# AN INSTITUTIONAL APPROACH TO THE CLEAN DEVELOPMENT MECHANISM: THE PIG FARMING CASE OF A SMALL RURAL PROPERTY

Weimar Freire da Rocha Jr, Christian Luiz da Silva, Camilo Freddy Morejon Mendoza, Yony Brugnolo Alves, Alain Hernández Santoyo and Mayra Casas Vilardell

*SUMMARY*

*The study consists of evaluating the institutional environment that regulates the implementation of the Clean Development Mechanism (CDM) projects in Brazilian pig production. It presents the institutional limitations and an estimation of benefits associated with the CDM through the analysis of a pig farming case study in Toledo, west of Paraná State, Brazil. Results show that the institutional environment of the carbon credit market is insufficient when it comes to encouraging Brazilian enterprises to enter this context. The environment is confusing and undergoes constant changes. Nevertheless, it was observed that the structuring and implementation of the CDM, as in the case of the pig industry, can result in technical, economic, social and especially environmental gains.*

## Introduction

Environmental aggression caused by anthropocentric actions has become a reality in contemporary society, and the intensification of the greenhouse effect requires attention as it has the potential to result in or heighten a wide range of problems for all species, particularly the human race. In order to mitigate (or even solve) environmental human disorders, it is necessary to take steps to tackle these problems from a technological, economic, social and political viewpoint, and at the same time modify or strengthen the institutions in charge of promoting harmony between economic agents to improve collective welfare.

The carbon market emerged with the Kyoto Protocol, implemented in 1997 for the purpose of combating global climate change and establishing a new relationship between development and environmental protection. The CMD is the only mechanism applied to developing countries and is "summed up in the fact of the reduction or sequestration for a unit of greenhouse gases (GHGs) emitted as a result of any industrial process in Annex I countries. It is operationalized by a company located in a developing country" (Silva *et al.*, 2012: 10).

In this sense, carbon credit trading, based on the Clean Development Mechanism (CDM), emerges as an economic incentive that can be used for the maintenance and expansion of several economic activities. The focus of this paper, pig farming, plays an important role in this sense because its incorporation into the carbon credits market requires a real change in terms of waste management, meaning that pollutant power has to be effectively minimized.

For these reasons, the research goal consists of evaluating the institutional environment that regulates the execution of CDM Projects in pig farming cases in Brazil.

Brazil, as a developing country attempting to accompany the ascension of other industrialized nations, should consider that the path to development path may be less devastating those experienced by countries that placed their signatures on the Kyoto Protocol (Annex I) at the United Nations Framework Convention on Climate Change (UNFCCC, 1998). Moreover, Brazil is one of the biggest global meat and grains suppliers. Consequently, its production processes contribute to the emission of greenhouse effect gases (GEG). According to Lima (2002), the emission of methane, a highly polluting gas, occurs in activities associated with ruminant enteric fermentation, through the anaerobic treatment of animal waste, and in flooded rice planting, it is the main polluting component of pig waste. It is also liberated in burning forests and agricultural waste and incineration.

Although there is a real opportunity for sustainable development through the CDM, its use remains incipient compared with the existing possibilities for the country. It occurs because of constant modifications to the rules of the market and the lack of information regarding this mechanism, especially for small rural properties and businessmen. It has been shown that large rural properties and enterprises are more familiar with gains from the CDM.

**KEYWORDS / Agribusiness / Clean Development Mechanism / Institutional Environment / Pig Farming /**

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**UN ENFOQUE INSTITUCIONAL AL MECANISMO DE DESARROLLO LIMPIO: EL CASO DE UNA CRÍA DE CERDOS DE UNA PEQUEÑA FINCA RURAL**

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*RESUMEN*

*Este estudio consiste en la evaluación del entorno institucional que regula la implementación de los proyectos del Mecanismo de Desarrollo Limpio (CDM por sus siglas en inglés) en la producción de cerdos en Brasil. Se presentan las limitaciones institucionales y una estimación de los beneficios asociados al CDM a través del análisis de un estudio de caso en una pequeña finca rural en Toledo, oeste del estado de Paraná, Brasil. Los resultados muestran que el entorno institucional del merado de créditos de carbón es insuficiente en cuanto a estimular a las empresas brasileras a incorporarse a este contexto. El entorno es confuso y está sujeto permanentemente a cambios. No obstante, se observó que la estructuración e implementación del CDM, en el caso de la industria de cría de cochinos, puede resultar en ganacias técnicas, económicas, sociales y, especialmente, ambientales.*

**O AMBIENTE INSTITUCIONAL DO MECANISMO DE DESENVOLVIMENTO LIMPO: O CASO DA SUINOCULTURA EM UMA PEQUENA PROPRIEDADE RURAL NO BRASIL**

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*RESUMO*

*O estudo consiste em avaliar o ambiente institucional que regula a execução dos projetos de Mecanismo de Desenvolvimento Limpo (MDL) na suinocultura brasileira. Apresenta-se as limitações institucionais e uma estimativa dos benefícios associados com o MDL através da análise de um estudo de caso da suinocultura em Toledo, oeste do Estado do Paraná, Brasil. Os resultados mostram que o ambiente institucional do mercado de crédito de carbono tem importantes fragilidades quando se trata de encorajar as empresas brasileiras para entrar neste contexto. O ambiente é confuso e sofre mudanças constantes. No entanto, observou-se que a estruturação e implementação do MDL, como no caso da suinocultura, pode resultar em ganhos técnicos, económicos, sociais e, principalmente, ambientais.*

With a view to reporting on Brazilian experience, this paper is organized into five sections: a theoretical discussion, the methodology, results and discussion, and a final section for conclusions.

## The Institutional Environment and Kyoto Protocol

According to Coase (1998), economists should use several tools to understand the economic system, including the political and legal systems. Adam Smith was the first to propose that economic system evolution depends on specialization (division of labor), but this division is only possible if there are low transaction costs. Thus, Coase (1998) concludes that low transaction costs depend on a country's institutions, i.e., the political, legal, educational and cultural systems and others.

To North (1991), the entire structure of the institutional environment, legal or otherwise, influences how transactions are determined. In addition to laws, an Institutional Environment is composed of customs and codes of conduct, and other factors that are not necessarily written, but are part of a certain community or nation.

Institutions are responsible for the emergence of organizations. "Organizations that come into existence will reflect the opportunities provided by the institutional matrix" (North, 1994: 361). This means that the institutional environment will determine which type of organization will exist in a society. To North (1994) the role of institutions is to reduce uncertainties to guarantee economic interaction between individuals. Therefore, institutions are endogenous, as claimed by Williamson (1998), Aoki (2007) and Toyoshima (1999).

For the carbon market to emerge, rules had to be created. It was then necessary to determine whether they are clear and if they encourage Brazilian enterprises to join the carbon market, establishing some obligations for Annex I countries and proposing joint actions by Annex I countries and including other actions with countries like Brazil (Seiffert, 2009).

The Kyoto Protocol established three loosening mechanisms for the reduction of GHG emission; they are: Joint Implantation (JI), Emission Trading (ET) and the Clean Development Mechanism (CDM). Of these mechanisms, Brazil can only participate in the CDM, emitting and selling credits with a Reduced Emissions Certificate (REC) or Emission Reduction Certificate (ERC). As a country not belonging to Annex I, it does not have reduction goals, at least not for the first period of 2008 to 2012 (Abifadel, 2005).

To Miguez *et al*. (2008), although developing countries are relieved of their reduction goals for 2008 to 2012, they have other obligations with UNFCCC, such as periodically elaborating and updating their national anthropocentric emission inventories by sources and removal by drainage. In addition to describing the country's measures for implementation, a report is issued as a result of this process called the National Communication.

The 'loosening mechanisms' were created for the purpose of providing an economic incentive to reduce emissions, provided that not only the Annex I countries should be concerned with emissions in this first period. However, all the countries should be alert and involved in providing sustainable development to developing countries. Furthermore, the loosening mechanisms help developed countries to achieve their reduction goals (Abranches, 2008; Serra, 2008;).

According to the CDM Manual for Project Developers and Policy Makers (CDM, 2006), there are rigid controls and CDM project supervision, so that the ERC or RECT are not overestimated. For this reason, emissions would not increase. Indeed, they would decrease with CDM project implantation. However, this is a new institutional model and it depends on the cultural change of the new market (Roland, 2004). In this sense, Didier (2008) discussed how mental perceptions are limited by the institutional change of pace, as on the carbon market.

Economically, the CDM makes GHG emission reduction cheaper, resulting in smaller losses for the global economy. To reduce the emissions of 1 $CO_2$ ton equivalent ($CO_{2e}$) in a developed country is more expensive than the same reduction in a developing country. Therefore, this will be an advantage when conceiving such projects. Estimations by the World Bank (2008) confirm that an emission reduction cost of 1 $CO_2$ t, in a developed country, is ~5-100 dollars per t, while in developing countries this cost is ~1-4 USD.

There are those that disagree with this statement, since the CDM can become a polluting mechanism rather than an emission reducer. From this point of view, the CDM does not constitute a joint effort to reduce emissions, but a system of trading pollution for monetary resources without a commitment to mitigate pollution. The CDM is controversial because it is the only mechanism that allows developing countries to participate in the carbon market (CGEE, 2008).

As it is recognized in Article 12 of the Kyoto Protocol, the CDM is subject to authority and direction from the Conference of the Parties (COP) and supervision from an executive board of the CDM (Godoy, 2005). In accordance with North (1991), the rules for CDM institutions are:

a) Conference of the Parties as a Meeting of Protocol Parties – COP/MOP: the superior CDM agency, according to the provisions of the Kyoto Protocol;

b) CDM Executive Board: an agency of the United Nations Framework Convention that supervises CDM operation. This council is formed by several countries that are signatories of the Protocol. One of its responsibilities is the supervision of CDM operations (Lehmen, 2006 p. 31).

c) Panels: the council, if deemed necessary, can establish work groups or panels to aid its functions. These can be temporary or permanent.

d) Designated Operational Entities (DOE): they basically have three functions and are accredited by the Executive Council, being national or international. Their functions are: to verify and submit to the Executive Council new methodologies; to validate and request a record of a CDM project proposal with approved methodology; to verify the effective emission reduction of a registered CDM project; to certify these reductions and request from the Executive Council the emission of the corresponding REC.

e) Project participants: only public or private entities may participate and all participation is subject to approval by the Executive Council. One of the Protocol innovations is that when conceiving a project, participants must develop the methodology to measure the emissions reduction and submit it to the Council and DOE.

f) National Designated Authorities (NDA): each country that wishes to propose a CDM project, or the parties, need to present or establish a National Designated Authority (NDA). In Brazil, the NDA is the Inter-ministerial Committee of Global Climate Change.

g) Secretariat: The secretary supports both the COP/MOP and Executive Council, aiding communication between agents involved in the CDM. According to the Decree of 1999, the role of the Committee's Executive Secretary will be exercised by the Ministry of Science and Technology.

h) Public: to be a reliable and credible process, it is necessary to be transparent. Thus, the maximum possible information concerning CDM projects should be available to the public in general.

In general, this is the institutional environment, or institutional outline, surrounding CDM projects in Brazil. However, for a project to be proposed and actually become a CDM project, it should be shaped according to size and field of operation, with its activities following a sequence. CDM projects can be divided and classified according to their size and the activities involved (Conejero, 2006). To Souza (2005), this division did not exist prior to 2002. Since then, proposing a CDM project means that it is necessary to determine to which category the project belongs (Nobre, 2008).

If it is a small scale project, it can be defined as one of three types: Type I which deals with renewable energy projects with a maximum production capacity equivalent up to 15MW (or a proper equivalent). Type II involves power efficiency improvement projects, with reduced power consumption, with offer and/or demand, equivalent to up to 15GW per year. Type III has to do with other project activities that reduce anthropocentric emissions through sources and emit directly less than the equivalent of 15000 tons of $CO_2$ annually (Rocha, 2003).

The present study, as it involves property used as a case study, is a small scale project and fits into Type III: Other project activities: III. D. 'Methane recovery in animal waste management systems'.

## Methodology

This study is characterized as descriptive (Gil, 2006). Based on the procedures adopted to achieve the proposed goals, the paper may be defined as a case study (Goldenberg, 2001), as a CDM project executed on a rural property with the use of a specific biodigestor (Biotor) model in the city of Toledo, Paraná State, Brazil.

A Biotor is an equipment that transforms urban or rural waste into methane gas by an anaerobic process. It consists of a removable hermetic tank that will lock after being fully loaded with raw material (urban or rural refuse). In the upper part, there is a set of valves and pipes through which the biogas (product of the anaerobic process) flows to be separated by a set of purification filters that separate methane gas and other undesired products such as sulfidric gas, carbon gas, etc.), The last part of the process is a tank with pure methane gas that can be compressed and stoked (Figure 1).

After a survey application and all necessary forms completed for the Document of Project Conception (DCP), the small scale CDM project for a farm in Toledo using the Biotor was put into practice. First, an amount of carbon credits in accordance with the number of pigs was simulated. This calculation was done using the property selected for the case study. The theoretical framework strictly complies with the methodology recommended by the UN. To update the simulation, it was necessary to follow all the methodological steps recommended by the UN and CDM regulating agencies in Brazil and worldwide.

According to these sources, the methodology adopted for calculating GHG emissions for pig farming is AMS-. III. D. 'Methane recovery in the agriculture and agro-industrial activities' version 14 of UNFCCC (2007).

This adopted methodology is called small scale methodology. For this reason it is simplified and suitable for most pig farms in the South of Brazil,

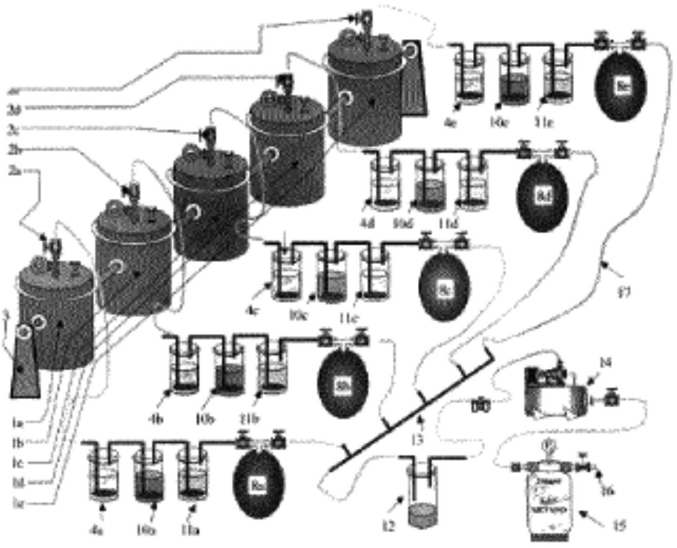

Figure 1. Features of Biotor. Source: Morejon *et al.*, 2012.

especially in Toledo. As a conception of the CDM project for a typical pig farm in Toledo, with ~1800 animals, using the Biotor as the emission reduction method, it was the response to the research issue. More technical details of the biodigestion process are found in Oliveira (1993) and Oliver (2008).

After the conclusion of the simulation and CDM project for the proposed case study, the relationships between the project and the institutional environment were established.

*Characterization of the case study*

The farm in question is standard for the region, belonging to the category of family agriculture, with the work performed daily by three people. The farm belongs to a property of 24ha, established in the feedlot system with a herd of 1,855 animals, quantified and categorized as follows: 1,500 piglets, 550 breastfeeding and 950 in daycare, 5 boars and 350 sows. The system is a unit of piglet production (UPL). Here, only gestation, lactation and nursery take place. When piglets are ~45 days old, they are transferred to other farms for fattening and finishing, and then slaughtered in a nationwide operated agribusiness (Bezerra, 2002).

Based on the animal waste generated, the calculation was simulated for the development of the CDM (Casagrande, 2003), using for analysis the BIOTOR biodigestor model, patented by the State University of West Paraná.

The researcher spent 15 days on the farm, close to the fallow land, observing and interviewing the owner, the manager and the worker that does the cleaning and provides food for the animals. The visit took place form October to November 2013 and the researcher interacted with the daily work processes of the farm.

**Results and Discussion**

*Bureaucratic limitations: CDM regulation for small scale pig farming*

One of the criteria imposed by the UNFCCC is that CDM projects be submitted to the market in English. These requirement represent two major barriers that hinder or prevent the proposition/submission of small projects: a) hiring specialized consultancies that are able to prepare documents in the required language and technically appropriate for the specific reality of each context; and b) the extra availability of financial resources in times of shortages. These limitations are important, given that when an enterprise seeks to present a small project, these two elements limit the development of a CDM project.

Regarding the outlay of financial resources identified as one of the major barriers to CDM projects, this is not restricted only to specialized consultancies hired to translate documents. As discussed above, proposing a CDM project requires financial resources for technological, operational and structural purposes.

These resources involve the readjustment of the property itself, changing the way the pig waste is treated, shifting from a traditional form of management to another that is less harmful to the environment. In the present case study, the management had adopted an anaerobic lagoon, which despite its low cost is highly pollutant (Hubner, 2005). Substituting an anaerobic lagoon for a biodigestor requires pre-investments on which there is no immediate return. Although the benefits to the environment are given in bureaucratic requirements, such as reduction with proof of a certain level of pollution, this return may not even occur, as there is no guarantee that the CDM project proposed will be approved.

*Marketing and technological limitations*

Another relevant institutional issue involves the lack of clarity regarding market rules for carbon credits (Alves *et al.* 2008). Although the UNFCCC provides a formal structure for monitoring CDM projects, it has a complex and constantly changing set of standards (Bartholomeu *et al.* 2006).

The DCP composition requires a description of the methodology to be used in each proposed project. Thus, for each segment there is a specific methodology to be used, for which the global standard does not consider the specificities of each country. For small scale pig farming, the methodological model (AMS-. III. D, version 14) omitted or did not specify information required, such as the model of the bio, the specific material used to build the biodigestor and specifications about the flare to be used.

There are several models of biodigestors and flares, and the methodological model does not indicate which are suitable for use. Beyond these questions, there are others related to local specifications, such as breed of pig and the country's climate, and other issues that may underestimate or overestimate the final value of the emissions (Kunz, *et al.* 2005).

The absence of relevant technical information, whether by lack of knowledge or the existence of a certain technology, leads to situations such as the disapproval of a consistently adequate proposed DCP due to a different but not thoroughly specified technology.

After a project is proposed, it will undergo monitoring. If, due to the absence of clear specifications of the correct equipment/instruments to use, it might not achieve the carbon credits proposed, because it is in this practical stage that emissions reductions will be credited. Therefore, if there are issues in the conception of the project, which occurs in the early stage, this will result in problems in the following validation stage.

It was verified that during the project proposition (the stage prior to monitoring), the rules for choosing the correct flare are not clear. They are not specified in any document or regulation. Therefore, due to economic issues, the proponent of the project may err in the choice of equipment, usually resorting to the least expensive. It is only in the monitoring stage that it will be discovered that the chosen flare may not be eligible for the carbon credits.

Another noteworthy question was raised by Souza (2005), who highlighted the lack of clear definitions, especially for CDM monitoring, and its constant changes. A point in

question is that the separation of CDM projects into small and large scales emerged in November 2002, and in July 2005 the CECDM published a review of the guidelines for the DCP filing for small scale projects. This means that the institutional environment of CDM projects has undergone changes that may confuse and intimidate new entrants.

This information was acquired through informal conversations with enterprises that manufacture this kind of product. Flares can cost between R$1,000 and R$25,000. Those authorized by the certification companies are usually the most expensive, although this is not made clear in the rules for project proposals.

North (1991) states that this situation characterizes a strong asymmetry of information that could be solved through clearer rules, such as requiring some kind of quality seal for flares, or a specific model or flare material and making this clear in the CDM proposal rules.

Through informal contact with several consultancies in the field, it was observed that there are very broad interpretations regarding the equipment for burning and measuring methane. Rules for the technical matters involved in a CDM project are subject to the interpretation of each agent. In this sense, hiring a specialized consultancy would resolve the issue of a pig farmer's lack of skill with the English language, and also would reduce the risk of unsafe investments in order to adapt the property to meet the requirements. However, on the other hand there its high financial cost.

Some consultancies claimed that there are no requirements from the institutional environment of the CDM, while others claimed otherwise, the following specifications being requested (MBRE, 2008): 1) The flare should be capable of enclosed combustion to obtain the total credit, because open combustion flares only earn a credit of 50%; this means that the pig farmer only would receive carbon credits for 50% of his emissions reduction, which may make a project economically unfeasible (however, these rules are not formal); 2) burn temperature should be achieved at 80% of combustion chamber size; 3) burn temperature should be higher than 500°C; and 4) burning retention time should be <1s (however, in the official document regulating small scale methodologies, these specifications do not appear).

Once again the lack of clarity in the carbon credit market rules is demonstrated. Some consultancies have information regarding these requirements for flares in the proposition of a CDM because they were acquired through leaning-by-doing. In the CDM 'rules of the game' these specifications are not made clear in any available document, increasing the risk for a CDM project as there are many brands of flare with many different materials and a wide range of prices. However, in informal conversations, it was stated that the cheaper products are not normally used in a CDM project.

*Technical rules*

The methodology used for the proposed DCP in this case study appears in the 14th version. This is demonstrative of the constant changes in the rules, which also are applied for pig farming to integrate the carbon credit market. Those preparing for a project for the carbon market feel a certain sense of insecurity, as the rules change during the drafting of the project, meaning that it has to be readapted. Any market that has erred in its definition of rules or in the process of setting rules will make participants feel insecure and this might lead them to avoid this market altogether.

The form for the Document of Project Conception (the third version of the CDM-SSC-DCP of December 22nd, 2006) was used. Constant modifications to the methodology and the DCP form itself can be justified by the short time that this kind of project has existed. Consequently, improvements of the 'ground rules' will be required, and these changes make potential participants wary of this market.

Out of the six stages that a CDM project activity needs to undergo, the preparation of the DCP (whose structure will be discussed later) is only the first one. As has been shown, in this DCP process, a number of barriers have been identified, such as the language and the cost of hiring consultants, which is usually necessary.

After the DCP comes the stage of Validation and Approval. In this stage the proponent will choose one DOE (Designated Operational Entity) that will conduct the project analysis to determine whether it is valid. In the case of small scale projects, services of the same DOE can be used for all the procedures, which is not the case for large scale projects.

As noted above, the DOE has a fundamental role in the analysis of projects for the carbon market. However, DOEs are in short supply. There are only 19 agencies, all of which are international. Furthermore, this does not mean that all of them are able to verify and validate CDM projects. Consequently, there are few choices when it comes to hiring one.

Since it plays a fundamental role in the approval/disapproval of CDM projects, it is understandable that there should be more DOE options to reduce the costs of proposing a project and provide a wider range of choices to the proponents of projects.

Table I illustrates the difficulties that must be overcome at each step of a small scale CDM project, based on the preparation of the DCP for this case study and the available literature.

TABLE I
BARRIERS IN EACH STEP FOR SMALL SCALE CDM IN PIG FARMING

| CDM Project Stages | Difficulties encountered |
|---|---|
| 1-. Document of project conception elaboration | 1.1. The projects should be submitted in English, being a trammel for small farmers. |
| | 1.2. High financial costs for hiring a consultancy service in the DCP construction. |
| | 1.3. Modifications in the DCP version occur, generating insecurity in who is elaborating it. |
| 2-. Validation and approval | 2.1. High financial costs of hiring DOE. |
| | 2.2. It is envisaged an increase in the number of DOE's, because the complexity of an entity to be accredited. |
| 3-. Registration | 3.1. High and increasing severity to register the CDM projects. |
| 4-. Monitoring | 4.1. Financial costs, especially with equipment necessary to verify the efficiency in the methane burning. |
| | 4.2. Lack of clearness in the rules imposed for this stage, according to Souza (2005) and informal consultations performed in several consultancies of the area and factories of methane burning equipment. |
| 5-. Verification and certification | 5.1. Financial costs hiring DOE. |
| | 5.2. There are few DOE's available among which it should choose one for validation and approval of project. |
| | 5.3. It is envisaged an increase in the number of DOE's, because the complexity of an entity to be accredited. |

One observation to be made is that the institutional environment is highly politicized. In Brazil, the National Designated Authority (NDA) is composed of representatives of 11 Ministries. In other words, there are considerable political interests at play in this market, and these can facilitate or interfere with the 'ground rules' for the Brazilian carbon credit market. Therefore, what occurs in practice is what the 'new institutional economics' (NIE; North, 1990) explains in theory, that the institutional environment directly influences the organizational environment.

As observed, the institutional environment of the carbon credit market has had a considerable negative impact on the participation of small pig farmers. There remains a great deal of asymmetry of information, i.e., there is no perfect communication between the institutional and organizational environments.

For the carbon market to become more attractive to small pig farmers, the rules of the market should be made clearer, i.e., there should be less information asymmetry, and there should be a greater interest and efforts on the part of pig farmers in the organizational environment to influence the institutional environment.

For issues such as the language barrier, more partnerships between universities and enterprises should be encouraged. In the case study in question, this would be feasible as in the region a wide range of language courses and courses for bilingual executive secretaries are available.

On the other hand, as a CDM project is analyzed by the pig farmer only in economic/financial terms, the farmer should be made more aware of the fact that his activities cause considerable pollution and waste, and that it is his responsibility to solve this problem. Therefore, the farmer would not only be concerned with the financial returns to be gained from CDM, but would also consider the environmental benefits and assume responsibility for addressing this issue. In short, there is little awareness on the part of pig farmers, as in any economic activity, because the greater motivation to enter the carbon credit market is the financial return to be gained from the use of waste rather than reductions in pollution levels.

*Shortcomings of the calculation of GHG emissions*

The calculation of current GHG emissions as well those related to reduction forecasts that would generate carbon credits, to be addressed below, has certain shortcomings that should be highlighted as a contribution to the academic environment and to aid future proponents of CDM projects.

The reference values that are used to calculate emissions from pig farming emissions are considerably different from the Brazilian reality. This is one of the limitations in the calculation, due to the risk of overestimating or underestimating emission reductions through the CDM project. The point should be solved by using local data, but this requires researchers to develop factors of GHG emissions, in accordance with the animals that inhabit the region, biological cycle stages, power supply, management conditions and climate, because these are determining factors that influence emission levels.

Compared to the theory of NIE, the existence of information asymmetry is verified, as there is a relatively new and unconsolidated formal institutional environment with the rules being constantly structured. The Kyoto Protocol is the regulatory framework. The methodologies for the development of a CDM are constantly improved and this raises doubts in the investments and process, combined with an existing informal institutional environment represented by the habits and customs of the pig farmers who are used to working with pigs without an efficient waste treatment, as this is the way they have always worked.

Issues related to the habits and customs of pig farmers could be addressed through campaigns to raise the awareness of these farmers, showing in practice how harmful their activity can be to the environment. After awareness is achieved, and through partnerships with universities and research institutes, the CDM would be presented as a solution for the environmental problems caused by the activity. Furthermore, the farmers would be presented with the idea of making financial investments and informed that this investment would reap dividends through carbon credits.

**Benefits of a CDM Biotor**

Figure 2 shows the evolution in pig waste management systems over time and is intended to provide evidence of the evolution of pig waste management systems, especially regarding the technology employed until today (June, 2009).

Method M1 shows that the waste is diluted in water and transported from the farm to the dunghill. Due to the slope of this dunghill, waste penetrates the ground and reaches

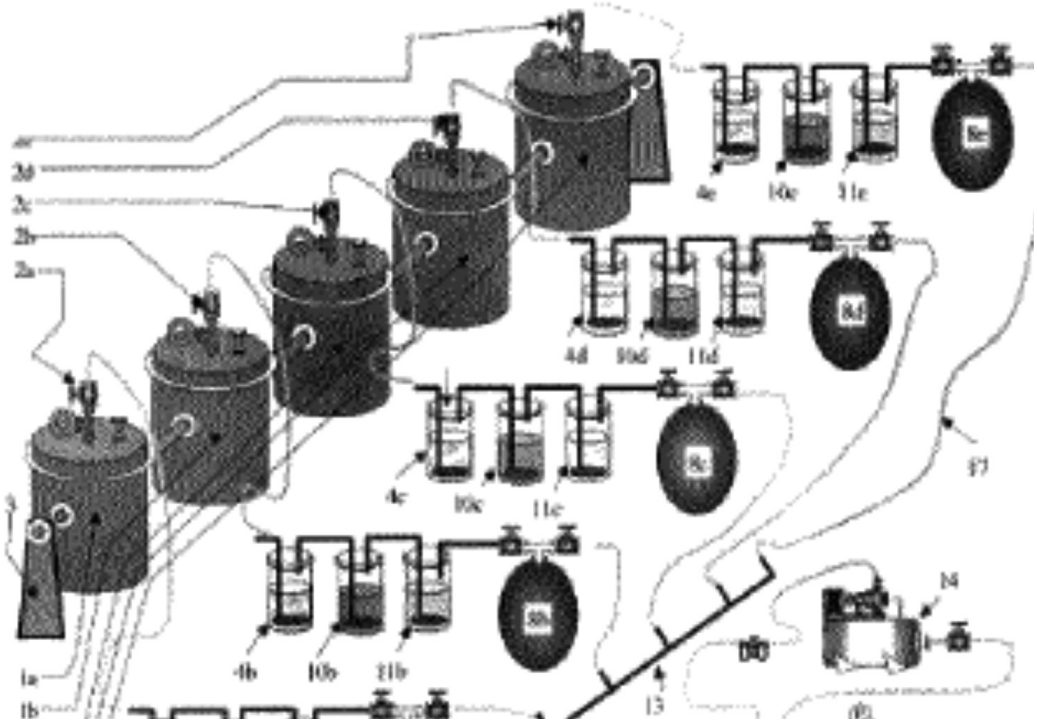

Figure 2. Evolution of pig waste management systems.

TABLE II
EXPECTED BENEFITS WITH MODIFICATION FROM LAGOON MANAGEMENT SYSTEM TO BIOTOR AND CDM CONFECTION

| Property aspects | Before | After |
|---|---|---|
| Waste treatment | Lagoons (stores only and do not treat) | Biotor (performs, indeed, some waste) |
| Waste flow | By gravity with water | Recipients using, *in-natura* |
| Water Consumption | 35 liters per animal/day, including the cleaning and consumption | Water consumption isn't necessary |
| Environment legislation | Not regular | Compatible with environment requirements |
| Electric power | Externally acquired | Able to use biogas |
| Bio-fertilizer | No treatment | Treated as the technical requirements |
| Health conditions of farm workers | No ideal conditions | Improvement in health conditions |
| Environment | Odors and bugs concentration | Odor reduction, liquid waste elimination and creation of an adequate environment activity |
| GHG emission | 544.29 tons $CO_2$ e/year | 57.56 tons $CO_2$ e/year |
| Carbon credits | Impossible | Possible |

the water table, thus contaminating water sources in addition to emitting GHG's. After a period of ~120 days, the waste (highly pollutant) is dumped on the property ground, as fertilizer. Constant repetition over time saturates the ground and the material continues to emit GHG's in the soil where it was spread. Method M1 is the most precarious pig waste destination. It is not a treatment method, but rather a way for the pig farmer to 'get rid' of undesirable waste.

In Method M2, the only evolution in comparison to M1 is that the waste, after a certain period in the dunghill, has a better use since it is turned into fish food, which may contribute to the economic sustainability of the property. Nevertheless, from an environmental viewpoint, this is not an improvement because while the waste remains in the dunghill, it penetrates the ground reaching the water table beyond, emitting GHG's.

The management system denominated M3 is considered to be the best option by environmental agencies that regulate the activity (MMA, IAP, etc.). It evolves technologically in relation to the previous methods, but is still not widely used due to its characteristics. In this system there is no change in the collection and transport of the waste, it has a high water demand, and it is still necessary to have a slope between the farm and the location of the biodigestor installations. The innovation lies in the biodigestion of the waste in which biogas is generated (that may or may not be used) and in the non-emission of GHG (that can be negotiated on the carbon credit market).

In Brazil, an attempted effort by the authorities and environmental agencies was identified that aimed to begin using M3 for pig waste management. Thus, it would be possible to reduce the GHG emissions generated by this activity and reduce the contact of pollutant waste with water sheets. However, the issues related to the considerable use of water to transport the waste and the need to have a slope on the property could not be changed. Therefore, it was accepted that this system is better than M1 and M2, but does not solve all the problems that stem from pig farming.

The system labelled M4 has better features in comparison with the previous systems in technologic, economic, environmental and social terms. The use of the biodigestor (patented by the Universidade Estadual do Oeste do Paraná under the name of 'Biotor') reduces the water consumption on the property, providing economic and environmental benefits. Not needing the slope transport is also an advantage over conventional systems; transport is carried out using tanks with waste containing a low volume of liquid. Furthermore, proximity to a river is no longer necessary, reducing the potential for pollution. Because of these characteristics, this model was chosen in the study to be compared with the traditional model.

According to data obtained in the field research, the farm has 1855 animals. The animal waste goes to the dunghill, where it remains for 120 days, after which it is dumped on the property ground as fertilizer. The waste is transported from the farm to the dunghill on a slope, requiring the use of water, as stated above, constituting a negative aspect of the system.

The management system used at this time, in accordance with DCP criteria, emits 544.29 tons of $CH_4$ in tons of $CO_2$ equivalent per year, according to the method used for this calculation: AMS-. III. D. 'Methane recovery in the agriculture and agribusiness activities' version 14 of UNFCC (2007). This methodology was adopted because the emissions of this project are <60000 tons of $CO_2$ equivalent per year. Thus, a methodology for small scale projects was adopted.

If the farm adopted the biodigestion system, specifically the Biotor, emissions would be reduced to 54.56 tons of $CH_4$ in tons of $CO_2$ equivalent per year. In other words, emissions would be reduced to a little more than one tenth of those that occur with the current management system (dunghills). Emission reduction would provide further proof of the validity of the project, and lower emission than without the project would permit the sale of carbon credits. If the project is not proved, no carbon credits can be sold.

Using the Biotor, the farm would obtain advantages: better waste treatment for application in the ground as bio-fertilizer; bio-food production; obtaining bio-gas together with carbon credit; or simply burning the methane without bio-gas production, but enabling the sale of the carbon credits.

## Conclusions

The Clean Development Mechanism (CDM) offers countries that have no emission reduction goals in the first effective period of the Kyoto Protocol (2008-2012), the opportunity to join the carbon credit market, selling credits to countries that do have reduction goals for the period.

The present study enabled an assessment of the institutional environment that governs the Brazilian CDM projects and identifies, analyzes and discusses the main points that are considered problematic or controversial in the carbon market. The study shows that this environment is represented by formal institutions on the

carbon market and subjected to rules for the proposition and approval of a CDM in Brazil.

The main observation is the large number of business rules, the difficulties related to the preparation of projects in English and the constant modifications, in addition to a low level of diffusion of the advantages and gains targeted by this market. This lack of information causes the withdrawal of economic agents, especially small enterprises, as observed in the case study.

Beyond the high financial costs of the proposition/validation of a CDM, a more diffuse and consistent publicity regarding the opportunities offered by the carbon market is lacking, especially regarding gains in social responsibility, sustainable economic development and above all environmental contributions.

A lack of clear and objective information was identified, especially with respect to obtaining and burning methane. Consequently, it is difficult for small entrepreneurs to enter the market. It is necessary to contract experienced external services (specialized consultants) to prepare a project. This leads to processes being shelved due to the high costs involved.

Concerning the ground rules for CDM projects, these were generally found not to be totally consolidated in Brazil or even in the rest of world, because at the last (14th) meeting of the Conference of the Parties (COP) held in Poland in December 2008, the Validation and Verification Manual was presented, the idea for which emerged in 2006. The main objective of this manual is to improve the flow of CDM projects, in view of their high rejection level.

With the presentation of the manual, the number of rejected projects is expected to fall, as the document aims to provide greater clarity about the rules for the CDM. Therefore, it can be said that a manual was required to clarify the CDM rules, implying that the institutional environment of CDM was not, at least until December 2008, totally clear to the candidates who wished to enter this market.

It can be seen that the rules for the entry of Brazilian enterprises or entrepreneurs in the carbon market are insufficiently clear to provide incentives for projects of this nature. The creation of the carbon market is relatively recent and the innovations it has brought, especially the CDM, have yet to realize their entire potential, due to the issues related to financial costs and the lack of clarity in the rules that have to be complied with prior to entry in this market.

Even in a market whose rules are not totally clear, the CDM can be viewed as having a great potential for developing countries such as Brazil. As stated previously, the cost of reducing GHG emissions in developing countries is lower than the cost of this reduction in developed countries. Furthermore, the CDM aids the creation and use of new and less pollutant technologies.

By means of the methodology used in this study, it was possible to identify the practical barriers of small entrepreneurs attempting to enter the carbon market. Clear information is lacking concerning the procedures to be followed and the equipment that can be used. A further barrier is that the documents have to be drafted in English. These obstacles, despite not being legally enforceable, oblige entrepreneurs to contract consultancy services to prepare the DCP, which results in considerable financial cost. Further costs stem from modifications that have to be made to the management system.

Proposing the CDM project, entrepreneurs will also bear the cost of hiring a DOE, and it should not be forgotten that there are few choices of DOE available worldwide. Therefore, the entrepreneur does not have many options. Nevertheless, advantages were also identified regarding the introduction of a new management system for pig farm waste, the focus of the present study, through the implantation of a CDM. The advantages are especially due to the use of the Biotor, an innovative biodigestor technology, and the revenue generated through the sale of carbon credits.

Using the Biotor is a solution to problems such as high GHG emission, excessive water use and the need to be in a geographic area with a slope. Moreover, the use of the Biotor will increase the demand for unskilled labor in the field, stemming rural exodus, and, together with the carbon credits, it will bring financial resources to the property. Furthermore, it would provide an economic solution to what used to be a problem. Consequently, there is a great opportunity for pig waste to stop being a problem and come to be viewed as a raw material.

Thus, it follows, in response to the research problem, that the institutional environment discourages small farmers from seeking access to the clean development mechanism. Contrasting results found with the theoretical reference to NIE, it can be concluded that the institutional environment continues to lack incentives for small entrepreneurs to enter the carbon credits market. Indeed, it is not technological differences that make Brazil a country that is still developing, because in the pig farming case, it was proved that there is sufficient technology to make this practice sustainable. However, institutional incentives to use this technology are lacking.

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