Composting Projects under the Clean Development Mechanism: Sustainable Contribution to Mitigate Climate Change

Cyrill ROGGER[a], François BEAURAIN[b], Tobias S. SCHMIDT* [a]

[a] Department for Management, Technology, and Economics, ETH Zürich, Weinbergstrasse 56/58, 8092 Zurich, Switzerland

[b] South Pole Carbon Asset Management Ltd., Switzerland, Technoparkstrasse 1, 8005 Zurich, Switzerland

* Corresponding author: tobiasschmidt@ethz.ch

Published in *Waste Management.* (doi: 10.1016/j.wasman.2010.09.007)

Please cite this article as: Rogger, C., Beaurain, F., & Schmidt, T. S. (2011). Composting projects under the Clean Development Mechanism: Sustainable contribution to mitigate climate change. *Waste management,* 31(1), 138-146.

Abstract

The Clean Development Mechanism (CDM) of the Kyoto Protocol aims to reduce greenhouse gas emissions in developing countries and at the same time to assist these countries in sustainable development. While composting as a suitable mitigation option in the waste sector can clearly contribute to the former goal there are indications that high rents can also be achieved regarding the latter. We compare composting with other CDM project types inside and outside the waste sector with regards both project numbers and contribution to sustainable development. We find that, despite the high number of waste projects, composting is underrepresented and identify a major reason for this fact. Based on a multi-criteria analysis we show that composting has a higher potential for contribution to sustainable development than most other best in class projects. As these contributions can only be assured if certain requirements are followed we present eight key obligations.

Key Words: Compost, Sustainable development, Clean Development Mechanism (CDM)

1 Introduction

Currently, international negotiations under the United Nations Framework Convention on Climate Change (UNFCCC) are trying to establish a follow-up treaty to the Kyoto Protocol, which expires in 2012 and aims at the reduction of greenhouse gases (GHG) within many sectors in both developed and developing countries (UNFCCC, 1997). Experiences form the current regime can be helpful for the design of such a post-Kyoto treaty. Thus, we want to shed light on one aspect, namely waste treatment and, more specifically, composting under the Kyoto Protocol's Clean Development Mechanism (CDM), which addresses climate change mitigation in developing countries. The Intergovernmental Panel on Climate Change (IPCC) considers waste as one of the seven key sectors contributing to climate change (IPCC, 2007). The proposed corresponding mitigation technologies by the IPCC focus either on landfill gas recovery or on the prevention of methane generation in landfills either by means of aeration or avoidance of landfilling (e.g. via composting). These strategies are already being applied at large scale in developed countries. For instance, the European Union with its 1999 landfill directive which promotes incineration, composting and bio-methanisation of waste (European Community, 1999) managed to reduce landfill emissions significantly (U.S. EPA, 2006). While the OECD is projected to decrease its landfill emissions by 31% in 2020 compared to 1990 levels, developing countries are expected to generate more waste and in the same period of time contribute to a 7 % increase in total global landfill gas emissions reaching 817 MtCO2eq in 2020. Fast growing populations and personal incomes as well as expanding industrialization result in increasing waste production in developing countries (U.S. EPA, 2006). Local authorities (especially in the cities) often do not cope with the challenging task of providing a proper waste management service (UNEP, 2005). This can lead to the contamination of streets and drinking water and, consequently, to severe threats to health particularly for the poorer population. Changing open dumpsites into sanitary landfills is a frequent approach to solving these problems. However, if the landfill is neither aerated nor equipped with gas capture systems, the GHG emissions will actually increase compared to an open dumpsite. Barton et al. (2008) compared different emission reduction options in this sector specifically for developing countries. In their study the landfill gas flaring and landfill gas to power scenarios reduced GHG emissions considerably, but composting and anaerobic digestion resulted in options being carbon neutral or negative. Bearing in mind its relatively simple technology, the authors propose composting to be the first process to be considered when replacing open dumping. The high percentage of biodegradables in waste in developing countries, the low labour costs and the relative simple and inexpensive, but labour intensive technology are the main reasons why composting is also considered by other authors as being a particularly favourable waste management system in developing countries (Barton et al., 2008; Elango et al., 2009; Gonzenbach and Coad, 2007; Hofny-Collins, 2006).

The Clean Development Mechanism aims to reduce emissions in developing countries (so-called non-Annex-1 countries of the Kyoto Protocol). The mechanism is project-based and issues certified emission reduction warrants (CERs), which can be used in developed countries (so-called Annex-1 countries) to comply with emission reduction targets. The CDM has a twofold objective. First, it supports developed countries in reaching their emission reduction targets through the mobilisation of more cost efficient reduction options in developing countries, where, second, the emission reduction projects shall contribute to sustainable development (UNFCCC, 1997). Amongst others, the waste sector is a target of investors in emission reduction projects under the CDM

(Fenhann, 2010a). Regarding the second objective of the CDM, Sutter and Parreño (2007) published a study in which by far not all of the assessed CDM projects contributed significantly to sustainable development. Furthermore, the fact that CDM does not offer adequate incentives for the achievement of the second goal in the host countries has led to criticism (Olsen, 2007). A shift within the business-sustainability trade-off in favour of the second objective only happens when value is attributed to sustainability e.g. by awarding labels such as the Gold Standard, the most prominent high quality credit label. It rewards outstanding CDM Projects in terms of their contribution to sustainable development leading to a higher market price for certificates. Though there are indications that composting is able to deliver high rents of sustainability in developing countries (e.g. Gonzenbach and Coad, 2007; Zurbruegg et al., 2005) composting projects are currently not eligible for the Gold Standard (Gold-Standard, 2010).

2 The situation of composting projects under the CDM

2.1 Number of projects

Thus far, the CDM has generated several types of mitigation activities whose shares in terms of project numbers are shown in Figure 1. In March 2010, over 50% of the 2062 projects which were registered at the UNFCCC as CDM activities (Fenhann, 2010b) were based on renewable energy and one quarter on methane avoidance (e.g. solid waste or animal waste and waste water) with almost 9% stemming from solid waste management. This share appears to be rather high compared to the global contribution to anthropogenic greenhouse gas emissions of the waste sector of 2.8% (IPCC, 2007). With 154 projects (6.6% of the total registered activities), landfill gas projects[1] (LFG) are by far the biggest contributor. In fact, landfill gas projects were among the first projects registered by the UNFCCC (UNFCCC, 2010) and many big dump-sites around the world have been "cleaned" thanks to the incentives created by the CDM. These are mainly based on revenues from methane destruction which make the projects financially very attractive, as recently shown by Schneider et al. (2010).

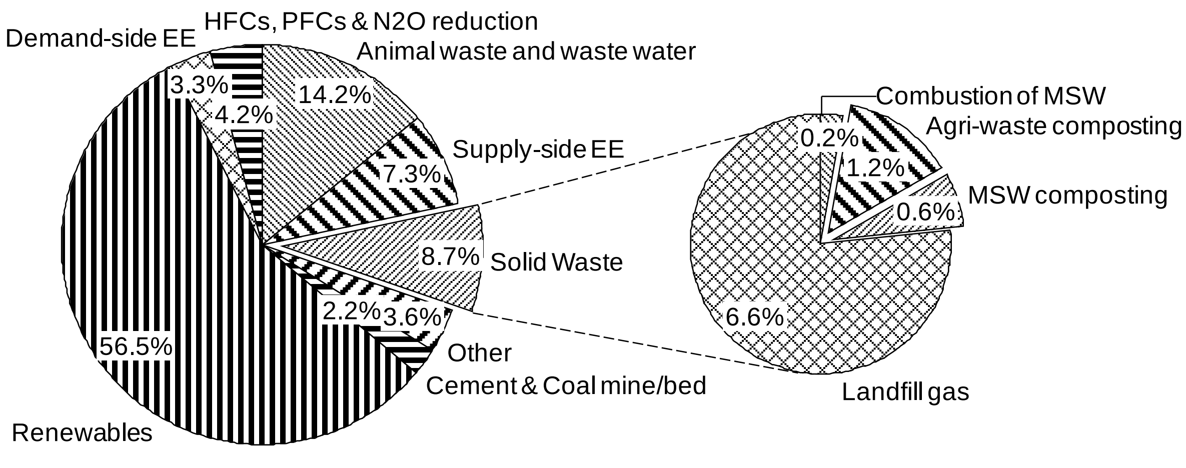


Figure 1 Number of projects (in %) of each project category with special focus on solid waste (based on Fenhann, 2010a)

[1] LFG flaring and LFG to energy

On the contrary, the number of composting projects is much smaller (37) though as mentioned above they are well suited for implementation in developing countries. The first composting project under the Clean Development Mechanism was accepted in 2006 (Barton et al., 2008) but only a few followed after that. By today, none of the 37 registered projects – 12 being based on municipal solid waste (MSW) and 25 on agro-waste – managed to issue credits, yet.

Though, according to Barton (2008) composting leads to higher emission reductions, most investors seem to prefer landfill gas projects. This might seem surprising but can be explained to a great extent by the methodologies for the calculation of the GHG emission reductions.

2.2 Methodologies for the calculation of the emission reductions

All methodologies that deal with solid waste refer to the same UNFCCC tool[2], which uses a first order decay model to calculate the baseline methane emissions, i.e. the quantity of methane that would have been emitted to the atmosphere in the absence of the CDM project[3]. Originally designed to assess GHG emissions from landfills (IPCC, 2006) this model is now used in all methodologies related to solid waste management. It distinguishes between different climatic circumstances, particular waste types, and landfill management practices. Each waste type is characterized by its degradation velocity and its degradable organic carbon content. According to this model, methane emissions that would have been emitted in year *y* from a quantity of waste dumped in year *x* is proportional to $e^{-k(y-x)}$ where k is degradation velocity of the waste. Each year the methane emissions decreases according to this first order decay law and the higher the degradation velocity, the greater the slope of the methane emission curve.

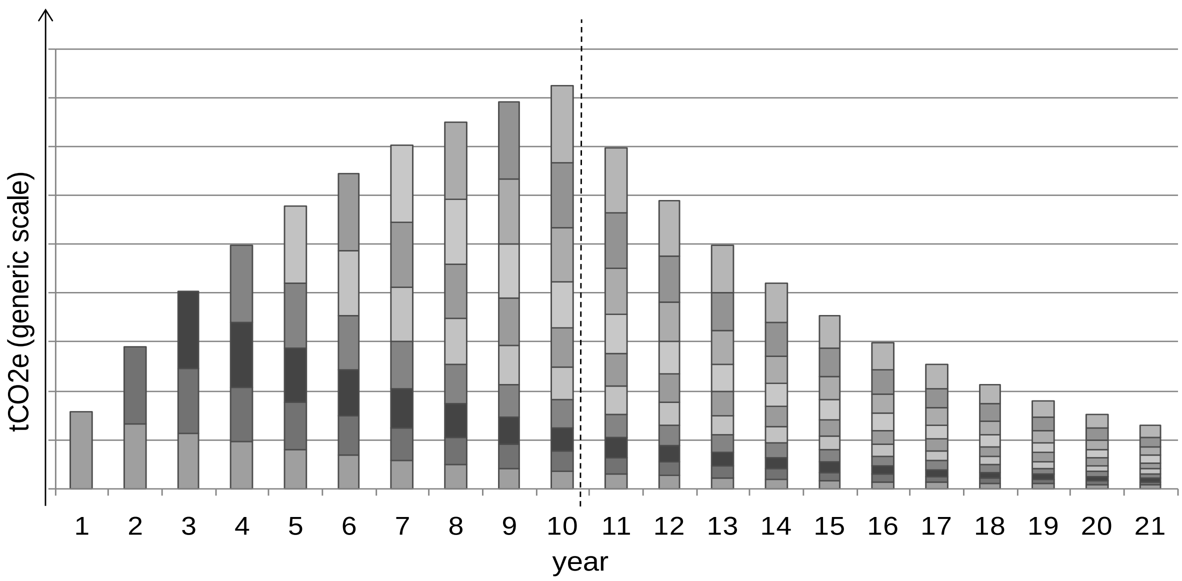


Figure 2 Methane baseline of a 10 year stream of waste calculated according to the UNFCCC (2010) tool[4]

[2] Methane tool of the UNFCCC (2006)

[3] A project's emission reductions are calculated by the subtraction of the project emissions (i.e. the emissions that occur due to a project) from the baseline emissions. (UNFCCC, 2010)

[4] The degradation velocity is based on "Garden, yard and park waste" for tropical wet climate and is equal to 0.17 y^{-1} which is the maximum value for this type of waste.

In Figure 2, we present the typical profile of the methane emission curve calculated as by the UNFCCC tool for a dump site where a supposed constant quantity of waste is being accumulated for 10 years, the typical CDM project duration. The curve represents the sum of the 10 different first-order decay curves from waste treated in year 1 to 10 (see the different shadings in Figure 2) and has a typical shape that we can split into two parts. First, the raising phase where the methane emissions ramp up before reaching a maximum after 10 years (to the left of the dotted line) and the decreasing phase where in the absence of fresh waste the methane emissions decrease according to the first order decay law (to the right of the dotted line).

Despite the fact that both composting and landfill CDM projects use the same tool, there is a fundamental difference between the two project types. In the case of composting, methane emissions which would have occurred in the following years are avoided, i.e. the actual emission reductions of a composting project lasting ten years would contain all emissions shown in Figure 2 and even those beyond the year 21. In landfill gas projects the methane destruction only starts after the landfill has been closed and covered (i.e. in year eleven). Therefore only the emissions to the right of the dotted line are avoided. However, according to the methodology, a composting project lasting ten years will only be rewarded for the rising part of the curve, a landfill project for the decreasing one. This has an important influence on the flow of CERs and therefore on the contribution of the CDM to financing these activities. Indeed, for composting projects most emission reductions occur close to the end of the crediting period while during the first few years of the crediting period the methane baseline emissions are very low. This translates into low cash flows in the early stages, and higher ones in the later stages of a project. Underlying an interest rate on investments, this has a negative impact on a project’s profitability as early revenues are discounted to a lesser extent than late ones when calculating the net present value (NPV) of investments (Brealey and Myers, 2000). This issue is even more critical now in a market where there is no clear post-2012 visibility for CDM. Moreover, if the project emissions (due to energy use in operating the composting plants) are subtracted from the baseline emissions, the resulting emission reductions from the project can be zero or even negative in the early phase. These constellations can prevent project developers from considering composting options under the CDM since such projects are not as profitable, or could even appear as a non-mitigating activity. In turn, landfill projects profit from high cash flows early on which make them financially attractive. Besides this methodological issue CDM composting projects clearly face other barriers which are, by contrast, inherent and not imposed by climate policy. The complexity of waste separation might be one of these barriers. This may explain why projects dealing with purely organic residues in agribusiness are more frequent than those dealing with MSW.

From a mitigation point of view, the situation is therefore a paradox: Though composting leads to the immediate avoidance of nearly all methane emissions, the monetary rewards are discounted and delayed. This was recently also criticised by a study on the CDM methodologies applicable to the waste sector (Müller et al., 2009). On the other hand, landfill projects, where GHGs are emitted until the landfill closure, benefit from a decisive incentive from the CDM. These facts explain to a large extent the LFG projects’ high investment attractiveness in comparison to composting projects and the difference in terms of project numbers, respectively.

3 Contributions to Sustainability

3.1 The triple bottom line of sustainability

As the CDM aims to not only reduce emissions but also to “assist Parties not included in Annex-I in achieving sustainable development” (UNFCCC, 1997, p.11) we now want to elaborate on this second goal. In order to move towards sustainability a consensus of three different interests, namely economic, social, and natural capital must be achieved (United Nations General Assembley, 2005). This so-called “triple-bottom-line of sustainability” should also be applied to the waste sector (den Boer et al., 2007; Morrissey and Browne, 2004) and thus will serve as foundation for the following chapter.

3.2 How to measure the sustainability contribution of CDM projects

While the GHG-emission reductions by CDM projects are calculated according to the methodologies provided by the UNFCCC, there is no comparable official regulation for measuring their contribution to sustainable development (Olsen, 2007). Several initiatives by researchers and labelling organisations have addressed this shortcoming by developing respective assessment methodologies in order to give more value to the second objective of the CDM.

The Gold Standard is the most prominent quality credit label for GHG-mitigation projects. Initiated by the World Wide Found for Nature (WWF), the Gold Standard today is supported by more than 60 NGOs worldwide. The Label awards outstanding projects in terms of their contribution to sustainable development. To achieve Gold Standard certification, CDM projects, as well as projects providing certificates for the voluntary market, have to fulfil the Gold Standard eligibility criteria, which exclude all project types other than renewable energy supply or energy efficiency. Furthermore, the evaluation includes an environmental impact assessment, a stakeholder consultation and a sustainability assessment. The latter comprises a set of twelve sustainability criteria (four for each sustainability dimension) assessed with the help of descriptive five-step scales (Gold-Standard, 2010). The assessment and its criteria stem from the methodology Multi-Attributive Assessment of CDM (MATA-CDM) which is based on the Multi Attributive Utility Theory. It has been developed by Sutter (2003) and is structured along the five step identification of sustainability criteria, defining indicators and their utility function, weighting the criteria, assessing the projects, and aggregating and interpreting the results. The twelve sustainability criteria identified in Sutter’s study differ only slightly from the Gold Standard criteria and have been used in other studies to assess sustainability rents of CDM projects (Heuberger et al., 2007; Nussbaumer, 2009; Sutter and Parreño, 2007).

The present study uses the simplified MATA-CDM, as described by Nussbaumer (2009)[5] dealing with the standardized Project Design Documents (PDD) for CDM projects as single source of information. One researcher assessed all projects in order to guarantee that one single standard for assessment was applied. The scores of each project on each dimension were then discussed among the three authors and partly corrected.

[5] For details on this methodology please refer to his study. Due to the lack of respective data, the scoring function for the criteria fossil energy resources has been modified, resulting in the criteria being qualitative.

3.3 Comparing composting projects with other best-in-class projects

In total, twenty-seven CDM projects were compared in this study regarding the twelve sustainability criteria. The projects are split into eight different project types according to Table 1. All assessed projects are labelled as Gold Standard (GS) projects or have applied for GS-registration except the composting projects as they are not eligible for the GS. GS projects tend to show higher sustainability rents than comparable non-GS projects (Nussbaumer, 2009) and therefore serve as stricter benchmark for composting projects.

Table 1 Assessed projects

Project type Abbreviations	Project type	Gold Standard	Number of assessed projects
Compost-M	Composting of municipal solid waste	Not eligible	5
Compost-A	Composting residues from agribusiness	Not eligible	5
GS-Landfill	Landfill gas to power	Labelled or applied for registration	3
GS-Biogas	Biogas to power	Labelled or applied for registration	3
GS-Biomass	Agricultural biomass to energy	Labelled or applied for registration	3
GS-Household	Energy efficiency on the household level	Labelled or applied for registration	3
GS-Solar	Solar cooking	Labelled or applied for registration	2
GS-Wind	Wind farm	Labelled or applied for registration	3

3.3.1 Sustainable development profiles of different CDM project types

For the comparison criteria by criteria, the study reverts to the amoeba graphs[6] described by Nussbaumer (2009). The specific sustainable development profiles of the 8 assessed project types are presented in Figure 3 and Figure 4. To facilitate the reading of the figures, the 12 criteria and their positions in the graph are presented in Table 2.

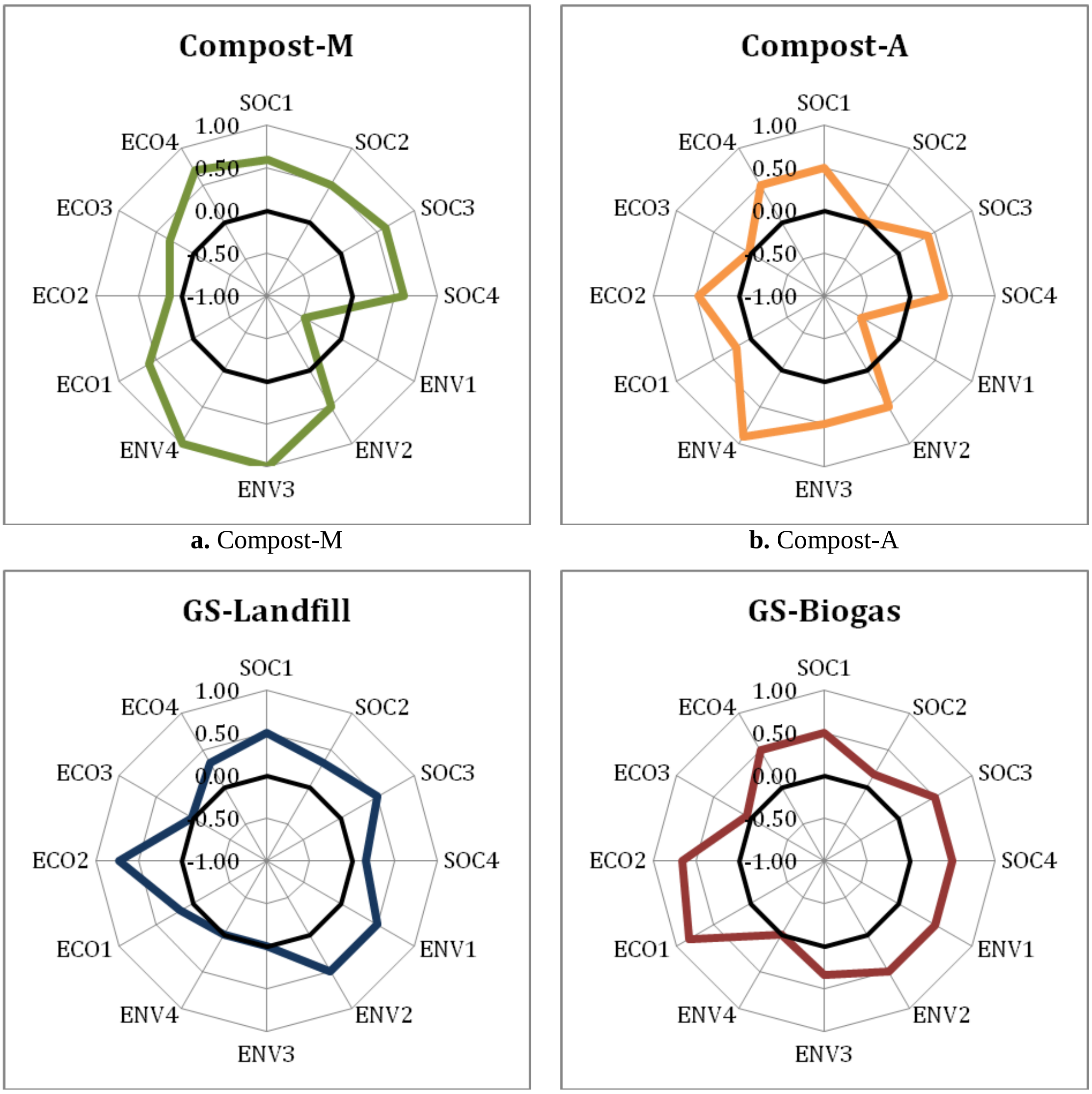
Table 2 Sustainability criteria

Abbreviation	Criteria	Position in the amoeba graph
SOC1	Stakeholder participation	12 o'clock
SOC2	Improved service availability	1 o'clock
SOC3	Equal distribution of the CER revenues	2 o'clock
SOC4	Human capacity development	3 o'clock
ENV1	Fossil energy resources	4 o'clock
ENV2	Air quality	5 o'clock
ENV3	Water quality	6 o'clock
ENV4	Land resource	7 o'clock
ECO1	Regional economy	8 o'clock
ECO2	Microeconomic efficiency	9 o'clock
ECO3	Employment generation	10 o'clock
ECO4	Sustainable technology transfer	11 o'clock

In our study we delineate two different types of composting projects, i.e. whether municipal solid waste (hereafter referred to as compost-M) or agricultural residuals (Compost-A) are composted. This delineation is based on the expectation that the two types might significantly differ regarding their sustainability contribution as they are based on very different waste and value chains. When looking at the results (Figure 3a and b), this expectation is confirmed. Compost-A projects achieve lower ratings regarding improved service availability,

[6] The 12 criteria with their scale from -1 to 1 are spanned in a circle similar to a clock face and where the scores by each project type define a characteristic sustainability profile. The resulting line represents the average of all projects which have been assessed per project type.

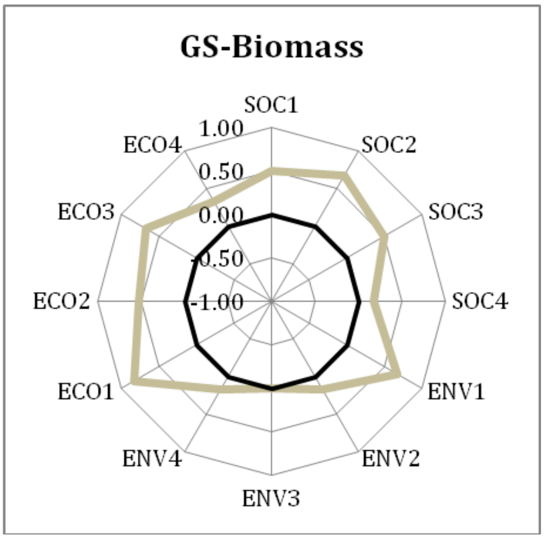
water quality, regional economy, and employment generation due to the following reasons. Firstly, while MSW-composting in the assessed cases improves waste management service for the involved population, composting residues from agribusiness do not have a comparable influence on the availability of services. Furthermore, compost produced by agribusiness is generally used within the respective plantation whereas MSW-compost substitutes expensive chemical fertilizers and therefore is of great value for small farmers. Secondly, MSW-composting reduces water content of the municipal waste and therefore toxic leakage in landfills, which often endangers the water quality in residential neighbourhoods. This improvement in water quality has been rated higher than the prevention of eutrophication thanks to composting residues from agribusiness. Thirdly, four of the five assessed Composting-A projects are located in Malaysia, whereas the assessed Composting-M projects are located in Bangladesh, India, Colombia the Philippines, and China. The Human development index (UNDP) of these countries is clearly smaller than the one of Malaysia and thus the contribution to regional economy has been rated higher. Fourthly, the employment generation in Composting-M projects due to the collection and the sorting of the municipal waste is much higher than in Compost-A projects where only little additional labour is needed. The only criterion where Compost-A projects achieve higher ratings than Composting-M is microeconomic efficiency.



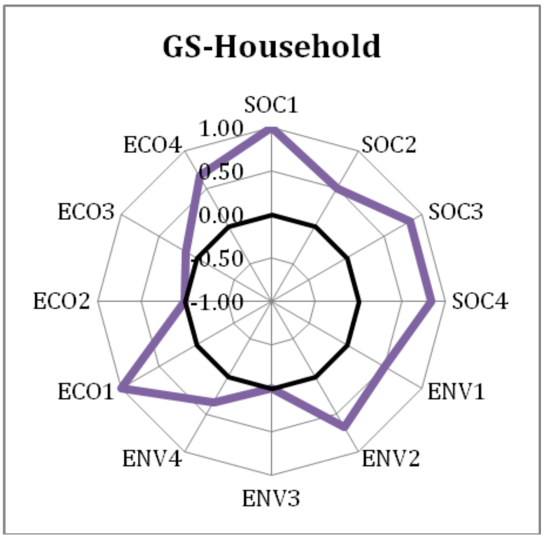
a. Compost-M **b.** Compost-A

c. GS-Landfill **d.** GS-Biogas

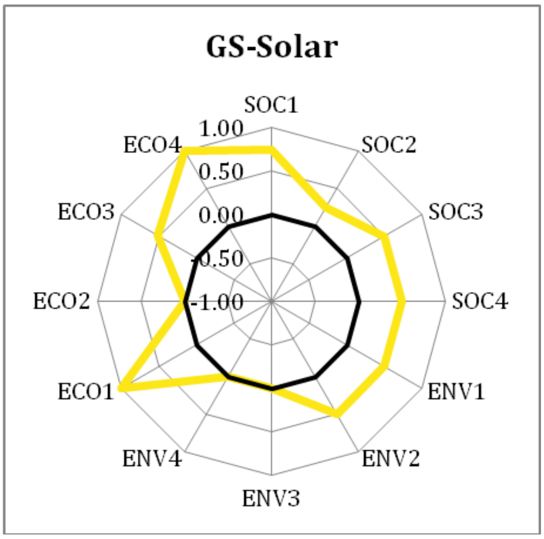
Figure 3 Sustainable development profile of CDM projects related to waste or biogas.



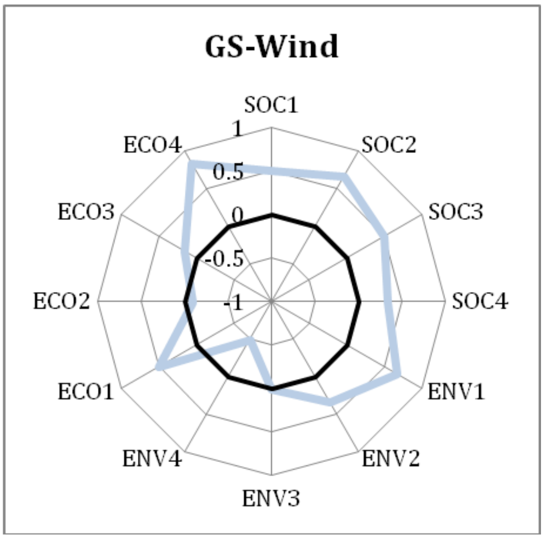
a. GS-Biomass



b. GS-Household



c. GS-Solar



d. GS-Wind

Figure 4 Sustainable development profile of CDM projects other than waste or biogas related.

Composting projects outperform all other project types regarding the criteria land resource (Figure 3Figure 4). The reasons for this high rating are the contribution of compost to carbon sequestration (Fortuna et al., 2003; Fronning et al., 2008) and, the capacity of compost to improve soil fertility in many ways. Compost for instance, is able to reduce erosion and nitrate leaching thanks to the increase in soil aggregate stability (Fuchs et al., 2008) and water holding capacity of farm land (Evanylo et al., 2008; Lima et al., 2009). Even degraded soils can be restored with the aid of compost (Cogger, 2005; Ros et al., 2003). With its content of plant nutrients such as nitrogen, phosphorus, and potassium, compost is furthermore a valuable fertilizer (Ngakou et al., 2008; Whalen et al., 2008) and thanks to its suppressive effect on plant pathogens (Abbasi et al., 2002; Hoitink and Fahy, 1986) compost has the capacity to control plant diseases. All these features account for the high rating of composting projects for the land resource criterion and are particularly important for agriculture in developing countries where crop inputs such as chemical fertilizers and pesticides are not readily available (Niggli et al., 2009).

A different picture is found when comparing the project types regarding the criterion fossil energy use. While all other project types provide alternative energy and hence are able to replace fossil energy which results in a positive rating, composting projects receive a negative rating for this criterion due to the fuel consumption of transport vehicles and turning machines (Figure 3Figure 4). The fact that compost is able to substitute chemical fertilizers (Ngakou et al., 2008; Whalen et al., 2008), thus reducing the fuel consumption of energy intensive fertilizer production (Kokkora et al., 2006), might change the picture but is not taken into consideration in the assessment as it lies outside the CDM project boundaries.

3.3.2 Aggregated contribution to sustainable development by project type

Unlike Nussbaumer (2009), the present study compares the aggregated contribution to sustainability of the different projects while being aware that this single figure only represents an imperfect value for absolute contribution to sustainable development. However, it provides a measurement for the contribution to sustainable development of the different project types on the scale from totally unsustainable (-1) to fully sustainable (+1). The average scores and respective standard deviations are shown in Figure 3 for each project type. All assessed CDM-project types contribute positively to sustainable development. The highest average score was reached by Household projects (0.54), followed by Compost of MSW, Solar Cooking, Biomass, and Biogas ranging from 0.50 to 0.42 (Figure 5). Lower scores have been attached to the project types Compost of Agricultural Leftovers (0.33), Wind (0.32) and the lowest for Landfill Gas to Power projects with a score of 0.31. The figures show clearly that composting at least keeps up with best in class of renewable energy supply or energy efficiency projects, and in case of MSW is even one of the most sustainable project types. Landfill Gas to Power is, by contrast, at the lower end of the compared project types.

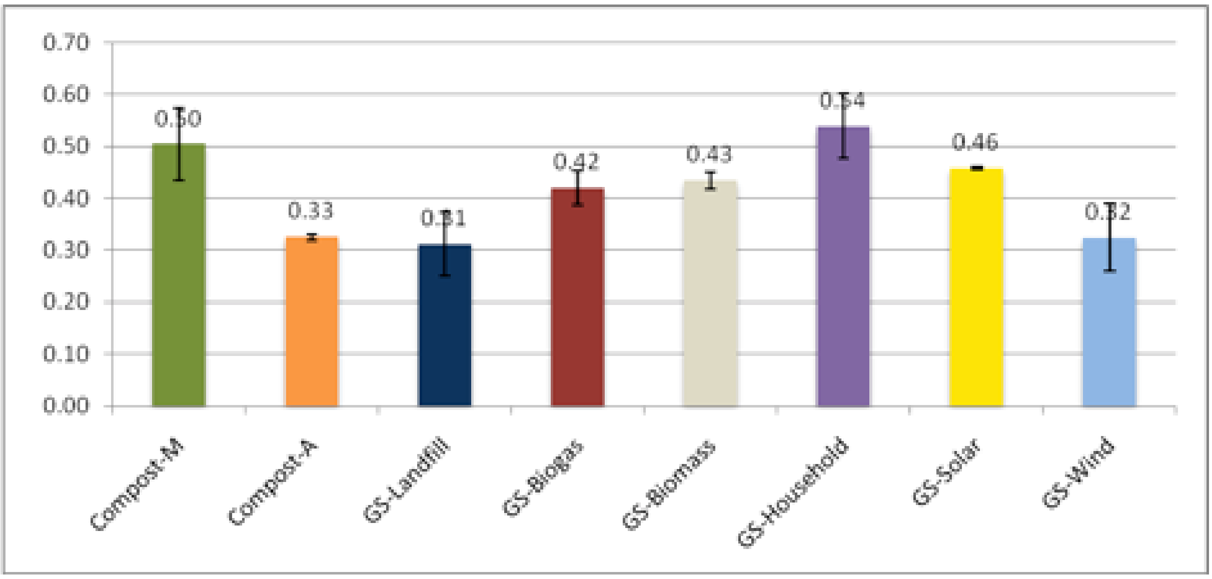


Figure 5 Sustainable development impact of CDM projects: Comparison of different project types.

3.4 How to assure high sustainability rents?

After having shown that composting project can definitely keep up with or even outperform other best-in-class project types regarding their contribution to sustainable development, this section defines the preconditions and requirements necessary to assure this contribution. For this reason, information from the sustainability assessment, different compost quality regulations, Gold Standard sustainability requirements (Gold-Standard) and interviews with six experts representing different areas of specialisation such as composting in developing countries, CDM, sustainability measurements or general compost quality (see Table A1 in the Annex) was compiled. These interviews served to reconfirm our choice of requirements regarding their relevance, sufficiency, and the feasibility of their respective control in developing countries.

In a first step, potential negative as well as positive effects of composting projects on sustainable development were collected. Secondly, measures to prevent the negative effects as well as preconditions to support the positive effects were specified. Thirdly, the most important effects and the related requirements were prioritised, which led to the short list of eight sustainability requirements for composting projects shown in Table 3.

Table 3 Sustainability requirements for composting projects

Requirement	Criteria	Source
Correct fermentation process	Temperature during composting process 55°C, 21 days or 65°C, 7 days	(Fuchs et al., 2004)
Limitation of heavy metals	Cadmium: < 1 mg/kg dry matter Copper: < 100 mg/kg dry matter Mercury: < 1 mg/kg dry matter Nickel: < 30 mg/kg dry matter Lead: < 120 mg/kg dry matter Zinc: < 400 mg/kg dry matter	(Fuchs et al., 2004)
Limitation of Impurities in compost	Glass, metal, plastic < 0.5% weight dry matter Stones (> 5 mm) < 5 % weight dry matter	(Fuchs et al., 2004)
Leachate control	Contamination of ground and water by leachate has to be avoided by adequate structural measures. (e.g. solid ground, roof , leachate collection system, compost-fleece)	(Duckworth, 2005)
High quality Compost is used in agriculture, horticulture, home gardens or potted plants	Project has to account for the use of the compost: It is neither dumped in landfills nor burnt	Evident criterion
Inclusion of stakeholders	Inclusion of stakeholders of the existing formal as well as of the informal waste management system, notably waste pickers, collectors and recyclers	(Gonzenbach and Coad, 2007)
Transparent statistic of project jobs including construction and maintenance of the composting plant	The number and classification of jobs in construction and maintenance of the composting plant should be declared in the PDD and monitored over the whole project period.	Criterion arisen from sustainability assessment
Clear commitment by project owner and associated agro-companies to sustainable development	For composting of palm oil residuals: compliance with the latest version of the roundtable on sustainable palm oil production For other production systems similar solutions have to be found	(Gold-Standard)

The first sustainability requirement focuses on the correct fermentation process within a composting project, which is of enormous importance for both the mitigation of methane and other GHG emissions and for the quality of the compost. If the latter is unsatisfactory, compost is not used and many positive contributions to sustainable development no longer have any effect. On the contrary, the use of bad compost could potentially result in contamination of arable land with heavy metals or impurities. That is why the proposed shortlist comprises four further requirements related to compost quality and its appropriate use, namely the limitation of (1) heavy metals and (2) impurities in compost, (3) leachate control and (4) the appropriate usage of the compost.

It is self-explanatory that a sustainable project must not disfavour marginalised and poor people. Many waste pickers or people who make their living from recycling waste may suffer under a new waste collection system. These people are important stakeholders and have to be included in the consultation process. The project should offer them alternative solutions for income generation (Gonzenbach and Coad, 2007).

In spite of the undoubted importance of employment for sustainable development, quantity and quality of jobs are often neglected in sustainability assessments of CDM projects. Because accurate figures were missing, the number of jobs generated has also in the course of the present study been difficult to evaluate. Transparent statistics regarding number and classification of generated jobs would be helpful to appraise CDM projects regarding their job creation potential. This requirement, however, is not specific for composting but also applies to all other project types.

Most projects composting residues from agribusiness are connected to the production of palm oil, which is widely used as cooking oil but has also become more and more important as a biofuel over the last 10 years. Against the background of the recent food crises, biofuel projects have generally become a bone of contention. In the case of palm oil, it is not only competition for arable land for food production that has become an issue, but also the fact that new plantations are often established on newly-cleared rain forest land (Reijnders and Huijbregts, 2008; UNDP, 2007; Wicke et al., 2008). On this account it is important to mention that all assessed projects comply with the latest standards of the roundtable on sustainable palm oil production (RSPO, 2010) as it is a precondition to receive Gold Standard certification.

4 Conclusions

The waste sector plays an important role for climate change and its mitigation in both developed and developing countries. Especially for the latter, composting seems to be a very appropriate mitigation option. The debate on a future international agreement to limit climate change can benefit from insights gained under the existing regime, i.e. the Kyoto Protocol. Hence, this article sheds light on current practice and the significance of composting within this regime’s Clean Development Mechanism which aims at GHG reductions and sustainable development in developing countries. We find that significantly fewer composting projects are implemented under the CDM than related project-types aiming at the mitigation of methane emissions from solid waste, i.e. mainly landfill gas projects which either flare the methane or use it to produce power. While these latter projects are, compared to the share of anthropogenic GHG emissions of the waste sector, clearly overrepresented, the barriers for the implementation of composting projects seem to be much higher, leading to their under-representation. The methodology for the calculation of emission mitigation was identified as one major barrier for composting projects. Originally developed for landfill gas projects, the model used in this methodology discriminates composting because the allocation of emission reduction certificates is postponed which reduces the projects’ financial attractiveness considerably. In turn, landfill gas projects are treated preferentially as emission reduction warrants are not deferred.

Regarding their contribution to sustainability, our analysis shows that composting projects can compete with other best in class CDM projects. Composting projects dealing with municipal solid waste perform better than projects composting residues from agribusiness (palm oil), and both perform better than landfill gas to power projects. The particularly good performance of composting projects regarding the sustainable use of land resources, where they surpass all other project types thanks to the high value of compost as soil conditioner, contributes to their high scoring. A different situation is observed when comparing the projects regarding their sustainable use of fossil fuel. However, the poor score for composting within this criteria is not necessarily reflected in reality to the same extent because the capacity of compost to replace fossil energy intensive chemical fertilizers has not been taken into account in the assessment. Furthermore, our results imply that the sustainability rents of composting projects strongly depend on the project quality. Therefore we propose a list of sustainability requirements for composting projects, which has been compiled using literature research and expert interviews and contains manifold aspects related to project quality. Issues like compost quality, stakeholder inclusion, job generation potential, and labour rights are included due to their great importance for assuring high sustainability rents.

In conclusion, composting projects have a higher potential for both GHG reduction and contribution to sustainable development than landfill gas projects. At the same time, they are financially dis-incentivised by the UNFCCC, a paradox which could be solved by two means: first, by modifying the methodology for the calculation of the emission reductions in order to generate high cash-flows earlier on, second, by remunerating projects for their sustainability contributions. The latter could be assured by sustainability labelling organisations making projects eligible for their sustainability labels or, in a more comprehensive manner, by taking into account the sustainability contributions in the crediting process of the UNFCCC under a post-Kyoto agreement.

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A Annex

Table A1 Name Contact and Area of expertise of experts involved in the elaboration of sustainability requirements

Name and Function	Contact	Area of expertise
Tobias Bandel Joint Managing Director Soil & More International BV Transportweg 7, NL 2742 RH Waddinxveen, The Netherlands	Email: tobias.bandel@soilandmore.com Phone: +31 (0)6 51090674 www.soilandmore.com	Composting projects in developing countries
Paul Butarbutar Country Director Indonesia South Pole Carbon Asset Management Ltd Jl. Terusan Hang Lekir II No. 15 Jakarta 12220 Indonesia	Email: p.butarbutar@southpolecarbon.com Phone: +62 (0)21 726 45 46 www.southpolecarbon.com	CDM project implementation
Jacques Fuchs Phytopathologie FiBL Research Institute of organic Agriculture Ackerstrasse, CH-5070 Frick, Switzerland	Email: jacques.fuchs@fibl.org Phone: +41 (0)62 865-7230 wwProw.fibl.org	Compost quality
Emmanuel Ngnikam Professor at National superior polytechnic school of Yaoundé and Coordinator of the NGO ERA (Environnement Recherche Action au Cameroun)	Email: emma_ngnikam@yahoo.fr Phone: 237 22 31 56 67 http://www.polytechcm.org/ http://www.era-cameroun.com/	Composting in developing countries
Christoph Sutter CEO South Pole Carbon Asset Management Ltd. Technoparkstr. 1, 8005 Zurich Switzerland	Email: c.sutter@southpolecarbon.com Phone +41 44 6337871 www.southpolecarbon.com	CDM and measurement of sustainability
Christian Zurbruegg Head of Water and Sanitation in Developing Countries Eawag, Ueberlandstrasse 133 P. O. Box 611 8600 Duebendorf, Switzerland	Email: christian.zurbruegg@eawag.ch Phone +41 44 823 5423 http://www.eawag.ch	Water and Sanitation in developing countries