Int Environ Agreements (2009) 9:63–80
DOI 10.1007/s10784-008-9088-0

ORIGINAL PAPER

A review of the CDM literature: from fine-tuning to critical scrutiny?

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Accepted: 15 December 2008 / Published online: 4 January 2009

Abstract As negotiations on the post-2012 climate regime are now taking off, it is time to look back and assess the experiences of the clean development mechanism (CDM) to this date. The CDM has been subject to extensive discussion in academic literature during the last few years, and this article reviews that literature in order to sum up its main themes. A common assessment is that the current structure of the CDM leads to a focus on cheap emissions reductions at the expense of sustainable development benefits for the host countries. Recently, the questionable additionality of many CDM projects has become a central issue. The article further argues that whereas a substantial body of work exists on the CDM, this work is mainly preoccupied with a 'fine-tuning' of the mechanism. As the CDM now becomes increasingly institutionalized, scholars should also take a step back and study the CDM in a more theoretically oriented way.

Keywords Kyoto Protocol · Clean development mechanism · Review · Additionality · Cost effectiveness · Sustainable development · Post-2012

Abbreviations

CDM	Clean development mechanism
CERs	Cerified emission reductions
COP/MOP	Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol
DNA	Designated National Authority
DOE	Designated operational entity
EB	Executive Board
GHG	Greenhouse gas
LULUCF	Land use, land use change and forestry
ODA	Official Development Assistance
REDD	Reducing emissions from deforestation and degradation
UNFCCC	UN Framework Convention on Climate Change

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1 Introduction

With the UN climate summit in Poznan in December 2008, negotiations on the successor to the Kyoto Protocol have definitely started. It is quite likely that a future climate regime will use some of the building blocks of the Kyoto Protocol, which means that evaluating these building blocks is of the utmost importance. As the role of developing countries in a future climate regime is one of the major issues in the debate surrounding the negotiations, the clean development mechanism (CDM) is in focus, since it actively engages developing countries in contributing to global greenhouse gas (GHG) emission reduction targets. Through implementing projects that reduce GHGs at low cost in non-Annex 1 countries (developing countries with no binding GHG emission targets under the Kyoto Protocol), and transferring the resulting certified emission reductions to Annex 1 countries (developed countries), the CDM is expected to fulfil a double goal: reduce the costs of Annex 1 countries in meeting their GHG emission targets while at the same time helping non-Annex 1 countries to achieve sustainable development (UNFCCC 1997). Although less clearly stated in the treaty text, the CDM is also expected to contribute to the transfer of technology to developing countries (UNFCCC 2001).

The CDM has been subject to extensive discussion in academic literature during the last few years. This article reviews about 160 articles and reports on the CDM, providing a summary of the main themes discussed.[1] However, it also takes a step back in order to get a broader picture of the literature on the CDM produced so far. Even though a substantial body of work on the CDM exists today, this work, in general, takes a piecemeal approach, evaluating narrowly defined aspects of the mechanism and suggesting improvements. This 'fine-tuning' of the CDM is certainly very important, but in the following it will be argued that as the CDM now becomes increasingly institutionalized, scholars should also move further and study the CDM in a more theoretically informed way.

This article is structured as follows. The following section provides a short introduction to the CDM, for readers who are not familiar with this policy innovation. Next, the main part of the reviewed literature is summarized thematically after the mechanism's two goals: to reduce GHG emissions and contribute to sustainable development in host countries. In Sect. 4, a summary of the most commonly discussed ideas for a successor to the CDM will be made. In the concluding section the main findings of the review are summarized, but the article also takes a step back in order to be able to look ahead.

2 The CDM: a brief overview

Article 12 of the Kyoto Protocol states that "[t]he purpose of the clean development mechanism shall be to assist Parties not included in Annex 1 in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex 1 in achieving compliance with their quantified emission limitation and reduction commitments" (UNFCCC 1997). The detailed rules and procedures

[1] The articles were collected starting in a search on "clean development mechanism" in the electronic article archive ELIN (Electronic Library Information Navigator, http://elin.lub.lu.se/elin), with links to journals from all major publishers. The references of these articles were then searched using a snowballing method until no further references of relevance were identified. The articles and reports referred to in the text were found to be representative of this broader selection of publications.

Table 1 Outline of the CDM project cycle

Stage in project cycle	Participants	Resulting documents
Project development ⇓	Project owner/project developer	Project design document (PDD)
Approval ⇓	Host country DNA (+ ev. Annex 1 country DNA)	Letter of approval
Validation ⇓	DOE_1	Validation report
Registration ⇓	EB	EB decision
Monitoring ⇓	Project owner	Monitoring report
Verification ⇓	DOE_2	Verification report
Certification ⇓	DOE_2	Certification report
Issuance of CERs	EB, CDM registry	

Source: UNFCCC 2001

for the CDM were negotiated in Marrakesh in 2001, but the first CDM project was not registered until 2004.[2]

The CDM has an intricate rule system to make sure that its goals are fulfilled. The highest authority of the CDM is the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol (COP/MOP), but the daily supervision of the mechanism is carried out by the CDM Executive Board (EB). The designated operational entities (DOEs) are firms accredited by the EB to perform the tasks of validating, verifying and certifying the CDM project activities throughout the CDM project cycle (UNFCCC 2001). An outline of the CDM project cycle is provided in Table 1 above.

First, the project developer has to prepare a project design document (PDD) describing the proposed project activity, which is validated by a DOE. To ensure that projects contribute to the sustainable development priorities of the host country, a letter of approval from the Designated National Authority of the host country is also required. Projects that involve an Annex 1 country also need a letter of approval from the DNA of this country. If the project gets a positive validation, the DOE sends its validation report, including the PDD and the written approval of the project from the parties involved, to the EB making a request for registration which then has to be approved by the EB. If the project is registered, the project owner then monitors the emission reductions made by the project and provides a monitoring report to a second DOE for verification.[3] On the basis of the monitoring report and information collected through on-site inspections, the DOE writes a verification report, and if the monitoring is found to be satisfactory, it certifies to the EB that the claimed emission reductions actually have been made. If the EB has no further objections, it issues an amount of certified emission reductions (CERs) corresponding to the verified emission reductions to the project participants through the CDM registry. A

[2] However, to facilitate a prompt start of the CDM, a decision by COP 7 allowed retroactive crediting for projects registered before 31 December 2005. These projects may thus have a crediting period that starts prior to the date of registration, but not earlier than 1 January 2000 (UNFCCC 2001).

[3] In order to prevent conflicts of interest, the same DOE is not allowed to perform both the validation and the verification of one project.

share of the proceeds is subtracted to cover for administrative expenses, and 2% of the CERs are set aside for the adaptation fund (UNFCCC 2001). The remaining CERs can then be used by the developed country actor to count against its own binding emission targets or traded on the carbon market, either on the regulatory market for Kyoto compliance, or on the voluntary offset market.

3 Does the CDM fulfil its double goal?

An impressive number of articles and reports discuss various aspects of the question whether the CDM is fulfilling its double goal, which makes it a useful entry point for structuring this review. These goals will be discussed in more detail in this section. Before doing so, I will first summarize the discussions on the provisions made for controlling that projects live up to these requirements.

3.1 Control mechanisms in the CDM

As already mentioned, the oversight of CDM projects has been entrusted to the DOEs, acting as the interface between project participants and the EB (Betzenbichler 2004). Given their important task to ensure the quality of CDM projects, for a long time surprisingly little was written on the DOEs. It was not until the last couple of years that the issue came up on the agenda. Recently, the market for validation and verification services has become very competitive, which has led to dropping prices and reduced the amount of time that the DOEs can spend to validate each project (Schneider 2007). There is a potential conflict inherent in this situation. As the DOEs want to make a profit, they want to keep their clients and thus have no interest in interpreting the regulations strictly. However, in the long run, insufficient control of projects may undermine the market's confidence in the CDM. An illustration of this conflict is that at least one DOE is known to have made contracts including success-related payments, so that the client did not make the last payment until the project was successfully registered (Schneider 2007). Schneider (2007) suggests that this problem might be solved by letting the EB select and pay the DOEs from the share of proceeds intended to cover administrative expenses (Schneider 2007). Even though the DOEs play an important role in the CDM project cycle, it is the EB that has the final say on whether any CERs shall be issued to a project. The EB is composed of 10 members and 10 alternate members from the parties to the Kyoto Protocol, but has the possibility to establish working groups, panels and teams to help it to perform its tasks (UNFCCC 2001). The UNFCCC Secretariat has also come to play an important role providing long-term organizational support (Streck and Lin 2008). As the administrative resources have increased over time, the EB and its panels have taken on a more active role reviewing the work of the DOEs, and an increasing share of the projects submitted to the EB is being rejected or sent back for review (Schneider 2007).

Since there is no visible good to be traded under the CDM, and since neither the seller nor the buyer has any interest in the emissions reductions per se but simply the right to them, the DOEs and the EB are necessary to uphold the integrity of the CDM market. However, the elaborate control mechanism also implies some transaction costs (Chadwick 2006). Among the CDM-specific transaction costs, preparing the PDD and paying for a DOE to validate it are among the larger posts (Krey 2005). Another substantial expense is the eventual development of a methodology to measure the emission reductions, in case the EB has not yet approved a methodology applicable for the project type in question

(Chadwick 2006). As more methodologies have been approved and as regulatory resources have increased, recent work confirms that 'regulatory bottlenecks' at the EB level have diminished (Lecocq and Ambrosi 2007). Many authors have also raised concerns about the risk that the transaction costs associated with the CDM project cycle will seriously hamper small-scale projects (Chadwick 2006; Fichtner et al. 2003; Locatelli and Pedroni 2006; Michaelowa et al. 2003; Michaelowa and Jotzo 2005). Although registration fees are considerably lower for small-scale projects and simplified methodologies and procedures exist for those projects, many other transaction costs are independent of project size and will thus have a bigger relative impact on small-scale projects.

3.2 Do CDM projects reduce GHG emissions?

As an offsetting mechanism, the CDM does not contribute to any net reduction of total emissions, since the reductions made in CDM projects are used to offset emissions made in developed (Annex 1) countries. This makes it even more important that the CDM projects actually do reduce emissions to the extent that they are credited for. If more CERs are issued than emissions are reduced, the CDM will actually lead to an increase in total emissions (Boyd et al. 2007; Pearson and Shao Loong 2003; Schneider 2007). Article 12 of the Kyoto Protocol, defining the CDM, therefore asserts that emission reductions from CDM projects shall lead to "[r]eal, measurable and long-term benefits related to the mitigation of climate change" and be "additional to any that would occur in the absence of the certified project activity" (UNFCCC 1997). What do these requirements mean, and do CDM projects live up to them? First, additionality will be discussed, since this is in many ways the most central concern, and thereafter the issues of measurability, leakage and permanence.

3.2.1 Are the emission reductions additional?

The notion of *additionality* is one of the most intensively discussed issues concerning the CDM. This is not surprising, since the question of whether CERs will be issued to non-additional (business-as-usual) projects or not is critical for the environmental integrity of the CDM. To decide whether a project is additional or not, an additionality test is used. In the early debates on additionality, two main definitions of additionality were discussed: *environmental* (or *emissions*) additionality and *financial* additionality. An environmental additionality test concludes whether emissions will be reduced compared to a situation without the project, whereas a financial additionality test concludes whether the project would have occurred would it not have been for the income from the sale of resulting CERs (Pearson and Shao Loong 2003). Critics argue that an environmental additionality test would mean that business-as-usual projects are accepted in the CDM, since such a test does not make any difference between projects that are planned independently of the CDM and projects that get off the ground because of the revenues from the sale of CERs (and thus reduce emissions also compared to a situation without the CDM) (Pearson and Shao Loong 2003). However, in the Marrakesh Accords, Parties did not adopt any specific approach, but agreed that a CDM project is considered additional "if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity" (UNFCCC 2001). The EB provides guidance on how this should be interpreted, and basically four different ways of demonstrating additionality are used, often in combination. Some project types are directly assumed to be additional since the CER-revenue is the only incentive for implementing them. So far, this rule has only been applied to projects destroying HFC-23 in HFC-22 production. The most common way to demonstrate additionality is through barrier analysis (Schneider 2007). This means that it can be demonstrated that barriers exist that would prevent the project from being realized if it was not registered as a CDM activity. Investment analysis demonstrates that the proposed project is financially less attractive than at least one other credible alternative. Finally, the common practice analysis considers whether the proposed project type is already commonly deployed in the relevant sector or region (Schneider 2007).

In recent years, the current approach of testing additionality has become the subject of discussion. A study of Michaelowa and Purohit of 52 Indian CDM projects concludes that the information provided in the PDD in many cases is insufficient for DOEs to assess additionality in a transparent way. The packaging of information also affects the result of the additionality test. If the project developer manages to conceal the economic attractiveness of the project in the PDD, it is more likely to pass the test (Michaelowa and Purohit 2007). The NGO International Rivers argues that all projects face barriers to some extent and that the barrier analysis is thus not credible as an additionality test (Haya 2007). Schneider (2007) also contends that it is likely that "a significant amount of registered projects" are not additional. To improve the credibility of the additionality analysis, Schneider suggests that the barrier analysis and the investment analysis should become more objective, with more detailed guidance from the EB on how the analysis should be performed. He also argues that it should be mandatory to demonstrate in what way the CDM has a meaningful impact in increasing the economic attractiveness of the project or overcoming the identified barriers (Schneider 2007). How an additionality test should be designed is, in the end, an optimization problem: a balance has to be struck so that not too many non-additional projects are allowed under the CDM, whereas at the same time not too many truly additional projects are ruled out (Sterk 2008).

3.2.2 Making emission reductions measurable: defining the baseline

To measure the emission reductions achieved by a CDM project, a *baseline* is used. The baseline is a counterfactual scenario describing the amount of GHGs that would be emitted if the project was not implemented, that is, under business-as-usual circumstances. Through subtracting the actual verified emissions from the baseline and accounting for leakage (see next section), the amount of CERs to be issued to the project is calculated. Three different principles for baselines are allowed in the CDM: existing or historical emissions, emissions from an economically attractive course of action, and the average emissions of similar projects undertaken in the previous 5 years under similar circumstances, whose performance is among the top 20% of their category (UNFCCC 2001). The EB has approved a range of baseline methodologies using these principles, and in case none of the existing methodologies is applicable to a new project, the DOE can submit a proposal of a new methodology to the EB for approval (UNFCCC 2001).

In the years after these three principles for baseline creation were settled in the Marrakesh Accords in 2001, several publications discussed how the principles should be interpreted (e.g. Bode and Michaelowa 2003; Fischer 2005; Kartha et al. 2004; Laurikka 2002; Painuly 2003; Winkler and Thorne 2002). In some cases, the baseline is easy to set, e.g. when the project increases energy efficiency or reduces emissions of GHGs from an existing plant, where earlier emissions are known. In other cases, the baseline will be much more ambiguous. If a new power plant using renewable energy is registered as a CDM project, what should its emissions be compared to? During the last few years, the discussion on baselines has been rather technical, mainly focusing on how baselines should be constructed for different project types (see e.g. Kallbekken et al. 2007; Sharma and Shrestha 2006; Shrestha and Abeygunawardana 2007; Zhang et al. 2006). In cases where several different principles can be used for setting the baseline, the amount of CERs issued may vary considerably depending on what alternative is chosen (Painuly 2003). To ensure the environmental integrity of the CDM, it is thus important to set the baseline in a conservative manner (Boyd et al. 2007). Today, baselines are developed by project participants and approved by the EB, but to increase their credibility, Sterk (2008) argues that the current bottom-up approach should be replaced by a model where the EB also develops the methodologies.

The issues of additionality and baselines are central for the environmental credibility of the CDM, and both issues are controversial in that they involve comparisons with a counterfactual scenario. These questions are thus likely to stay on the agenda as long as a CDM-like mechanism is part of the climate regime.

3.2.3 Are the emission reductions real? The issues of leakage and permanence

In order to be 'real', a claimed emission reduction in the CDM project should of course take place, which the DOEs are supposed to check. But it should also not lead to an increase in emissions elsewhere. This is referred to as the risk of *leakage*. In the Marrakesh Accords, leakage is defined as "the net change of anthropogenic emissions by sources and/or removals by sinks of GHGs, which occurs outside the project boundary, and that is measurable and attributable to the [...] project" (UNFCCC 2001). Schwarze et al. (2002) distinguish between two types of leakage: activity shifting and market effects. Others use the terms 'primary' and 'secondary' leakage to describe the same phenomena (Boyd et al. 2007). An example of activity shifting (or primary leakage) could be a forest-conservation project displacing farmers living in the project area, leading them to clear adjacent forests. Market-driven (or secondary) leakage would occur if a successful forest-conservation project reduces the local timber-supply, leading to increased prices and thus inducing a larger pressure on unprotected forests elsewhere (Schwarze et al. 2002). Leakage has mostly been discussed in connection with forest-conservation projects, and much of this discussion is not very relevant any more since this project type finally was not included in the CDM. The large risk of leakage in forest-conservation projects was, in fact, one of the main reasons for excluding them from the CDM (Boyd et al. 2007). However, leakage might also occur in other project types. Another example of market-driven leakage could be that projects building relatively clean-burning natural gas plants increase the price of natural gas in an area, creating a relative advantage for coal or oil (Schwarze et al. 2002). To account for the problem of leakage, it was decided in the Marrakesh Accords that adjustments should be made for leakage when calculating the amount of CERs to be issued from a CDM project (UNFCCC 2001).

The *permanence* of carbon sequestration is an issue relevant only for forestry projects, and possibly in the future also for CCS (carbon capture and storage), although this project type is not yet allowed in the CDM. It refers to the fact that the storage of carbon in forests is not necessarily permanent but can be reversed in the future, voluntarily or accidentally. Before the rules on forestry projects for the CDM were agreed upon, there was a long discussion on how to handle the permanence issue in terms of the issuance of CERs (Dutschke 2001; Kerr and Leining 2000; Maréchal and Hecq 2006; Marland et al. 2001). One of the most frequently occurring proposals was the ton-year approach, where temporary carbon sequestration was to be converted into permanent credits through an equivalence factor based on the residence time of carbon dioxide in the atmosphere (Maréchal and Hecq 2006). Finally, the delegates at the 9th Conference of the Parties (COP) in Milan in 2003 agreed upon the "Colombian proposal," introducing the concept of expiring credits (Dutschke et al. 2004). An expiring credit is valid only during a defined period of time and then has to be replaced with another credit, expiring or permanent. This decision thus provided a way of dealing with the problem of permanence, and the issue has not been much discussed since. However, temporary credits have turned out to fetch lower prices than permanent credits, and forestry projects are not taking off as expected under the CDM.

3.3 Sustainable development

The difficulties to solve the additionality problem discussed above were identified already by Grubb et al. (1999). They stated that "if real, quantified additionality in the form of assessing 'what would have happened without the crediting' is so uncertain, then real policy should not be based primarily on the chimera of accurate quantification" (Grubb et al. 1999, p. 230). Instead, they suggested that the CDM should primarily be used as a lever for achieving sustainable development. So, to what extent does the CDM contribute to sustainable development in host countries? Many authors argue that there is an inherent bias in the CDM towards promoting cost-effectiveness at the expense of sustainable development, since sustainable development has no monetary value in the mechanism. In the first section below, the conflict between these two goals is further discussed. The next section examines how the sustainable development benefits for host countries could be increased. The last section discusses the possibilities of the CDM to promote technology transfer.

3.3.1 The conflict between cost effectiveness and sustainable development

In comparing the effects of likely CDM projects with national development priorities in China, India and Brazil, Austin et al. (1999) argue that there is a substantial overlap between the two. Often, though not always, the projects preferred in terms of climate mitigation impact also tend to bring the largest sustainable development benefits (Austin et al. 1999). This positive view of the possibilities of the CDM to bring about its double aim has been seriously challenged in more recent articles. Several authors identify an inevitable trade-off between cheap emission reductions and sustainable development as one of the main problems with the CDM (Ellis et al. 2007; Olsen 2007; Pearson 2007; Sutter and Parreño 2007). It is argued that credits from cost-effective, large-scale projects, with little or no sustainable development impact (such as the capture and destruction of HFC-23, a very powerful GHG) are likely to dominate the market, whereas smaller projects which are generally supposed to contribute more to sustainable development are too expensive to carry out (Ellis et al. 2007; Muller 2007). Since the CDM is a market-driven mechanism and there is no market incentive to promote sustainable development, this is not seen as surprising (Ellis et al. 2007; Pearson 2007).

Since public funds are limited, private investments are seen by many authors as the key to large scale GHG mitigation (Zhang and Maruyama 2001). Basically, private actors have two incentives for participating in the CDM: to comply with their emissions targets or to make a profit. According to Kolk and Pinkse, companies primarily view the CDM as a business opportunity. Multinational corporations exploit their presence in developing countries by financing projects that can be registered as CDM activities (Kolk and Pinkse

2007). Interestingly, the trade structure of the CDM has not developed quite as anticipated. It was thought that the CDM would follow an investment model, where actors from developed countries would invest in projects and then receive the emission reductions achieved in exchange. But today, the CDM works more like a commodity market, where emission reductions are produced in projects initiated by the host country or by firms that invest in developing countries anyway, and then are sold on the market without any interference of the buying party (Lecocq and Ambrosi 2007). In the context of the conflict between cheap emission reductions and the sustainable development goal of the CDM, an early assessment by Grubb et al. (1999) is quite interesting, stating that:

> "The conventional view of the CDM in most OECD countries is that it should be primarily a way of minimizing the costs to them of the Kyoto commitments, by allowing investment in emissions-avoiding activities to generate credits wherever it is cheapest to do so. [...] [T]his is unlikely to be how the CDM can—or even should—work in practice. Rather, it is concluded that the primary role of the CDM should [be to] guide foreign corporate investment in developing countries towards goals of sustainable development." (Grubb et al. 1999, p. 226)

In hindsight, it is quite clear that the focus on cheap emissions reductions that Grubb et al. experienced as the "conventional view of the CDM in most OECD countries" in 1999 has been dominating ever since, perhaps in an even more pronounced way than predicted. Previously, most commentators expected fuel switching, energy efficiency and forestry projects to dominate the CDM market. That projects abating gases other than carbon dioxide would account for more than 70% of CERs produced in the CDM's first one and a half years came as a surprise to most analysts (Lecocq and Ambrosi 2007). Although this development proves that the CDM can function as a real market, identifying the cheapest options to reduce emissions, it limits the scope of the CDM to promote sustainable development and spread energy efficient technology. However, the potential for projects reducing the most powerful industrial GHGs will soon be fully reaped, and in the most recent figures renewables and energy efficiency projects are catching up (UNEP Risoe Centre 2008). Depending on the evaluation method used, different project types can also be rated differently in terms of sustainable development benefits. Analyzing the PDDs of 744 registered CDM projects, Olsen and Fenhann (2008), for example, concluded that contrary to expectations, projects reducing methane (CH_4) in general had a high number of sustainable development benefits compared to energy efficiency projects. Small-scale projects had a slightly higher number of sustainable development benefits than large-scale projects, especially socio-economic benefits, but the largest differences could be attributed to project type (Olsen and Fenhann 2008).

3.3.2 How can the benefits for host countries be increased?

It is the task of the host country to decide whether a proposed CDM project contributes to the country's sustainable development priorities and in most countries this task lies with the DNA (Boyd et al. 2007). However, this means that host countries vary a lot in their requirements on projects. In practice, many countries are primarily interested in attracting investment and, thus, do not require very much in terms of additional sustainable development benefits. Competition among non-Annex 1 countries to attract CDM investment could also lead to a 'race to the bottom', where sustainable development standards are set lower and lower to create favourable conditions for investment (Sutter and Parreño 2007). The lack of common standards is seen as problematic. Suggestions have been made to create an international standard for assessing the sustainable development benefits from projects (e.g. Olsen and Fenhann 2008), but it is an open question whether this would be politically feasible or even practically possible given the context-specific nature of the notion of sustainable development. Another way of solving this problem could be to create a market demand for high quality projects through the establishment of high standard credits such as the Gold Standard (Humphrey 2004). On the other hand, critics have argued that initiatives such as the Gold Standard might lead to ordinary CDM projects being labelled as 'dirty', thus in the end being counterproductive (Michaelowa 2005).

Not surprisingly, there is broad agreement that the sustainable development benefits that accrue to developing countries from the CDM depend on how the mechanism is designed as well as on local conditions (Humphrey 2004; Michaelowa 2003; Miranda et al. 2002; Zhang 2006). Many articles on developing countries in the CDM consequently focus on how the institutional capacity of host countries could be developed to increase benefits (Ellis and Kamel 2007; Humphrey 2004; Jung 2006; Michaelowa 2003; Miranda et al. 2002; Zhang 2006). Several authors emphasize that host countries could actively coordinate CDM activities with local development goals to increase the benefits of projects (Michaelowa 2003; Miranda et al. 2002; Zhang 2006). This could be done through rent extraction, where an income tax is imposed on CDM projects and the revenues are earmarked for sustainability projects in the host country. The tax could also be differentiated according to the projects' contribution to sustainable development (Muller 2007). This is already happening to some extent. China has, for example, chosen to apply a differentiated tax on CDM projects, giving incentives to projects contributing more to its development priorities (Muller 2007).

The impact of CDM projects on the local population depends heavily on the project type, and the same project may also affect different groups of people in different ways. Studying the impact of land-use change and forestry projects on the rural poor in India, Gundimeda (2004) concludes that the poor, depending heavily on forest resources, are most likely to lose from these projects. To improve the sustainability of projects, Gundimeda argues that a balance has to be struck between the short-term needs of the local population and the demands from the international community of long-term carbon storage. Brown and Corbera (2003) discuss similar issues in a paper on equity in the CDM. Their conclusion is that differences in property rights between social groups lead to an unjust distribution of the benefits from forestry projects in the CDM. On the basis of a case study on a reforestation project in Costa Rica, Miranda et al. (2002) emphasize that if the local population benefits from the reforestation project, it is more likely to succeed.

To make sure that CDM projects benefit the local population, it is required that project developers invite comments from local stakeholders on the project design (UNFCCC 2001). However, critics argue that this consultation often takes place late in the planning process when most decisions are already taken, and that it does not guarantee any real influence over decisions (Lövbrand et al. 2007). Accountability mechanisms are also largely lacking in the CDM, and several authors suggest that the creation of some kind of appeals procedure to secure the rights of local stakeholders, investors and governments (Baumert and Petkova 2000; Streck 2007; Streck and Lin 2008).

So far, the distribution of CDM projects has been rather unequal, with projects being concentrated in a few countries in Asia and Latin America (Boyd et al. 2007; Michaelowa 2005). Funding for capacity building has mainly gone to countries with a perceived potential for providing cost-effective CERs (Silayan 2005). To improve the geographical spread of projects, several authors suggest that efforts should now be put into capacity building in the poorest countries (Ellis and Kamel 2007; Jahn et al. 2003; Jung 2006;

Silayan 2005). However, some conditions for a well-functioning CDM market are more difficult to change than others. The supply of feasible emission reduction projects and political stability are basic requirements but hard to influence through capacity building. Ellis and Kamel (2007) identify three key areas where capacity building activities are worthwhile. These are the CDM-specific framework and policy of the host country, the CDM-related institutions and their capacity, and the awareness of climate change and the CDM among relevant stakeholders. More specific suggestions include the promotion of local DOEs (Zhang 2006) or of local intermediary firms specializing in the coordination of CDM activities (Humphrey 2004). Even though it is clearly stated in the rules of the CDM that CDM investment should not lead to any diversion of Official Development Assistance (ODA), some authors argue that public funds could be an important complement to private investments to make the distribution of CDM projects more equal (Zhang and Maruyama 2001; Dutschke and Michaelowa 2006). Banuri and Gupta (2000) provide a more radical suggestion on how to level the playing field between host countries: If the contribution to the adaptation fund from CDM projects was differentiated according to the level of per capita income in the host countries, it would become more economically attractive to invest in the poorest countries.

Another opportunity to counter the tendency of unequal geographical distribution is to promote *unilateral* CDM, where projects are developed and financed solely by domestic actors. Since transaction costs may be lower for local investors having better knowledge about regional conditions than foreign investors, unilateral CDM could be a possibility for countries that are considered too risky to attract bilateral CDM investment to still get some benefits from the CDM (Jahn et al. 2003). Using a model for identifying countries with the best potential for carrying out unilateral CDM projects, Jahn et al. (2004), however, find that countries in Asia and Latin America that already receive a substantial part of bilateral investment are also the most likely countries to carry out unilateral projects, suggesting that unilateral CDM might not after all be a feasible solution for the poorest countries. This is also in line with Michaelowa's findings that the proportion of unilateral projects decreases between the CDM pipeline and registration of projects, suggesting difficulties in attracting financing (Michaelowa 2007).

3.3.3 Does the CDM contribute to technology transfer?

Although not explicitly stated in the Kyoto Protocol, it is often argued that one way in which the CDM could contribute to sustainable development in non-Annex 1 parties is through the transfer of clean technology (Haites et al. 2006). Technology transfer could contribute to environmental ‘leap-frogging’ in developing countries, putting them on a cleaner track early on in their industrialization (Forsyth 2005). The potential access to new technology could also be an incentive for non-Annex 1 countries to participate in the CDM (Millock 2002). However, the meaning of technology transfer has led to considerable discord between developed and developing countries, relating to different views on the obligations of developed countries. The main conflict concerns property rights, where developing countries view technology transfer as a transfer of property rights, whereas the enterprises in developed countries providing the relevant technology see technology transfer as new business opportunities (Forsyth 1999, 2005). Aslam (2001) provides a good example of what benefits technology transfer is expected to bring from a developed country's perspective, in terms of export to new markets.

Foreign direct investment is often seen as the model for technology transfer in the CDM. However, Humphrey (2004) argues that partnerships between developed (Annex 1) and developing countries could be more rewarding in terms of technology transfer. Whereas foreign direct investment leads to the transfer of the *results* of technological development, joint ventures between local companies and specialist technology suppliers from Annex 1 countries might lead to the transfer of technology *capabilities* (Humphrey 2004). According to Haites et al. (2006), one-third of PDDs state that the project contributes to technology transfer. The transfer of technology is more common in bilateral than in the unilateral projects, indicating that the active participation of Annex 1 parties promotes technology transfer (Haites et al. 2006).

4 Role of the CDM in a future climate regime

Most authors anticipate that the CDM in some form will be included in the post-2012 climate regime (e.g. Michaelowa et al. 2005a, b; Streck and Lin 2008), perhaps in combination with more flexible levels of commitments so that some developing countries are able to take on binding commitments (Christiansen 2004). Some scholars suggest that the CDM should be reserved for the least developed countries (Lecocq and Ambrosi 2007). If the CDM seriously aims at contributing to sustainable development, most authors agree that the link between sustainable development and GHG mitigation has to be strengthened. Ellis et al. (2007) argue that even if a stronger focus on sustainable development results in more expensive projects, the potential of the mechanism to contribute to local sustainable development is likely to be the key to motivating developing countries to take on future mitigation commitments. To more effectively stimulate the development of energy-efficient technologies, Wara (2007) argues that the CDM should deal exclusively with CO_2 emissions. To solve the additionality problem, Schneider (2008) suggests that CERs in the future should be discounted, so that more CERs would be required to offset a given amount of GHGs. On an aggregate level, the CDM would then actually provide real "atmospheric benefits."

When it comes to the design of the CDM (or another project-based market mechanism for emissions reductions) in a future climate regime, there are as many ideas as there are authors. Cosbey et al. provide a good overview, sorting the different approaches into five broad categories (Cosbey et al. 2007). The focus here will be on the most frequently discussed suggestions of new project types under the CDM post-2012: the partly overlapping concepts of sectoral CDM and programmatic CDM, and the possibility of including avoided deforestation under the CDM. Both of these concepts have been dealt with in earlier issues of this journal (see Michaelowa et al. 2005a, b for a general discussion on the post-2012 climate regime, Sterk and Wittneben (2006) for a good introduction to the sectoral approach and Palm et al. (2008) for an overview of the literature on forestry in the CDM), so they will not be examined in great detail here.

4.1 Sectoral CDM and programmatic CDM

One of the most frequent suggestions of new project types is the sectoral CDM. Different authors have different ideas about what should constitute a sectoral approach, but it is possible to identify a few main alternatives. In the most widespread notions, 'sectoral' refers to industrial sectors. Through setting a common baseline for an industrial sector, nationally or internationally, it is possible to issue credits for all emission reductions below that baseline. The baseline could be either fixed or flexible, relating to, for example, sector output (Bosi and Ellis 2005; Sterk and Wittneben 2006). The most suitable baseline design may vary between sectors. A sector with homogenous and internationally traded products may be well suited to a transnational sectoral crediting mechanism. Such a mechanism would also reduce the risks of loss of competitiveness and leakage (Bosi and Ellis 2005).

Others use the term sectoral CDM to refer to a policy-based mechanism where a government receives CERs for implementing policies that lower GHG emissions in either a particular sector or a region. However, defining a baseline and measuring the emission reductions attributable to the policy is difficult (Bosi and Ellis 2005). This form of sectoral CDM is similar to "programmatic CDM," where a private actor or government coordinates a programme of activities intended to reduce emissions, which is already permitted in the CDM (Sterk and Wittneben 2006). The main difference is that programmatic CDM focuses on individual projects, although they are coordinated, whereas the policy-based mechanism is not connected to individual project activities (Sterk 2008). An example of a programmatic CDM activity could be replacing inefficient domestic appliances (Reddy and Balachandra 2006). However, a case study on a similar project suggests that it can be difficult to change consumption patterns without heavy subsidies (Khalil et al. 2006).

Sectoral and programmatic CDM are seen to be promising since they are assumed to contribute to the structural changes necessary to promote long-term mitigation of GHG emissions in developing countries, and also could make projects with larger sustainable development benefits viable under the CDM (Sterk and Wittneben 2006).

4.2 Avoided deforestation

There has been a lot of debate concerning the question of whether forestry projects should be eligible for the CDM or whether they divert efforts from permanent reductions in energy consumption (Fearnside 2001). Under the first commitment period of the Kyoto Protocol, only afforestation and reforestation activities are eligible as CDM projects. Avoided deforestation is not included, partly because of difficulties in monitoring leakage from such projects, but also because of the potentially large supply of cheap carbon credits that would weaken the commitments already made by Annex 1 countries (Schlamadinger et al. 2007). Much of the discussion on the role of forestry projects in a future climate regime therefore concerns whether avoided deforestation should be allowed or not in the CDM. At COP 13 in Bali, a work programme called 'Reducing Emissions from Deforestation and Degradation' (REDD) was initiated to deal with emissions from the forestry sector. One of the objectives of this programme is to come up with recommendations on methodologies that would make it possible to include REDD projects under the CDM. Central problems concern the establishment of a baseline and the issues of permanence and leakage, but it is hoped that modern technology could help solve some of the issues relating to monitoring and the establishment of baselines (Clémençon 2008).

5 Summary and outlook

As we have seen in this review, a large body of work on the CDM has been published in the last 10 years. Some of the themes discussed were identified early on as key issues. The question of how to ensure the additionality of CDM projects was, for example, a main concern already when Grubb et al. wrote about it in 1999. Other questions, such as how to account for emission reductions from forestry projects, were intensively discussed in the early years of the Kyoto Protocol but then settled by decisions from the COP or the EB. This interaction between researchers and policymakers is discussed by Palm et al. (2008), drawing on the literature concerning forestry projects in the CDM. Several issues came up as CDM was implemented and the mechanism did not always develop the way analysts thought it would. Against expectations, projects eliminating industrial gases became very popular, raising concerns about the lack of sustainable development benefits of CDM projects. Transaction costs turned out to be higher than expected, drawing attention to potential solutions for this problem. In the last few years, the role of the CDM post-2012 has dominated the debate.

What can be concluded from this review of literature? Is the CDM a win–win mechanism providing both sustainable development and cost-effective emission reductions, or is it just another cheap way out for developed countries at the expense of developing countries hungering for investments? Most evaluations are rather moderate in their judgment, acknowledging that the CDM is working quite well in terms of its ability to provide CERs, but also highlighting problems such as the inequitable geographical distribution of projects and the lack of sustainable development benefits from many projects. As noted earlier, a common conclusion is that the market structure of the CDM and the resulting focus on cheap emissions reductions lie behind these problems. Recently, the issue of additionality has risen on the agenda again, with several authors seriously questioning the way additionality is currently assessed. This is likely to be a key issue in the years to come, both for upholding the credibility of the current CDM and in the negotiations on its successor. However, the never-ending flood of suggestions on how to improve the mechanism provides evidence that most scholars do not consider the CDM a lost case.

But even though many aspects of the CDM are discussed in this body of work, most articles take the existence of the CDM as their rather unproblematic starting point and focus on the fine-tuning of some particular aspect of the mechanism. Using Cox's (1981) distinction between "problem-solving" and "critical" theory, the main part of the research reviewed in this article can be classified as problem-solving. Although certainly useful in the day-to-day policy-making process, problem-solving research works within the current paradigm and thus never calls the prevailing system into question. As Wapner recently argued, a realistic environmental agenda must go further than that and "retain its ability to step back from contemporary events and analyze the structures of power at work" (Wapner 2008, p. 12). The discussion seems to have been less narrow before the rules of the CDM were agreed upon in the Marakesh Accords in 2001, but among the articles written since, only a handful have been identified where the authors try to take this step back and look at the CDM from a broader perspective. Among these publications, two main types can be identified. Some very critical voices question the whole idea of a CDM-like mechanism in the climate regime. One example is Bachram (2004), who describes the CDM as "carbon colonialism" and argues that the CDM transfers the burden of reducing emissions to developing countries while distracting attention from the changes urgently needed in the developed countries (Bachram 2004). Lohmann (2006) similarly points at the problems faced by local inhabitants when CDM project activities infringe on their ordinary use of the land. He also highlights the perverse initiative that the CDM provides for companies to keep polluting activities going in order to be able to claim more emission reduction credits from them (Lohmann 2006). The second group of articles takes one step further away and look at the CDM through a theoretical lens. Matthews and Paterson (2005) provide one interesting example of this kind of work, using elements of Marxist theory to explain the logic behind the climate regime. From this perspective, the CDM can be seen as a new site of capital accumulation, legitimized by an ecological modernization discourse (Matthews and Paterson 2005). Bumpus and Liverman (2008) use similar theoretical tools comparing the CDM and the voluntary carbon market. Streck (2004) uses the CDM to illustrate a new form of networked governance, where an international treaty is implemented through partnerships between public and private actors.

Clearly, these more theoretically oriented articles provide important insights as to how the CDM can be understood, and constitute an important complement to the more policy-oriented literature dominating so far. One can thus only wish that this handful of articles soon will be followed by others.

Acknowledgements Valuable comments on previous draft versions were provided by Karin Bäckstrand and Johannes Stripple, as well as the editors and two anonymous reviewers. Funding from the Swedish Energy Agency is gratefully acknowledged.

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