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Original research article

Carbon emission reductions by substitution of improved cookstoves and cattle mosquito nets in a forest-dependent community

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ABSTRACT

Collection of fuelwood and its inefficient use for cooking and protecting animals from insects contribute to forest degradation and deforestation in developing countries. Assessment of fuelwood dependency can provide a basis for introducing effective measures for reducing emissions and fuelwood collection without compromising the basic needs of local people. Using a community located in Phnom Tbeng forest area in Cambodia, this case study assessed fuelwood dependency quantitatively via random surveys of 105 households and to project potential carbon emission reductions realized by the substitution of three-stone stoves with improved cooking stoves and the use of mosquito nets instead of wood burning to protect animals. Heads of households were targeted because of their main roles in daily family management. Three discounted rates were used to assess carbon prices as financial incentive for the substitution three-stone stove with improved cookstoves. We found that only 4% of the households had access to power from an independent power producer for lighting alone. Approximately 98% of the surveyed households collected firewood from nearby forests and used it as fuelwood for cooking, with the remaining 2% using both charcoal and fuelwood for this purpose. All respondents used the three-stone cooking stove for cooking. On average, fuelwood consumption was 2.0 ± 0.1 Mg household^{-1} yr^{-1} for daily cooking or 3.8 ± 0.2 $MgCO_2$ of carbon emissions. Burning wood for protecting cattle from insects consumed 4.3 ± 0.2 Mg household^{-1} yr^{-1} or 7.9 ± 0.3 $MgCO_2$ of carbon emissions. Using improved cookstoves and mosquito nets to protect cattle can reduce emission up to 1.1 $TgCO_2$ for the whole study site.

Substitution of conventional cookstoves with improved cookstoves and the use of mosquito nets instead of fuelwood burning could result in using less fuelwood for the same amount of energy needed and thereby result in reduction of carbon emissions and deforestation. To realize this substitution, approximately US$ 15–25 $MgCO_2^{-1}$ is needed depending on discount rates and amounts of emission reduction. Substitution of cookstoves will have direct impacts on the livelihoods of forest-dependent communities and on forest protection. Financial incentives under voluntary and mandatory schemes are needed to materialize this substitution.

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1. Introduction

Addressing climate change was a critical issue discussed at the 20th Conference of Parties to the United Nation Framework Convention on Climate Change in Lima 2014. Reducing emissions from deforestation and forest degradation was also discussed, given that these activities constitute the major source of greenhouse gas emissions in developing countries. Data for 2000–2009 suggest that land use change was responsible for the release of 1.1–2.7 PgC yr^{-1} (Friedlingstein et al., 2010; Pan et al., 2011). Fuelwood extraction from forests is an important driver of deforestation and forest degradation in developing countries. According to the International Energy Agency, 2.7 billion people or 40% of the global population rely on the use of biomass to meet their residential energy needs, predominantly cooking (IEA, 2006, 2010). Although the three-stone stove is the conventional technology for using wood biomass for cooking, this type of cookstove is not efficient and results in the unnecessary use of fuelwood by people in developing countries. In addition to deforestation, burning of biomass also releases atmospheric pollution, which threatens health and accelerates global warming (Zhang and Wang, 2005). Appropriate strategies for reducing fuelwood consumption by introducing more efficient cookstoves can reduce pressure on tropical forests and improve local people's standard of living.

Cambodia is the most vulnerable countries to climate change in the Mekong region (Yusuf and Francisco, 2009; Bradley, 2011; Tin, 2011). Climate change already became apparent in Cambodia as evident by the rise of mean temperature and erratic rainfall pattern since 1960s until recently (Tin, 2011). This change is likely to affect main sectors of Cambodian economy such as agriculture, forestry, fishery, and health. Climate impacts on forests coupled with rapid deforestation and forest degradation in Cambodia affect local livelihood because almost 100% of the rural population depend on forests and their ecosystems for daily subsistence and energy needs. Until recently, fuelwood and charcoal have been the most common sources of cooking energy for rural population in Cambodians (Geres, 2007). Depending on the location, 50% or more of fuelwood is collected from natural forests in Cambodia (CCCO, 2003). Firewood and charcoal are often considered as conventional fuels, yet they remain the dominant source of cooking energy in Cambodia, even in the cities. The World Bank (2009) reported in 2009 that over 90% of Cambodian population use firewood and charcoal, and that with increasing population, dependence on fuelwood has contributed to deforestation and forest degradation. In the late 1960s, forest cover in Cambodia was 13.2 million ha or 73% of total land area (Tran and Kol, 1987) but forest area has undergone a substantial decline to 10.4 million ha in 2010 (DFW, 1998; FA, 2011) due to logging and forest clearing during the civil wars, clearing for economy land concessions and dams, unsustainable exploitation of forests for fuelwood consumption, rapid expansion of urban area, and increasing population. Recent studies revealed that annual deforestation rate from 1973 to 2003 was 0.7% (Sasaki, 2006) and from 2002 to 2010 was 0.8% (FA, 2011; Sasaki et al., 2013), suggesting that forest cover in Cambodia is declining at an alarming rate. Firewood extraction is one of the main drivers of deforestation and forest degradation, because alternatives to fuelwood for cooking are generally expensive and rarely available in rural Cambodia (Ty et al., 2011). Although Cambodia has set a goal of providing an electricity grid to 70% of households by 2030 (Kunthy, 2012), there is still a long way to reaching this goal, and rural electricity prices are higher than urban prices due to lack of access to national grid. A fuelwood-saving solution is critically needed to reduce the massive collection of fuelwood for energy. With recently increasing interest in reducing deforestation under the REDD+ scheme, an improved cookstove (hereafter, ICS) project is seen as an ideal method for reducing fuelwood consumption with easy-to-use technologies for forest-dependent communities. In addition to emission reductions through the adoption of ICS, avoiding the burning of wood for protecting domestic cattle from insects can also result in huge emission reduction. Ty et al. (2011) reported that burning fuelwood to protect animals from insects at night was one of major drivers of forest degradation and deforestation in rural Cambodia. At night, local people traditionally burn fuelwood for several hours to protect their cattle and such burning results in huge carbon emissions. Ty et al. (2011) proposed to use mosquito nets instead of burning fuelwood. Not only this practice reduces wood collection from the forests, but it also improves human and animal health, the latter resulting in more livestock production from health animals (FAO, 2013). Until recently however, there is no study on potential carbon emissions and reductions from using mosquito nets to prevent domestic cattle in Cambodia.

Financial incentives for reducing carbon emissions in developing countries are available under Clean Development Mechanisms (CDM) of the Kyoto Protocol, the REDD+ scheme of the UNFCCC, and other voluntary carbon offsetting standards. Among the ongoing projects, ICS projects have attracted increasing attention from carbon developers. In recent years, ICS projects have been successfully implemented in Africa and Southeast Asia. CDM is one of the three flexibility mechanisms designed to reduce greenhouse gas emissions while contributing to sustainable development in developing or host countries through technology transfer and creation of environmental, social, and economic benefits. Under CDM projects, developers can acquire certified emission reductions (CERs) for activities that result in carbon emission reductions. These CERs can be sold in compliance and/or voluntary markets. To claim emission reductions (carbon credits) for sale under the CDM, carbon developers need to follow various processes and adopt the approved CDM methodologies of the UNFCCC. For example, five steps were used to obtain carbon credits in domestic cooking stoves program in Mozambique, namely development of an ICS project activity (step 1), approval by host country (step 2), validation and registration ICS project (step 3), monitoring of project activity (step 4) and verification and certification of carbon credits (step 5). According to the UNFCCC registry (PoA Registry, 2015), ICS projects generally claim emission reductions between 1 and 5 $MgCO_{2e}$ per ICS, as example ICS project in Cambodia, Nepal and Haiti has claimed emission reduction approximately 1, 1.9 and 2.5 $MgCO_{2e}$ per ICS, respectively. This change depends mainly on fuelwood consumption in a baseline scenario (a scenario occurs in the absence of project activities) and the efficiency of ICS projects. With these carbon-based incentives and given that most