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‘Carbon Footprint’ quantification of a tea agro-ecosystem based on the development of a model of related material flows

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Abstract

Climate change is one of the major challenges of the 21st century and in fact, it is the developing countries that are affected most by the inherent impacts. Realizing that the steep increase of GHG emissions is first and foremost caused by human activity – and above all, by the industrialized countries – the Kyoto protocol has been committed. As an international agreement linked to the UNFCCC it defines legally binding targets and timetables in order to stabilize the level of atmospheric CO_2. Under the Treaty, countries must meet their targets primarily through national measures. However, it offers an additional means by way of market based mechanisms whereby in this study the main focus is laid on the Clean Development Mechanisms and Emission Trading, the so-called voluntary carbon market.

Agriculture is the mainstay of 75 percent of the developing world's poor and in the context of climate change, this sector plays a particular role being able to function as both, a sink and a source of GHG emissions. Moreover, the agricultural sector is of high significance in terms of food security in view of the increasing population. Despite of that, it is quite amazing that agriculture is not adequately considered as a potential field to enhance climate change mitigation, in fact. This is mainly due to knowledge gaps concerning the measuring and verification of the associated CO_2 flows. Therefore, this study exemplifies the 'Carbon Footprint' calculation of a tea ecosystem in a modelling approach. As the overall objective, it provides a simple method particularly adaptable to small-scale cultivation.

Tea is one of the most important foreign exchange earners ('cash crop') that is especially cultivated by smallholders in developing countries. In consequence of the very particular inherent management practices such as residue recycling or no-till, several studies indicate a high CO_2 sequestration capacity of tea plantations. Estimations on this sink potential run up to 69,4 t CO_2 ha^{-1} a^{-1} over a lifespan of 80 years. Starting with a general topic overview, the study covers an analysis of the requirements for verification as a sink project in the CDM and the current standard methodology for the quantification of the Product Carbon Footprint (PAS 2050) with special reference to the obstacles for smallholders. Apart from that, chapter three elucidates the particular carbon flows of a tea ecosystem amplifying the most important plant and soil parameters with regard to tea cultivation. Based on literature review, own measurements and interviews with stakeholders it summarizes ecosystemic as well as climate conditions. In the following, chapter four designs a carbon model within the background of the collected data, comprising the simulation of several scenarios: the

original carbon footprint, the integration of an assumed CO_2 fertilizing effect and then, different climate change predictions.

Therefore, the study illustrates the Carbon Footprint concept against the overall background of climate change and in the context of small-scale agricultural structures. Beside an ecological analysis, it also covers the perspective of development aid as to rural affaires and climate policies. A possible attempt to quantify the specific carbon flows within crop plantations is outlined for a tea agro-ecosystem as a case study.

Climate change is mainly caused by anthropogenic perturbations on the global carbon cycle while it is the developing countries that are suffering most from its effects. Therefore both, identifying and maintaining viable sinks for atmospheric CO_2 must gain high priority on the political agenda. Carbon trading is one of the possible instruments in order to decrease GHG emissions. Another market-based option is the product communication within the carbon footprint as a value-added of the supply chain. However, at present time both these approaches are in parts not yet methodologically sound and therefore unrewarding. Since especially in the agricultural sector some unaccounted issues remain, this study intents to meet the requirements of intensive research on this important topic.

So far, carbon credit benefits with regard to land use have not much exceeded the considerations of (forest) biomass, but agricultural soils can also have a considerable potential in terms of their C-stocks. According to the Food and Agriculture Organization (FAO), nearly 90 percent of the climate change mitigation potential of agriculture could be realized through soil carbon sequestration (e.g. http://www.fao.org/news/story/0/item/11356/icode/en/). Nevertheless, neither the Clean Development Mechanisms (CDM) of the United Nations Framework Convention on Climate Change (UNFCCC) nor the current standard methodology for carbon footprint calculations (PAS 2050) account for agricultural CO_2 uptake in an appropriate way – especially with regard to smallholders. This is mainly due to uncertainties in measuring, monitoring and verification guidelines.

While the particular species type determines net primary productivity (NPP) and hence carbon accumulation in plant matter, it also influences the quality and quantity of residues. Representing another important factor, prevailing management practices can make a significant contribution to plant development and moreover, to soil carbon changes. The amount of residue retention and soil cover further prevents erosion and leaching of soil organic matter and therefore affects soil health. These net effects on carbon flows and balances are discussed for the specific case of an averaged tea plantation by using a modelling approach. As one of the most important cash crops, tea

is first and foremost cultivated by small-scale farmers in developing countries. Addressing climate change mitigation and analysing the assumptions of its high carbon sequestration potential could therefore have some influence of global significance.
That is why this study aims to highlight the key processes and, aside from that, to contribute to knowledge generation with respect to agricultural greenhouse gas exchanges. In order to provide a simple method, it makes some recommendations of possible evidence for the use and inclusion of agricultural category rules in terms of future climate policies to be incorporated in the UNFCCC strategies and for the application in the ISO 14067 standard assessment of Product Carbon Footprint calculations. Moreover, it discusses several climate change scenarios and thereby, possible mitigation practices enhancing both, the adaptation to climate change impacts and soil carbon sequestration.

The main important results confirm the hypothesis of a sustained carbon sequestration within ageing tea plantations accounting for 5,1 t CO_2 ha^{-1} a^{-1}. However, the evaluated value is not in accordance with the predicted appraisements. This might be because of a different mode of calculation: on the one hand, it seems that harvest outputs and the conversion of residues into organic matter through decomposition have been accounted for and on the other hand, it seems that neither losses due to soil respiration nor erosion and leaching have been considered. Briefly, instead of establishing a realistic quantification, the original guesstimate is probably made too vague or too optimistic. Anyway, this question remains unsolved since the exact calculation is not publicly available. With regard to this conducted study with its downright presented data and methods, the results might turn out to be more accurate and funded. While in comparison to an averaged tropical forest, the values are on top of that including various factors of influence and intercorrelations within a multilayered simulation.
Nevertheless, it is high time to enhance sustainable development and here agriculture is a key sector for environmental services. The combination of a modelling approach including the main factors with category rules describing the quality of certain management practices can be a solution, at least as a temporary stop-gap.