Influence of climate change on irrigated organic carbon to rice cultivated lowlands in tropical mountainous regions

Petra Schmitter[a, b], Holger Fröhlich[c], Thomas Hilger[a], Gerd Dercon[a, d], Nguyen Lam[e], Tran Duc Vien[e], Georg Cadisch[a]

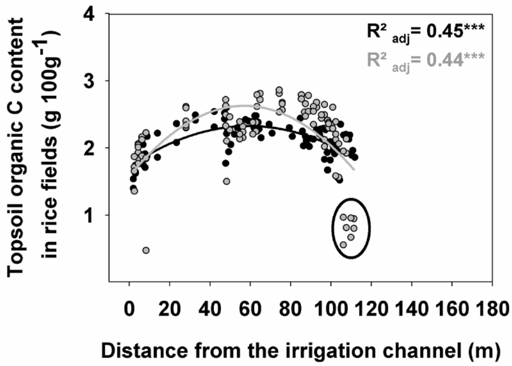
[a] Institute of Plant Production and Agro-Ecology in the Tropics and Subtropics, University of Hohenheim, Stuttgart, Germany
[b] Present: Singapore-Delft Water Alliance, National university of Singapore, Singapore
[c] The Uplands Program (SFB 564), University of Hohenheim, Stuttgart, Germany
[d] Present: Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency (IAEA), Austria
[e] The Center for Agricultural Research and Ecological Studies (CARES), Vietnam

Shifts in rainfall intensity and variability within the monsoon period are expected to change while overall rainfall can increase between 2.5 and 4.8% by 2050 in Vietnam (e.g. Chaudhry and Ruysschaert, 2007). This will not only cause greater flood and drought risks but will also affect irrigation systems, created to support rice production in the dry season under intensified agricultural practices. In the rainy season, reservoirs and channels capture and transport the, through water erosion generated, overland flow derived from the intensified upland areas. This study based on observations in the Chieng Khoi watershed, Son La province, NW Vietnam aimed at predicting the effect of increased rainfall intensities and irrigation requirements due to climate change on carbon redistribution via irrigation and direct overland flow to paddy fields. Irrigation discharge and rainfall was recorded and irrigation water was collected flow proportionally for 25 rainfall events in 2008 and analyzed on organic carbon (C) content using the combustion method (Schmitter et al., 2011). A mixed effects model was built in SAS to quantify the organic C loads irrigated to the paddy fields (baseline scenario). The obtained mixed effects model included rainfall intensity (RI), irrigated discharge (Qirr), overland flow discharge (QOF) and discharge released from the reservoir (Qreservoir): ln(organic C) = -4.662+0.022RI+0.566Qirr+0.151 QOF+0.335Qreservoir (Schmitter et al., 2011). Afterwards RI (mm h-1) within the model was increased by 2 and 5% as it was strongly correlated with rainfall ($r=0.99$, $p<0.0001$) (scenario 1) resulting in 20-33% rainfall increase, respectively. In relation to drought, Qirr was increased by 2, 5 and 10% (scenario 2). Furthermore top soil was sampled before and after each rice season as described in Schmitter et al. (2010). The baseline scenario showed that a total of 5.493 Mg of organic C was irrigated to the lowland paddy area (6.5 ha) from May to September 2008. Preliminary results show only a slight increase for scenario 1 in irrigated organic C loads ranging from 0.01 to 0.05% compared to the baseline scenario. This can be explained by the strong contribution of the reservoir (93%) on irrigated organic C loads throughout the period. The reservoir acts as an organic C trap throughout the rainy season and controls the release of organic C throughout the year. As a result, increased irrigation practices in the dry period will play a key role in additional irrigated C loads (scenario 2, Table 1). Irrigated organic C loads increased from 1 to 4% when irrigation amounts were increased by 10%. However, further scenarios changing rainfall variability throughout the monsoon season are needed to understand the effect of rainfall shifts in transported C loads to paddy field. Although an increase in rainfall only had a slight effect on irrigated organic C loads to paddy fields through direct overland flow contribution, flood risk of downstream paddy area increased strongly. A sequence of strong monsoon rains followed by a typhoon in 2007 caused severe flooding of downstream paddies as the reservoir had reached its maximum buffer capacity. These flash floods decreased organic C content in paddy fields through sandy rich depositions by 24% while sand content increased by 41% (Schad et al., 2011; Schmitter et al., 2010) (Figure 1). Therefore, the positive gain of irrigated organic C loads in dry periods can be rapidly altered in degrading rice production areas through flash floods. The strong monsoon rains in 2011 and the consequent flooding of large rice production areas in both Vietnam and Thailand show once more the need for appropriate water and dam management schemes to alleviate short term (crop failure) and long term (soil degradation) effects of flooding under current climate change scenarios.

Table 1. Effect of climate change scenario's on irrigated organic C load (Mg) into paddies.

Scenario	Sub-scenario	Irrigated organic C load (Mg)[a]
Baseline	-	5.493
Scenario 1	2% Rainfall intensity increase	5.494 (0.01%)
	5% Rainfall intensity increase	5.496 (0.05%)
Scenario 2	2% Irrigation increase	5.550 (1.02%)
	5% Irrigation increase	5.644 (2.60%)
	10% Irrigation increase	5.795 (3.96%)

[a] percentage of relative increase towards the baseline is given in parenthesis.



The black dots represent the organic C status before planting (Organic C = 1.72 + 0.02distance–2.00E^{-04} distance^2, R^2_{adj}=0.45, p<0.0001) while the status of organic C after harvest is given by the grey dots (Organic C = 1.77 + 3.37E^{-03} distance–3.00E^{-04} distance^2, R^2_{adj}=0.44, p<0.0001). Flooded paddy fields were located at a distance between 100 and 120m from the irrigation channel (circle) (modified after Schmitter et al., 2010).

Figure 1. Effect of irrigation and flooding on changing top soil organic C content along paddy rice cascades in 2007

Reference

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