Soil and Water Conservation Planning on the Loess Plateau in Northern China

Coen J. Ritsema[1]***, Jannes Stolte***[1]***, Erik G.M. Van Den Elsen***[1]***, Li Rui***[2]***,***
Baoyuan Liu[3]***, Bojie Fu***[4]***, Chen Liding***[4]***, Victor Jetten***[5]***, Rudi Hessel***[1,5]***, Stig Ledin***[6]***,***
Ingmar Messing[6] and ***Minh-Ha Fagerström***[6]

[1]Alterra, Wageningen, Netherlands
E-mail: c.j.ritsema@alterra.wag-ur.nl
[2]Institute of Soil and Water Conservation, Chinese Academy of Sciences and Ministry of Water Resources, Yangling, P.R. China
[3]Beijing Normal University, Beijing, P.R. China
[4]Research Centre for Eco-Environmental Science, Chinese Academy of Sciences, Beijing, P.R. China
[5]Utrecht University, Utrecht, Netherlands
[6]Swedish University of Agricultural Sciences, Uppsala, Sweden

Abstract: The continuous degradation by soil erosion is threatening the agricultural production and thus the livelihoods of many farmers on the Chinese Loess Plateau. In 1997 the EROCHINA project (funded by the European Union and the Dutch Ministry of Agriculture, Nature Management and Fisheries) started with an unique approach to find acceptable and effective conservation strategies, which are based on the integration of soil erosion modeling and participatory soil and water conservation planning. This article provides an overview of the developed approach and its application.

Keywords: China, soil erosion modeling, participatory conservation planning, LISEM

1 Introduction

Thousands of gullies betray the strong presence of soil erosion in the Loess Plateau region of China, were annual losses can mount up to 100 ton per hectare (Zhang *et al*., 1998). Farmers in these areas struggle for their existence under these hard environmental and climatological conditions, and only few are able to make their agricultural activities profitable. Most of the agricultural land is situated on the top of the hills and its adjacent steep slopes, and there are only very small areas of terraces and river land. The main crops in this region are foxtail & pearl millet, maize, beans, potatoes, and other types of land use are orchards (apple & pear), forestland and grasslands. China’s government acknowledges the severeness of the soil erosion problem in this region, and formulated policies to combat it (Trouwborst *et al*., 1999). Although China has many years of experience with a variety of conservation measures (Wen, 1993), a proper method to derive optimal combinations of land use and conservation measures is not available yet. With this knowledge the EROCHINA project aimed to develop a farmers supported soil conservation strategy by using the unique combination of physical soil erosion modeling, land evaluation and participatory research methods.

2 An interdisciplinary approach

Physical soil erosion modeling allows for prediction of soil and water losses under changing conditions, and thus assessment of the effects of land use changes and/or conservation measures. The past has taught us that successful conservation work depends on the participation of the local communities (World Bank, 1992; Rickson *et al.*, 1993). The approach developed in the EROCHINA project aims to actively involve the local community in a planning process, using modeling and land evaluation results as a basis for decision upon future changes. Use has been made of the recently developed, physically-based, soil erosion and hydrological model LISEM (de Roo *et al.*, 1996).

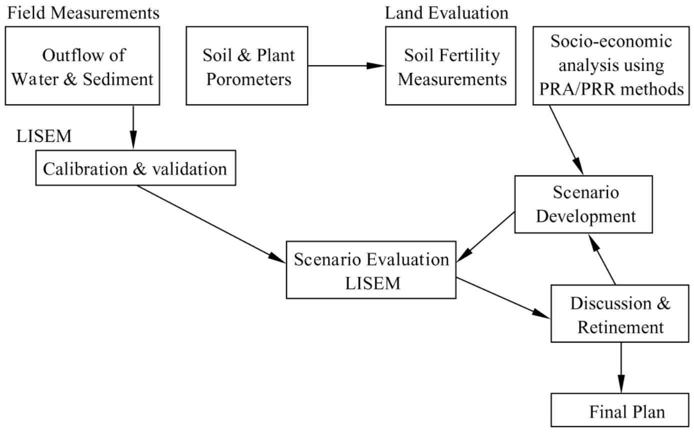
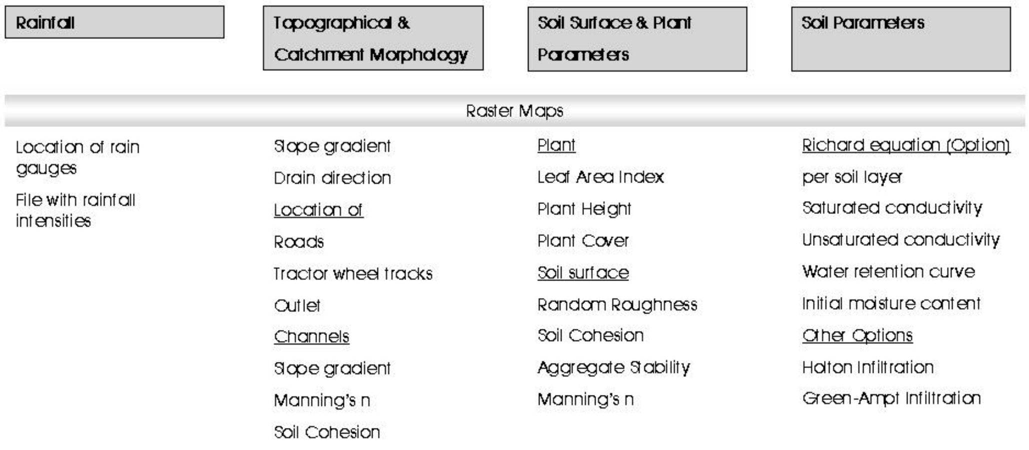


Fig. 1

The project was divided in three main parts (Figure 1). describes the structure and interrelationships between the different components. Firstly, a data collection programme was set up to enable calibration and validation of the LISEM model for this specific region. Secondly, a land evaluation study was initiated, which resulted in a suitability classification of the land for different land uses, and crop types. This work involved a participatory socio-economical analysis of the area and resulted in ideas for feasible land use alternatives. Thirdly, a participatory planning phase has been executed, aiming at evaluating alternative land use and conservation strategies for, and in close consultation with the farmers. Within this process, defined alternatives have been evaluated quantitatively by the LISEM model on their effectiveness to reduce soil and water losses. Results, presented in maps and figures, provide information for a renewed discussion and continued improvement of the scenarios. At the end, this iterative process converges to a compromise, effective in conserving the land and water, and acceptable for the local community.

Table 1

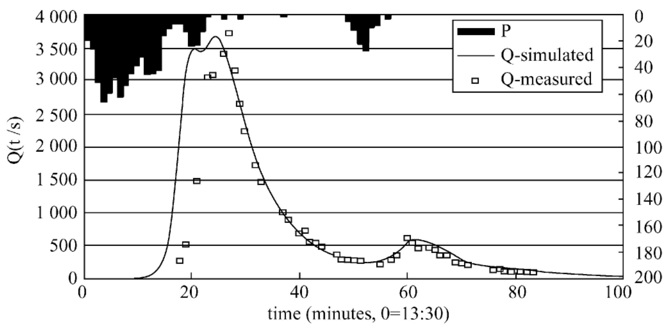


Rainfall	Topographical & Catchment Morphology	Soil Surface & Plant Parameters	Soil Parameters
Raster Maps			
Location of rain gauges	Slope gradient	Plant	Richard equation (Option)
	Drain direction	Leaf Area Index	per soil layer
File with rainfall intensities	Location of	Plant Height	Saturated conductivity
	Roads	Plant Cover	Unsaturated conductivity
	Tractor wheel tracks	Soil surface	Water retention curve
	Outlet	Random Roughness	Initial moisture content
	Channels	Soil Cohesion	Other Options
	Slope gradient	Aggregate Stability	Holton Infiltration
	Manning's n	Manning's n	Green-Ampt Infiltration
	Soil Cohesion		

3 Soil erosion modeling with LISEM

Table 1 shows needed data to apply the LISEM model. Details on measurement techniques and methodologies used within this project have been presented extensively by Ritsema (2001). Data needed for the calibration and validation of the LISEM model are water and sediment discharges at the main catchment outlet. For this purpose, a flume was constructed and a turbidity sensor and an ultrasonic water level sensor were installed. Additionally, a pressure transducer water-level sensor and a suction sampler were installed too.

The actual procedure followed to calibrate and validate the LISEM model has been described by Hessel *et al*. (2001). Figure 2 presents the results of a calibration and validation run. The simulated outflow and measured outflow show great resemblance, and indicate that the model is providing us with reasonable predictions, and as such can be used for planning purposes.


Calibration

Validation

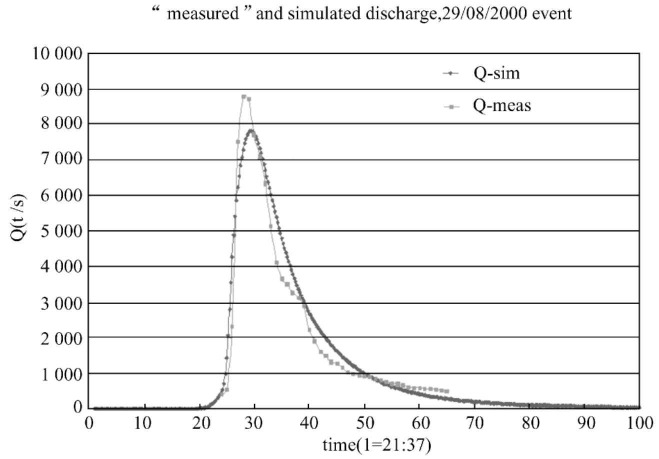

“ measured ” and simulated discharge,29/08/2000 event

Fig.2

4 Land evaluation and participatory planning

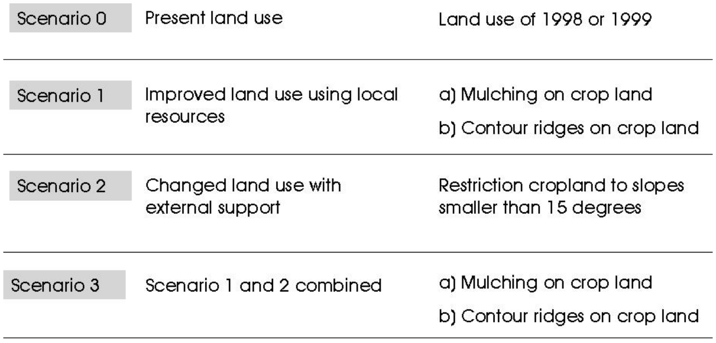
FAO [1983] has defined Land Utilization types to describe the land use according to its socio-economic setting and technical requirements. To determine the suitability of the land for different LUT's, the requirements of a LUT are compared with the climatic and soil/landscape variables collected during the data collection. The output is a series of maps showing the suitability of each part of land within the watershed for each defined LUT.

To determine the Land Utilization Types (LUT), and prepare for the participatory planning process, the participatory work was divided in two parts. The field work in the first project year was a general survey about the social, economic and physical conditions of the research area and the livelihood strategies of the farmer families. During this work, participatory methods, like village sketch, field walk, trend lines, problem flow were integrally used. The results provided a good overview and gave insight in the differences of livelihood strategies and the economical importance of agriculture for groups of farmers. In total, three general types of farming systems in the area were distinguished. In the second year the work focused on a more in depth analysis of farmers perceptions about several subjects like fertilizer use, local soil classification, and preferences of soil conservation measures. It also focused on obtaining the farmers visions for future land use. In total 4 scenario’s were developed to act as a starting point of the planning process (see Table 2).

5 Planning process

The calibarted and validated LISEM model was used to evaluate the effects of the different scenarios defined in consultation with the farmer groups. Results in Figure 3 show that the potential reduction of soil & water losses is limited in case only local resources are used (scenario 1). But a major change in land use (scenario 2) will result in a reduction of 80 per cent of the current losses in water and soil. This scenario can only be implemented with external support from the government to facilitate the transition from agricultural land to forest and grassland. Success of this scenario will depend on the economical viability, social acceptability, and technical feasability of the anticipated measures.

Table 2



Scenario 0	Present land use	Land use of 1998 or 1999
Scenario 1	Improved land use using local resources	a) Mulching on crop land b) Contour ridges on crop land
Scenario 2	Changed land use with external support	Restriction cropland to slopes smaller than 15 degrees
Scenario 3	Scenario 1 and 2 combined	a) Mulching on crop land b) Contour ridges on crop land

Although solutions, as for instance presented for scenario 2, are very promising, some considerations need to be made. In the current situation, all families in the region have land use rights, without owning it, and the fields are scattered all over the area. The legal possibilities of land exchange is still very limited making individual changes to forest lands and grasslands difficult. Another point is that the present agricultural system is the source of food security for rural families, while the money for consumption is mainly earned outside the farm. As long as the money earned outside the farm is not enough to completely support the family, no incentives will exist to stop with agricultural practices and return the land to the community, and subsequently change it into forests or grasslands. Therefore, large-scale land use transitions will depend at least partly on the development of the secondary and tertiary sectors in the region, or, alternatively, on sustained external support from the government. The developed method can be very helpful to further explore and discuss the future direction of the farmer livelihood strategies in relation to soil and water conservation practices.

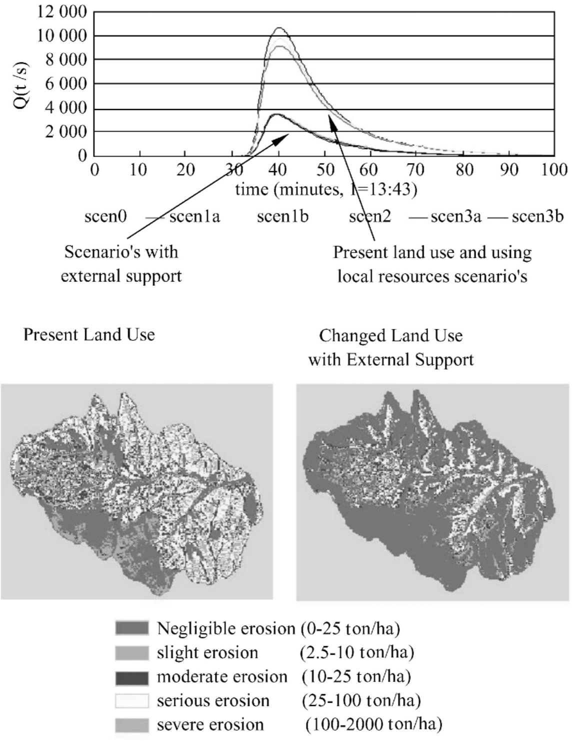


Fig. 3

Acknowledgement and remarks

This work has been executed within the framework of Contract ERBIC18CT970158, financed by the European Commission, and the Netherlands Ministry of Agriculture, Nature Management, and Fisheries (Programme 330).

More information about the project can be found at http://www.alterra.wageningen-ur.nl/erochina

A comprehensive overview of the work in the EROCHINA project will be published in a special issue of CATENA in 2002.

References

FAO, 1983. Guidelines land evaluation for rainfed agriculture. Soils Bulletin 52. Rome.

Hessel, R. and V. Jetten. 2001. Calibration of the Lisem model for a small Loess Plateau Catchment. Catena Special Issue. Submitted

Rickson, T.S., R.E. Rickson and P.J. Nowak. 1993. Farmer responses to land degradation Dilemmas in sustaining land resources in tropical agriculture. Applied Resource Management, Vol 3: 77-101.

Ritsema, C.J. (Ed.) 2001. ‘Soil erosion on the Loess Plateau in China’, Special Issue, Catena, pp. 360, in prep.

Roo, de, A.P.J., C.G. Wesseling and C.J. Ritsema. 1996. LISEM: A single-event physically-based hydrological and soil erosion model for drainage basins. I: Theory, Input and Output. Hydr. Processes 10:1107-1118.

Trouwborst, K.O. and P.J. van Eijndthoven. 1999. China Resource Book. Wageningen, Winand Staring Centre, Report 176: 11-31.

World Bank. 1992. *Development and Environment*: *World Development Indicators*. New York, Oxford University Press.

Zhang, X., T.A. Quine and D.E. Walling. 1998. Soil erosion rates on sloping cultivated land on the Loess Plateau near Ansai, Shaanxi Province, China: an investigation using ^{137}Cs and rill measurements. Hydr. Processes 12:171-189.