Intensification of Upland Agriculture – Development or Degradation?
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The large scale conversion of extensive swidden agriculture to intensive market oriented production of maize in upland areas of South East Asia is a cause of concern – both in relation to the environmental and socioeconomic impacts. This study investigates (1) the drivers behind intensive maize cultivation in an upland area of Northern Thailand (2) the effects of this intensification on soil quality; (3) the potential of Permanganate Oxidizable Carbon (Pox-C) as a fast, low cost indicator of soil quality and (4) the socio-economic impacts of maize cultivation.

Study Site
A series of field studies were carried out in Nan Province in Northern Thailand between 2010 and 2012. Nan is the second largest maize-producing province in Thailand and the area under maize in this province tripled between 2005 and 2009. We focused on the village of Ban Huai Puk, which has 160 households and 540 inhabitants mainly of Khamu ethnicity. The area is dominated by hilly landforms, typically with slopes between 15° and 25°.

Results
The area under active fields more than tripled from 2002 to 2012 (Figure 1). This development mainly took place in areas that used to be under old fallows. In 2002 all respondents cultivated upland rice in a fallow-based system, while maize was cultivated by less than 25%. In 2010, 50% of the respondents cultivated upland rice, while maize was cultivated by 90%. The total area under maize was more than five times larger than the area under upland rice.

Maize cultivation: CP888 was the most popular type of maize seeds used in the area. Fertilizers and herbicides were used by all respondents, and 60% decided to purchase these inputs. 85% of maize production from Nan was sold to the Charoen Pokphand Group (CP).

Causes of Land Use Changes
The observed land-use changes are driven by a combination of economic and political factors. Maize prices tripled from 2005–2011, and the favorable prices were mentioned as an important reason for cultivation of maize by all of the respondents. Governmental support programs, such as maize pledging schemes were also mentioned as important incentives for focusing on maize cultivation. However, lack of alternative low investment cash crops capable of growing on the infertile upland soils was also frequently mentioned as a reason for the sole focus on maize.

Surveys, Interviews and Participatory Mapping:
Questionnaire surveys about agricultural activities, and perceptions of soil fertility were carried out in 2010 and 2011 (n=60). In 2013, households were revisited and interviewed about maize yields and constraining factors. Qualitative data was generated from in-depth interviews (n=20) and ranking exercises focusing on maize production, including information about indebtedness. Information about land use changes was acquired from participatory mapping and group interviews. Land use classification was done based on two high resolution, multi-spectral and pan-sharpened images from 2002, and 2012.

Plot selection and soil sampling: To investigate the effects of maize cultivation on soil quality, sampling plots were selected to represent a chronosequence of maize cultivation intensity (n=16). Soil samples were collected from four depths of three replicate profiles (60 cm) per site. Samples were analysed for soil texture, pH concentrations of soil organic carbon (SOC), Total N, Permanganate Oxidizable Carbon (Pox-C), available P, exchangeable base cations, iron and aluminium (hydr-) oxides, and for Carbon Exchange Capacity (CEC).

The abandonment of the traditional swidden agriculture system has been driven by a) the changing of land use policies and an increased penalties for violating these. Over the recent decade, different Thai governments have increased efforts to eradicate the system that is blamed for causing deforestation. Since early 2000, the farmers in Ban Huai Puk have experienced increased inspections by government officials and recently by soldiers. Farmers have been fined for clearing land or sent to prison accused of forest encroachment after being caught when clearing what they perceived as their idle farmlands. The enforced ban on open burning and the different opinions about what constitutes a fallow and a forest means that farmers are afraid of leaving their land fallow and thereby risk being accused of open burning or of forest encroachment when clearing it.

Pox-C and soil quality
The Pox-C concentration of the 0–5 cm soil layer is positively and significantly correlated with all investigated indicators of soil quality, and with a few exceptions, this is also the case in the 15–20 cm layer (Table 1). A close relation was found between farmers’ perception of soils as good and concentration of Pox-C (p=0.028, paired t-test). These patterns suggest that concentration of Pox-C represents an integrative measure of soil quality in these depleted Ultisols. Combined with low acquisition and operating costs, and its applicability in the field, the method has potential for application by extension services.

We document a widespread change from swidden agriculture to intensive maize cultivation resulting mainly from economic and political drivers: Farmers have been forced out of swidden agriculture due to policies aiming to eradicate the system, and simultaneously drawn into maize cultivation by high maize prices, and policies ensuring plentiful credit opportunities.

Concentration of Pox-C in the topsoil of the maize fields is closely related to common indicators of soil quality, and to farmers’ perceptions of soil quality.

Maize cultivation has a negative effect on soil quality and this effect is captured by Pox-C. We conclude that Pox-C is a sensitive indicator of effects of land use intensity on the soil.

Farmers in Ban Huai Puk are faced with declining maize yields, indebtedness, beginning soil degradation, heavily enforced restrictions on leaving land fallow and limited room for maneuver.

We suggest that extension efforts should focus on finding integrated solutions that acknowledge the production realities of smallholders in upland areas and that extension efforts should build on the knowledge of local people as well as on established research-based knowledge. We call for a more demand driven extension service approach, which pays attention to farmers’ knowledge instead of the current top-down approach.

Figure 2: Correlations between land use intensity and Pox-C concentration in the upper 5 cm of the soil.

Table 1: Correlations between selected indicators of soil quality.

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<tr>
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<tr>
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<td>0.30</td>
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</table>

* p < 0.05; ** p < 0.01; 0.05 0.01