Driving factors of soil fertility in mountain terraced paddy fields of Yuanyang (China)

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INTRODUCTION

Yuanyang County, in southern Yunnan (Figure 1), is famous for its rice terraces which claim as the world's largest and most spectacular one (circa 11 000 ha). They were crafted out by the Hani people more than one thousand years ago and are still in use to-day (Figure 2).

The region has to face problems of landscape conservation within a context of tourism development and drift from the land.

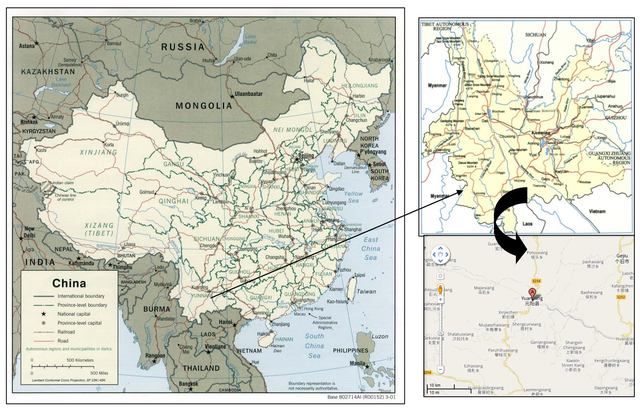


Figure 1: Situation map of Yuanyang County

Figure 2 : Illustrations of the Hani Agro-ecosystem in Yuanyang County

RESEARCH THEME

The 11,000 ha's of Hani terraces constitue the most remarkable feature of a structured ecosystem in which forests, grasslands, dry fields and paddy fields are arranged across relief in order to fullfill production services as well as global ecosystem sustainability. Forests, for example, on the summit contribute to regulate local climate and water resources for downstream irrigated fields. This preliminary study aims at exploring soil distribution, evaluating their physical-chemical properties and identifying main drivers of soil fertility in this area.

METHODOLOGY

The Qin Kou sub-catchment within the YuanYang County present the typical organization of the Hani landscape (Figure 3): forests and « natural » grasslands and steppes occupy the summit (> 2,000 m elevation); cultivated terraces are present on upper, middle and lower slopes (1,400 to 2,000m). Outcropping lithology is dominated by metamorphic gneisses and amphibolites. Steep slopes are locally cut by level surfaces (Figure 4). Most precipitation (1,200-2,000mm) falls at summer moonsoon.

Paddy fields are present in every part of terraced area but their proportion increases from upper slopes to the bottom of the catchment (Figure 4). Hani villages are usually located on middle and sunny mountain slopes.

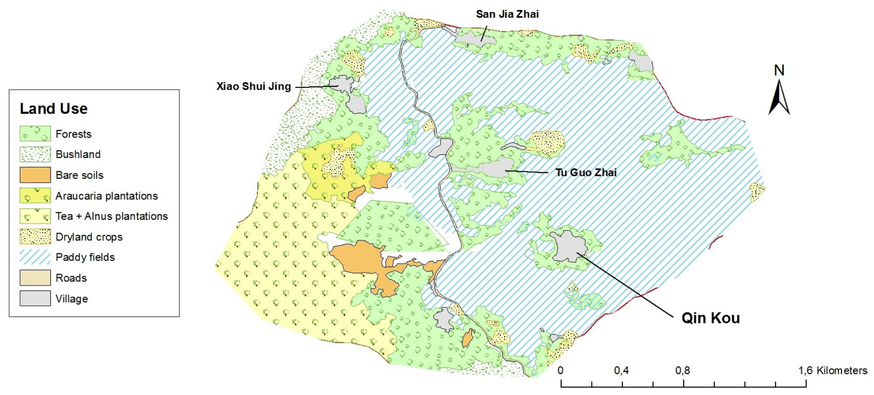
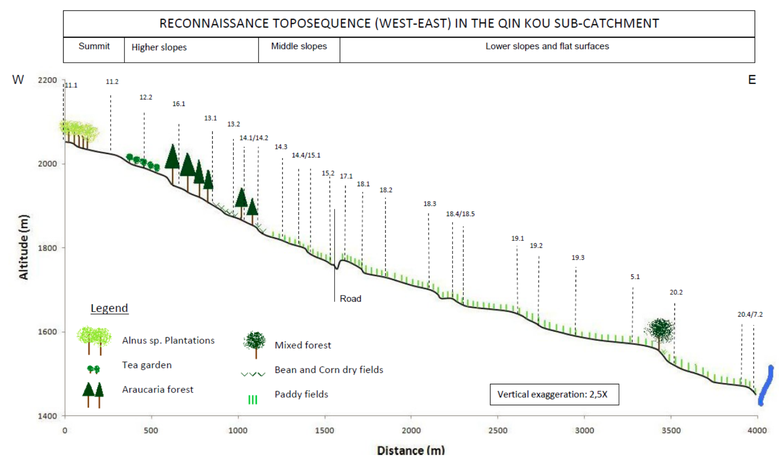
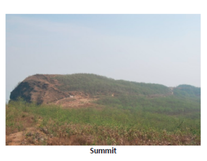


Figure 3 : Land use in Study watershed

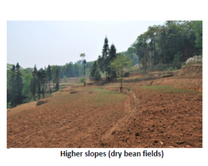
A reconnaissance soil survey was conducted, based on a geomorphopedological approach. Sixty-nine augering points and eight profiles were described and classifed according to WRB. Twenty-five composite soil samples (0-20cm) were analyzed for evaluation of soil fertility : pH (water and 1N KCl), exchangeable acidity (Yuan), total organic carbon and nitrogen (Springer-Klee, Kheldahl), available Ca, Mg, K, Na and P (CH_3COONH_4+EDTA; Lakanen-Erviö).





Summit

Higher slopes (Tea plantation)



Higher slopes (dry bean fields)

Lower slopes (paddy fields)

	Summit	Higher slopes	Middle slopes	Lower slopes and flat surfaces
Geomorphology	Mean slope : 15% / plane surface	Slope : 16 to 25%	Mean slope : 20%	Mean slope : 20% / plane surfaces : 8%
Morphology	Gneiss outcrops Shallow soils Bright colour No diagnostic horizon	Polygenic soils Burden humiferous horizon Higher chroma in subsurface layers Higher clay content and stoniness (15 to 50%) in subsurface layers	Gneiss outcrops / stony soils Dark polygenic soils Deep cracks Plough pan Local redoximorphic features Higher clay content in subsurface layers	Gneiss outcrops in gullies, gneiss rolled blocks Dark polygenic soils Deep cracks Plough pan Local redoximorphic features Higher clay content in subsurface layers Yellow and red soils on interfluves Alluvial deposits in lowest area
Land cover	Alnus plantations Grazed meadows and steppes	Tea plantations Araucaria woods Dry fields (bean, corn)	Paddy fields	Paddy fields Few dry fields
Land management	-	Terraces	Terraces	Terraces
Edaphic constraints	Soil shallowness Acidity and low saturation	Consistancy Acidity and low saturation	Structure and consistancy Blocky stonecharge Acidity and low saturation	Structure and consistancy Stone charge Acidity and low saturation
Soil Group (WRB)	Regosols	Umbrisols	Hydragric Anthrosols	Hydragric Anthrosols

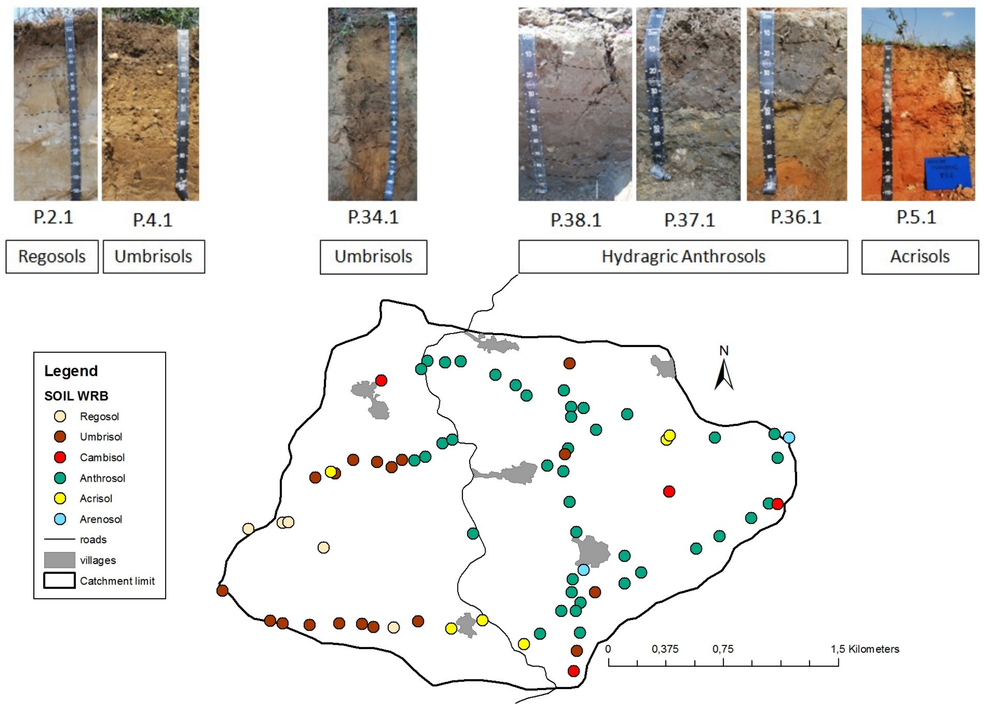


Figure 4 : Soil organization model in the Qin Kou subcatchment (Koulos,2010)

MAIN RESULTS

Soil distribution in the Hani landscape

In an « homogeneous » lithological environment, the spatial distribution of soils is driven by redistribution processes of weathering products, on the one side and by human activities (building of Hydragric Anthrosols). Soil organization across relief is presented at figure 4.

The link between soil distribution and elevation is rather clear. Anthrosols are clearly linked to the paddy fields below the main road of the catchment. Regosols and Umbrisols are associated to forested and dryland crops. Cambisols and Acrisols are found in association to Anthrosols in middle or lower elevations. Arenosols are located along the largest streams.

The most frequently used qualifiers for soils of the sub-catchment were : Colluvic, (Hyper-) Dystric, Escalic, Hydragric, Gleyic, Stagnic, Cambic, Humic, Leptic, Endoclayic, Rhodic, Pachic, Chromic or Haplic. Some of these qualifiers express an acid, nutrient-poor environment, others man-induced soil alterations.

Soil fertility

A first survey of the fertility status of the fields was realized. Results can be summarized as follows.

Soils are acid or slightly acid. Most pH_{water} are between 5 and 6. Kawaguchi & Kyuma (1977) found similar levels for soils from 410 paddy fields in Southeast Asia. However, the exchangeable acidity is relatively low. The situation should not therefore be considered as a huge edaphic constraint. The organic status appears rather high. This might indicate that the transformation of organic matter (straw residues) is probably slowed down by the redox conditions and by cool local climate. The enrichment in C and N by algal development is well known in paddy fields. However, the dry fields of Qin Kou sub-catchment did also show high level of organic status. The nutrient status appears rather low and weakly variable from field to field. There don't seem to be ionic disequilibrium (Landon, 1991). The weak variability of base status should be linked with a relative homogeneity of soil parent material. The effective CEC might be considered as relatively weak too (Kawaguchi & Kyuma, 1977; Landon, 1991), which is the case for Al saturation too. Al toxicity does not seem to be feared at first sight.

The comparison of wet rice fields to dry terraces devoted to bean and maize lead to the findings that the fertility status is globally better in dry terraces than in paddy fields. Dry soils are less acid and a little bit richer in N and in base cations. The distance to village could be put forward as a significant factor.

These findings should be validated by a broader survey

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