing interest lately in the role of microfinance to support environmental management of micro-enterprises and poor households. Worldwide, the number of green microfinance projects increases, yet there seems to be little discussion on how effective green microfinance is in achieving its environmental goals. This paper aims to position itself in this debate. We look at the first large-scale green microfinance programme for biodiversity conservation: Proyecto CAMBio. It consists of a combination of credits, technical assistance and conditional payments for environmentally friendly agricultural activities (PES). We focus on its implementation in Nicaragua by the microfinance institution FDL and the NGO Nitlapan. We perform an in-depth econometric analysis of a survey we conducted on a sample of 128 rural producers. We assess the clients' characteristics that influenced the evolution of the environmental value of their farm –as defined by the indicators we used– on a span of five years, and we assess Proyecto CAMBio's possible role in this evolution. Moreover, we further look into the effectiveness of PES in rewarding environmental betterment. Factors such as the decision to change the main economic activities, or clients' strategies or opportunities in land accumulation- appear to have the strongest influence on the evolution of the environmental value of the clients' farm. While the project per se, even if carefully implemented in agreement with its guidelines and well performing at financial level, does not appear to have significantly influenced the evolution of the environmental value of the clients' farm. Moreover, the PES does not seem to reward environmental improvement while instead it rewards the more credit-worthy activities, producers with more access to land and credit and in addition producers that plant fewer trees per hectare. With these results, we underline the importance of the local territorial dynamics and the complexity of the socio-environmental systems against a vision based simply on single economic actors. From our results it appears that green microfinance, without strategic articulation with local actors and broader territorial dynamics, would tend to (indirectly) support preexisting socioeconomic structures and the possibly related environmental degradation processes. We hence call for a more proactive engagement of green microfinance in the territorial dynamics and with local actors with the aim to support more sustainable livelihood trajectories and development pathways.

Keywords: Microfinance, Green Microfinance, Rural Development, Payments for Environmental Services, Agricultural Finance, Ecosystem Services, Biodiversity, Central America, Proyecto CAMBio, Quantitative Analysis.

JEL Classifications: Q57, Q01, Q12, Q14, Q15, Q23, O13, G21, C01

CEB Working Paper N° 16/018
March 2016

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Green Microfinance and Ecosystem Services

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ABSTRACT

There has been growing interest lately in the role of microfinance to support environmental management of micro-enterprises and poor households. Worldwide, the number of green microfinance projects increases, yet there seems to be little discussion on how effective green microfinance is in achieving its environmental goals. This paper aims to position itself in this debate. We look at the first large-scale green microfinance programme for biodiversity conservation: Proyecto CAMBio. It consists of a combination of credits, technical assistance and conditional payments for environmentally friendly agricultural activities (PES). We focus on its implementation in Nicaragua by the microfinance institution FDL and the NGO Nitlapan. We perform an in-depth econometric analysis of a survey we conducted on a sample of 128 rural producers. We assess the clients' characteristics that influenced the evolution of the environmental value of their farm –as defined by the indicators we used– on a span of five years, and we assess Proyecto CAMBio's possible role in this evolution. Moreover, we further look into the effectiveness of PES in rewarding environmental betterment. Factors such as the decision to change the main economic activities, or clients' strategies or opportunities in land accumulation- appear to have the strongest influence on the evolution of the environmental value of the clients' farm. While the project per se, even if carefully implemented in agreement with its guidelines and well performing at financial level, does not appear to have significantly influenced the evolution of the environmental value of the clients' farm. Moreover, the PES does not seem to reward environmental improvement while instead it rewards the more credit-worthy activities, producers with more access to land and credit and in addition producers that plant fewer trees per hectare. With these results, we underline the importance of the local territorial dynamics and the complexity of the socio-environmental systems against a vision based simply on single economic actors. From our results it appears that green microfinance, without strategic articulation with local actors and broader territorial dynamics, would tend to (indirectly) support preexisting socio-economic structures and the possibly related environmental degradation processes. We hence call for a more proactive engagement of green microfinance in the territorial dynamics and with local actors with the aim to support more sustainable livelihood trajectories and development pathways.

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1. INTRODUCTION

There are a great number of reasons why agricultural actors and landscapes deserve attention from academics and policy-makers. In addition to its clear purpose of food (and energy) production for an increasing world population, it is also the main source of income and subsistence for poor people living in rural areas (World Bank, 2015). Family farmers cultivate 80% of the agricultural land and produce about 80% of the world food, yet 70% of poor and food-insecure people live in rural areas (FAO, 2014, World Bank, 2015). For its prominence and expansion in the developing world and its role in people's livelihoods, agriculture is a key area to focus on for poverty alleviation and food security. The viability of smallholder farming is however influenced by the distribution of economic opportunities as well as the costs and benefits related to agricultural production and value chains (Vermeulen and Cotula, 2010). In addition to these socio-economic concerns, there are also environmental issues related to present agricultural practices. Through its pressure on natural resources –e.g. through the advancement of the agricultural frontier or the over-exploitation of existing agricultural areas– it has an important role in the loss of biodiversity, land degradation, deforestation and water contamination, while at the same time providing other environmental services (Kroeger and Casey, 2007, Geist and Lambin, 2002). In addition, the rural territories and livelihoods dependent on agriculture are highly vulnerable to these environmental stresses, shocks, energy and food price volatility, and climate change (IPCC, 2014).

These –interlinked– social and environmental concerns indicate why agricultural landscapes are and should be at the centre stage of the current quest for 'sustainable development'. The best-known proposals for linking environment and development in rural areas include protected areas (Brockington, 2002), integrated conservation and development programmes (Berkes, 2007), and the currently popular policy instrument of payments for ecosystem services (PES) (Wunder, 2005). More recently, we observed the emergence of a new trend: green microfinance. Indeed, microfinance practitioners have increasingly started to worry about the environmental impact that microfinance (MF) might have, as well as its potential as an environmental policy tool (Anderson et al., 2002, Wenner et al., 2004, Hall et al., 2008, Schuite and Pater, 2008, Allet, 2014, Cranford and Mourato, 2014, Forcella, 2014, Agathou and Schuite, 2015, Huybrechs et al., 2015a, Forcella and Schuite, 2015, e-MFP and MIX, 2015, e-MFPAG).

While worldwide, the number of such 'green microfinance' projects increases, there seems to be little discussion on how green microfinance interacts with rural development, and how effective it is in achieving its environmental goals. This paper aims to position itself in this debate as it assesses the role, outcomes and limitations of a green microfinance programme in biodiversity conservation and rural development.

In this paper, we analyse first large-scale green microfinance programme for biodiversity conservation: Proyecto CAMBio (Central-American Markets for Biodiversity) (PCAMBio, 2014). Proyecto CAMBio was implemented in five Central American countries in the period 2007-2013 and consisted of a combination of credits and technical assistance for agroforestry, silvopastoral practices or other environmentally friendly agricultural activities; and conditional payments for environmental services (PES). In this paper we focus on Proyecto CAMBio as implemented by the Microfinance Institution (MFI) Fondo de Desarrollo Local (FDL) and the NGO Nitlapan (Forcella, 2012) in Northern-Central Nicaragua. We focus on the micro-level and try to assess how the characteristics of microfinance clients and their interaction with local territorial dynamics influence the environmental performance of their farms. We perform an in-depth econometric analysis on a database from a survey we conducted on a sample of 128 rural producers. We thereby assess the clients' characteristics that influenced the evolution of the environmental value of their farm –as defined by the indicators we used– on a span of five years, and we assess Proyecto CAMBio's possible role in this evolution. We then assess if and how a green microfinance project fosters better environmental practices, and if environmental subsidies in terms of Payments for Environmental Services (PES) promote and reward more sustainable practices and better environmental outcomes. We thereby provide the first quantitative analysis of characteristics that influence environmental outcomes of a microfinance programme aiming for ecosystem service provision.[3]

Our results underline the importance of the local territorial dynamics and the complexity of the socio-environmental system, challenging the oversimplified relation between providing individual green credits or environmental rewards and the entailing results. Indeed although the studied project was carefully implemented in line with the guidelines, and performed well financially, it does not appear to have significantly influenced the evolution of the environmental value of the clients' farm. Instead, other factors (such as the decision to change the main economic activities, or the clients' strategies or opportunities in land accumulation) appear to have the most significant influence on the evolution of the environmental value of the farm; and these factors are more related to broader livelihood strategies and development pathways than to a singular project. Moreover, and contrary to the underlying logic, the PES component of the project does not seem to reward environmental improvement. Embedded in the credit logic, it rewards the more credit-worthy activities, and it appears that it mostly benefited producers that plant fewer trees per hectare and have more access to land and credit.

Even if we focus on a specific region and institution, the results of this paper are strengthen and supported also by related studies in other regions (Forcella, 2012, Huybrechs et al., 2015b), and other another implementing institution in another country (Lucheschi, 2014, Forcella and Lucheschi, 2016).

The remainder of the paper is structured as follows. In the next section we elaborate on the links between rural development, agriculture and the environment. We also introduce the

[3] The results from the quantitative analysis in this paper have also been used in Bastiaensen et al. (2015a) and Huybrechs et al. (Forthcoming), where the interested reader can also find a more elaborate discussion of the qualitative analysis. The present paper is instead dedicated to the quantitative analysis.

concept of Microfinance for Ecosystem Services – of which Proyecto CAMBio is an important pilot programme. In section three we introduce our research questions and the main hypotheses. Section four is dedicated to the methodology and dataset. The results emanating from the different-tests and regression analyses are presented and discussed in section five, after which we proceed to the conclusion.

2. LITERATURE REVIEW

2.1 RURAL DEVELOPMENT AND ENVIRONMENT

Agriculture and rural development are key elements of sustainable development, representing opportunities and limitations for the economic, social and environmental pillars of development. With smallholders' current adverse inclusion in value chains, the pressure on land holdings and rural populations' vulnerability to different stresses and shocks, there is much work to do to make the current development pathways in rural areas more inclusive (Bolwig et al., 2010).

A lot of attention in research and policy circles has been given to the role of agriculture in deforestation and environmental degradation (Geist and Lambin, 2002, Angelsen et al., 2001); and the understanding of the direct relationship between poverty and environmental degradation. Research hereon is inconclusive, especially regarding causality and the question of how to create pathways out of poverty through the sustainable use of natural resources (Suich et al., 2015). Furthermore, Lambin et al. (2001) warn from focusing too much on poverty as a cause of deforestation, and others point to how depicting poverty as an isolated main driver for environmental degradation falls short of recognising more structural patterns where different actors and responsibilities can be highlighted (see also Ravnborg, 2003). Hence, a more multi-dimensional and relational approach to poverty – embracing the various socio-economic and environmental aspects and understanding the systemic characteristics – is more suitable for investigating the link between poverty and environmental degradation.

In trying to understand impacts and driving forces, Geist and Lambin (2002) stress the importance of distinguishing between 'proximate causes' and 'underlying driving forces'. The former is a human activity with a direct impact on forest cover/land management, whereas the latter are processes which are in turn related to and fuel the proximate causes (such as population dynamics, institutions, agricultural policies…). An increasing number of authors thereby point to the need to look at the very local level, and then to see how this is influenced by and related to broader, more global dynamics (Shriar, 2014, Lambin et al., 2001, Suich et al., 2015).

Development pathways and complexity

The analytical framework of this paper builds on the recognition of linkages between different social, economic and ecological aspects of rural development. It also takes into account the importance of disaggregating outcomes and responses for different actors (Daw et al., 2011, Suich et al., 2015) and to be aware of different feedbacks, interactions, and mediating factors (Lambin et al., 2001, Bacon et al., 2012, Suich et al., 2015).

We conceive rural territories not simply as a set of individual rural producers, but emphasize their interaction with the socio-economic and environmental structure. New properties emerge from the interaction between different actors and the social, economic and political structures: formal and informal rules, entitlements, access to knowledge, credit and economic opportunities, etc. This makes the system intrinsically non-linear and complex, and feedback effects can strongly modify final outcomes (Bastiaensen et al., 2015b).

Within this framework we very much look at the micro-level of farms, but we also interpret the results in the broader institutional context (Bacon et al., 2012). We particularly focus our attention on how an external intervention aiming to foster environmentally friendly rural development interacts with the underlying territorial dynamics, and how such interaction shapes the final outcomes (and evaluation) in terms of environmental performance.

2.2 GREEN MICROFINANCE AND ECOSYSTEMS

There is a long history of searching for ways to match rural development with environmental concerns. In this article we will be focusing specifically on the recent trend of Green Microfinance (GMF). GMF aims at a triple bottom line: providing economic, social and environmental benefits. GMF is a multidimensional topic that includes environmental risk management, credits or non-financial services dealing with access to renewable energy or energy efficient devices; implementation of organic or agroforestry activities; support of practices to better adapt to climate change; etc.(Anderson et al., 2002, Wenner et al., 2004, Hall et al., 2008, Schuite and Pater, 2008, Allet, 2014, Cranford and Mourato, 2014, Forcella, 2014, Agathou and Schuite, 2015, Huybrechs et al., 2015a, Forcella and Schuite, 2015, e-MFP and MIX, 2015, e-MFPAG). Huybrechs et al. (2015a) define green microfinance as follows:

> "Green microfinance tries to induce changes in decision-making and behaviour of microfinance clients – either passively (refusing to finance harmful activities), or actively (providing environmentally conditioned micro-financial and non-financial services, possibly combined with targeted subsidies) – in order to reduce the clients' vulnerability to environmental stresses and/or to mitigate the impact of their practices on the environment, for reasons of financial risk reduction, livelihood improvement and/or conservation and restoration of natural resources."

The main rationality underlying the implementation of green microfinance is that micro entrepreneurs are among the drivers and the main affected actors of environmental degradation, and that microfinance has comparative advantages to promote better environmental management and resilience to environmental degradation for its direct relation and proximity to micro-entrepreneurs .

Debates are ongoing regarding the actual ability, willingness and need of MFIs to implement such GMF initiatives (Allet, 2014, Forcella and Hudon, 2014, Wenner et al., 2004). Nevertheless, when the environmental performance of microfinance institutions is being analysed it is mostly focused on the 'processes': e.g. the existence of dedicated policies, procedures and products (Forcella and Hudon, 2014, Allet and Hudon, 2015, Allet, 2012,e-MFPAG, 2014). Also, there generally seems to be an assumption that engaging with these issues will lead to positive outcomes. This operational assumption is largely due to the intrinsic difficulty to assess the impact. The effectiveness and limitations of green microfinance to tackle socio-environmental problems indeed remains largely unexplored. Very little research is being done on actual implementation and results, nor is there much reflection on the theory of change underlying the approach, wondering about how the tool might interact with the clients' practices and motivation, or with the local context in which he/she is operating. Exceptions are Allet (forthcoming), Forcella (2012), Lucheschi (2014), Huybrechs et al. (2015b), and Forcella and Lucheschi (2016).

This paper deals with environmental concerns regarding rural development and it focuses on a subtype of GMF, which seeks to engage in active support of rural environmentally sustainable practices such as agroforestry and silvopastoral activities, by providing specific incentives and non-financial services to its clients. We refer to this kind of GMF as 'Microfinance for Ecosystem Services' (Cranford, 2011), which hints at the currently popular environmental policy tool PES, and it distinguished itself from GMF for clean energy and technologies, while focusing on ecosystems and climate change adaptation. There is indeed a widespread belief that a solution to the problem of environmental degradation is the creation of payments or markets for ecosystem services (ES) –benefits people derive from nature– in order to encourage economic actors to include the otherwise unvalued positive externalities (i.e. ES) in their decision-making. The expectation is thus that the provision of this economic incentive (in this case, in combination with relieving constraints on access to credit (Cranford and Mourato, 2014)) will lead clients to making decisions towards the adoption of more environmentally-friendly investments (Ferraro and Simpson, 2002). Some studies however question this approach, noting a number of possible drawbacks and inherent problems. Although the concept of Ecosystem Services might have its use as an awareness-raising tool, some argue that it has become instrumentalised for backing the economic valuation and exchange of nature, masking the underlying complexities and multiple valuations, and eschewing a recognition of trade-offs and underlying social relations (Norgaard, 2010, Huybrechs, 2013, Kosoy and Corbera, 2010, Van Hecken and Bastiaensen, 2010b). It might also preserve and enhance the local and international inequalities; and definitively the fact that PES intend to create a market solution for problems generated by the market, implying that tiny modifications inside the market logic could overcome the environmental degradation without the necessity for deep reforms inside the growth model (McAfee, 1999, McAfee, 2011, Farrell, 2014, Muradian et al., 2013).

Proyecto CAMBio

As a case study we will analyse a project called CAMBio (Central American Markets for Biodiversity), often referring to it as "PC" in the rest of the paper. It was designed to remove barriers (related to funding, market opportunities and political barriers) to environmentally-friendly entrepreneurship, and to support an enabling environment for the development of environmentally friendly practices of small rural producers, to foster biodiversity conservation and increase ecological connectivity among protected areas (PCAMBIO, 2014). It offered micro-credits to finance agroforestry activities such as coffee and cocoa cultivation, as well as the use of trees for shade, fodder and fencing in cattle raising practices. Additionally, it provided conditional incentives –similar to PES (Wunder, 2005)– that were supposed to reward the additional efforts towards the adoption of biodiversity-friendly practices such as planting more trees. A third component was the provision of technical assistance to actually implement the activities financed with the credit (Forcella, 2012, Lucheschi, 2014).

The programme ran from 2007 until 2013 in five Central American countries (Guatemala, Honduras, El Salvador, Nicaragua, and Costa Rica). It was led by the Central American Bank for Economic Integration (CABEI), the Global Environmental Facility (GEF) and the United Nations Development Programme (UNDP), and implemented by 26 local financial institutions.

Proyecto CAMBio is the first large-scale programme mixing MF with PES. The evaluation of some of its main outcomes –which we present here for the specific case of its implementation in the Northern Central region of Nicaragua–, is hence fundamental. CABEI is currently undertaking a final evaluation of the project. A series of academic studies have been previously done (Forcella, 2012, Guerrero Pineda, 2012, Lucheschi, 2014, Huybrechs et. al. 2015b, Bastiaensen et al., 2015a and Huybrechs et al., Forthcoming, Forcella and Lucheschi, 2016).

We contribute to the discussion on the analysis of Proyecto CAMBio through this in-depth analysis of a specific case, which we link to broader discussions on how such projects interact in complex ways with the wider socio-ecological context. The latter is something that we feel is often missing in the evaluation of the project – and other interventions – so far (Huybrechs et al., 2015b). The current paper is one of the first quantitative analyses of the environmental outcomes of green microfinance programmes and it should be useful to better understand how green microfinance interacts with rural development pathways and to go beyond the mere assumption of positive results when including environmental concerns in microfinance practice. In particular it aims to unveil some of the characteristics and drivers of clients and incentives that influence the environmental outcomes of the intervention of microfinance for ecosystems services, when interacting with local rural dynamics.

In this paper, we focus on the implementation of Proyecto CAMBio by the microfinance institution Fondo de Desarrollo Local (FDL) in Nicaragua. FDL implemented the project together with its partner institution Nitlapan, which was in charge of technical assistance. An interesting characteristic of the way in which FDL-Nitlapan implemented the project, is that it seemingly most closely related to the idea of coupling three incentives: specific credits with reduced interest rates, PES and TA[4], that were indeed offered as a single product for all the credits part of the Proyecto CAMBio. The line of credit is provided by the CABEI to FDL, that uses it to provide credits at reduced interest rates to its clients dedicated to support sustainable rural practices (mainly investments for agroforestry practices for coffee or cacao, or silvopasture). Nitlapan provides free dedicated TA to their clients, paid by the GEF, to train them on the new environmentally friendly practice. The GEF provides a PES for every client that successfully implemented the environmentally friendly investment (equivalent to 14% of the credit to clients and 6% to the MFI)[5].

As we can see in Table 1, in Nicaragua they received more than a third of the available funds for lending, but almost all the resources for TA and the PES. Also, it was considered by UNDP as one of the most successful implementers of the project (Mendoza et al., 2012).

Intermediary Financial Institution (IFI)	Proportion of credits to IFIs	Proportion of TA beneficiaries	PES	
Coop 20 de Abril	0.78%	-	$ 2,232.07	0.76%
FDL	38.60%	95.71%	$ 291,372.94	99%
Lafise-Bancentro	49.77%	3.67%	-	-
Banpro	10.55%	0.61%	-	-

Table 1: Distribution of credits, TA and PES per intermediary financial institution. Situation per December 2012
Source: Proyecto CAMBio website (access 2015): http://www.proyectocambio.org

3. RESEARCH QUESTIONS AND HYPOTHESES

In this paper we look at what are the environmental outcomes of GMF. To this end, we analyse the characteristics of rural producers, their influence on the evolution of the environmental value of their farms and the effectiveness of PES to reward environmental betterment.

Main characteristics and variables related to clients, activities, incentives, that influence the environmental outcomes of GMF programme for biodiversity conservation are assessed in

[4] In this case, the PES is equal to the 14% of the credit, and it is offered to the clients that have successfully fulfilled the environmental targets established within the contract, usually involving the planting of a certain number of trees in a given area of the farm. In this way, the payment is thought to reward the additional ES provided by the clients, while the credit is used to fund the implementation of an environmentally friendly and economically rewarding activity, and the TA to provide the missing human capital. An additional payments of 6% of the credit is offered to the MFI, for each successful client, to reward its effort.

[5] For more details we refer to (PCAMBIO 2014, Forcella 2012).

detail. From the results of this analysis we discuss how a GMF programme for biodiversity conservation interacts with the local territorial dynamics and livelihood strategies, and we assess how the outcomes stem more from complex interactions with the local context or from project operations and incentives. The outcomes of such interaction are assessed in terms of the evolution of the environmental value of the MFI's clients' farms [6].

Our two main research questions are:

1. Are green microcredits (in this case coupled with TA and PES, and targeted to environmentally friendly agricultural practices), able to induce positive environmental outcomes?

2. Is PES, in a GMF programme, an effective tool to reward the environmental improvement of farm land?

These two main questions will be supported by two sub-questions, respectively:

1'. What characteristics of microfinance clients influence the evolution of the environmental value of their farm?

2'. What characteristics of microfinance clients influence the amount of PES they receive, and how do they interact with MFIs' credit strategy?

To better answer to these research questions, we present a number of subjacent hypotheses, which will drive our investigation in the rest of the paper and will support our analysis.

3.1 HYPOTHESES FOR RESEARCH QUESTION 1 AND 1'

Research questions 1 and 1' try to assess if the provision of green credits (with additional services) is enough to foster positive environmental outcomes, or if green credits, interacting with the underlying complex socio-economic and environmental dynamics, culture, values, habits and development pathways turn out instead to have no effect –or even a negative one – on the promoted environmental value. With the aim of understanding better how the green microfinance project translates into practice, we select a set of proxies, other than the green credit, that could underline the influence of such complex dynamics on the environmental outcomes at farm level, and we present a number of related hypotheses. We generically refer to these proxies as "client characteristics", although we recognise that these characteristics of the client are induced by the client's interaction with the socio-economic-environmental local

[6] We will introduce the indices we used for this value later. Please note that we do not pretend that there is one single way to pin down this value, and that every intent to do so is reductionist and involves value-judgements (Vatn, 2009, Sagoff, 2011). We use the indicators, however, as a way to provide an image of possible evolutions on the farms to inform wider discussions about the interactions of the project with the local context. Thereby, we will recognise that more deliberative approaches to valuation and the understanding of complex impact are necessary.

dynamics. The idea is to try to reflect on the outcomes' relation to the intervention as well as other characteristics and dynamics. Other variables that influence the outcomes in terms of the evolution of the environmental value of the farm are then seen as proxies to go beyond the mere external programme's intervention. The formulation of hypotheses drives us to explore what is known in the literature about the variables that influence the environmental evolution of the farm and test them against our empirical data.

- **Access to credit**

It is reasonable to believe that more credit could foster better land management activities. An improved access to financial means could increase the productive capacity of the land; thereby making a certain production less intensive in land use. The discussion on poverty and the environment (Ravnborg, 2003, Suich et al., 2015) underlines different points of view on whether or not the provision of credit could be related to the more or less damaging effect of smaller farms. However, one of the key ideas behind microfinance's increased attention to its environmental bottom line (Anderson et al., 2002, Wenner et al., 2004) is that the activities of poor households or micro enterprises might exacerbate the impact on the environment. In addition, Gerber (2014) points to increased short-termism in a debtor's management, as it needs to reply to the immediate demands of creditors. At a more regional level, a number of studies also point to the relation between more credit and more deforestation (Angelsen et al., 2001).

H1: *Having access to more credit induces a worse environmental performance of the farms*

- **Access to green credits**

The straightforward hypothesis –which is also the one underlying GMF–, is that receiving specific green credits induces better environmental performance on the farms. Indeed the combination of green credits (with or without additional services) could enable rural producers to invest in more environmentally friendly activities, thereby influencing the overall environmental impact of MFI' clients. Cranford and Mourato (2014) point however to the low conditionality that is related to 'concessional lending'. In our case too, the loan is provided for a specific activity but cannot be retrieved if the activity has not taken place. Nevertheless, for its relationship with the other incentives (TA, PES, etc.), we do see some level of conditionality in our case and will apply the hypothesis that underlies the project.

H2: *access to green credit induces better environmental performance on the farms*

- **Principal Activity**

There are some specific linkages between the type of agricultural activity that is undertaken, and the environmental performance of the farm. Additionally, the main economic activity that has been chosen, or that is being imposed, also influences the specific investment choices that can or will be taken in the future (Forcella, 2012). This focus on the clients' choices puts the emphasis on the client's livelihood strategies and decision patterns. This suggests not only to look at the client's activity at a given time, but also its evolution over time, including a possible change in main economic activity. This can teach us something about the livelihood trajectories within the existing pathways (de Haan and Zoomers, 2005), and how this evolution characterizes environmental performance. Hence it seems unlikely that clients' activities, shaped by local possibilities, would not influence the environmental performance. However its actual influence would depend on the specific activity and livelihood trajectory.

***H3**: The principal economic activity of the household (and its evolution) influences its environmental performance.*

- **Size of the farm**

Land holdings tend to be strongly related to the socio-economic position of farmers in rural areas. A farm, however, can be of a smaller size for different reasons, as it can be either an economically poor farmer, or a farm which very intensive production on a small area. Some consider bigger farms to be more efficient, though it could be based on more intensive mono-cropping practices. This will depend on context, type of crop, and the set of externalities that are taken into account. Farm surface is also interlinked with the debate between family-based farming and more entrepreneurial forms. The former might have more diversified farming practices, leaving more land fallow because of rotating crops and lack of capital, and arguably holding a more altruistic attitude towards its immediate surroundings and the impact of the farming practices.

***H4**: The size of the farm negatively affects its environmental performance*

This would also bring us to hypothesize that in terms of land dynamics – i.e. the evolution in farm size over the years – an increase in area would also negatively affect the environmental performance.

***H5**: An increase in farm area negatively affects its environmental performance*

- **Historical Environmental value of the farm**

If a farm is already performing well in terms of environmentally-friendly land-uses, it is more difficult to improve it. This is sometimes discussed regarding the targeting of environmental programmes, trying not to direct the incentives towards people who are already complying with some standards (Blackman and Naranjo, 2012, Wunder, 2005). Nevertheless, one might also argue that farmers who are performing well in environmental terms do so based on what they consider rewarding practices (be it economically, environmentally (e.g. water, timber, micro-climate,…) or socially (altruistic behaviour, interdependencies,…)), and that they wish to maintain or further increase said performance; and vice-versa. We should also recognise that farmers are acting according to some strong beliefs and habits that might not be so easily redirected (Hiedanpaa and Bromley, 2014). In light of programmes which want to address this, as well as the possibility of a saturation point, we will hypothesize the following:

***H6**: The higher the environmental value at a given moment, the more difficult it is to increase it.*

3.2 HYPOTHESES FOR RESEARCH QUESTION 2 AND 2'

For the expected conditional relation between the incentive and the outcomes, the logic behind the payments would be that 'the more you pay, the more you get'. Expectations of additionality and the relation between the supposed underlying motivations for changes in environmental practices would require the payment to reflect the improvements (Engel et al., 2008). This relationship is arguably also important in line with warnings about potential motivation crowding with such payment schemes. Indeed, by bringing in an economic/market logic in relation to environmental conservation, there is the risk of eroding other, intrinsic motivations; a risk which is higher when payments are considered low or insufficient (Rode et al., in press).

There is a variety of studies on the impact of PES on promoted practices and ecosystem services, obtaining different conclusions depending on the settings and the theoretical approach/ depth of the analysis; with e.g. Arriagada et al. (2012) finding a significant impact of PES on forest cover on farms in Costa Rica; and Van Hecken and Bastiaensen (2010a) and Pagiola et al. (2007) coming to different conclusions regarding the same project in the same area.

We then subdivide research questions 2 into three main hypotheses, to better understand the influence of the local territorial dynamics on the effectiveness of PES in rewarding environmental betterment.

- **PES and environmental objective of the project**

The idea of PES projects is to reward the environmental objective of the programme in terms of the indicators established to measure them. The misalignment of programme objectives or bad governance could disentangle PES and environmental targets. Programmes implying a verification of the investment done with the credit should be expected to reward better environmental practices in terms of the programme's objectives.

***H7:** PES rewards higher environmental engagement in the project*

- **Effectiveness of PES to reward environmental betterment**

In a broader vision, PES should also reward environmental management measured beyond the environmental targets of the programme and beyond the specific targeted plots of the participant. Indeed, it would be problematic if the positive effects on one part of the farm/area were counterbalanced by a ‘leakage’ on others parts of the farm/area. Additionally, the idea of payments and projects to remove barriers for the adoption of environmentally-friendly practices should also lead to the further adoption of these practices, also beyond the direct area of influence. We therefore think it is necessary to look at the environmental value of the whole farm.

***H8**: A higher payment is related to a bigger improvement in the farm's overall environmental value*

- **Existence of other client characteristics that influence the environmental reward**

In theory, PES should reward the value of the additional ES provided by the clients, independently from other clients’ characteristics. A pure economic vision would conclude that every actor, independently from its characteristics, can provide an ES if the PES is high enough and aligned with its needs. However, there are two main reasons to question this vision. Firstly, the local dynamics can shape the possibilities and opportunities of farmers to provide a certain ES, which in turn depends on the clients’ characteristics. Secondly, the payment is linked to a credit provision that is implemented by an MFI; and the clients’ characteristics likely influence decisions of credit provision. Indeed it is natural to believe that the provision of credit and hence PES is not neutral but influenced by socio-economic opportunities and limitations, and the decision of the MFI to whom and how much credit provide interacts with local dynamics, in terms of credit worthiness and cultural values and believes.

H9: *Client characteristics, other than the ES provided, influence the provision of PES*

4. METHODOLOGY AND DATASET

Our study is located in the Central Northern region of Nicaragua, in the municipalities of El Cuá, La Dalia and Rancho Grande. This area, which surrounds the nature reserve ‘Macizo de Peñas Blancas’, was chosen for its importance for biodiversity and environmental connectivity, as it is part of the Meso-American biological corridor and lying in the buffer zone of the Bosawás Biosphere reserve (see Figure 1). These characteristics also led to the region being a focus area for Proyecto CAMBio. From the participants of Proyecto CAMBio, as implemented by FDL-Nitlapán, 21% were located in this area.

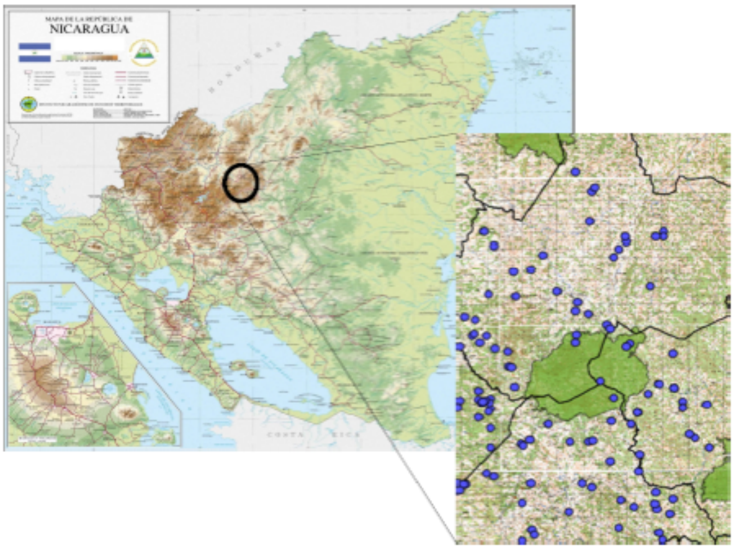

Figure 1: Geographic location of the study region (blue dots indicate Proyecto CAMBio participants)
Source: authors' own elaboration based on (INETER, 2009)

To answer the research questions, we analyse a unique set of primary data concerning 128 rural producers: 88 clients of FDL that participated in Proyecto CAMBio and 40 clients of FDL that did not participate. Data were collected by Frédéric Huybrechs and a team of five enumerators in the period October-November 2013. In addition, long-term presence in the zone, conducting semi-structured interviews and participatory observation, provides for qualitative data to understand and interpret better the quantitative results; and vice-versa.

The questionnaire was inspired by previous studies on PES and Proyecto CAMBio in Nicaragua (Forcella, 2012, Van Hecken and Bastiaensen, 2010a). We asked for information concerning: the economic activities, credit sources and use of credit, family structure, membership of organisations, livelihood strategies, and these characteristics' evolution during the last five years. For the evaluation of the environmental performance of the farms, we use the Ecosystem Services Index (ESI), further subdivided into a carbon index (CI) and biodiversity index (BI), as a proxy for the environmental outcomes of the combined land uses of the rural producers. It is a specific index designed by regional rural development organisations, indicating the biodiversity and carbon offsetting potential of the various activities on the farm (Murgueitio et al., 2003). It ranges from a value of 0 for land uses assumed to deliver least services of carbon sequestration or biodiversity (like degraded pasture) to 2 for the land use supposedly contributing most to the delivery of both (like primary forest). In between, incremental improvements in the delivery of the services are reflected in higher indices (see Table 2) (Murgueitio et al., 2003).

	Carbon index	Biodiversity index	Ecosystem Services Index
Annual crops	0	0	0
Degraded pasture	0	0	0
Natural pasture without trees	0.1	0.1	0.2
Improved pasture without trees	0.4	0.1	0.5
Sun-grown coffee	0.2	0.3	0.5
Natural pasture with low tree density (<30/ha)	0.3	0.3	0.6
Natural pasture with high tree density (>30/ha)	0.4	0.4	0.8
Living fences (per km)	0.4	0.45	0.85
Windbreaks (per km)	0.5	0.6	1.1
Improved pasture with low tree density (<30/ha)	0.5	0.3	0.8
Improved pasture with high tree density (>30/ha)	0.7	0.6	1.3
Monoculture fruit plantation	0.4	0.3	0.7
Fodder banks	0.5	0.3	0.8
Fodder banks with woody species	0.5	0.4	0.9
Cocoa with shade	0.5	0.6	1.1
Shade-grown coffee	0.7	0.6	1.3
Scrub habitats	0.8	0.6	1.4
Riparian forest	0.7	0.8	1.5
Secondary forest	1	0.9	1.9

Table 2: Values of indices for different land uses
Source: adapted from Van Hecken (2011) and Murgueitio et al. (2003)

Based on the information gathered through the survey, we look at the evolution of the three indicators' value per hectare (for reasons of comparability among different farms with different sizes): the ESI/ha, BI/ha and CI/ha. We calculate these indicators' value at the moment of the survey (2013) and for the recall period 'five years ago'. We look at the whole farm; not just the 'influence area'. We do so to understand potential spill-overs (Arriagada et al., 2012), and we assess if the intervention of GMF in a limited farm surface and for a given time is able to induce changes in the full environmental value of the farm, or if instead the intervention of the GMF is a marginal change in clients' investment strategies that however do not influence their livelihood trajectory.

The sample of Proyecto CAMBio producers was obtained as a random sample of 115 producers from the list of contracts of Proyecto CAMBio, looking for a distribution that matched the population in terms of activity (agroforestry and silvopastoral) and in terms of being client of the El Cuá or La Dalia FDL branch.

The group of FDL clients who did not participate in this project, has been randomly chosen at first, among of set of non-participating clients, that would have had the right characteristics (in term of FDL policy) to be part of the programme. It is intended to inform us about patterns of change of non-participating farms. The distribution of such sample of producers that where not part of the programme is chosen to reflect the spatial and sectoral distribution of the sampled Proyecto CAMBio's contracts. However it does not pretend to be a "control group" in the strict statistical meaning of the term. The size of the sample was mainly driven by temporal and financial constraints, with the main emphasis being on the necessary size of the sample of producers of Proyecto CAMBio. The randomly chosen sample has to some extent been adapted for logistical reasons. Moreover it is clear that the two samples do not differ only for the fact to be part of not of the Proyecto CAMBio, but also by other characteristics both explicit as it will appear from our data, but also hidden characteristics, simply due to the fact to have been chosen or decided to participate or nor to the programme. In our analysis the we always control for the various characteristics of the two groups when comparing them. We will call the producers that participated to the Proyecto CAMBio the "PC" group or producers, while the producers that did not participate to the Proyecto CAMBio the "non-PC" group or producers.

We obtained information from 99 PC producers; a response rate of 85%. For the non-PC group, 48 of the 58 respondents were found and replied; a response rate of 83%. 19 were rejected for incomplete or inconsistent information, leaving us with 88 for PC and 40 for non-PC client group.

4.1 DESCRIPTIVE STATISTICS AND SAMPLE REPRESENTATIVENESS

Table 3 reports the descriptive statistics of the main variables we use in our analysis and the comparison with data at national level and in the same region (the three municipalities La Dalia, El Cuá and Rancho Grande).

At national level FDL, had 1,079 clients that participated in Proyecto CAMBio and 238 participating clients in our region of investigation (in October 2013). In the area of investigation FDL had 1,005 clients with a credit for coffee actives and 69 clients with a credit for cattle (in October 2013). This implies that our sample is quite large, corresponding to 37% of the clients that participated to Proyecto CAMBio in the same area (full population) and 8.2% at national level. Moreover the full sample corresponds to 11.9% of the clients of FDL in that area.

The majority (80.7%) of the clients in the PC group received a credit for agroforestry (AF) activities, for an average amount of 3,066.4 USD; while 19.3 % received it for silvopastoral (SP) activities for an average amount of 2,282.9 USD. The distribution between producers with SP or AF credit in our sample is very similar to the one at regional level: 78.6% and 21.4% respectively.

Table 3: Profile of the respondent rural producers and comparison with regional data: descriptive statistics

	Number of observations	Min	Max	SE	Mean	Regional	National
Producers with PC	128	0	1	0.465	0.688	-	-
Producers with PC for Agroforestry	88	0	1	0.397	0.807	0.786	0.697
Producers with PC for Silvopasture	88	0	1	0.397	0.193	0.214	0.303
Evolution Ecosystem value per Ha	128	-0.938	1.3	0.329	0.137	-	-
Evolution Biodiversity per Ha	128	-0.522	0.6	0.158	0.058	-	-
Evolution CO2 Capture per Ha	128	-0.415	0.7	0.176	0.078	-	-
Evolution Ecosystem value Total	128	-14.49	52.29	9.46	5.49	-	-
Evolution Biodiversity value Total	128	-6.51	22.05	4.16	2.45	-	-
Evolution CO2 Capture per Total	128	-7.98	30.24	5.38	3.04	-	-
Number of planted trees with PC	63	20	1,000	205.6	173.0	162.9	-
Density of planted trees with PC	62	9.5	1428.6	193.4	120.4	81.4	-
Surface invested in P CAMBio (Ha)	78	0.175	14.7	2.28	2.07	1.98	-
Credit PC Agroforestry (USD)	70	469.5	10,000	2,386.0	3,066.4	2,508.1	1,795.1
Credit PC Silvopasture (USD)	17	669.6	6,000	1,688.3	2,282.9	3,139.3	2,669.4
Credit No PC received last 5 years (USD)	122	0	62,000	9,445.4	6,132.0	-	-
Environmental Reward: PES (USD)	84	65.7	1,400	317.1	390.4	381.7	-
Environmental Reward per tree (USD/ tree)	62	0.34	12	2.54	3.04	3.1	-
Ecosystem Index per Ha 5 years ago	128	0.122	2.1	0.365	0.894	-	-
Biodiversity Index per Ha 5 years ago	128	0.067	1.09	0.176	0.424	-	-
Carbon Index per Ha 5 years ago	128	0.056	1.01	0.193	0.470	-	-
Total farm surface 5 years ago	128	0.875	150.15	26.19	19.66	-	-
Cattle as Principal Activity 5 years ago	127	0	1	0.358	0.150	-	-
Diversified production 5 years ago	127	0	1	0.244	0.063	-	-
Coffee as Principal Activity 5 years ago	127	0	1	0.496	0.575	-	-
Change principal activity to Coffee	126	0	1	0.325	0.119	-	-
Change principal activity to Cattle	126	0	1	0.176	0.032		
Change principal activity to diversified prod.	126	0	1	0.295	0.095		
Evolution in the surface of the farm (Ha)	128	-18.73	56	9.92	3.49		
Access to electric grid	126	0	1	0.500	0.452		
Family working force in the farm	127	0	1	0.252	0.659		
Social Capital	128	0	2	0.615	0.625		

The average credit received with Proyecto CAMBio is 2,915.2 USD in our sample, which is comparable with the average credit from Proyecto CAMBio in the region of study: 2,642.4 USD, but bigger than the average credit at national level: 2,070.3 USD. Both at regional and at national level the amount of credit per SP activities is bigger than the one for AF activities, while for our sample the trend is the reverse. However, simple statistical tests show that this difference is not significant.

The credit was received on average in 2010 with 65% of the clients receiving it between 2009 and 2011. Only 2 clients received credits twice from Proyecto CAMBio. Simple statistical and econometric tests reveal that the date of the credit does not have a significant influence on the evolution of the environmental value of the farm.

The clients that participated in Proyecto CAMBio planted on average 173 trees on 2.07 Ha with an average density of 120.4 trees per Ha. The number of trees planted and the area invested are similar to the ones of the full population of Proyecto CAMBio participants in the same area, while the tree density is higher compared to 81.4 trees per Ha for the full set of PC group.

98.9% of clients in the PC group achieved the previously agreed environmental targets and 90.8% received the environmental reward (PES). The PES was on average of 390.4 USD, which is equivalent to 3.04 USD per tree and very similar to the values for the full population of clients that received Proyecto CAMBio in the region.

In the last five years, the clients in the sample cumulated on average 6,132 USD of credit (sum of all credit received, excluding Proyecto CAMBio).

Five years ago, 57.5% of the clients in the sample had coffee as main activity; 15.0% raised cattle as main economic activity; and 6.3% mentioned more than one principal activity (from now on termed ‘diversified producers’). The rest had staple crop production as principal activity. It reflects the strong focus on coffee production in this region, while pointing to a heterogeneous set of producers (Arribard, 2013).

However in the last five years there has been quite some dynamics with 11.9% of the producers switching to coffee as their principal activity; 3.2% changing their main economic activity to cattle and 9.5% becoming diversified producers. Only one producer moved to staple crop production as a main economic activity.

In our sample, the average farm surface five years ago was of 19.7 Ha. This is a relatively high average for a region where about 80% of the farms have less than 14 Ha (INIDE-MAGFOR, 2013a, INIDE-MAGFOR, 2013b); although it does to some extent reflect the unequal distribution of land holdings (Gómez et al., 2011), as our sample has a long tail with a few larger farms. We also observe that the clients in the sample on average increased their farm surface by 3.49 Ha in the last 5 years.

Five years ago the ecosystem value per Ha (ESI/ha) in the sample was on average 0.894, further subdivided in a biodiversity value per Ha (BI/ha) of 0.424 and the CO2 capture value (CI/ha) of 0.470.In the last five years we observe in the sample a tendency of improved environmental values of the farms, both per Ha and for the total environmental value of the farm.

In the remainder of the paper we also use three other proxies to characterise the clients interviewed. The first one is access to electricity from the grid: a dummy variable about access to the electricity from the grid (45.2 % in the case of our sample). This variable is meant to measure the remoteness of the clients, and their access to energy and markets (road, trading centres, etc.). We also have a variable regarding family working force in the farm, which is the ratio between the number of family members (women plus men) working in the farm over the number of people living in the house. It measures the working force of the family employed in the household's farming activities. It aims to be the proxy for a multitude of constraints that influence the livelihood strategies of farmers, among which: the need or opportunities for further employment other than the family activities, the family structure, etc. Finally, we also have the social capital index, consisting of the sum of four dummy variables that assess whether or not the client is part of a cooperative, a producers' association, a church or a political organisation. It aims to estimate the social capital of the clients.

Comparisons between Proyecto CAMBio and non-Proyecto CAMBio clients

Before proceeding with our analysis concerning our two main research questions, it is interesting to explore what are the observed difference between the clients in the PC group and the non-PC group.

We see that on average the PC group has a higher percentage of producers with cattle raising and coffee growing as principal activity five years ago: 16.1% and 60.9%, respectively, compared to 12.5% and 50% respectively for the non-PC group. The latter group has instead a higher percentage of producers with staple crops as principal economic activity five years ago: 30% compared to 16.5% of the PC producers. Indeed, it seems that the producers that participated to Proyecto CAMBio were already involved in economically more rewarding activities five years ago, compared to the clients in the non-PC group. This difference points towards a credit logic, more than an environmental strategy, behind the choice of the MFI concerning the producers that could participate or not in the programme.

To better understand the differences between the two samples we perform some simple statistical tests between the PC and non-PC group on the variables reported in Table 4. We first perform a two side t-test for the two groups to assess differences in means, without assuming equal variance for the two populations. However, we observe that in many cases our sample does not allow to conclude that the two populations are normally distributed - as required by the t-test - and there is no standard variables transformation that makes the sample more normally distributed. As robustness check we hence decide to perform the Mann–Whitney–Wilcoxon (MWW) test too; a non-parametric test that does not assume normality of distributions. Results are reported in Table 4.

Table 4: differences between PC and A group clients

	Ecosystem value per Ha 5 years ago	Biodiversity value per Ha 5 years ago	CO2 capture value per Ha 5 years ago	Farm Surface 5 years ago (Ha)
Proyecto CAMBio				
Clients (Num Obs)	0.90 (88)	0.42 (88)	0.47 (88)	24.0 (88)
No-Clien (Num Obs)	0.89 (40)	0.43 (40)	0.46 (40)	10.1 (40)
t-test	0.05	-0.26	0.34	**3.71*** **
MWW-test	-0.00	-0.29	0.18	**3.98*** **
	Tot Cumulated credit in the last 5 years (USD)	Access to electric grid	Family working force in the farm	Social Capital
Proyecto CAMBio				
Clients (Num Obs)	9297.0 (86)	0.46 (87)	0.68 (87)	0.70 (88)
No-Clients (Num Obs)	5686.7 (36)	0.45 (39)	0.61 (40)	0.45 (40)
t-test	**1.81***	-0.14	1.52	**2.31** **
MWW-test	**3.81*** **	-0.14	1.38	**2.15** **

t-test: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$, MWW-test: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

Table 4 clearly shows that clients in the PC group are more capitalised (owning larger farms), that they have more/higher credits[7], and that they have higher social capital.

These facts make us conclude that Proyecto CAMBio was offered to better-off clients. Moreover, the fact that the environmental value of the farm is not different between the two groups implies that Proyecto CAMBio was not used to reward past better environmental performance.

[7] It is maybe worth to observe that the cumulated credits amount (excluding credits from Proyecto CAMBio) received in the last five years is 6318,4 USD for the PC group and 5686,7 USD for the non-PC group. The difference in cumulated credit volume between the two groups is not significant, however it become significant including the credit from PC, implying that the PC group has overall a better access to credit.

Local territorial dynamics

As highlighted in the presentation of our analytical framework, an understanding of the characteristics of rural producers that influence the environmental value of the farm requires the assessment of local territorial dynamics in which farmers' decisions and actions take place. To complement our broader, qualitative, understanding of regional dynamics and to further link the developments on the farms in our sample to broader territorial dynamics, we decided to analyse the land and environmental dynamics of our sample. In the previous section we observed that there is a tendency towards land accumulation and improvement of environmental value of the farm. In this subsection we want to assess if this average tendency is indeed significant or if it is instead peculiar of our sample.

To fulfil this objective we perform two statistical tests: the paired, or dependent, t-test (which assumes that the difference in the two distributions is normally distributed) and the Wilcoxon signed rank sum test (which is a non-parametric version of the t-test and does not assume normality). We apply these tests to the difference between the ecosystem, biodiversity and CO2 capture value per hectare today and five years ago, and to the total farm surface today and five years ago. These tests assess the difference between two dependent distributions and are suitable for samples of the same variable measured at two different moments in time, while the usual t-test or MWW test are not applicable because they assume the independence of the two distributions. The results are reported in Table 5.

From Table 5 it is clear that there is an overall ongoing process of land accumulation and at the same time a tendency towards improvement of the environmental value of the farm per Ha. This is the case also for the two subgroups of producers: the ones who participated in Proyecto CAMBio and the ones that simply have access to credit from FDL, but not Proyecto CAMBio.

Table 5: evolution of environmental value and land between today and 5 years ago

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

	Number Observation	Ecosystem value per Ha	Biodiversity value per Ha	CO2 capture value per	Farm surface (Ha)
Full Sample					
Today	128	1.03	0.482	0.549	23.1
5 years ago	128	0.894	0.424	0.470	19.7
paired t test		**4.72*** **	**4.18*** **	**5.04*** **	**3.98*** **
Wilcoxon signed rank sum test		**5.06*** **	**4.51*** **	**5.10*** **	**4.65*** **
PC Group					
Today	88	1.03	0.476	0.549	27.0
5 years ago	88	0.896	0.420	0.475	24.0
paired t test		**4.87*** **	**4.53*** **	**4.94*** **	**3.25*** **
Wilcoxon signed rank sum test		**4.93*** **	**4.35*** **	**4.87*** **	**3.58*** **
A Group					
Today	40	1.04	0.495	0.548	14.7
5 years ago	40	0.89	0.431	0.460	10.1
paired t test		**2.10** **	**1.78* **	**2.33** **	**2.34** **
Wilcoxon signed rank sum test		**1.99** **	**1.83* **	**2.14** **	**3.06*** **

4.2 EMPIRICAL METHODOLOGY

In this paper, we want to assess the main characteristics of the rural producers which influence the change in environmental value of the clients' farm. We also want to assess if Proyecto CAMBio was able to foster the envisaged on-farm environmental improvement and if the environmental incentives (PES) were effective in rewarding and fostering better environmental practices. To reach these objectives, we conduct statistical and econometric analyses. Our strategy is to first perform mean difference t-tests and non-parametric tests of distribution difference to assess the main characteristics that influence the evolution in environmental value of the farm and the amount of environmental reward received by the producers. We then perform ordinary least square regressions with these variables.

To assess the characteristics that influence the evolution of the environmental value of the farm we compare the evolution of the ecosystem-, biodiversity- and CO2 capture value per Ha of the farm, in the last five years, along seven main categories.

i) We analyse the difference between participants and non-participants.

ii) We assess the difference between the producers of the PC-group that received a credit for AF activities and the ones that received a credit for SP activities.

iii) We assess the influence of the principal economic activity of the producers five years ago. With this aim, we divided our sample into four categories of producers based on their respective main economic activities: cattle raising, coffee growing, diversified producers, and staple crop.

iv) We assess the influence of the capitalisation of the producers. We use the total surface of the farm as a proxy, dividing our sample in two groups: we define small producers as the ones in the sample with a farm smaller than 10.5 Ha while we define large producers as the ones that own a farm larger than 10.5 Ha. The value 10.5 Ha seems a reasonable value to distinguish large and small producers in the region of study and it has been chosen because it is the median of our sample.

v) We also divide our sample into the clients that increased their farm surface over the last five years and the ones that decreased it or did not change their farm surface.

vi) The access to credit is included to assess the influence of available funds on environmental outcomes. We defined clients with high access to credits as the ones that received more than 4,615 USD (the median value in our sample) in credits in the last five years, while the ones with low access to credits received less than 4,615 USD.

vii) As a proxy of the livelihood trajectory of the clients we divide the clients on the basis of the switch they made to another principal economic activity in the last five years; switching to coffee, cattle, or becoming a diversified producer.

To assess the effectiveness of the PES, we analyse the total amount of PES as well as the PES paid per tree planted, and we do so for the following dimensions

i) the evolution of ISE/ha
ii) the evolution of BI/ha
iii) the evolution of CI/ha
iv) the number of trees planted,
v) the surface dedicated to Proyecto CAMBio
vi) the density of trees installed within the surface dedicated to Proyecto CAMBio
vii) the principal activity five years ago
viii) the farm surface
ix) the cumulated credit volume in the last five years excluding the credit from Proyecto CAMBio
x) the activity financed with Proyecto CAMBio (AF or SP)
xi) evolutions in farm size.

We performed a two side t-test on the evolution in ESI, BI and CI per Ha for the first 7 dimensions, and for the PES and the PES paid per tree for the other 11 dimensions; without assuming equal variance of the two populations. The t-test for difference of means uses the hypothesis that the two samples belong to populations that are normally distributed. As this is not always the case for these variables in our sample, we decide to support and check the validity of the t-test with a non-parametric test: the Mann–Whitney–Wilcoxon (MWW) test. We conduct both tests for the eighteen categories, and report the results in Table 6 and Table 9.

We use the results of the t-test and the MWW test to build nine multivariate regressions: the first three refer to the hypotheses concerning our first research question, while the other six relate to our second research question.

The first group of three regressions has the following *dependent variables*: the evolution of the ecosystem value per Ha (EVOIseHa); the evolution of the biodiversity value per Ha (EVOBiHa); and the evolution of the CO2 capture value per Ha (EVOCiHa). The *explanatory variables* we use are:

- the amount of credit received for agroforestry activities (PCAF);
- the amount of credit received for silvopastoral activities (PCSP);
- the total amount of credits cumulated in the last five years (excluding the credits within Proyecto CAMBio) (TOTCRNOPC);
- the ecosystem, biodiversity and CO2 capture value per Ha five years ago (ESiHA5y, BiHa5y, CiHa5y);
- the total surface of the farm five years ago (TOTHa5);
- three dummies variables with values 1, 0, distinguishing the clients that had cattle, were diversified, or had coffee as principal activities five years ago (CATTLE5y, DIV5y, COFFE5y);
- three other dummy variables that assess if a client changed her/his main activity, respectively to coffee, cattle or became diversified (ChCoffee, ChCattle, ChDiv);
- and a variable regarding the increase or decrease of farm land within the last five years (ToTEvoHa).

We also added three control variables to the set of explanatory variables already described. These additional variables are introduced because it is reasonable to believe that they could influence the environmental evolution of the farm and some simple statistical tests on the regressions without including such variables point out that there were some missing variables in the regression and the t-test would not be valid. These variables are: AcElGrid: a dummy variable assessing the access to electric or not of the clients; FAMIndex: assessing family members working in the farm over the full family components, and SOCIALIndex: assessing the social capital of the clients: sum of four dummies variables assessing the link of the client to cooperative, association, churches, or political organisation.

The regressions are hence defined as follow:

$$EVOEnvValueHa(j)_i = \alpha_i + \beta_1 *PCAF_i + \beta_2 * PCSP_i + \beta_3 *TOTCRNOPC_i + \beta_4 *EnvValueHA5y(j)_I + \beta_5 *TOTHA5_i + \beta_6 *CATTLE5y_i + \beta_7 *DIV5y_i + \beta_8 *COFFE5y_i + \beta_9 *ChCoffee_i + \beta_{10} *ChCattle_i + \beta_{11} *ChD_iv_i + \beta_{12} *ToTEvoHa_i + \beta_{13} *AcElGr_id_i + \beta_{14} *FAMIndex_i + \beta_{15} *SOCIALIndex_i + \varepsilon_i$$

the index j=1,2,3 runs on the three measurements of environmental value we use in the paper, namely:

EVOEnvValueHa(1)=EVOIseHa,
EVOEnvValueHa(2)=EVOBiHa,
EVOEnvValueHa(3)=EVOCiHa
EnvValueHA5y(1)=ESiHA5y,
EnvValueHA5y(2)=BiHA5y,
EnvValueHA5y(3)=CiHA5y.

We then run two other sets of regressions to respond to our second research question. The dependent variable of the first set of regressions is the amount of money that participants received as environmental reward (PES). The dependent variable of the second set is the logarithm of the amount of money received as a reward per planted trees (Log(PESperTree)). We had to take the logarithm of the PES received per tree because the residues of the regression done for PESperTree are not normally distributed – invalidating the t-tests - while the Log is the variable transformation that generates normally distributed residues at the best level of confidence. The explanatory variables we use include some of the ones used in the previous set of regressions (EVOIseHa, EVOBiHa and EVOCiHa (one per regression in both groups of regressions); TOTCRNOPC; TOTHa5, CATTLE5y, DIV5y, COFFE5y, ToTEvoHa, AcElGrid, FAMIndex, SOCIALIndex); and some additional variables:

- the number of trees planted by the clients according to the targets established within the first credit received with Proyecto CAMBio (ARBPC1);
- the density of the trees planted (TreeHaPC);
- and a dummy variable with value 1 for clients that received a credit for agroforestry and 0 for clients that received a credit for silvopastural activities (AF).

We do not include the area of the farm invested in the activities financed by Proyecto CAMBio because it is highly correlated with ARBPC1, TOTCRNOPC and TOTHa5 and it would introduce important multicollinearity in the regression. In the second set of regressions we do not include the variables AcElGrid, FAMIndex and SOCIALIndex because they do not seem to be relevant nor statistically significant and due to the reduced number of observation (restricted to PC group) we prefer not to include them.

The first three regressions are hence defined as follow:

$$PES_i = \alpha_i + \beta_1*EVOEnvValueHa(j)_i + \beta_2*ARBPC1_i + \beta_3* TreeHaPC1_i + \beta_4*TOTCRNOPC_i + \beta_5*AF_i + \beta_6*TOTHA5_i + \beta_7*CATTLE5y_i + \beta_8*DIV5y_i + \beta_9*COFFE5y_i + \beta_{10}*ToTEvoHa_i + \beta_{11}*AcElGrid_i + \beta_12*FAMIndex_i + \beta_{13}*SOCIALIndex_i + \varepsilon_i$$

while the second three are defined as:

$$Log(PESperTree)_i = \alpha_i + \beta_1*EVOEnvValueHa(j)_i + \beta_2*ARBPC1_i + \beta_3* TreeHaPC1_i + \beta_4*TOTCRNOPC_i + \beta_5*AF_i + \beta_6*TOTHa5_i + \beta_7*CATTLE5y_i + \beta_8*DIV5y_i + \beta_9*COFFE5y_i + \beta_{10}*ToTEvoHa_i + \varepsilon_i$$

For all nine regressions we first performed a careful analysis of possible outliers that could wrongly influence our results. We plotted the residues against leverage for all the observations and we carefully analysed the observations that had unusual residue or leverage or both. For the most relevant of them we ran regressions with and without including them (we performed this procedure one by one for all the possible outliers) and checked if coefficients or their significance changed or not. We then systematically excluded the potential outliers that influenced the regressions in a relevant way: one single observation should not change the results if statistically sound. We proceeded like this for all potential outliers until we reached robust regressions.

For all nine regressions we also performed various checks to verify that the assumptions for OLS regression are satisfied. First, we verified that none of the explanatory variables are highly correlated with the others (we report the correlation Table for the first group of regressions in the Appendix, where we also check if correlations are significant). We then proceeded to check the normality of the residuals by drawing a Q–Q plot and doing a Shapiro–Wilk test; which turned out to be significant. We then checked the absence of heteroscedasticity using the White's test and the Breusch–Pagan test. We used the Variance Inflation Test to check the absence problems related to multicollinearity. We then performed a couple of simple tests to check the absence of problems related to omitted variables. We also checked that the residues have zero expectation value.

5. RESULTS AND DISCUSSION

In this section, we present the main results of our analysis. We divide our analysis into two subsections; one per research question and associated sub question.

5.1 FINDINGS FOR RESEARCH QUESTION 1 and 1'

Our first research question aims to assess if a carefully designed green microfinance product aiming to support ecosystems conservation can improve the environmental performance of rural micro-enterprises and support an overall improvement of the environmental value of their farm, or if, through its interaction with the local dynamics, habits, and development pathways, it might rather end up having no effect, or even indirectly support potentially dangerous activities, simply because they are the economically and socio-culturally characteristic of the main development pathways. With this aim, supported by the research sub-question 1', we test the characteristics of the rural producers that influenced the evolution in the environmental value of the farm and in particular the effect of the intervention of Proyecto CAMBio in the region studied.

The t-test and MWW test do not allow us to conclude that the farms of the producers that participated in Proyecto CAMBio had a better evolution in terms of environmental value compared to the ones from other clients that did not participate in the programme. Other factors such as the principal activities and the livelihood of the producers (the activity to which they change to) had a significant influence (Table 6). The three multivariate regressions (Table 7) strengthen these results and show the importance of the underlying territorial dynamics. Indeed, the econometric analysis reveals that the green programme appears to have been unable to influence the evolution of the environmental value of the farm by itself, while other variables such as the livelihood strategy, land dynamics, past environmental assets, access to credits, and capitalisation in terms of farm land are the variables that had a statistical significant influence on the environmental outcomes.

Let us briefly go through this analysis, hypothesis per hypothesis.

- *Access to credit*

Our results for equality of means and distributions refute the hypothesis that more access to credits induces worse environmental performance of the farm (H1), pointing instead toward no influence of the credit on the environmental value of the farm. This is also confirmed by the correlation analysis in table Appendix A. However, the three multivariate regressions point towards the opposite conclusion namely that more credits (regardless of whether they are green) provide better environmental outcomes – although the effect and significance is small.

This result could be explained by the fact that in the absence of any targeting of a specific activity, credits passively support the local pre-existing economic and environmental dynamics. Indeed, in a previous section we have shown that in the region of investigation there is an ongoing process of environmental improvement and the access to credit is reasonably supporting this dynamics, without targeting being the main reason for it. The effects of credit on the environmental outcomes probably depend a lot on the underlining dynamics. Indeed in another analysis (qualitative), the opposite conclusion has been reached (Forcella, 2012): access to credit, also green credits, worsens environmental outcomes. In that other region however the dynamics are quite different and mainly dominated by extensive cattle raising with negative effects on the environment, in contrast with the predominant coffee activities in our current area of research. The two results together then support the passive nature of credits that are limited to supporting pre-existing dynamics.

- *Access to green credit*

Our results for equality of means and distributions, correlations, and the three multivariate regressions refute the hypothesis that access to green credits for ecosystem conservation has a positive influence on the environmental performance of the rural clients (H2). Moreover, there is no observed difference in evolution of environmental indicators depending on the activity that was financed with the green credit. Neither is the amount of green credit a significant variable.

These results look surprising, especially when considering that the total amount of cumulated non-green credit have a positive influence on the environmental outcomes of the micro enterprises. This requires further explanation. First of all, it points towards the fact that green microfinance is not a panacea: it is not enough to provide green products –not even if linked with technical assistance and specific monetary incentives– to contribute to improving the environmental value of clients' activities. Moreover, looking at the correlation table in appendix A, it is tempting to infer that one of the reasons for these results could be attributed to the targeting of the MFI for this specific green product. Indeed it appears that the programme was not able to ride on the favourable underling socio-economic dynamics to try to influence producers' choices towards more environmentally friendly livelihood strategies, but instead it mainly rewarded bigger producers, with the tendency to increase their farm, and with the most profitable activity in the area: coffee and cattle. Such characteristics are related to little or no positive influence on the environmental outcomes (see forthcoming analysis). The main characteristic which positively influences the environmental value of the farm – namely the change in main economic activity –, however, was not part of the targeting. These results support the hypothesis that green credits should couple with the underling socio-economic and environmental dynamics and strategically work to foster more sustainable trajectories. The targeting of clients should then not simply be done according to a financial risk analysis or clients' ability to repay the loan, but should include an assessment of the potentialities of the clients to better improve the local environment. With this aim, strategies should be developed to articulate with local actors to support the upgrading of producers towards more sustainable trajectories.

Similar conclusions have been reached in (Forcella, 2012) in a region dominated by environmentally more detrimental trajectories. The results in this paper, in an overall environmentally positive underlying dynamics (as explained in the previous section), strengthens the overall hypothesis for the need of an institutional-territorial approach in green credit provision.

- *Principal activity*

Our results for equality of means and distributions, correlations, and the three multivariate regressions support the hypothesis that the principal activities influence the evolution of the environmental value of the farm (H3). When farmers primarily dedicated to cattle farming five years ago are compared to farmers with other main activities in the same period, the test for equality indicates a negative influence on environmental performance, while a positive influence is revealed for staple crops. Nevertheless, our regressions underline that it is not the principal activity per se that influences the environmental outcomes, but rather the change in principal activity. The change of principal activity toward coffee fosters a betterment of the environmental value of the farm, while the change to cattle rising has negative environmental effects. The livelihood trajectories of the clients induce a positive or negative effect on the evolution of the environmental value of the farm.

Such results could be explained by the relevance of the livelihood trajectories in influencing environmental outcomes and the correlation between economic opportunities, depending on goods, market values and products characteristics, and environmental results. It underlines the need to focus on what the opportunities and constraints are that shape decisions and the evolutions for the various kinds of farmers.

- *Size of the farm*

Our results provide a mixed vision on the hypothesis that the bigger the farm is, the worse the evolution of its environmental value (H4). Only the evolution of the carbon capture value of the farm is negatively influenced by the farm surface. These mixed results only partially confirm H4 and point towards the need to focus more on the kind of trajectories of the producers rather than the farm surface itself. Indeed, for a given farm surface, the activities and strategies of a producer can very much change the environmental impact: larger farms could sometimes have better efficiency and hence lower environmental impact, while in other cases they have less incentive to intensify their production. The client's livelihood strategy can then pretty much influence the environmental value of the farm.

An analysis of the land dynamics indeed supports this hypothesis. The correlation table in appendix A shows a negative and significant correlation between the increase of farm land and the environmental outcomes: namely the more a rural producer increases its farm surface, the more the environmental value per hectare is reduced. This fact is explained by a reduced incentive towards intensification if the underling dynamics support land accumulation. The three regressions indeed confirm the hypothesis that increasing the farm size negatively affects the environmental value (H5).

- *'Historical' environmental value*

Our results for correlations in appendix A, and the three multivariate regressions confirm the hypothesis that the higher the environmental value of the farm, the more difficult to further increase it (H6). Indeed, the associated coefficient in the three regressions is the biggest one and very significant. This result could be interpreted as the fact that beyond a certain level of environmental value there is a trade-off between environmental betterment and economic activities. Indeed coffee is a more rewarding activity in this area –which additionally has a strong cultural importance in the zone. It strongly influences habits and pathways, and it has intrinsically a high environmental value. Going beyond the value of coffee with shadow in all the farm would probably imply a reduction in the profitability of the clients' activities that offset the will and possibility of a producer to go beyond a certain level of environmental value.

- *Other significant variables*

There are of course plenty of other variables that could have influenced the evolution of environmental value of the farm. Indeed, when we performed the regressions it appeared that without some further control variables we introduced before, there would have been some missing variables implying a bias in the regression coefficients. Once these additional control variables are introduced, it results that the family working force in the farm has a negative and significant influence on the evolution of the environmental value of the farm. These results could be explained considering that the more are the family members that work in the farm, the less it is likely that they will have access to more modern and sustainable practices, because they have reduced possibilities to learn from or communicate with other experiences and the world outside the farm. They would hence be trapped on older less environmentally friendly practices that, in particular in some of the region in Nicaragua, see the tree as an obstruction to development. However further studies are needed to better understand the meaning of this last variable. Moreover some other related variables could be studied to clarify its influence.

Table 6: equality of means and distribution tests per environmental outcomes

	Obs	EVOIse Ha	EVOBi Ha	EVOCi Ha		Obs	EVOIse Ha	EVOBi Ha	EVOCi Ha
Proyecto CAMBio					***Farm Dimension***				
Clients	88	0.130	0.056	0.074	Big (> 10.5 Ha)	64	0.100	0.038	0.059
No-Clients	40	0.153	0.064	0.088	Small (<10.5 Ha)	64	0.175	0.078	0.097
t-test		-0.30	-0.21	-0.32	t-test		-1.29	-1.44	-1.22
MWW-test		0.04	-0.05	0.17	MWW-test		-1.78	-1.56	-0.95
Activity financed					***Land dynamics change farm surface***				
SP	17	0.111	0.033	0.075	Increased	83	0.135	0.052	0.083
AF	71	0.134	0.061	0.074	Reduced	45	0.141	0.069	0.070
t-test		-0.61	-1.39	0.06	t-test		-0.102	-0.57	0.40
MWW-test		-0.33	-0.70	0.81	MWW-test		0.49	-0.15	0.92
Principal Activity 5 years ago					***Access to credit in the last 5 years***				
Cattle	19	0.096	0.028	0.067	High (>4615USD)	61	0.136	0.055	0.081
Coffee	73	0.081	0.034	0.046	Low (<4615USD)	61	0.154	0.069	0.085
Diversified	8	0.317	0.144	0.182	t-test		-0.30	-0.47	-0.12
Staple crop	26	0.263	0.116	0.144	MWW-test		-0.28	-0.61	0.044
Cattle-Other					***Change in main activity to***				
t-test		-0.89	-1.30	-0.47	Coffee	15	0.477	0.220	0.257
MWW-test		-0.32	-1.08	0.17	Cattle	4	0.113	0.033	0.071
Coffee-Other					Diversified	12	0.21	0.087	0.12
t-test		**-2.09****	**-1.82***	**-2.28****	*Others - to Coffee*				
MWW-test		**-2.38****	-1.62	**-2.61*****	t-test		**2.89****	**2.99*****	**2.81****
Diversified-Others					MWW-test		**3.28*****	**3.35*****	**3.17*****
t-test		1.09	1.11	1.13	*Others - to Cattle*				
MWW-test		0.67	0.63	0.74	t-test		-0.40	-0.85	-0.27
Staple Crops -Others					MWW-test		0.01	-0.43	0.28
t-test		1.53	1.47	1.50	*Others - to Diversified*				
MWW-test		**2.58*****	**2.33****	**2.38****	t-test		0.89	0.73	0.99
					MWW-test		1.18	0.81	1.23

t-test: * p < 0.10; ** p < 0.05; *** p < 0.01, MWW-test: * p < 0.10; ** p < 0.05; *** p < 0.01

Table 7: OLS regressions for the evolution of environmental value of the farm

		Evolution Ecosystem EVOIseHa	**Evolution Biodiversity** EVOBiHa	**Evolution CO2 Capture** EVOCiHa
Credit PC Agroforestry	PCAF	4.26e-06	1.14e-06	3.71e-06
Credit PC Silvopasture	PCSP	1.59e-05	2.06e-06	1.48e-05
Credit No PC received last 5 y	TOTCRNOPC	**4.69e-06***	**2.21e-0.6***	**2.48e-06***
Ecosystem Index Ha 5 y ago	ESiHA5y	**-0.609*****	-	-
Biodiversity Index Ha 5 y ago	BiHA5y	-	**-0.600*****	-
Carbon Index Ha 5 y ago	CiHA5y	-	-	**-0.628*****
Total farm surface 5 y ago	TOTHa5	-1.77e-03	-6.51e-04	**-1.17e-03***
Principal Activity cattle 5y ago	CATTLE5y	6.22e-02	2.25e-02	4.25e-02
Diversified production 5y ago	DIV5y	6.22e-02	3.05e-02	3.74e-02
Principal Activity coffee 5y ago	COFFE5y	9.00e-02	4.02e-02	5.18e-02
Change to Coffee	ChCoffee	**0.275*****	**0.125*****	**0.150*****
Change to Cattle	ChCattle	**-0.211***	**-0.116****	**-9.77e-02***
Change to diversified	ChDiv	-4.45e-03	-6.836e-03	8.917e-04
Evolution in area of the farm	ToTEvoHa	**- 6.73e-03*****	**-3.92e-03*****	**-2.73e-03****
Access to electric Grid	AcElGrid	4.43e-02	1.74e-02	2.60e-02
Family working force	FAMIndex	**-0.187****	**-9.78e-02*****	**-9.32e-02****
Social Capital	SOCIALIndex	-2.06e-02	1.31e-02	-1.76e-03
Number Observations	_	115	115	115
R2	_	0,678	0,682	0,674
F	_	13.88	14,14	13,63
Prob > F	_	0,000	0,000	0,000

t-test: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

5.2 FINDINGS FOR RESEARCH QUESTIONS 2 and 2'

In this section we discuss our findings concerning the second research question: the effectiveness of economic environmental incentives to foster environmental conservation. To reach this objective we also investigate the research sub-question 2' along its main hypotheses.

As a first observation we look at the correlations (Pearson and Spearman) between the PES paid per producer and per tree, and some of the possible proxies to measure the environmental outcomes. In addition to the environmental proxies we have already used up to now, we also include the number of trees planted, the density of the trees planted, and the farm area dedicated to implement the activity agreed under Proyecto CAMBio. These last three indicators are quite limited, because they only measure the environmental improvement directly related to the activity financed and agreed under Proyecto CAMBio. In our analysis they are used as first step analysis to assess if the PES was first able to reward the clients' involvement with the programme, while the ecosystem, biodiversity and CO2 capture indicators will be employed to assess if the PES correctly rewarded the clients that had overall better environmental outcomes. Table 8 reports the results for the correlations between PES and the various environmental proxies. For these analyses we excluded the three producers that participated twice in Proyecto CAMBio. Various producers do not report on the number of trees planted, and this unfortunately limits the dimension of the sample too. Moreover, among the clients that received Proyecto CAMBio, we had to exclude the ones that reported activities that are difficult to compare with more standard ones (coffee or cattle for example) in terms of number of trees planted. Two producers that implemented a coffee filter and one that declared to have invested the credit form Proyecto CAMBio in fodder plants were then excluded from the analysis. The remaining sample is then reduced to 63 rural clients.

Table 8: Pearson / Spearman Correlation

	PES per client	PES paid per tree
Number of planted trees	**0.35***** / **0.43*****	**-0.30** / - 0.44*****
Surface invested in P CAMBio	**0.53*****/ **0.72*****	0.03 / 0.17
Density of planted trees	0.05 / -0.18	-0.20/ **-0.71*****
EVOIseHa	-0.13 / -0.08	-0.19 / -0.11
EVOBiHa	-0.12 / -0.07	-0.20 / -0.16
EVOCiHa	-0.14 / -0.07	-0.19/ -0.08
ToTEVOIse	**0.40*** / 0.56*****	0.03 / 0.12
ToTEVOBi	**0.45*** / 0.55*****	0.06 / 0.09
ToTEVOCi	**0.35*** / 0.50*****	0.00 / 0.10

* p < 0.10; ** p < 0.05; *** p < 0.01

Table 8 shows that the PES rewarded the number of trees planted and the amount of surface of the farm dedicated to the activity financed with Proyecto CAMBio; producers that dedicated more land received more subsidies. Moreover, the total environmental value in terms of ecosystems, biodiversity and CO2 capture value on the entire farm was rewarded accordingly too. This is not the case for the density of trees and the environmental values per hectare.

The amount of money paid per tree is negatively correlated with the number of trees planted, and receiving more PES per tree does not seem to have influenced better environmental evolution. The Spearman correlation points towards a strong negative and significant correlation between the PES received per tree and the density (see intensification) of trees planted.

These results ask for a more in depth investigation. In Table 9 we report equality of means and distribution tests per environmental outcome using the t-test and the MWW test. In Table 10 we report six multivariate regressions assessing the drivers that influenced the amount of PES per clients and the amount of PES per tree per client. Due to data constraints the regressions are performed on a limited number of observations and they should be interpreted together with the equality of means and distributions tests.

We divide our analysis according to the hypotheses previously formulated.

- *Effectiveness of PES to reward higher environmental engagement in the project*

Results for the equality of means and distribution tests provide a mixed vision on hypothesis H7. Indeed, they reveal that the higher the number of planted trees and the amount of surface engaged within the activity promoted by Proyecto CAMBio, the higher the amount of PES paid per producer. However they also underline that the density of planted trees does not influence the amount of environmental reward received. Moreover it results instead that the surface of the farm dedicated to activities promoted by Proyecto CAMBio does not influence the amount of money paid per tree, while the number of trees and the density of trees negatively affect the PES received per tree.

The multivariate regressions presented in Table 10 confirm these results and they unveil that the number of trees planted has a significant influence on the PES received, while the density of trees planted has negative influence on the PES received. Additionally, the number of trees and density of trees negatively influence the amount of PES received per tree. Such results underlined the inability of PES to stimulate the intensification of tree cover in the farm. They can be explained by the mostly economic character of PES that, following the efficiency economic paradigm, provides a reward proportional to the amount of credit received without direct relation to the achieved environmental betterment. Such strategy could be in principle more effective and less costly than others. However, it implicitly assumed that more green credit would imply better environmental outcomes, a hypothesis that we have previously refuted. Indeed the results here support once more the hypothesis that green credit without a careful associated green policy, that tries to strategically maximise the environmental outcomes, will end to be influenced by a financial logic and reward more the most credit worthy producers, without necessarily being the actors with potentially better environmental outcomes. The absence of a careful environmental strategy rewards the pre-existing socio-environmental dynamics.

- *Effectiveness of PES to reward environmental betterment*

The analysis of equality of means and distributions refutes the hypothesis that a higher environmental reward is linked to a better improvement of the environmental value of the farm (H8). Indeed, in Table 9 there is no significant effect of positive environmental outcomes in terms of ecosystem, biodiversity or CO2 capture on the PES received per producer or per tree. It is interesting to underline that such analysis instead unveils a tendency to give higher rewards to producers that decreased their environmental value compared to the ones that instead improved it. Such average tendency is however not significant.

The multivariate regressions straighten such results and contribute to refute the hypothesis (H8). The regressions do not underline any significant effect of the improvement of the environmental value of the farm on the amount of PES received per producer or per tree. Such result could be explained, as in the previous subsection, by the too simplistic economical approach of green MF that without considering the underling dynamics mainly adapts a financial strategy for client targeting, products provision and subsidy that ends supporting non-effective environmental subsidies that are not able to reward environmental improvement, but rather relate to creditworthiness. The existence of other characteristics of the producers that are able to influence the accumulation of environmental incentives, independently from their environmental outcomes, is underlined in the next subsection.

- *Existence of other clients characteristics that influence the environmental reward*

The results for equality of means and distribution, and the multivariate regressions support the hypothesis that other characteristics of the producers could influence the amount of environmental reward received in green microfinance programmes (H9)

Indeed the from Table 9 and Table 10 it clearly appears that the environmental subsidy (PES per clients) rewarded clients with better access to credits, bigger farms and land accumulation in the last five years, as these characteristics positively influence both PES per clients and per tree. Such results could be explained by the predominantly financial approach/logic used to decide to whom and at which conditions to provide green credits, in terms of better guarantee, more rewarding activities, and less cost, instead of targeting better environmental outcomes. This seems to be true also for products such as Proyecto CAMBio that adopts a “financial plus” perspective including training and environmental conditions in the credit provision.

Moreover, the regression also shows the significant influence of the type of activity that was financed by Proyecto CAMBio on the amount of PES per client and per tree. The project namely provided higher rewards to the clients implementing agroforestry activities compared to silvopastoral practices. This result can be explained by the tendency of an MFI to finance the more rewarding and culturally accepted activities: coffee in the region of study.

The influence on PES of such characteristics seems also to provide better understanding of way PES per tree and per clients is higher for clients that invested more of their land in the green credit: it is indeed a variable highly correlated with the access to credit and the total surface of the farm.

Table 9: equality of means and distribution tests per environmental incentives

	Num Obs	PES (USD)	Num Obs	PESperTree (USD)		Num Obs	PES (USD)	Num Obs	PESperTree (USD)
EVOIseHa					***EVOBiHa***				
Pos	60	378.40	43	3.00	Pos	54	384.22	39	3.00
Neg	24	449.31	20	4.04	Neg	30	424.64	24	3.86
t-test		-0.84		-0.92	t-test		-0.54		-0.87
MWW-test		-0.41		-0.71	MWW-test		-0.15		-1.03
EVOCiHa					***Activity financed***				
Pos	57	369.65	40	2.84	SP	15	296.29	10	2.99
Neg	27	459.89	23	4.17	AF	69	420.91	53	3.39
t-test		-1.06		-1.26	t-test		**-1.87***		-0.55
MWW-test		-0.17		-0.80	MWW-test		-1.39		0.48
Principal Activity 5 years ago					***Farm Dimension***				
Cattle	12	462.56	8	2.73	> 10.5 Ha	49	537.22	34	4.27
Coffee	51	423.25	39	3.60	< 10.5 Ha	35	204.67	29	2.23
Diversified	5	387.57	4	5.02	t-test		**6.25*****		**2.65****
Staple crop	14	295.36	10	2.42	MWW-test		**5.03*****		**2.33****
Cattle-Other					***Land dynamics***				
t-test		0.75		-1.14	Increased Farm	49	429.49	37	3.26
MWW-test		1.05		0.65	Reduced Farm	35	355.49	26	3.41
Coffee-Other					t-test		1.08		-0.16
t-test		0.83		0.82	*MWW-test*		1.44		0.61
MWW-test		0.15		0.48	***Total Credit volume received in the last 5 years no PC (USD)***				
Diversified-Others					High (> 3000)	42	505.44	32	4.04
t-test		-0.15		0.77	Low (< =3000)	*42*	275.42	31	2.60
MWW-test		0.42		0.43	t-test		**3.55*****		**1.74***
Staple Crops -Others					MWW-test		**3.52*****		0.82
t-test		**-1.86***		-1.49	***Surface invested in P Cambio***				
MWW-test		-1.05		-1.26	>1.4 Ha	27	572.35	21	3.96
Density of Trees planted (Trees/Ha)					<=1.4Ha	46	235.34	41	2.79
> = 85.71	32	316.09	32	1.98	t-test		**5.07*****		1.09
< 85.71	30	417.48	30	4.48	MWW-test		**5.26*****		0.71
t-test		-1.31		**-3.21*****	***Number of Trees planted***				
MWW-test		-1.10		**-4.34*****	> 100	30	515.43	30	2.49
					< = 100	33	242.92	33	4.09
					t-test		**3.79*****		**-1.95***
					MWW-test		**3.66*****		**-2.63*****

t-test: * p < 0.10; ** p < 0.05; *** p < 0.01, MWW-test: * p < 0.10; ** p < 0.05; *** p < 0.0

		PES (USD)	PES (USD)	PES (USD)	LogPESperTree	LogPESperTree	LogPESperTree
Table10: OLS regressions for Environmental Subsidies							
Evolution of Ecosystem value per Ha of the farm	EVOIseHa	-7.96	-	-	0.209	-	-
Evolution of biodiversity value per Ha of the farm	EVOBiHa	-	-17.83	-	-	0.420	-
Evolution of Ecosystem value per Ha of the farm	EVOCiHa	-	-	-17.39	-	-	0.382
Number of planted trees with PC	ARBPC1	**0.408*** **	**0.409*** **	**0.409*** **	**-1.84e-03*** **	**-1.84e-03*** **	**-1.84e-03*** **
Density of planted trees with PC	TreeHaPC1	**-0.545** **	**-0.545** **	**-0.547** **	**-3.21e-03*** **	**-3.23*** **	**-3.20e-03*** **
Total volume of credit received in the last 5 years without	TOTCrNoPC5y	**7.43e-03* **	**7.42E-03* **	**7.42e-03* **	-1.23E-05	-1.21E-05	-1.22E-05
P CAMBio for AF (1) or SP (0)	AF	**198.12*** **	**198.25*** **	**198.00*** **	**0.410** **	**0.408** **	**0.414** **
Total farm surface 5 y ago	TOTHA5	**8.93*** **	**8.93*** **	**8.92*** **	**1.55e-02*** **	**1.54e-02*** **	**1.55E-02*** **
Cattle as Principal Activity 5y ago	CATTLE5y	-117.64	-117.87	-117.24	7.60E-02	8.38E-02	6.84E-02
Diversified production 5y ago	DIV5y	16.07	16.25	15.68	**0.686** **	**0.682** **	**0.686** **
Coffee as Principal Activity 5y ago	COFFE5y	15.36	15.46	15.24	2.23E-02	1.82E-02	2.20E-02
Evolution in area of the farm	ToTEvoHa	**10.08* **	**10.05* **	**10.10* **	**3.88e-02*** **	**3.94e-02*** **	**3.82e-02*** **
Access to electric Grid	AcElGrid	-54.95	-55.06	-54.57	-	-	-
Family working force in the farm	FAMIndex	117.13	116.91	117.11	-	-	-
Social Capital	SOCIALIndex	-28.65	-28.51	-28.56	-	-	-
Number Observations	_	56	56	56	57	57	57
R2	_	0.8228	0.8228	0.8228	0.7611	0.7547	0.7557
F	_	15	15	15	10.29	14.15	14.23
Prob > F	_	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

t-test: * p < 0.10; ** p < 0.05; *** p < 0.01

6. CONCLUSIONS

This paper, to the best of our knowledge, is among the very first, if not the first, quantitative study on the ability of a green microfinance programme to foster environmental betterment, how certain characteristics of the MFI's clients influence this, and how effective the environmental rewards are in promoting environmental improvement.

The simple possibility of performing such a detailed analysis on an existing and large scale programme, clearly shows that complex programmes linking green credits, technical assistance and PES can be actually incorporated into the operations of certain MFIs and that they can fulfil the indicators required by the programme. This possibility should open the way to the implementation of innovative green microfinance projects, and incentivises better environment management and conservation.

However the results of our quantitative analysis shows that green credits, also supported by additional services, correctly implemented and well performing, and with the aim to foster biodiversity conservation, might not be able to influence the evolution of the environmental value of the clients' farm. The evolution of the environmental value of the farm seems instead influenced by other characteristics of the clients and their livelihoods trajectories. Our analysis clearly shows that elements such as the access to credit, the strategic choices of producers towards which kind of activity to invest in, their capitalisation in the term of land accumulation, the pre-existing environmental value of their farm and their family characteristics and working strategies instead have relevant influence on the evolution of the environmental value of the farm.

We interpret the influence of such other dimensions on the environmental evolution of the farm as a support of a complexity system theory for the human-environmental system and the need for a territorial strategy to better tackle environmental issues. The provision of green credit indeed interacts with pre-existing socio-economic dynamics that are by themselves shaped by culture and habits, socio-economic inequalities, unequal access to opportunities and uneven power structures. Green credits cannot by themselves revert environmental degradation, and rather end up financing the pre-existing dynamics or fail to have significant outcomes if the complex interactions with the local development pathway are not taken into account. However, the existence of certain characteristics of the clients that positively or negatively influence the evolution of the environmental value of the farm points towards possible strategies and actors with whom green microcredit programmes could or should try to articulate to redirect the local territorial dynamics towards more socially-inclusive and environmentally friendly outcomes. The current analysis rather wants to point to this necessity of engaging with such dynamics; an engagement which ought to be a strongly deliberative processes and for which we certainly do not want to suggest to have a blueprint on the basis of a number of client characteristics (Huybrechs et al., 2015b, Bastiaensen et al., 2015a, Bastiaensen et al., 2015b).

The analysis of the environmental rewards supports such conclusions and underlines the necessity not only to consider the interaction of green credits with clients' characteristics, but also to look at the relevance of the interaction between financial providers and intermediaries, and the organisations implementing green credits programmes (Forcella and Lucheschi, 2016). In particular, attention needs to be paid to the strategies and decisions underlying the targeting of green credits, and the underlying motivations. Indeed our results clearly shown that a green credit without a clear green policy that directs the decision of financial intermediaries to invest more in more environmental rewarding activities, ends supporting allocation of environmental subsidies towards more credit worthy clients that are not necessarily the ones with better environmental outcomes. Our analysis shows that PES did not reward better environmental outcomes neither in terms of ecosystems, biodiversity and carbon capture value, or in term of the density of trees planted. Such results point towards the necessity to work to align the incentives of the various stakeholders participating in the green microfinance programme towards environmental betterment, the necessity of a carefully design green credit policies, and the need to engage with the underlying socio-economic and environmental dynamics.

The message from this paper is to build on the actual experience of Proyecto CAMBio, and other existing rural green microfinance programmes, to foster a more territorial approach that recognises the intrinsic link between socio-economic inequalities, existing power structures and environmental degradation. Our results call for a more proactive role of green microfinance in reshaping existing livelihood strategies toward more socially inclusive and environmental friendly pathways. In this case, in the context of land accumulation and social differentiation in the region, we want to raise attention to the inevitable political stance taken by suchlike projects and MFIs more broadly when wondering about whom to support, how, and what for.

ACKNOWLEDGEMENTS

We would like to acknowledge the rural producers of Nicaragua that kindly opened their doors to our questions and they shared with us their precious expertise and experiences. From them we learnt the most. Moreover we would like to thanks Nitlapan and FDL, the management team and the field officers and technicians that very kindly supported our investigation. Johan Bastiaensen and Marek Hudon are kindly acknowledged for their precious comments on the content of the paper.

FH is funded by a VLADOC scholarship of VLIR-UOS, and his fieldwork to conduct this survey was supported by the IOB research fund.

APPENDIX A – correlation table

Pearson and Spearman correlations for the variables used in the regressions

Pearson/ Spearman	Evo ISE Ha	TotEvo ISE	EvoBI Ha	TotEvoBI	EvoCI Ha	TotEvoCI	PC AF	PCSP	TOTCRNOPC	ESiHA5y	BIOiHA5y	COiHA5y	TOTHA 5	CATTLE5y	DIV5y	COFFE5y	ChCoffee	ChCattle	ChDiv	ToTEvoHa	AcElGrid	FAMIndex
TotEvoISE	0,061 **0.34*****																					
EvoBIHa	**0,99***** **0.98*****	0,013 **0.28*****																				
TotEvoBI	0,076 0.34***	**0,99***** **0.99*****	0,035 **0.29*****																			
EvoCIHa	**0,99***** **0.99*****	0,12 **0.38*****	**0,97***** **0.94*****	0,11 **0.36*****																		
TotEvoCI	0,051 **0.34*****	**0,99***** **0.98*****	-0,003 **0.26*****	**0,97***** **0.95*****	0,10 **0.39*****																	
PCAF	-0,039 -0.037	**0,30***** **0.21*****	-0,17 -0.0009	**0,35***** **0.23****	-0,054 -0.44	**0,26***** **0.17***																
PCSP	-0,051 0.0054	-0,12 0.0045	-0,074 -0.059	**-0,16*** -0.032	-0,033 0.034	-0,07 0.032	**-0,22**** **-0.40*****															
TOTCRNOPC	-0,056 0.054	**0,47***** **0.36*****	-0,07 0.037	**0,46***** **0.35*****	-0,041 0.066	**0,46***** **0.34*****	**0,35***** **0.25*****	-0,099 -0.086														
ESiHA5y	**-0,69***** **-0.66*****	-0,012 **-0.18****	**-0,69***** **-0.61*****	-0,02 **-0.17***	**-0,69***** **-0.67*****	-0,007 **-0.18****	0,12 0.13	-0,012 -0.082	0,89 -0.0059													
BIOiHA5y	**-0,69***** **-0.65*****	0,003 **-0.16***	**-0,69***** **-0.61*****	-0,006 **-0.16***	**-0,68***** **-0.65*****	0,009 **-0.17***	0,095 0.12	-0,021 -0.095	0,092 0.0032	**0,99***** **0.99*****												
COiHA5y	**-0,69***** **-0.67*****	-0,027 **-0.19****	**-0,68***** **-0.61*****	-0,035 **-0.18****	**-0,70***** **-0.68*****	-0,022 **-0.21****	0,14 0.13	0,001 -0.070	0,85 -0.0162	**0,99***** **0.99*****	**0,98***** **0.97*****											
TOTHA5	-0,084 -0.11	**0,31***** **0.38*****	-0,076 -0.12	**0,33***** **0.37*****	-0,092 -0.12	**0,29***** **0.35*****	**0,54***** **0.40*****	**0,29***** **0.21****	**0,33***** **0.34*****	0,04 0.017	0,026 0.016	0,065 0.028										
CATTLE5y	-0,053 -0.024	0,099 **0.17***	-0,079 -0.073	0,057 0.15	-0,027 0.0084	0,13 **0.19****	-0,078 -0.11	**0,41***** **0.23****	-0,073 0.0044	0,20 -0.005	0,032 0.0004	0,010 -0.013	**0,40***** **0.35*****									
DIV5y	0,14 0.052	-0,039 -0.012	0,14 0.044	-0,038 -0.027	**0,15*** 0.059	-0,036 0.0020	-0,036 -0.067	0,016 0.10	**0,20**** 0.12	-0,11 -0.10	-0,10 -0.094	-0,13 -0.12	0,015 -0.041	-0,11 -0.12								
COFFE5y	**-0,20**** **-0.27*****	-0,043 **-0.16***	**-0,17*** **-0.18***	-0,026 -0.15	**-0,22**** **-0.25*****	-0,055 **-0.18****	**0,21**** **0.24*****	**-0,29***** **-0.25*****	0,078 0.047	**0,35***** **0.37*****	**0,32***** **0.35*****	**0,37***** **0.37*****	**-0,21**** **-0.19****	**-0,49***** **-0.47*****	**-0,30***** **-0.32*****							
ChCoffee	**0,38***** **0.30*****	-0,034 0.016	**0,37***** **0.30*****	-0,026 0.026	**0,37***** **0.29*****	-0,041 0.011	-0,063 -0.11	-0,089 -0.073	-0,13 **-0.18***	**-0,27***** **-0.26*****	**-0,26***** **-0.25*****	**-0,27***** **-0.25*****	-0,14 **-0.20****	**-0,15*** -0.15	0,11 0.10	**-0,42***** **-0.45*****						
ChCattle	-0,014 -0.0055	0,012 0.045	-0,029 -0.048	0,017 0,0282	-0,009 0.021	0,007 0.062	-0,091 -0.11	0,027 0.074	0,010 0.095	**-0,20**** **-0.21****	**-0,19**** **-0.21****	**-0,19**** **-0.20****	0,58 0.13	-0,076 -0.074	-0,047 -0.05	-0,026 -0.032	-0,067 0.072					
ChDiv	0,072 0.099	-0,0009 0.051	0,057 0.062	-0,01 0.0437	0,082 0.11	0,004 0.054	0,079 0.043	**0,23**** **0.22****	-0,023 -0.012	-0,10 -0.11	-0,092 -0.10	-0,11 -0.12	**0,23**** 0.13	**0,17*** **0.32****	-0,084 -0.091	-0,10 -0.11	-0,12 -0.13	-0,059 -0.063				
ToTEvoHa	**-0,24***** -0.059	**0,83***** **0.72*****	**-0,28***** -0.13	**0,81***** **0.70*****	**-0,19**** -0.0010	**0,84***** **0.72*****	**0,17*** 0.062	-0,10 -0.0057	**0,42***** **0.20****	**0,19**** 0.076	**0,19**** 0.089	**0,18**** 0.047	0,14 0.081	0,0015 0.096	-0,039 0.017	0,12 0.054	**-0,16*** **-0.15***	-0,041 -0.070	-0,075 -0.053			
AcElGrid	**0,17*** **0.21****	**0,18**** **0.24*****	0,139 **-0.18***	**0,19**** **0.24*****	**0,20**** **0.22****	**0,18**** **0.21****	0,065 0.083	0,065 0.021	0,11 **0.21****	**-0,15*** **-0.17***	-0,12 **-0.16***	**-0,16*** **-0.18****	0,032 0.14	0,13 0.15	0,089 0.10	-0,09 -0.083	0,005 0.020	-0,077 -0.072	-0,083 -0.073	0,065 0.098		
FAMIndex	-0,42 -0.035	**-0,20**** -0.13	-0,048 -0.065	**-0,21**** -0.14	-0,042 -0.047	**-0,19**** -0.14	-0,05 -0.027	0,10 **0.16***	0,019 0.053	-0,084 -0.10	-0,09 -0.094	-0,74 -0.091	0,070 **0.16***	0,082 0.012	0,092 0.099	-0,10 -0.078	0,029 0.036	0,073 0.076	0,045 0.045	**-0,17*** -0.15	0,010 0.043	
SOCIALIndex	0,0054 -0.0056	-0,76 -0.017	0,039 0.024	-0,049 0.0013	-0,022 -0.026	-0,095 -0.047	**0,22**** **0.26*****	**-0,16*** **-0.16***	-0,017 0.056	0,073 0.074	0,05 0.064	0,09 0.077	0,091 **0.16***	0,049 0.31	-0,10 -0.11	0,03 -0.043	0,034 0.040	-0,033 -0.037	**-0,15*** **-0.17***	-0,072 -0.050	0,085 0.14	0,035 0.070

Statistically significant correlations are written in bold, with the following indication of significance: * p < 0.10; ** p < 0.05; *** p < 0.01

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