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Toward MDG1 & 7 through Development Aid or Emissions Trading?

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Abstract

The shared and partially conflicting interests in poverty alleviation and development on the one hand and climate change mitigation on the other, has produced two major instruments within international agreements: 1) the Clean Development Mechanism (CDM) as a product of climate change negotiations; 2) the Millennium Development Goals (MDGs) to reduce global poverty. Both systems share some goals but apply very different methods to achieve these goals.

My research project attempts to provide an indication of how well climate change protection can be incorporated in poverty alleviation measures and how well poverty alleviation can be incorporated in the emissions trading regime. This will be discussed by assessing to what extent an MDG-supporting renewable energy project contributes to the MDGs and whether similar effects can be achieved if the project was funded via emissions trading.

In the study, I will analyse project outcomes with respect to poverty alleviation and greenhouse gas emission reduction. This will be compared to the feasibility of the project under the emissions trading regime and the possible effects on poverty reduction.

The study is supported by data collected during a field study in project and non-project villages.

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Introduction

Climate change is a threat to global security and demands collective action, but poverty alleviation and development are often of higher priority to developing countries than solving environmental problems. Yet, developing countries will be affected more severely by climate change due to the geographic location of most of these countries and their relatively lower capacity to cope with climate change impacts. The shared and partially conflicting interests in poverty alleviation and development on the one hand and climate change mitigation on the other, has produced two major instruments within international agreements: 1) the Clean Development Mechanism (CDM) as a product of climate change negotiations; 2) the Millennium Development Goals (MDGs) to reduce global poverty.

With the growing awareness that long-term development will be strongly influenced by climate change impacts, development assistance has increasingly embraced activities related to climate change. This is a direct result of the growing awareness of climate change effects occurring and growing in frequency, and the negative impact these have particularly on the poor. But it also denotes a paradigm shift from an income-based conception of poverty towards a multi-dimensional definition that includes social, economic and environmental causes and effects of poverty.

Generally, however, climate change mitigation is associated with the Kyoto Protocol agreements. It might seem surprising to see it included in the MDGs. This is particularly the case, as developing countries fear that funds originally assigned for poverty reduction could be diverted to fulfil obligations towards the Kyoto Protocol. At the same time, CDM projects have been exposed to increasing pressure from international non-governmental organisations to deliver positive spill-over effects for the host community. This refers to the dual mandate of the CDM not only to mitigate climate change but, in doing so, to also promote sustainable development in the host country[1]. In the CDM literature, sustainable development is most often discussed in relation to activities that involve poor communities for which relatively high positive social, economic and environmental impacts can be expected[2].

If both the MDGs and the CDM are applied for poverty alleviation and climate change mitigation, what are the effects of fostering these changes within either framework?

In order to explore this question, I will assess a development project that can potentially fulfil both objectives, (i) poverty alleviation and (ii) climate change mitigation. This will be discussed on the basis of empirical evidence from a poverty alleviation project that utilises renewable energy to supply water for irrigation in remote villages of Zhejiang Province in China. The project has been carried out by the Bremen Overseas Research and Development Association (BORDA), a German non-governmental organisation engaged in development co-operation projects in Asia and Africa. At the core of their project in Zhejiang is the transfer of renewable energy technology which has mainly consisted of the subsidised supply of the hydraulic ram pump to poor communities. The hydraulic ram uses the kinetic energy from a stream or river to lift the water and hence does not require any electricity or fossil fuels. With the dissemination of the ram pump, the project thus constitutes a contribution towards both poverty alleviation and climate change mitigation.

Relevance of Poverty Alleviation and Climate Change Mitigation in Zhejiang

Although Zhejiang belongs to the wealthy provinces along the Eastern coast, income disparities between the urban and rural population has been on the increase. Wan and Zhou observe that significant income disparities can exist between villages within a province and between households within a village[3]. Information on the number of the poor in Zhejiang and other provinces is sparse, but in the year 2004 105,000 people were officially reported to live on less than 1$ a day[4]. The provincial government has identified 211 “less-developed” townships and villages that lack basic infrastructure such as roads, electricity, water supply and telecommunication. Hence, despite the fast economic growth in the province over the past two decades, there is still need for poverty alleviation measures.

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[1] UNFCCC 1998, Article 12.2
[2] cf. Olsen 2007
[3] Wan & Zhou 2004, p.4
[4] MOST 2005

Moreover, China has witnessed a rising incidence of extreme weather events and natural disasters that has temporarily displaced thousands of people and driven many into poverty[5]. Zhejiang experienced typhoons in 2004 and 2006 and was affected by snow storms in early 2008 which are highly unusual in this Southern province. The Intergovernmental Panel on Climate Change has repeatedly documented a global trend of extreme weather events associated with climate change[6]. As part of their climate related policy, China is particularly interested in technology transfer to implement a more sustainable development path. In its Poverty Reduction Programme of 2001, the national government "encourages peasants to develop ecologically- and environmentally-friendly agriculture" and intends to widen international co-operation to achieve this[7]. Between 1995 and 2003 rural electricity demand rose from 169.17 GWh to 409.04 GWh and diesel used for agriculture increased from 1.032 million tons to 1.758 million tons (Zhejiang Statistical Bureau 2004, p.270-279). Although industry is largely responsible for soaring greenhouse gas emissions in the province, agriculture does further contribute to rising emission levels.

Within this context, this study will evaluate the impact of the hydraulic ram project on poverty alleviation and CO_2 emissions reductions between 2001 and 2006. This period was chosen, as the project has since been funded by the German government to contribute towards the MDGs. The objective is to analyse the project within an MDG context and discuss possible changes that might occur within a CDM framework. It will first be necessary to establish whether the two objectives of interest can actually be fulfilled. It will further be of interest to establish, whether project outcomes are expected to change if it was carried out within the Clean Development Mechanism.

Methodology

For the purpose of this discussion, I will focus on MDG indicators 1 and 28, the former measuring progress in terms of the 1$ per day poverty line, the latter quantifying CO2 emissions per capita. The selection of the 1$ a day measure is based on two considerations, (i) it reflects the main objective of the project of interest, i.e. to improve the income of poor households through the provision of water supply for agricultural production; and (ii) it offers a parallel to the poverty alleviation indicator as prescribed by the sustainable development assessment tool of the CDM Gold Standard. The latter evaluates project contribution to poverty alleviation "by calculating the change in number of people living above income poverty line compared to baseline".[8] It is important to note that the baseline definition within CDM differs from the definition of the MDGs. While the MDGs seek to increase the number of people having access to certain commodities

[5] ReliefWeb 2005

[6] IPCC Assessment Reports, e.g. IPCC AR4

[7] Chinese Government 2001

[8] Ecofys 2005, p.34

The reason for choosing the CDM Gold Standard as reference is due to a lack of a standard definition provided by UNFCCC documents. Instead, it was decided in the Marrakech Accords that the definition of sustainable development and the assessment of CDM project contribution towards this end should be left to the individual host country (UNFCCC 2002, p.20).

and improving their capacities with reference to the 1990 base year[9], the CDM baseline measures desired outcomes in relation to a dynamic business-as-usual scenario in which the reference value is likely to change over time. Theoretically this implies that in a situation where poverty incidence is expected to increase, the CDM activity would be considered to measure positive poverty outcomes already, if it merely reduced the number of people falling into poverty. In contrast, the MDGs require that poverty has to be reduced with respect to the base year. These shall both be considered in the project impact assessment.

The diverging interpretations of poverty alleviation measures are due to differing priorities of the two frameworks. Correspondingly, the MDG indicator concerning CO_2 emissions is rather vague compared to the numerous specifications of baseline and additionality methodologies developed under the United Nations Framework Convention on Climate Change (UNFCCC). MDG indicator 28 neither provides a specified target nor does it advise on an acceptable per capita emissions level. Taking reference from MDG indicator 27, in which improvements in energy efficiency are to be preferred for a given stage in economic development[10], it can be assumed that lower CO_2 emissions are preferred for a given level of per capita income. Within the UNFCCC, GHG emission reductions are measured relative to the business-as-usual scenario[11]. In the case of CDM activities in developing countries, this means that any emission level that is lower than its expected value at a given future point of time is considered an emission reduction. As MDG indicator 28 lacks a clear signal of how to evaluate the scale of project contribution, the UNFCCC methodologies shall here lend the basis for the project impact assessment.

The Poverty Line

In 2001, the Chinese government adopted the 1$ poverty line as estimated by the WB in purchasing power parity (PPP) of 1993[12]. Chinese authorities call this the ‘low income’ threshold. This differs from the national poverty line, which the World Bank estimates to be equivalent to 0.75$ a day in PPP terms[13]. According to a paper by the National Bureau of Statistics, the national poverty line was 630 RMB in 2001 and was adjusted upwards in 2003 to 637 RMB[14]. The 1$ a day ‘low income’ line was estimated by the World Bank at 872 RMB in 2001 and was adjusted upwards in 2004 to 888 RMB[15]. Local authorities and university personnel in Zhejiang agree that both the national poverty line and the ‘low income line’ do not reflect the actual necessary income to satisfy the assumed basic consumption level. Researchers and local authorities maintain, they use 1000 RMB as the ‘low income poverty line’. In the China Quarterly Update of January 2008 the World Bank acknowledged, that previous PPP calculations had been too low[16]. In an online discussion on this update, Dollar states that this implies an upward correction of 7-13%

9 cf. UN 2003, p.5
10 cf.UN 2003, p.60
11 UNFCCC 1998, 12.5.c
12 UN 2003, p.6
13 Chen & Wang 2001, p.4
14 National Bureau of Statistics 2004, p.9
15 cf. National Bureau of Statistics 2004, Dollar 2008
16 World Bank 2008, p.1

for the old figure and 3-7% for the 2004 figure[17]. In this paper I will therefore assess poverty with three benchmarks:

- Chinese national poverty line (=0.75$ a day) with 637 RMB for 2001 and 637 RMB after 2004
- Chinese national 'low income line' (=1$ a day) with 630 RMB for 2001 and 888 RMB after 2004
- Locally applied low income line of 1000 RMB for 2006 which is estimated to be 897 RMB for 2001 based on the consumer price index[18] (approximation to the recent World Bank correction of 1$ a day).

The CO_2 Baseline

Generally, the baseline is defined as the emissions in tons of CO_2 equivalent (CO2e) that would occur if the CDM project did not take place and therefore conventional energy sources would be used that generate these emissions. Depending on the scale of the project, the type of greenhouse gas that is mitigated and the technology used, there is a large variety of approved methodologies for baseline calculations. The BORDA water supply project can be categorised as a small-scale project with a maximum output capacity below 15 megawatts[19]. As a water pump the hydraulic ram replaces either stand-alone diesel pumps or electric pumps that are connected to the local grid. The UNFCCC has approved two different methodologies that cover each case.

(1) Small Scale Methodology AMS-I.B: Mechanical energy for the user
(2) Small Scale Methodology AMS-I.D: Grid connected renewable electricity generation

Both calculations require knowledge of the power output of the hydraulic ram, in order to derive the volume of avoided emissions of CO_2 equivalent (CO_2e). According to the energy mix that is prevalent in the studied sample, a combination of the two methodologies will be used. An experiment was carried out by the project office to derive the water lifting power of the hydraulic ram. The experiments also included tests on comparable diesel pumps.

The Survey Structure

The BORDA project office has collected data for every village participating in the project. The data sheets, however, lack information on individual recipient households. Yet, household level data is necessary in order to evaluate the contribution of the project in raising the poor above the 1$ a day poverty line. This is particularly the case as the project targets individual households. With the currently available data, however, it is not possible to compare the household situation both before and after the intervention. Household level data collected by Chinese ministries or bureaus is not publicly available and household surveys conducted by the World Bank include only parts of Yunnan and Hebei Province and can therefore not be used for this study.

[17] Dollar 2008
[18] Zhejiang Statistical Bureau 2006, p.157
[19] cf. UNFCCC 2005

Consequently, the impact evaluation required a reconstruction of the economic situation of households in previous years through a memory recall. Although memory of past years is subject to present developments, interests and emotions and might at times be fragmentary, there is good reason to believe that the effect of this on the reliability of the provided information is similar across respondents and hence similarly distributed in both the treatment and non-treatment group. While this method does not produce a reliable estimate of the true value of the past income level, it will still be possible to obtain a valid understanding of relative changes particularly if changes in the treatment group are compared to changes in a non-treatment group.

Hence, a survey was conducted interviewing randomly selected households in both treatment and non-treatment villages. Treatment villages were identified based on data monitoring sheets provided by the project office. All sample villages were selected by multi-dimensional scaling to find suitable matches between treatment and comparison group. The matching method used data from a questionnaire posted to 200 village directors across the poorer South-Western part of Zhejiang province. This region had also been the target of the hydraulic ram project. The first stage village sampling was necessary for two reasons, (i) to ensure that irrigation conditions such as available water, irrigation systems in place and local topography are comparable between treatment and non-treatment groups; (ii) household data or address registers are not available, which requires a pre-selection of villages in which household selection can then be administered once in the field.

In a second stage, households were selected based on path instructions, a method commonly used in surveys where household registers are unavailable[20]. Each estimator was given a path and was instructed to follow it until the end, noting down each household along that path. They were then instructed to interview every *i*-th household in order to ensure that households were selected at random. It was aimed to interview 20 households per village or less (in case the number of hydraulic ram pump users or the number of residents in the village was less). In total, 58 treatment households and 175 eligible non-treatment households were interviewed. With 90.2 per cent, the response rate was high among the comparison group. In the treatment group, only a response rate of 43.9 per cent could be reached. This is due to a shift in target group policy. During the project pilot phase, most pumps were provided for community development, but experience had shown, that community devices often suffered from poor maintenance as a result of unclear ownership. As the knowledge of the hydraulic ram spread to neighbouring villages and the project implementing agents became more experienced, priority was given to small user groups and individual users in the dissemination phase between 2001 and 2006. Although this seriously reduces the number of beneficiaries, it is believed to be more sustainable and increase project impact considerably among beneficiaries. With the number of beneficiaries per village being reduced considerably, this would have required to ensure that the few beneficiary households can be successfully interviewed. However, this information was only revealed as a result of interviews during the survey. It was not possible to adapt the sampling strategy in the

[20] Meyer 2006

field to achieve a higher response rate, as the survey was conducted during spring harvest.

The data used for this study relates to agricultural income as well as overall household income. Contained in the questionnaires were queries into output, produce price, agricultural revenue, profit and production costs, probing into costs for seeds, pesticides, fertiliser, machinery, fuel and labour, if any of this was paid for. This string of questions was asked separately for each crop that the respondents grow. Agricultural income Y_{agri} can then be calculated from information on revenue minus production costs, as described in the formula below.

$$Y_{agri} = revenue - costs$$

Table 1 depicts the average values for these variables by the most common crops. In those cases, where information was missing for all instances, the observation was deleted from the sample. However, in cases where information was missing only for variables of individual crops, missing values could generally be imputed from data provided in the same and other questionnaires using linear regression. Imputation was carried out by crop, where missing values were randomly distributed across respondents. It is worth noting, that cost was often provided as a percentage of the revenue rather than an absolute value.

This explains why there are missing values for some crops in the treatment group in Table 1. Once the revenue for each crop was imputed where missing, it was possible to calculate the costs relative to the imputed revenue values. Finally, extreme outliers were deleted from the dataset as they were due to unusually large investments in land and new crops in both treatment and comparison group.

A comparison between both the dataset with missing values and the dataset with imputed values shows, that the average total agricultural household income in 2001 and 2006 does not differ much in both sets. In fact, the average treatment effect on the treated seems slightly smaller after imputation. This indicates that imputed values do not represent a major selection bias and in any case result in a rather conservative estimate of project impact.

Comparing crop diversity in either treatment and non-treatment group suggests that the treatment group was relatively more diversified in 2001, as only 45.57% of farmers in this group grew rice, whereas 93.18% of farmers in the other group grew rice. However, this is partly due to the method of answering crop questions where some farmers combined information of crops they grow for their own consumption (typically rice and some seasonal vegetables) such that other crop variables in the dataset not included in Table 1 further relate to rice growing. The average trend in revenue, costs and profit per crop is fairly similar between both groups, but there are notable differences for tea plantation. This can largely be explained by one farmer in the treatment group, who started growing tea in 2001 and was able to increase the profit by nearly 30,000 RMB over the last six years. This extreme case was later deleted from the dataset.

Table 1

	Treatment Group				Comparison Group			
number of households		58		58		170		170
number of observations by crop	2001		2006		2001		2006	
rice	36	(45.57%)	34	(33.01%)	123	(93.18%)	117	(44.15%)
tea	8	(10.13%)	22	(21.36%)	12	(9.09%)	29	(10.94%)
mushroom	6	(7.60%)	5	(4.85%)	18	(13.64%)	21	(7.93%)
rape	4	(5.06%)	4	(3.88%)	6	(4.55%)	6	(2.26%)
bamboo	3	(3.80%)	4	(3.88%)	7	(5.30%)	8	(3.02%)
average revenue by crop	2001		2006		2001		2006	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
rice	875.367	547.026	1369.43	890.5597	877.289	570.305	1049.38	701.007
tea	2500	2267.79	6137.5	8152.928	3712.5	3454.78	2346.15	3676.33
mushroom	10620	5815.67	19000	2000	8650	3681.71	17290	8166.1
rape	600	282.843	1066.67	416.3332	378	208.235	513.333	304.281
bamboo	700	424.264	1216.67	775.1344	2085.71	3536.21	2300	3522.78
average production cost by crop	2001		2006		2001		2006	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
rice	503.069	361.343	622.704	374.449	442.114	324.805	543.626	393.254
tea	471.429	415.188	2097.82	2176.057	742.857	846.28	1284.5	1396.07
mushroom	5613.33	4386.92	10000	2449.49	4905.77	2685.73	8507.5	3436.2
rape	240		320	56.56854	129.6	97.7001	160	104.269
bamboo	80		300	282.8427	8	17.8885	28.3333	44.9073
average profit by crop	2001		2006		2001		2006	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
rice	385.241	425.192	775.222	666.3041	417.725	436.466	477.132	575.809
tea	1847.5	2024.51	4824.89	6736.08	3866.67	2628.05	1690.5	3492.96
mushroom	4100	1954.48	10200	2949.576	4191.07	2176.17	8782.5	5436.31
rape	480	113.137	853.333	260.2563	184.2	55.8677	256.2	107.658
bamboo	680	169.706	1066.67	635.0853	2672	4151.86	2555	3791.54
	2001		2006		2001		2006	
average total agricultural household income	Mean		Mean		Mean		Mean	
	1789*		6380*		1492.0794		3015	

* without extreme outlier, with outlier the mean would be -277 and 11258 respectively

Impact Assessment

Project Effects on Per Capita Income

At first, I will look at the treatment effect on the treated based on changes in agricultural income, as this is the income directly affected by the water pump project. For the purpose of this paper, I will use a difference-in-difference (DID) approach to estimate the average treatment effect on the treated, where the difference between the average of the outcome variable before and after the time of the treatment is compared to differences in the average of that outcome variable in the comparison group at the same two points in time[21]. This can be expressed with the following formula:

$$\hat{\alpha}_{DID}(X) = [\bar{Y}_{t1}^{1}(X) - \bar{Y}_{t0}^{1}(X)] - [\bar{Y}_{t1}^{0}(X) - \bar{Y}_{t0}^{0}(X)]$$

where $\hat{\alpha}$ stands for the treatment effect estimated through DID, $\bar{Y}$ stands for the mean outcome, superscript 1 and 0 denote the treatment status D where D = 1 if the respondent received treatment, i.e. benefited from the hydraulic ram, and D = 0 otherwise. Furthermore, subscript t denotes the time, with 1 indicating the time after treatment of the treated within the sample group and 0 indicating the time before. This method is based on the assumption that there is no temporary individual-specific effect influencing the participation decision. If such effect was present at large, it could over or underestimate the treatment effect. There is no evidence, that the treatment group was at large exposed to a situation that would induce the individual-specific effect to influence the participation decision among many project participants. Hence, the bias, if present, is considered to be negligible.

As can be seen in Table 2, the average agricultural income is skewed to the right in both groups. I will therefore compare the average treatment effect on the treated based on the mean with a 'median' based treatment effect on the treated. With the mean, this would lead to an average treatment effect of the treated of 632.249 RMB. If the median is used for estimations, the 'median' treatment effect would amount to 703.874 RMB.

Table 2

	Treatment Group	**Comparison Group**
Average Agricultural Income 2001 [RMB]	1331.13	1688.48
Median Income in 2001, $\tilde{Y}_{t0}$	607	752
Standard Deviation	2114.144	2193.576
Average Agricultural Income 2006 [RMB]	3584.056	3309.157
Median Income in 2002, $\tilde{Y}_{t1}$	1820.5	1261.626
Standard Deviation	6983.639	4474.185
Difference $\bar{Y}_{t1} - \bar{Y}_{t0}$ [RMB]	2252.926	1620.677
Difference $\tilde{Y}_{t1} - \tilde{Y}_{t0}$ [RMB]	1213.5	509.626

Second, it is necessary to assess how the poor are affected by this. As can be seen from Table 3, the percentage of people living above all per capita poverty lines increased by 13.21% in the treatment group and only 5.73% in the comparison group. This is mainly due to large improvements for treated households in the highest poverty line margin. While the percentage of people lifted above the national poverty line are fairly similar in both treatment and comparison group, i.e. a drop of 1.89% and 1.91% respectively, the number of people living below the World Bank poverty line actually increased somewhat in the treatment group (1.89%), while it slightly decreased in the comparison group (-1.27%).

[21] cf. Blundell & Costa Dias 2002, p.18

Table 3

	Treatment			Comparison		
	Frequency [%]	Std. Error	Cum. Freq. [%]	Frequency [%]	Std. Error	Cum. Freq. [%]
income status '01						
nat. pov.	9.43%	0.0405348	9.43%	10.19%	0.0242219	10.19%
WB pov.	3.77%	0.0264255	13.21%	9.55%	0.0235357	19.75%
adjust. pov.	18.87%	0.0542571	32.08%	8.92%	0.0228176	28.66%
above pov.	67.92%	0.0647289	67.92%	71.34%	0.0362037	71.34%
income status '06						
nat. pov.	7.55%	0.0366311	7.55%	8.28%	0.0220643	8.28%
WB pov.	7.55%	0.0366311	15.09%	10.19%	0.0242219	18.47%
adjust. pov.	3.77%	0.0264255	18.87%	4.46%	0.0165247	22.93%
above pov.	81.13%	0.0542571	81.13%	77.07%	0.0336575	77.07%
change in frequency of income status						
nat. pov.	-1.89%		-1.89%	-1.91%		-1.91%
WB pov.	3.77%		1.89%	0.64%		-1.27%
adjust. pov.	-15.09%		-13.21%	-4.46%		-5.73%
above pov.	13.21%		13.21%	5.73%		5.73%

nat. pov: per capita income below national poverty line; WB pov.: per capita income below the 872/888 RMB poverty line by the World Bank; adjust. pov.: the poverty used by researchers in Zhejiang, which comes closer to the revised PPP estimations by the World Bank.
Frequency: percentage of the population below the given poverty line; please note that the WB pov. and adjust. pov. frequencies refer to the margin of the population above the previous poverty line, i.e. 3.77% in the WB pov. row for 2001 indicate that nearly 4% are above the national and below the WB poverty line.
Std. Error: standard error
Cum. Freq.: cumulative frequency, indicating the percentage of the sample population below the respective poverty line, i.e. 13.21% in the WB pov. row indicate that 13.21% of the sample population lived below the 872 RMB WB poverty line in 2001.

This would suggest that the hydraulic ram is more beneficial to farmers with higher income. Moreover, investment in agriculture was slightly higher among the treated compared to the non-treated (see Table 4). This would explain why very poor farmers cannot benefit as much from the hydraulic ram as they have less initial capital to invest in agriculture.

Table 4

	Treatment Group	Comparison Group
Invested in variety change	23.47% *(.0430311)*	19.28% *(.0250492)*
Invested in crop change	27.55% *(.0453627)*	15.66% *(.023079)*
Increased use of fertiliser	27.55% *(.0453627)*	13.65% *(.0218039)*

Standard error in italics in brackets

Finally, there appears to be a direct link between the hydraulic ram installation and increased agricultural output and an indirect link to improved total per capita income. The correlation between a change in agricultural profit and a change in the per capita income status (poor, non-poor) seems not very strong with 0.2775 in the treatment group, but it is higher than in the comparison group with 0.0833. This indicates that agricultural profit contributed slightly more towards total income increase among the treated compared to the non-treated where most of the income improvements seem to have come from outside agriculture. Furthermore, a relatively larger proportion of farmers in the treatment group stated that irrigation was a reason for increased agricultural output (28.71% vs. 6.02%), which implies that the hydraulic ram had a considerate effect on agricultural output growth.

As above evidence suggests, there is a link between the hydraulic ram project implementation and per capita income improvements, although the effect on poverty alleviation depends heavily on PPP estimators. Although the World Bank claims that adjustments of the 1$ a day poverty line based on new estimates for the purchasing power parity in China would not alter the great achievements of the Chinese government in reaching the Millennium Development Goals, it does imply a great difference on judging achievements on project level. With the presently applied MDG poverty line (888 RMB), the hydraulic ram project would have had no positive effect, albeit a small effect in raising households above the national poverty line (637 RMB). However, if the MDG poverty line is adjusted to the new PPP calculations (ca. 940~1040 RMB), the project would have had a significant positive effect. This also holds true within the CDM baseline assessment. Since poverty was also reduced in the comparison group, the CDM related baseline definition requires that the project reduces poverty in excess to achievements in the comparison group in order to be considered having positive poverty effects. As with the evaluation of the MDG effect, this depends on PPP estimations.

In light of varying judgements on project impact on poverty alleviation depending on poverty line definitions, it becomes particularly interesting to analyse, whether the project would be more suitable as a CDM project. This shall be discussed in the next sections.

Emissions Baseline

As the hydraulic ram project targets remote areas with poor infrastructure, the pumps are often provided to households that had not used a pump previously. In this case, the project contributes to a reduction in future emissions only, if there is evidence that the likelihood of these farmers to use an electric or a diesel pump has been increasing. According to the Yearbook 2006 of the Zhejiang Statistical Bureau, in the years between 2001 and 2005 the number of diesel pumps used for drainage and irrigation rose from approximately 78,800 units to 85,600 units, while electric pumps increased from 344,300 to 416,300 units[22]. It is worth noting, that electrical pumps include a relatively greater proportion of village devices with large capacity, while numbers of diesel units account more for private use with smaller capacities[23]. This suggests that the use of pumps for agriculture is on the increase.

As diesel and electric pump usage is rising, it can be assumed that the installation of each hydraulic ram constitutes a replacement of a potential diesel or electric pump that would have been used if the project would not have taken place. This is further corroborated by the relatively high investment costs associated with a hydraulic ram, which costs 8000~15000 RMB compared to 7000~8000 RMB for comparative diesel pumps and 500~1500 RMB for small-scale electric pumps. In addition to the capital cost for the hydraulic ram itself, the ram pump requires additional investment in pipes, intake pond and water storage tanks. This adds considerably to the cost of the system and can range from 500~40,000 RMB or more, depending on the distance between water source and farming land.

In order to establish, how much CO_2 emissions are mitigated through the use of the hydraulic ram, the energy output/consumption of the ram pump is compared to the most commonly available pumps in China, i.e. stand-alone diesel pumps and electric pumps that are connected to the local grid. The volume of CO_2 emission reductions is assessed using the UNFCCC approved methodologies AMS-I.B. and I.D as mentioned previously. Estimates are based on

[22] Zhejiang Statistical Bureau 2006, p.253 and p.260
[23] ibid, p.260

the experiment carried out by the project office. Calculations are based on the formula for the water lifting power P:
$P = q * H * g$
where q denotes the quantity of water lifted, H stands for the height of the lift and g refers to earth acceleration.

According to Thomas (1994, p.5) the water lifting power of the hydraulic ram pump is
$P = h * (Q * \eta * g)$
Where:
$q = \eta * h * Q/H$
h = water drop of water source
Q = water flowing into hydraulic ram
η = efficiency of hydraulic ram

P is considered a function of the drop h, as Q, η and g are assumed to have constant values for the given pump type. This constant value is derived from the experiment. Finally, the water lifting power is corrected for friction by multiplying with the factor (1+H*r), where r is determined empirically as 0.045 [l/m] based on the results of the diesel pump measurements. This value is also applied to the hydraulic rams where the water lifting power is multiplied by the factor (1/(1+H*R)).

(1) AMS-I.B for mechanical energy use
The hypothetical diesel consumption avoided by using the hydraulic ram can be written as
$Cons_{hyp} = Cons_{diesel} * P_{hyd} * t$
Where:
$Cons_{hyp}$: hypothetical diesel consumption of hydraulic ram
$Cons_{diesel}$: measured diesel consumption divided by the factor (q * H * g)
P_{hyd}: water lifting power of the hydraulic ram (h * (Q * η * g))
t: time in operation

In this case, the friction factor is cancelled out. As a result of the experiments which were repeated for different drops and heights on both diesel and ram pumps, the average hypothetical diesel consumption [kg diesel/Wh] of the two hydraulic ram types is
HBIL 420 $Cons_{hyp} = 0.00145 * 129.3 * h * t = 0.187 * h * t$
HBIL 630 $Cons_{hyp} = 0.00145 * 258.9 * h * t = 0.375 * h * t$

For the four HBIL 840 ram pumps, an estimation was carried out based on experiments conducted as described by Diemer and Ma (Diemer & Ma 2002) and results from the most recent test series. The hypothetical diesel consumption for HBIL 840 was estimated to be
HBIL 840 $Cons_{hyp} = 0.00145 * 355.6 * h * t = 0.516 * h * t$

According to AMS-I.B, the emission coefficient for diesel is 3.2 kg CO_2 per kg of consumed diesel. Considering the average water drops and operation times per ram type, the following emissions can be avoided on average by each ram type respectively:
HBIL 420: CO_2e saved per year: 5.296 t
HBIL 630: CO_2e saved per year: 25.815 t
HBIL 840: CO_2e saved per year: 18.160 t

(see Table 5 below)

Table 5

	420		630		840	
	sample	population	sample	population	sample	population
number of devices	26	352	27	77	4	10
average t [h/year]	2846		3377		2340	
sample weight	13.54		2.85		2.50	
total t [h/year]		38526.5354		9631.10296		5850
average h [m]		3.11		6.37		4.7
average years		2.67		4.14		6.3

Finally, if this is aggregated by the total number of hydraulic rams utilized for irrigation and the total number of years these rams have been in operation, the 'replacement' of diesel by the ram pump avoided CO_2 emissions of 93,714.22 t in the period 2001-2006. (Note: also electric pumps)

(2) AMS-I.D: Grid connected renewable electricity generation
The AMS-I.D. states that "the baseline is the kWh produced by the renewable generating unit multiplied by an emission coefficient (measured in kg CO_2e/kWh)" which constitutes a "combined margin (CM) consisting of the combination of operating margin (OM) and build margin (BM)"[24]. The Chinese national authority designated to CDM approval provides a list of OM and BM values for the various regional electricity grids. With Zhejiang being connected to the East Network, the combined margin is
CM = (0.9411 + 0.7869)/2 = 0.864

As mentioned earlier, the power P of the hydraulic ram is calculated by
P = h * (Q * η * g)

In the project period 2001-2006, the average power for a HBIL420, 630 and 840 were 402.12 W, 1649.19 W, and 278.08 W respectively. Differences are due to variations in average lifted heights. This amounts to a total of 19,726.2278 MWh in the time between 2001 and 2006. Multiplying this figure by the emission coefficient provided by the Chinese designated authority, the replacement of pumps feeding off the electric grid with the same power and operation time as the ram pumps utilized between 2001 and 2006 mitigated the emission of 17,043.4608 t of CO_2e.

Combining Results from Both Methods

Clearly, the hydraulic ram does not constitute a replacement of either diesel or electric pumps only, but rather a combination of both. In the sampled population, the share of diesel and electric pump users was 26.6% and 73.4% respectively. As to the past project period, this would accrue to the reduction in emissions of 37,437.88 t CO_2e (93,714.22 t *.266 + 17,043.4608 t *.734).

Conclusions of the Impact Assessment

The previous sections have shown that the project contribution towards MDG target One (indicator 1) depends very much on the rather arbitrary definition of the 1 $ a day poverty line in purchasing power parity terms, while the contribution towards MDG target Seven

[24] http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_MPT5X3QC5NESZQMY2ELP0MNEU340LJ

(indicator 28) appears to be evident. This raises the question whether it would be more feasible to finance this project through climate change mitigation, i.e. the CDM.

What if the Project was carried out under CDM?

For the project to be carried out under CDM, it is essential that it is financially feasible, as generally the project should not depend on development assistance for the acquisition of certified emissions reductions (CERs)[25]. At a current price of 21.45 EUR per ton of CO_2e, emission reductions achieved between 2001 and 2006 would generate a revenue of 803,042.53 EUR for the 439 hydraulic rams installed over the six years. The price has certainly increased during that period, but in this study I am interested to infer from emission reductions in the past to possible implications for future implementation of the hydraulic ram project as a CDM activity, not an estimation of revenue that could have been gained if the project had been carried out under CDM. The reason for this is that I want to investigate into possible future project investment options rather than fictional past.

Considering the cost for each ram type[26] including intake pond, water tank and pipes, the provision of hydraulic rams over the project period has required an investment of approximately 915,000 EUR. This is in excess of the revenue potentially generated through the sale of certified emissions reductions (CERs) as calculated above. While the project had been carried out with the help of development assistance, half of the cost for the hydraulic ram installation were borne by local authorities and the provision of labour by beneficiaries. Over the past six project years, this would amount to a local contribution of roughly 457,500 EUR or over 4.6 million RMB. Assuming the project would gain CDM approval, the overall contribution of the local authorities could be reduced to 111,960 EUR or 1.2 million RMB[27].

However, the payment of CERs is scheduled to take place at 12 months intervals and depends on empirical evidence that the emission reductions have been achieved. The local authorities would thus have to cover the full cost of the ram pumps installed each year until the full CERs are paid out. With an average of 73 pumps installed each year within the six year period (2001-2006), this would demand an annual upfront payment of approximately 151,925 EUR or 1,656,686 RMB. This constitutes more than double the amount of the local authority's previous annual contribution. Assuming a mix of hydraulic ram types similar in distribution and power output to those between 2001-2006 being installed evenly across each year of another 6 year period, an annual CER revenue of 14,566.27 EUR or 158,840 RMB would be generated for the first batch. In six years, the local authority would have amortized 57.5% of its investment, leaving the authority with a contribution of 703,646 RMB per 73 hydraulic rams installed each year. This is slightly less than their contribution to co-finance development assistance.

It becomes evident that the risk of not obtaining the CER revenue might seriously reduce the interest of the involved parties to continue their level of previous investment. Indeed, interviews with government representatives on county and village level have shown that the concern about the risks involved combined with an entirely unfamiliar procedure to regain investment, is a major deterrent to participate in project realization under the CDM rulebook. With a guarantee provided by a foreign investor, however, they are willing to increase time and effort to scale up the hydraulic ram dissemination.

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[25] Dutschke and Michaelowa 2006, p.236

[26] considering price changes over the period 2001-2006 and irrigation system investment in the typical range of 1500~3600 EUR.

[27] exchange rate of March 2008

There are several options to make the project under CDM financially more attractive. First, the project could focus on areas that require less costly irrigation systems. Second, it could seek to increase the amount of emission reductions by providing pumps to farmers engaged in water intensive cropping. Third, the project could attempt to achieve higher prices on the premium market; and fourth, it could consider requiring farmers to pay a share towards obtaining the hydraulic ram. Each option would have different impacts on project outcome.

The first option would most likely reduce the project effect on poverty alleviation, as poor farmers that lack access to water supply are generally more remote from the water source. Restricting hydraulic ram locations to easily accessible water sources would therefore seriously reduce the poverty alleviation effect.

The second option might produce conflicts between emission reduction accreditation criteria and the farmer's investment criteria to adapt cropping to market conditions. This could therefore constitute problems for achieving the approved emission reductions and is considered less sustainable either in terms of agricultural income or emission reductions.

The third option would provide additional CER revenue, thereby increasing the reward for the risk involved with pre-financing. Atmosfair, for instance, offers contractually guaranteed purchasing of CERs at premium prices[28]. South Pole, Myclimate and others also specialize in the purchase of CDM projects with a high impact on sustainable development as defined by the CDM Gold Standard. Although premium prices are not published on the internet, these organizations can sometimes provide prices nearly double the market price (depending also on the current market price). Considering a hypothetical premium price of 30 EUR per ton of CO_2e, this would raise CER revenue from 803,042.53 EUR to 1,123,136.4 EUR or 12.25 million RMB. For the 73 ram pumps installed in year 1 and running over 6 years as assumed above, this would generate a revenue of 222,153 RMB per year or 1,332,918 RMB in six years. This considerably reduces the risk for the local authority and puts less pressure on the authorities to focus on financially attractive project sites, thereby ensuring that poor farmers can be included in the target group.

The fourth option constitutes a measure towards a possible gradual commercialization of the hydraulic ram as farmers are required to pay for obtaining the pump. Considering the price for electric or diesel pumps, the average treatment effect on the treated of over 600 RMB per household within six years, as well as the long lifetime of the pump, it can be assumed that a price below the average treatment effect and cheaper electric pumps of around 300 RMB is a feasible contribution. Assuming that on average one hydraulic ram is shared by four households, this would amount to a contribution of 1,200 RMB per pump and 87,600 RMB for 73 pumps. This is particularly attractive if combined with option three, where the local authorities would then have to pay 1,569,086 RMB in one year and would regain 222,153 RMB per year. This would reduce the contribution of the local authorities per 73 rams to 236,168 RMB as opposed to 764,920 RMB contributed to the development assisted project.

Finally, we assume that the local authorities might be willing to continue sponsoring the project as in the past 6 years and would consequently be willing to share CER revenues with the farmers. Without any further adjustments to maximize CER proceeds, each participating household would obtain 209 RMB in addition to the average treatment effect calculated earlier. Assuming a premium price of 30 EUR per ton CO_2e, farmers would gain an additional 1,510 RMB by the end of six years. With the fourth option, beneficiaries would still obtain an

[28] CDM Bazaar 2008

extra 210 RMB including their own 300 RMB contribution. If premium prices are combined with farmers' contribution and CER proceeds are shared between local authorities and project beneficiaries, the latter would receive up to 569 RMB each in addition to the average treatment income effect.

Conclusion

As could be seen from the project impact assessment, poverty alleviation effects of the ram project as carried out over the last six years depend heavily on arbitrary PPP estimations and the subsequent shift of the 1$ a day poverty line. This is not to say that a technology transfer of the hydraulic ram within development assistance will always produce such effects. The greater project benefits reaped by farmers near exiting poverty could be partly due to target group selection policy as well as the particular project structure.

On the other hand, project contribution to CO_2 emission reduction is far less arbitrary. Yet, turning the development aided project into a CDM activity would require the local authorities to provide large upfront payments for a comparatively risky investment. If they are willing to embark on this, they could either reduce their subsidy of the hydraulic ram project or share some of the CER proceeds with the project beneficiaries. This could benefit the poor either directly through the receipt of CER revenue or indirectly through freeing up local authority capital in the long-run which can be spent on other development activities. As with the realization of the project within the MDG framework, this depends much on project structuring, target group selection and budgetary decisions by local authorities. More importantly, it depends on the capacity and willingness of local governments to take up the CDM investment risk. While CDM project finance can potentially add value in terms of curbing CO_2 emissions and/or poverty, these might be also achievable through restructuring the development assistance project without incurring the risks associated with CDM. Official development assistance, however, is paid through public funds, whereas CER proceeds stem from the private sector.

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