Calibration and Up-Scaling of an Erosion Model as a Tool for Farmers Involvement to Define Alternative Land Use

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Abstract: The Hilly Purple area of the Sichuan Basin has been degraded by constant soil erosion, which has reached to 3 035 t/km^2. Soil erosion has direct negative effects on the productivity of the land by loss of nutrients, water and soil. This loss of productivity affects the farmers income. Also, it increases the pollution and siltation of the Yangtze river, causing several problems downstream. The EROCHINUT project has started in 1998 with the overall objective to develop a new methodology to improve land and water management on farm and watershed level in the current socio-economic situation by integrated use of participatory and soil erosion and nutrient modeling techniques. By using a calibrated model, calibrated on a small catchment, and upscale the results base on slope classes, a reliable view of possible effects of alternatives on these features is achieved. These results are visualized on maps, and act as support tools to discuss with farmers and policy makers on the feasibility and possibilities of alternative land use.
Keywords: soil erosion, modeling, farmers participation, nutrient losses

1 Introduction

The Hilly Purple area of the Sichuan Basin is one of the most important agricultural areas in Western China. This area has been degraded by constant soil erosion, which has reached 3,035 t/km^2 (Luo Xiachuan, 1992). Soil erosion has direct negative effects on the productivity of the land by loss of nutrients, water and soil. This loss of productivity affects the farmers income. Also, it increases the pollution and siltation of the Yangtze river, causing several problems downstream. China’s agricultural policy formulated in the ninth Five Year Plan (1996—2000) and the 2010 long-term planning focuses on a steady annual growth of agricultural production and farmer income (Ministry of Agriculture, 1996). At present, China faces a transition from organic fertilizers to chemical ones (FAO, 1997). The replacement of the organic fertilizers will lead to a further deterioration of the physical soil structure, and erosion and runoff are expected to increase during the coming years. With the strong emphasis in China on the increase of production and the efforts of the government to keep the market prices of fertilizers as low as possible, fertiliser use is expected to grow continuously. This might lead to even higher losses of nutrients by runoff and erosion.

2 Erochinut project

The EROCHINUT project has started in 1998 with the overall objective to develop a new methodology to improve land and water management on farm and watershed level in the current socio-economic situation by integrated use of participatory and soil erosion and nutrient modeling techniques. The physically-based model LISEM (De Roo *et al.*, 1992) is used to quantify the losses of soil and water. The model is extended with a nutrient-module to quantify losses of nutrients. The research watershed for the socio-economical study encompasses about 7 km^2, and is located near Chengdu in the Sichuan Province (Fig.1).

Fig. 1 Sichuan Province

Within this watershed, a catchment is selected for the soil erosion modeling work (Fig. 2). This catchment is about 9 ha. in size.

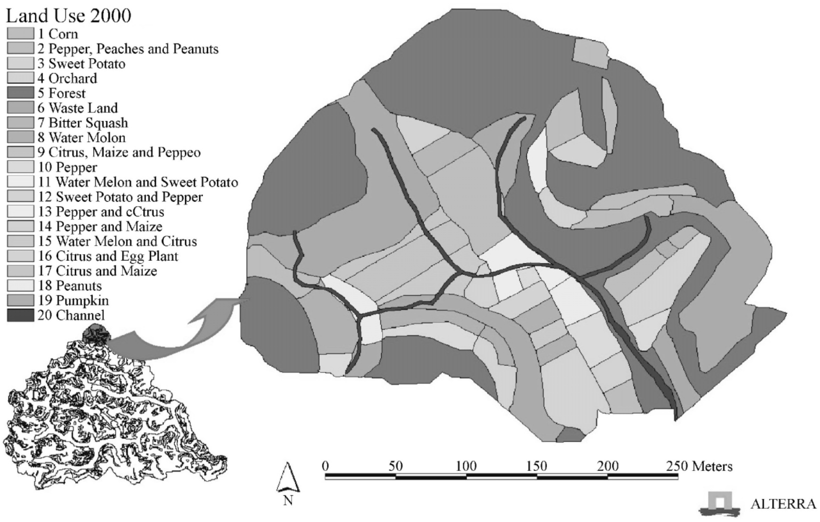

Fig. 2 Study area (left bottom) and catchment for model calibration with land use in 2000

The extended LISEM model is calibrated for a single rain event, and validated for several other events. With this calibrated data set, a table is constructed containing a slope-crop matrix. For a pre-defined field, for each item in the table the discharge rate, sediment loss and nutrient losses are calculated. An integrated farm and watershed management approach is used to gather data on management and economical situation. To be able to communicate directly with the farmers about the effects of proposed alternative land use, preliminary results of the effects on soil, water and nutrient losses are used. This is done by classify the results according to the slope-crop interaction, and visualize this on an area map. The results of this table is used to estimate the effects of alternative land use, as a result of farmers consulting, for the total watershed. Alternatives can than be re-fined, and final alternatives will be composed.

3 Results

The LISEM model is calibrated for an rain event on 17 August 2000. All necessary model parameters (i.e. crop-, soil-, soil surface- and nutrient characteristics, discharge and rainfall) have been collected continuously throughout the rain season. Calibration results for the discharge is given in Fig. 3.

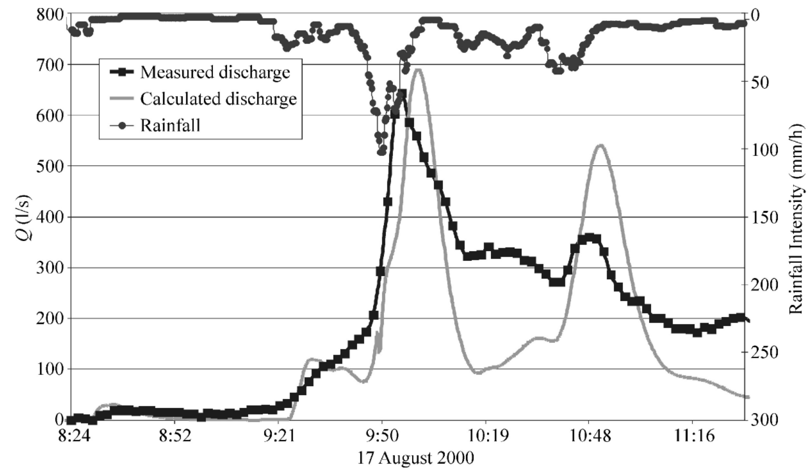

Fig. 3 Calibration result of the LISEM model for an event on 17 August 2000 for the study area

The data set for this event is used to calculate for a representative field the discharge, sediment and nutrient losses under different crop-slope combinations. Results are for the discharge/rainfall ratio are given in Table 1.

Table 1 Matrix crop-slope-soil loss ratio for the calibration storm

Land use	Average soil loss (%)									
Slope(%)	7	11	15	18	22	26	30	33	36	39
Forest	0.0	3.6	3.6	5.1	7.2	9.2	11.2	12.7	14.1	15.6
Waste land	0.4	4.4	4.4	6.0	8.2	10.3	12.5	14.1	15.6	17.1
Orchard	1.1	15.8	15.8	21.8	29.5	36.9	44.2	49.6	55.0	60.3
Peanuts	3.4	23.4	23.4	31.9	42.7	53.2	63.5	71.3	79.0	86.5
Sweep potato	3.7	24.7	24.7	33.4	44.6	55.6	66.4	74.6	83.1	91.3
Pepper peaches peanuts citrus	3.6	24.7	24.7	33.5	44.8	55.8	66.6	74.7	82.7	90.9
Water melon citrus	3.7	24.8	24.8	33.6	44.9	55.8	66.7	74.8	82.8	91.0
Citrus- maize-(& pepper)	3.7	24.8	24.8	33.6	44.9	55.9	66.7	74.9	82.9	91.2
Pepper	3.7	25.0	25.0	33.8	45.2	56.3	67.2	75.4	83.4	91.7
Pepper citrus	3.7	25.0	25.0	33.9	45.3	56.5	67.4	75.6	83.7	91.8
Sweet potato pepper	3.8	25.3	25.3	34.3	45.9	57.1	68.2	76.5	84.6	92.9
Soybean	3.8	13.5	25.4	34.4	46.0	57.2	68.3	76.6	84.8	93.2
Mungbean	3.8	13.7	25.7	34.8	46.5	57.8	69.0	77.4	85.6	94.0
Sugarcane	3.8	13.2	25.5	34.4	46.2	57.6	69.2	77.7	86.1	94.9
Water melon	3.8	25.8	25.8	34.9	46.6	58.0	69.2	77.6	85.9	94.2
Corn & pepper maize	3.8	26.2	26.2	35.4	47.3	58.8	70.3	78.9	87.3	95.8
Bitter squash	4.0	14.2	26.8	36.2	48.4	60.2	71.8	80.8	89.3	97.9
Pumpkin	4.0	26.8	26.8	36.2	48.4	60.3	71.9	80.8	89.3	97.9
Citrus- egg plant	4.1	14.5	27.4	37.0	49.5	61.5	73.4	82.5	91.2	100.0

From Table 1 it can be concluded that much reduction in soil loss can be gained in the steeper areas by changing the land use from crop land to wasteland and forest. To visualize this for the total study area, this table is translated using slope classes of the total area. Two results are shown in Fig. 4. Here, the effects on soil loss of one crop and of forest are shown. These kinds of maps are used to communicate with the local farmers to discuss options of reducing the discharge and soil and nutrient losses.

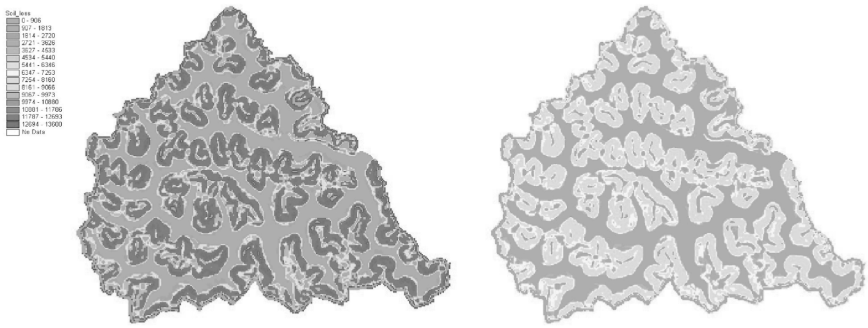

Fig. 4 Calculated effects of cropland (left) and forest (right) on soil loss. Results are up-scaled from a susceptibility table. Up-scaling is based on slope classes. Red is severe soil loss, green is minor or no soil loss.

4 Conclusion/discussion

The EROCHINUT project integrates soil erosion modeling with social-economical surveys. To be able to communicate with farmers, and discuss possible land use alternatives to reduce discharge and soil and nutrient losses, model results have to be presented in a understandable format. By using a model, calibrated on a small catchment, and up-scale the results based on slope classes, a reliable view of possible effects of alternatives on these features is achieved.

The model proved to be able to calculated the discharge, though in some parts of the hydrograph it underestimates, and in some parts it overestimates the discharge. From the susceptibility table it showed that much reduction in soil loss can be gained in the steeper areas by changing the land use from crop land to wasteland or forest. But also within the crop land units, a reduction of 20% is possible. Based on this table, and on socio-economical data, land use alternatives will be defined in close cooperation with farmers and local policy-makers. The effects of the alternatives on discharge, soil and nutrient losses as well as on income of the farmers will be calculated, and presented for the whole study area.

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