Site description of the Red Soil Site, South East China

Research objectives

The general objective of the project is to identify, describe and regionalise landscape ecological process combinations in a red basin of SE-China. These basins are favoured for their agricultural potential for diversified crop growing and have long been considered as an supplementary reserve for agricultural use in the economically booming Yangtze Delta. The whole project follows the concept of hierarchical landscape dimensions, ranging from plot scale to the medium landscape scale, represented by maps (1: 20,000). The specific objectives of the project are to classify and measure landscape components of these landscape ecosystems in a nested approach. The focus is laid upon water, solid matter and nutrient fluxes from the plot scale to the scale of small watershed. Upscaling of the landscape ecological process combinations are carried out from the catchment scale to the medium landscape scale. These up-scaling procedures are not considered in the paper due to the limited space of the paper. Instead, this paper narrows the scope to the objectives connected to the experimental catchment.

Study area

The study area is located near the Ecological Experimental Station of Red Soil, Chinese Academy of Sciences, Yingtan, Jiangxi Province. The climate is representative for subtropical SE China. Typical monsoonal rainfall peaks in April, May and June, exceeding 250 mm per month, mean monthly temperature between June and September range between 25 and 30° C. Potential evapotranspiration exceeds rainfall from August to November causing seasonal drought. Sun Jia catchment was selected in the research due to its representatives in topography and land use of red basins. It covers an area of 46 ha of gently sloping terrain and exhibits an altitudinal range of 15 m. Slope inclination is up to 8.5%. The land use in Sun Jia catchment include paddy fields (double cropping of rice) and three ponds on the valley bottom and lower slopes and upland fields on the slopes (Fig. 1). The upland fields are used for rain-fed agriculture with small vegetable fields, large peanut (*Archis hypogaea*) fields and orchards where chestnut (*Castanus sativa*) and citrus (*Citrus unshiu*) fruits are grown. Paddy fields account for 20.2 % of the total area, whereas peanut fields make up 49.5 % and orchards 17.0 %.

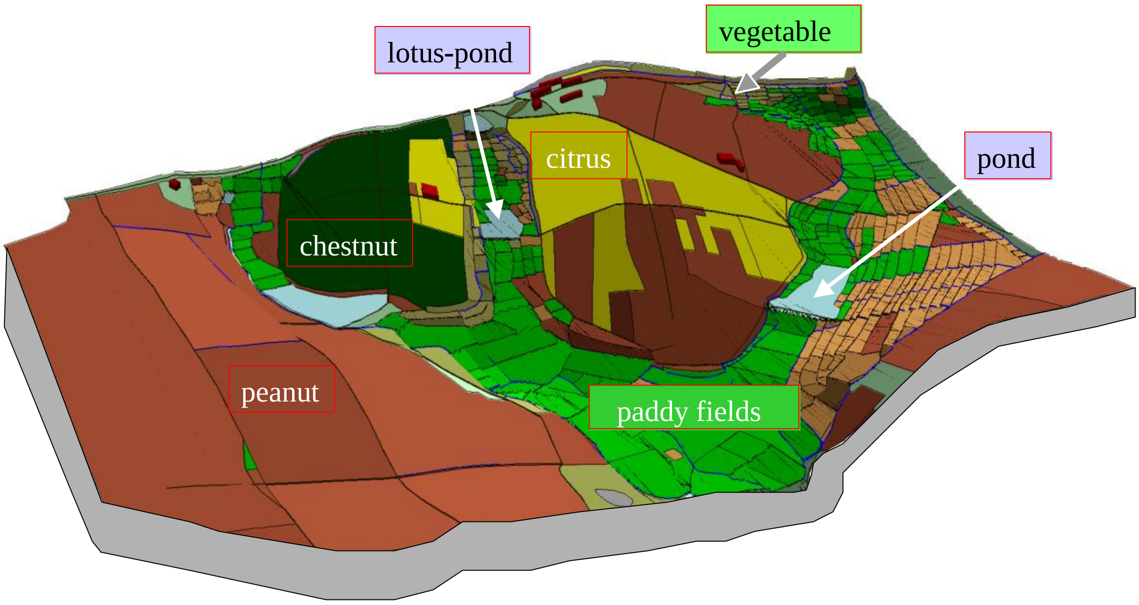

Fig. 1. Topography and land use in Sun Jia Catchment.

METHODOLOGY TO QUANTIFY HYDROLOGICAL PROCESSES

In the Sun Jia catchment the significance and magnitude of hydrological and soil erosion processes are evaluated by quantifying water budget of individual plots as well as of the total catchment, by detecting spatial gradients of solid matter fluxes and by analysing pathways of nutrients and suspended matter fluxes.

On the plot scale we study soil moisture on a daily basis (Fig. 2). Aggregation of the daily data leads to information on soil moisture regime. Soil moisture regime reflects the seasonal variation at various depths. There are various possibilities to describe, quantify and classify soil moisture regimes, the basis of which can either be volumetric water content or soil matric potential. In addition, these variables measured on a daily basis are commonly used to calibrate hydrological simulation models for the soil-plant-atmosphere-continuum (SPAC). These models can output the daily water budget figures such as transpiration, evaporation, interception and deep drainage. Summing up daily values leads to estimations on a yearly base, which facilitates comparisons between landscape ecological units. Based on the assumption that similar combinations of soil and vegetation variables result in similar water budgets, the modelling results that are obtained for specific sites may afterwards be regionalised to the whole catchment using Geographical Information Systems (GIS). By area weighting the site specific water budget it is possible to quantitatively estimate the catchment's hydrological water budget. The reliability of the information depends on the representativeness of the selected sites and the accuracy of the simulation model. This procedure has one general disadvantage that lateral water fluxes, especially input water fluxes from spatial units at higher elevations are not considered explicitly when one-dimensional modelling is chosen. The lateral water fluxes on the soil surfaces and within the soils contribute to quick direct runoff and interflow. When considered with high time resolution, these flow components can not be reflected with high accuracy

Another method to estimate the catchment's water budget is based on continuous discharge measurements at gauging stations, especially at the catchment's outlet. Hydrographs allow the detailed analysis of quick flow although neither spatial resolution nor accurate information on the contributing areas that generate quick flow is possible. Flow separation only gives hints as to the relative significance of quick slope hydrological fluxes as opposed to slow base flow. Analysis and interpretation of the discharge measurements and area weighted water budget can be compared. Ideally, the two methods produce similar results at the catchment scale and for the year to month time-scale.

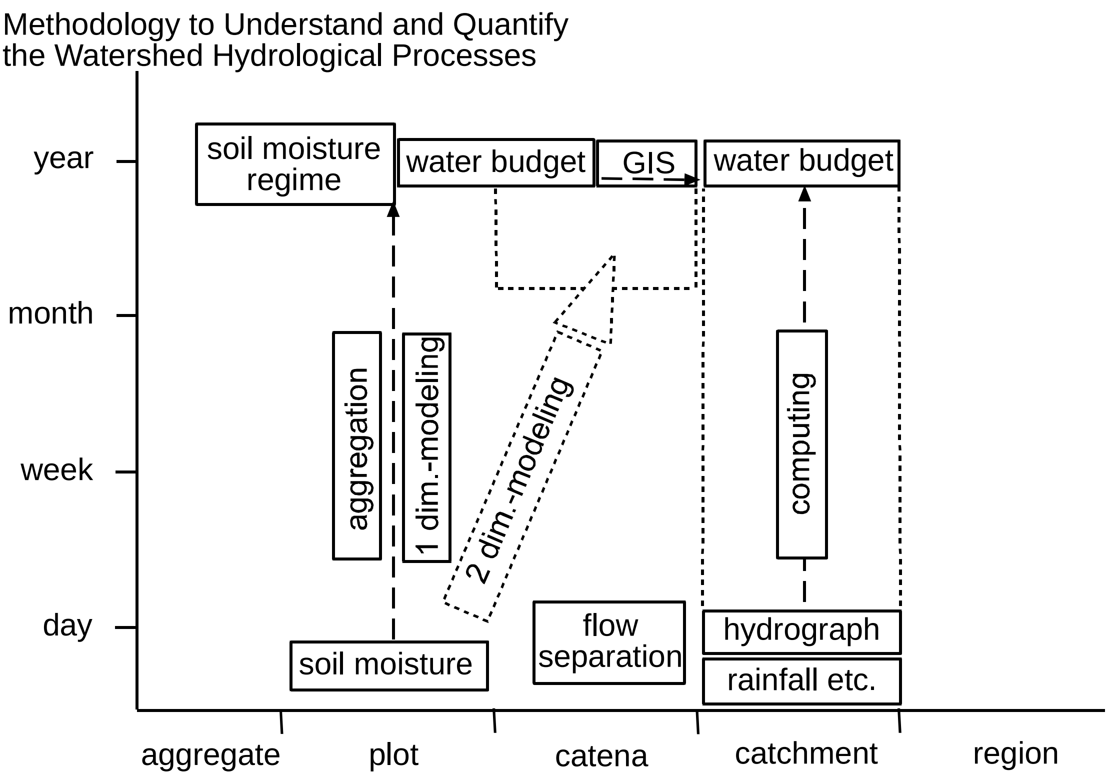

Fig. 2 Watershed hydrological processes in a time scale diagram.

Methodology to quantify soil erosion processes

Soil erosion processes are studied in a similar hierarchical way (Fig. 3). Sediment from the upper slope may be deposited in slope positions which are characterized by convergent flow. In favourable field conditions the study of soil material deposited at lower slope positions enables to derive the significance of soil erosion. One must on the other hand consider that part of the transported material can be delivered further to the stream channel. The soil erosion processes are studied using erosion plots built in the upland agricultural fields, using pedons along the slope and measuring sediment concentration in the channels in the Sun Jia catchment. Paddy fields are thought to have little susceptibility for erosion. As in the case of soil moisture the plot data on soil erosion are summarized to information on a year base. The total load (to/year) through the channels, especially through the outlet of the catchment are calculated by multiplying the sediment concentration with discharge. Comparing the temporal variations of flow components from the hydrograph analysis with the sediment concentration peaks may lead to insights about the mechanism of sediment transport between slopes and stream channels. These findings are qualitative in nature and can be assured by additional chemograph analysis.

With the help of the RUSLE (Revised Universal Soil Loss Equation) soil erosion is described by major influencing factors such as slope, erodibility, rainfall erosivity, land use and others. The RUSLE outputs the results of gross erosion (to/year and ha), which is not equivalent to the net erosion that can be calculated with MUSLE. The net erosion takes into account the sediment input from the upper slope. A full three-dimensional estimation of net soil erosion is possible with ERUSLE. Multi point calibration of this model is possible after long time observation on erosion plots will be completed.

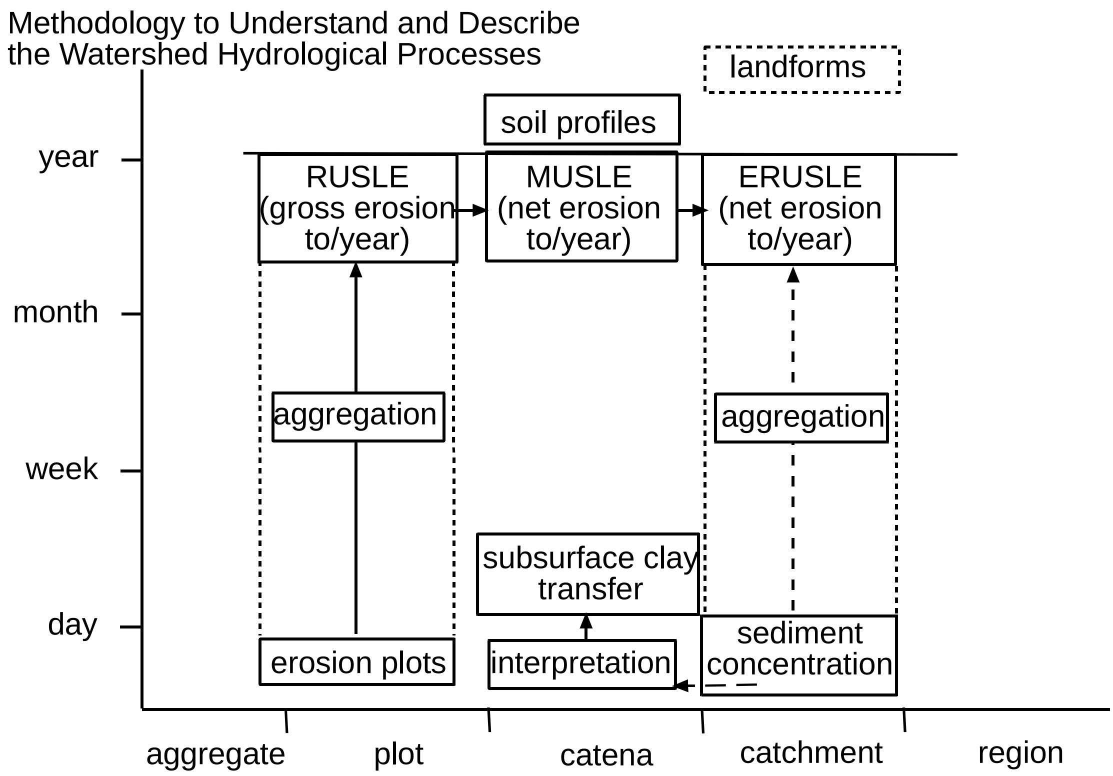

Fig. 3. Catchment sediment transfer processes in a time scale diagram.

Experimental design

Catchment scale

The studied catchment is Sunjia Catchment (Fig. 4), which is located 4 km away from the Station. The catchment was chosen because it has very typical geomorphology and land uses. The catchment has well defined drainage divides and separated hydrological units. In addition, the catchment receives little influence from the residential area and the on-farm-research in the catchment can be facilitated by cooperation with only three farmers.

Several stations were installed in the catchment to record rainfall and monitor catchment hydrology, soil hydrology and corresponding chemical dynamics. The discharge stations were installed in the inlets (No. 1 and No. 2) and at the outlets (No. 3 and No. 4) to measure discharge and sample stream water. The No. 4 station was the catchment outlet. Two additional discharge stations (No. 5 and No. 6) were installed along the foot of upland hill cropped within peanut to measure irritation water and soil surface runoff from the hill. Stream water samples were regularly sampled and measured for chemical content and sediment content. They were weekly sampled and more intensively sampled during rainstorms. Rainfall was recorded by using an automatic rain gage.

Plot scale

Six soil catenas were equipped to monitor soil moisture or soil erosion and measure soil water quality (Fig. 4). Two paddy field catenas represented a new paddy field shifted from upland after terracing and an old paddy field which were cropped with double-rice a year for a long term. They were equipped with tipping bucket system to measure surface runoff from the field. Soil water and runoff water were weekly sampled for chemical measurement. Four catenas were in the upland under different land uses of peanut cropping, peanut intercropped with citrus, citrus and chestnut. The upland soil catenas except for under chestnut were also installed with erosion plots. All upland soil catenas were installed with tensiometers to measure soil water potentials with depths, neutron access probes to measure volumetric soil water content with depths, and suction cups to collect soil water samples.

Overland flow was monitored with tipping buckets connected to one channel data loggers or magnetic counters. The tipping bucket system consisted of two buckets, runoff sampling system and sediment collector. The tipping bucket systems were installed at the lower ends of the erosional plots at the stations of the upland catenas and at the drainage outlets of the paddy fields. The bucket volumes were calibrated in the field. The surface runoff was recorded for each runoff event in the erosional plots and everyday in the paddy fields. The runoff water was sampled and the sediment was collected for chemical analysis.

Soil water potential was measured using different tensiometers. The Equi-tensiometers were used to automatically measure soil water potential at a very low range in the dry season. The transducer-equipped tensiometers were used to automatically soil water potential of surface soil (10 cm) at a range higher than -85 kPa. The Equi-tensiometers and transducer tensiometers were connected to a data logger (DL2, Delt T, Lt., UK) and readings were recorded at 10 minute intervals. The septum tensiometers were used in combination with a needle pressure transducer and readings were manually recorded at 9:00 am every two days. The depths of the tensiometers are given in (TABLE I). There were two replicates of transducer tensiometers at the depths of 20 and 40 cm as replicates and one transducer tensiometer and one septum tensiometer at the depths below 40 cm. Usage of the septum tensiometer reduced the instrument cost and the data from the septum tensiometer were used to repair the missing data in case that another transducer tensiometer did not work.

Soil water content was measured using the access tubes for neutron moisture gauge in the soil profiled below 20 cm and using frequency domain reflectometer (FDR) in the surface soil (10cm). Three neutron access tubes and one FDR sensor were installed at each station of the catenas. Reading of neutron moisture gauge was manually recorded every 5 days for each station. Addition measurement was made before sowing harvest of peanut. The FDR was connected to a data logger (DL2, Delt T, Lt., UK) and the reading was recorded every 10 minutes. The depths of reading and sampling are shown in TABLE I.

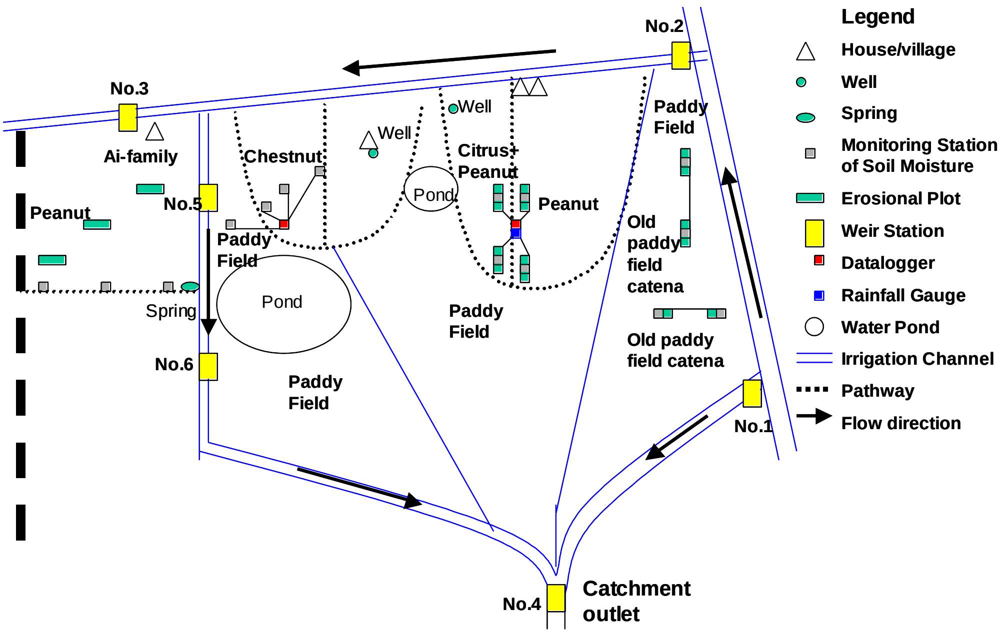

Fig. 4. Sketch map of Sun Jia Catchment.

TABLE I

Instrumentation along the slopes under different land use and measuring depths (cm)

Land use	Position	FDR	Manual tensiometer	Automatic tensiometer	Neutron access probe	Suction cup
Peanut	Backslope	10	60, 85, 115, 150	20, 40, 60, 85, 150		
	Footslope	10	60, 85, 115, 150, 200	20, 40, 60, 85, 150		
Citrus intercropped with peanut	Backslope		60, 85, 115, 150	20, 40, 60, 85, 150		
	Footslope		60, 85, 115, 150, 200	20, 40, 60, 85, 150	20, 40, 60, 85, 115, 150, 200	20, 40, 85
Chestnut	Hilltop	10	60, 85, 115, 150, 200	20, 40, 60, 85, 150		
	Backslope		60, 85, 115, 150, 200	20, 40, 60, 85, 150		
	Footslope	10	60, 85, 115, 150, 200	20, 40, 60, 85, 150		
Rice paddy field				20, 40		

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