DECISION SUPPORT ON MANAGEMENT OF CONSERVATION UPLAND FARMING THROUGH INTERNET

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Abstract

Soil erosion is one of the most serious environmental problems in the world today, because it seriously threatens agriculture and the natural environment. Therefore good management of conservation farming system is necessary.

This paper describes the development of a Decision Support System (DSS) for management of upland farming with special consideration on soil conservation, and discuss how the internet can be used for efficient transfer of that technology and knowledge sharing.

After having user input data of certain field and farm practice, the DSS examines rules and databases and then estimates the potential annual soil loss, in terms of soil water erosion. When predicted soil loss is beyond the tolerable soil loss the DSS will help the user to find some better alternatives of farm practice for conserving soil. Furthermore, the DSS will also suggest the most suitable soil tillage machinery for each derived alternative. As the computer program was developed by using web-based programming language, it can be located in the web-server and can be accessed by many users through internet.

At present, the DSS is loaded with databases collected from Cidanau watershed in Banten Province, Indonesia. However, field test for verifying the program has not been done.

Introduction

At a time when agricultural efforts are focused on increasing food production, soil degradation world wide is increasing. Soil erosion is one of the most serious environmental problems in the world today, because it seriously threatens agriculture and the natural environment (Pimentel, 1993). It was noted that 84% of the soil degradation in the world is due to soil erosion (56% for water erosion and 28% for wind erosion), leaving chemical deterioration (12%) and 4 % of physical deterioration (UNEP, 1992 in Takase, 1995).

Soil erosion in agricultural land causes the deterioration in the quality of land that brings about decreased productivity and increased expenditure on fertilizers to maintain fertility. In extreme cases yield become so poor so that land has to be taken out of cultivation. Besides it, the effects of soil erosion are felt also in the areas down valley or downwind where the ground is covered with sand and silt deposits, ditches and canals are clogged with sediment and reservoirs silt up. The siltation of reservoirs and rivers reduces their capacity, furthermore creates flood hazard, and the sediment is a major pollutant that lowering water quality.

Many factors control the working of the soil erosion system. A considerable number of researches on soil conservation against water erosion have been carried out. However the researches usually investigate only a partial factor from which a practical implication for soil conservation is difficult to be derived. Furthermore, there are also some problems in the dissemination of research results to practical users. The integration of such research results into widely accessible software-driven systems has potential to aid managers of agricultural resources.

The availability of information and communication media promises the efficient and cost effective ways of technology transfer and knowledge sharing. However, the choice of the appropriate medium seems to be crucial. No one medium is the best. The selected medium must be adapted to the message, target audience, and social-economics environment. Interpersonal communication, including extension agents, group meetings, and demonstrations are the best way to transfer knowledge, but, sometimes its effectiveness is hindered by some limiting factors such as time, space, human resources and budget. Radio and television are more appropriate for one way communication, reaching a lot of people quickly with fairly simple ideas. Print media are suited to provide a timely reminder of information. For dynamically changed information, interactive computer systems may be the best way to resolving the problem of relevant and timely information. As the result, the combination of media utilization in agricultural information dissemination is indispensable.

The objective of this paper is to describe the development of a Decision Support System for management of upland farming with special consideration on soil conservation, and discuss how the internet can be used for efficient transfer of that technology and knowledge sharing.

Theoretical Background

Field management of upland farming with special consideration on soil conservation theoretically can be carried out by applying the Universal Soil Loss Equation (USLE) for estimating sheet and rill erosion losses from cultivated fields proposed by Wischmeier and Smith (1978). The equation is :

$$A = R \times K \times LS \times C \times P,$$

where A is the computed annual soil loss per unit area, t/ha; R is the rainfall and runoff factor, j/ha; K is the soil erodibility factor, t/j; LS is the slope length and steepness factor, dimensionless; C is the cropping management factor, dimensionless; and P is the erosion control supporting practice factor, dimensionless.

The USLE was originally proposed for use on cropland in the area of the United State, east of the Rocky Mountains. It has, however, been tested and used in other section of the United States, in Europe, and in the tropics, especially in Hawaii and West Africa. It has also been tested for use on rangeland and in forest area. The equation has been useful wherever tested, although some factors have occasionally had to be modified for effective prediction (Troeh et al, 1980).

The soil loss prediction procedure may provide farm managers with a concise reference from which they can investigate, for each particular situation encountered, which specific land use and management combination will provide the desired level of erosion control. A number of possible alternatives are usually indicated, mostly by affecting the C or P factor in the USLE. This can be done for example by changing the cropping management practice, changing the conservation support practice, or both. The L factor can be modified by constructing terraces. Adding a certain amount of organic matter to the soil may also considered to affect the soil erodibility factor K. From these, the farm managers will be able to make a choice in line with his desire and financial resources.

Methodology

The research was carried out with three approaches, i.e. field experiments, field surveys, and desk studies.

Field experiments were carried out in Leuwikopo experimental field, Darmaga - Bogor, to obtain and verify crop and soil management factors. It were including experiments with several methods of soil tillage as well as several crops. Through the survey, several types of data were collected, i.e. spatial data of Cidanau watershed, especially topographic data and land use data, also daily precipitation within the last ten years and physical properties of soils in the area. The social economic aspect of upland farming was also investigated. The data then were organized in the form of relational databases as well as spatial databases (various thematic map). Computer programming was done by using Java Script and VB Script programming languages. Spatial data were organized by using PC ARC/INFO software.

Result and Discussion

1. Basic Data

Five categories of basic data for the decision support system have been collected and organized into databases, namely rainfall database, soil physic database, topographic database, conservation pattern database, and crop database.

Rainfall database will be accessed to calculate R factor. The study area was divided into 4 sub-areas, each has its rainfall measurement station. Daily rainfall data for the period of ten years have been collected from each station.

Based on available map of land system, the study area consists of 10 units homogenous soil physic. Samples of each unit were taken to be analyzed in the laboratory, and the results were organized into soil physic database. This database will be used for generating K factor.

Spatial data, especially topographic data was derived from land sat image. It contains, among others, 25m-distanced contour lines. This data was used to derive slope (steepness) and slope length database. Land use map produced by local government was used to identify the upland farming area within study area.

Conservation practice database was constructed to organize the pattern of conservation (contouring, terracing, strip-cropping) and its respective standard P values for various steepness and slope length provided by Wischmeier and Smith (1978).

Crop database, as the results of field experiments and literature review, is containing the range of temperature for crop growth, growth period and C factor of various crops.

2. The Decision Support System

The DSS for management of upland farming was developed in the form of computer package program. Figure 1 shows the flowchart of the computer program, while Figure 2 shows the DSS in the internet environment with its data flow diagram. It will give its best performance if been accessed by Internet Explorer 5 or browser with similar level.

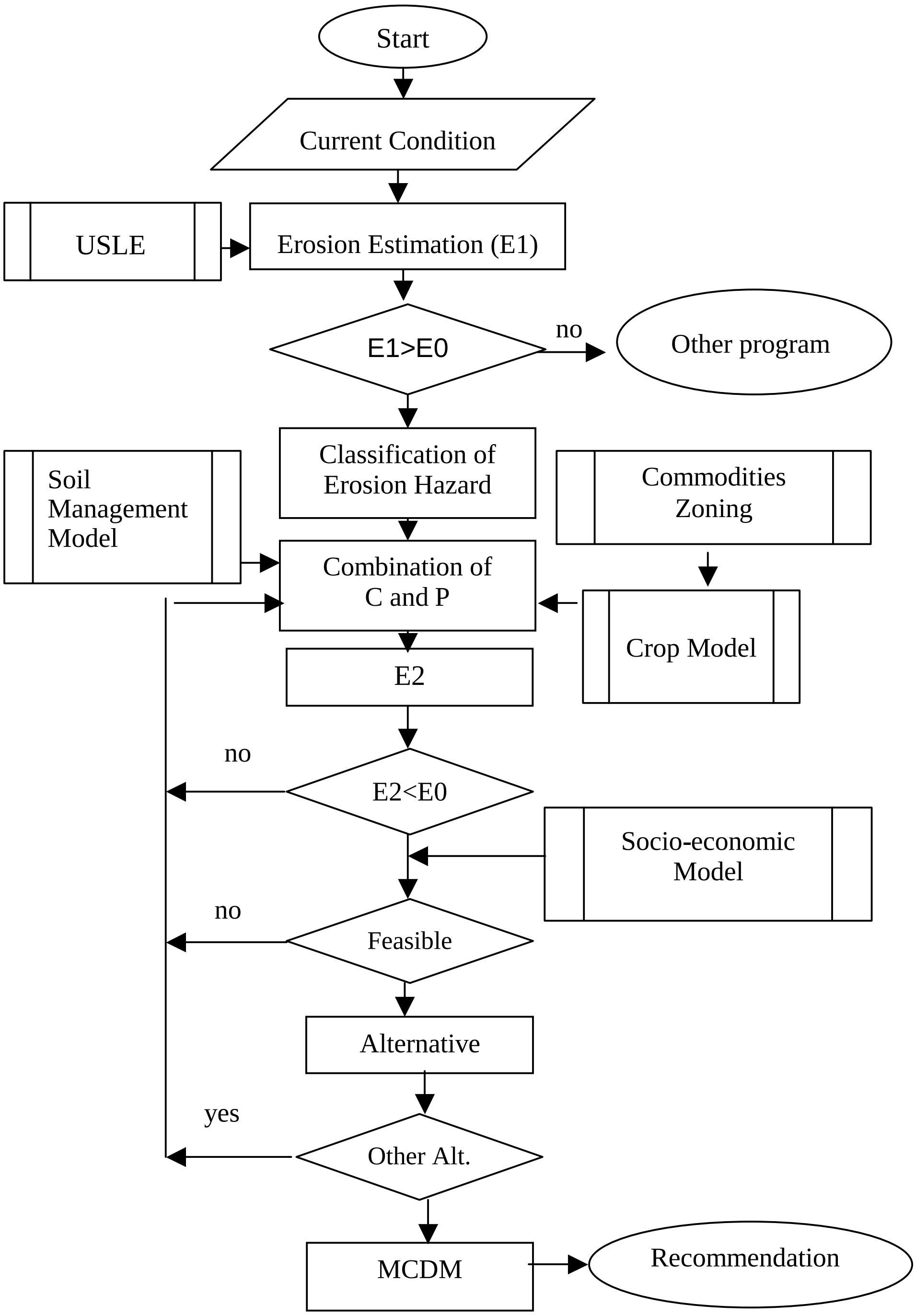

Figure 1. Flowchart of the computer program

Although various default data have been prepared in the form of databases for running the program, for better result the program may receive specific input data from the users such as physical properties of the soil, slope and slope length, crop to be cultivated and soil management being practiced. After having the necessary input data from the user, the DSS will examine rules and databases and then estimates the potential annual soil loss, in terms of soil water erosion. It is then compared with the tolerable soil loss value for the region. When predicted soil loss is beyond the tolerable soil loss, warning message is given to the user, and by performing a simple simulation procedure the DSS will help the user to find some better alternatives of farm practice for conserving soil. In this case, alternatives of farming practice that reduce the amount of annual soil loss are searched step by step forward, start from the practice currently being practiced in the farm to the more conservative ones. For example, from removing plant residue to leaving plant residue in the field, from up-and-down row crop to contour wise row crop, and so on. In the same way, when it is intended to do, crop will also be changed only with other crop having less soil loss ratio. No back step will be considered at all.

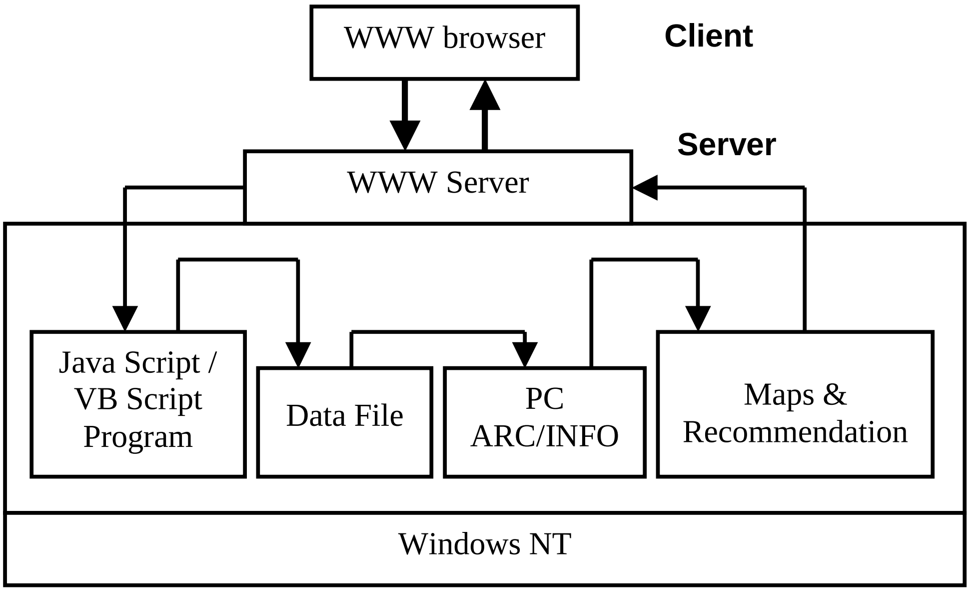

Figure 2. The DSS in the WWW environment

The DSS will also suggest the most suitable soil tillage machinery for each derived alternative. As it is found from the experiments, use of various soil tillage implement will have different effect on soil erosion. In this case, it is limited to the selection of tractor and implement type. Factors to be considered are including slope steepness, soil and residue management, crop to be planted and land acreage. The suggestion can be a hand tractor with rotary, two wheel drive riding type tractor with blade, four wheel drive tractor with rotary and ridger, or some other combinations.

3. Prospect of the DSS Use

By using the DSS, the farmers or farm managers can interactively consult about the field management of their farms anytime in a relatively low cost. However, due to very limited internet access among Indonesian farmers nowadays, the DSS is intended for use by farm advisors and others when consulting with farmers on adoption of conservation cropping system. A modern agricultural advisory service with internet access will be established throughout the country as the part of agricultural information system development program.

In the long run, as the growth rate of internet facilities and users in Indonesia is quite high, it is expected that even farmers can have direct access to the internet, especially with the emerging internet cafes in the country following the telecommunication cafes growth. Based on recent survey by PT Pacifc Rekan Prima, in the year 2000 there are 70 Internet Service Providers in Indonesia with about 400.000 subscribers and 3.670 telecommunication cafes. As not all of internet users are internet subscribers, it is estimated that the number of internet users in Indonesia nowadays is about 2 – 3 millions, and it is continuously growing. Therefore, it can be expected that in the future the web-based DSS can turn out to be a best medium for transfer of knowledge and technology.

4. The Remaining Problems

The remaining problem, among others, is the inability of the DSS in providing cost and benefit analysis, or analysis on financial consequence of each alternative recommended. It is absolutely expected by the users, but there are some difficulties to perform the analysis. As it is known, conservation practices vary greatly in effectiveness, costs, and returns. The effectiveness of conservation practiced can be predicted using USLE, and the costs of soil conservation are usually obvious. However, the returns (profits) are less identifiable. Some conservation practice produce an immediate return, some lead to a delayed profit in exchange for immediate costs, and some produce no monetary profit but are used for non monetary reasons - like reduction in sediment damage and environmental benefits. Efforts should be made to find alternatives of cost and benefit analysis.

Beside incompleteness described above, at present the program has not been verified by field test. A systematic steps need to be done to perform the field tests to assure the usability of the program in the real world situation.

Conclusions

The Web-based Decision Support System (DSS) has been developed to assist farm managers making plan of their conservative cropping system on upland farming. It can be used first, to predict annual soil water erosion risk, for both the existing situation as well as for the projected effects of proposed land use practices, and next to find the more conservative cropping practice. Some efforts still need to be done to find alternative of cost and benefit analysis.

References

1. Pimentel, D. 1993. World Soil Erosion and Conservation. Cambridge University Press, Great Britain.
2. Takase, K. 1995. Global Environment and Agricultural Resource Management (IV) -With Special Emphasis on Land Degradation by Salinization and Soil Erosion -International Development Center of Japan.
3. Troeh, F.R., J.A. Hobbs and R.L. Donahue. 1980. Soil and Water Conservation for Productivity and Environmental Protection. Prentice-Hall, Inc., Englewood Cliffs, New Jersey 07632.
4. Wischmeier, W.H. and Smith, S.D. 1978. Predicting rainfall erosion losses -a guide to conservation planning. U.S. Department of Agriculture, Agriculture Handbook No.537 .