# A USER FRIENDLY GEOGRAPHIC INFORMATION SYSTEM FOR SOIL CONSERVATION PLANNERS

A Thesis Presented in Partial Fulfilment of the Requirements
for the Degree of Master of Agricultural Science in Soil Science
at Massey University

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**1994**

# ABSTRACT

Soil conservation is an important activity for sustainable, productive landuse. To ensure sound effective soil conservation planning, the people who are involved in this activity - the planners and the decision makers - should know (among other things) how best to use a land resource inventory database, which has been stored in a computer.

Using Geographic Information Systems (GIS) to analyse such data is a technique which is being widely advocated. Unfortunately, most GIS computer programs are too difficult for the people like soil conservation planners who usually have little knowledge of computers. To help them understand GIS and then use GIS for their planning, a user friendly interface to the GIS was created.

Two systems were created for the Pijiharjo sub-watershed, Indonesia; one with a **popup** menu, the other with a **pulldown** menu. Both interfaces were created using the SML (Simple Macro Language) command which is available under pc ARC/Info version 3.4D Plus. Although they looked different to the user, both used the same commands to execute the various operations.

Once the initial design was completed, an evaluation was held to check whether the design was satisfactory from the user's point of view. The result of the evaluation showed that both systems were simple and easy to understand.

However, there were some aspects that should be revised, such as the HELP facility.

Similar databases from other areas could be analysed using these interfaces with the only requirement being a modification to the introductory remarks. Ideas for the future development of such systems are also discussed.

# ACKNOWLEDGEMENTS

I would like to express my gratitude and appreciation to the following people for their contribution towards the completion of this thesis :

Mr. M.P. Tuohy, for his supervision and suggestions during the course of my study.

Mr. R.G. Gibb, for his supervision, continual guidance, encouragement and valuable suggestions.

Messrs. J.R. Fletcher, M.R. Jessen and other officials in Landcare Research Ltd. Aokautere New Zealand, for their friendship.

Mr. L.J. Brown and Mrs. S.D. Hendriksen, for their comments, suggestions and friendship.

All of the people who evaluated my systems, for their comments and suggestions.

The New Zealand Ministry of Foreign Affairs and Overseas Trade, for the scholarship grant and the Ministry of Forestry of Indonesia, for granting study leave.

All Indonesian friends at Massey University.

My parents and sister, for their encouragement and continual prayers.

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# CHAPTER I

## INTRODUCTION

### Background of Study

Soil erosion is a common problem in tropical countries, where rainfall, as the most erosive factor, is abundant. The loss of soil and subsequent land degradation often results in a reduction of farmers' incomes. To improve this situation, action must be taken to conserve the soil and manage the land in a more sustainable way.

Soil conservation can include a variety of activities by humans to control the rate of degradation, loss of soil and yield of sediment from the landscape (Perrens and Trustrum, 1984). These activities may be categorized into two major groups, biological control and mechanical control. Biological control activities attempt to conserve the land naturally, by tree planting, multiple cropping, or conservation tillage. Mechanical control, on the other hand, generally involves building dams, drop structures, or terraces.

Perrens and Trustrum (1984) also discuss two levels for making soil conservation decisions; policy making and planning. At the policy making level, the scope is broad, influencing the national and regional land and water management options.

At the planning level the scope is more limited and consequently more detailed. Planners must have a thorough understanding of the land and water resource before recommending any regional management.

Unfortunately, in developing countries decision making for soil conservation purposes is not simple. Problems arise when planners start to collect the data. Socio-economic data which are essential for planning are usually unavailable. If they are available, planners often neglect them, because it is difficult to combine land resource data and socio economic data which may relate to areas which do not have similar boundaries.

Institutional coordination is another problem. Soil conservation policy may involve many agencies, including forestry, planning and irrigation, which are not in the same department. They often have their own data, design their own planning and execute it according to their own schedule. For the farmers who own and manage the land, this situation can cause confusion. They are confused by the many activities which are sometimes similar, but conducted by different agencies. This may lead to a reluctance to implement soil conservation practices.

Ventura *et al.* (1988) suggest that the use of a Geographic Information System (GIS) for soil conservation planning could solve the institutional coordination problem. Automation could be used as an opportunity for agencies to coordinate their data collection and to eliminate duplication or redundancy.

By implementing GIS for soil conservation planning, it is assumed the decision makers and the planners understand the system. They need to know how to extract information for their particular application. Unfortunately most GIS's are not that easy to understand. This could mean that the users, in this case the decision makers and the planners, must be trained to operate GIS before they can use it effectively. Another way to help the planners and decision makers use the data is to make the GIS easier to use. Complicated instructions could be kept disguised behind tailor-made programs designed specifically for the non GIS specialist. A user-friendly interface or tailor-made program could make the GIS much more accessible.

The objectives of this study are :

- to demonstrate the use of GIS for soil conservation planning using already-available data
- to design a user interface for the policy makers and planners

**The Study Area**

The study area is located in Pijiharjo sub-watershed, Upper Solo watershed, Central Java, Indonesia, and occupies an area of about 533 ha (Figure 1). It is mainly flat with some rolling low hill country, mostly bench-terraced, which supports crops such as dry-land paddy, maize, cassava, and peanuts (Jessen, 1992).

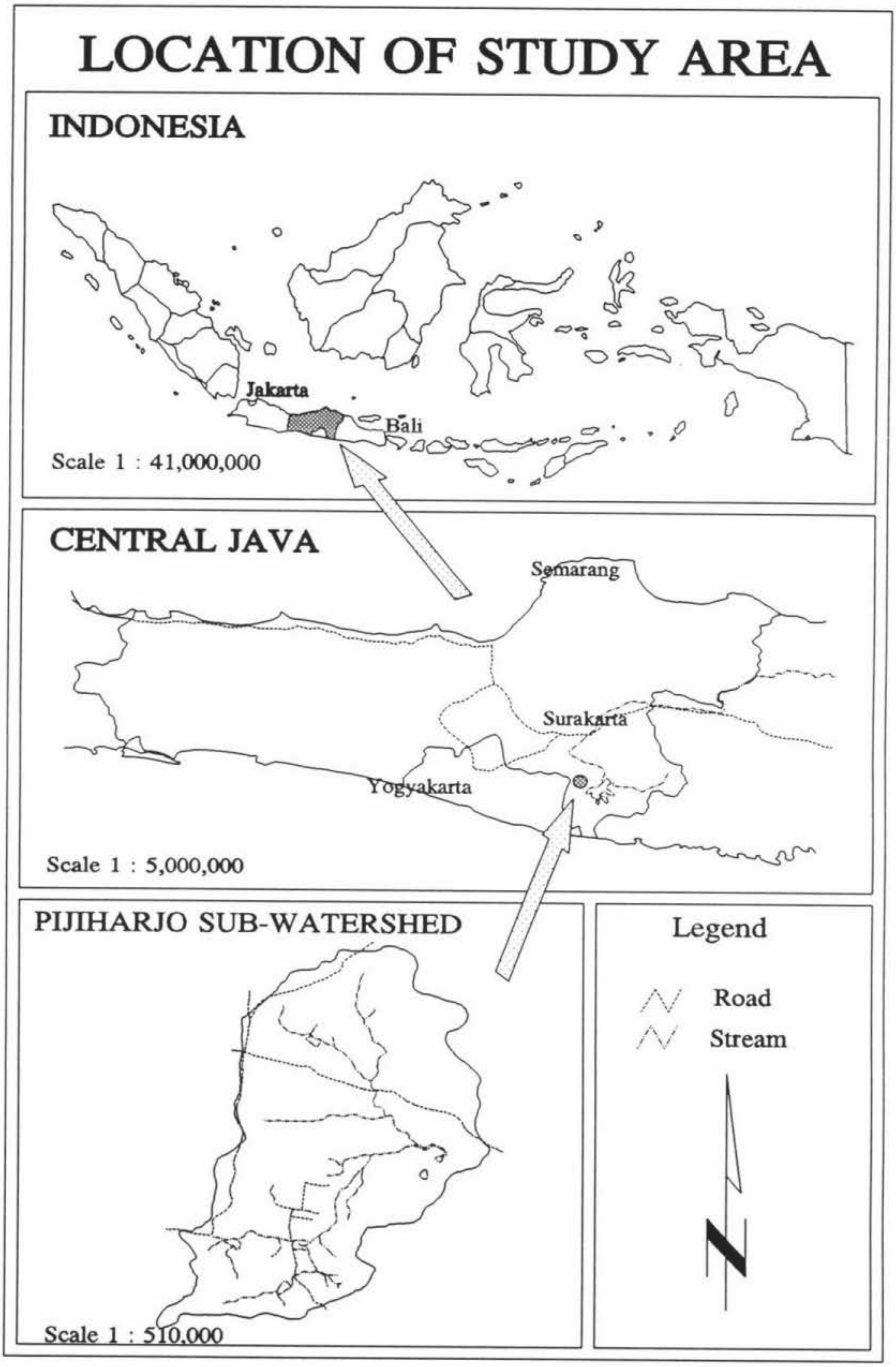


Figure 1. Location of the Study Area

Pijiharjo is part of the region which constitutes the Indonesia-New Zealand Project. The objective of this project is to train the planning staff of the Watershed Management Technology Centre (WMTC) Solo - which is under the Ministry of Forestry (MOF) - and to collect the land resource inventory data for soil conservation planning (Fletcher and Gibb, 1990).

Fletcher and Gibb (1990) introduced a simple and useful inventory system, called IRIS (Indonesian Resource Inventory System). It involved multi-factor mapping within homogeneous map units, recognised on the basis of their land management requirements for long term sustained use. One advantage of this system is that the data can be joined with other resource information such as socio economic data or environmental data.

**Existing data**

The Pijiharjo inventory survey was completed in 1991 by WMTC - Solo staff. The objectives of the survey were (Jessen, 1992) :

- to test the suitability (and applicability) of IRIS at an intensive mapping scale (1 : 5000).

- to enhance opportunities for improving the sustainable landuse of the Pijiharjo sub watershed by using integrated watershed management planning.

- to make a contribution to the knowledge of land resources in the Upper Solo watershed.

- to train MOF staff in land resource mapping.

Jessen (1992) developed the IRIS survey data using multi-factor mapping of landform, slope, rock, soil, erosion, soil conservation measures and land cover/use factors within homogeneous map units. The result was a 1 : 7500 scale presentation based on a 1 : 5000 reference map with a database of 386 map units which were grouped into 19 landuse capability (LUC) units. A full list of items stored in the land resource inventory database is given in Table 1.

The resource inventory data were originally stored and manipulated using the interface called ARC/Manager. ARC/Manager was designed specifically to help arrange the data, from entering the field data to producing maps, based on PC ARC/INFO commands. It was hoped, that by following the steps in ARC/ Manager, good data management could be achieved and a high degree of data integrity assured. More details of this interface can be found in Gibb (1990).

To enable more detailed analysis it was necessary to further subdivide the items which carried the information on terracing, LUC units, erosion and land-cover.

Table 1. Land Resource Inventory Items as stored in IRIS

| COLUMN | ITEM | DESCRIPTION | |
|---|---|---|---|
| 1 | Area | } | Items built |
| 14 | Perimeter | } | by PC |
| 27 | ICLM_ | } | ARC/INFO |
| 38 | ICLM_ID | } | |
| 49 | LF | Landform | |
| 55 | RO | Rock type | |
| 63 | RD | Regolith depth | |
| 64 | SL | Slope | |
| 67 | ER | Erosion | |
| 76 | SDL | Soil depletion | |
| 77 | TE | Terrace | |
| 82 | LU | Land-cover | |
| 94 | SO | Soil | |
| 102 | SD | Soil depth | |
| 103 | BR | Bare rock | |
| 104 | LUC | Landuse Capability | |
| 110 | MU | Map unit | |
| 121 | HA | Area in HA | |
| 134 | Percentage | % of total | |

The terrace inventory included four types of information; intensity of terracing, type of terrace, percentage of terrace risers that are vegetated and terrace condition. For example, if the terrace data is '6Br2m', it means that the intensity of terracing is 6 (more than 80% terraced), the terrace type is Br (Bench Reverse), terrace risers are vegetated to level 2 (20 - 50%), and the terrace condition is m (moderate).

Like the terrace inventory factor, the Land Use Capability (LUC) item is divided into three subitems, class, sub class and unit. If the LUC data is 'VIIs1', it means that the class is VII, the subclass is s (soil limitation), and the unit is 1.

Erosion data, was also encoded in a complicated way. The erosion inventory item contained three kinds of data; erosion severity, erosion type and erosion extent. If the erosion data code is '1S 4 1G 1', this means that two kinds of erosion occur in one map unit, the first of which is dominant. For the dominant type, the erosion severity is 1 (slight erosion); the erosion type is 'S' (Sheet erosion); and the erosion extent is 4 (40 - 60% of the area is eroded). The minor type has an erosion severity of 1 (slight erosion); an erosion type of 'G' (Gully erosion); and an erosion extent of 1 (1 - 10% of the area is eroded). Table 2 presents the expanded items. The user interface, then, was designed with these modifications. Further details of the database can be seen in Jessen (1992).

Table 2. Items from IRIS that Have Been Expanded

| Old Item (width, type, n.dec) | New Items (width, type, n.dec) | Description |
|---|---|---|
| TE (5, C, 0) | Intte (1, N, 0) | Intensity of terracing |
| | Typte (3, C, 0) | Type of terrace |
| | Riste (1, N, 0) | % risers vegetated |
| | Conte (1, C, 0) | Terrace condition |
| LUC (6, C, 0) | Class (1, N, 0) | Class |
| | Sub (1, C, 0) | Subclass |
| | Unit (1, N, 0) | Unit |

| Old Item (width, type, n.dec) | New Items (width, type, n.dec) | Description |
|---|---|---|
| ER (9, C, 0) | Dominant : | |
| | Sever1 (1, N, 0) | Erosion severity |
| | Typer1 (2, C, 0) | Erosion type |
| | Exter1 (1, N, 0) | Erosion extent |
| | Minor : | |
| | Sever2 (1, N, 0) | Erosion severity |
| | Typer2 (2, C, 0) | Erosion type |
| | Exter2 (1, N, 0) | Erosion extent |
| LU (12, C, 0) | LU1 (4, C, 0) | Dominant land-cover |
| | LU2 (4, C, 0) | Second dominant |
| | LU3 (4, C, 0) | Minor land-cover |

# CHAPTER II

## OVERVIEW OF GEOGRAPHIC INFORMATION SYSTEMS

### Introduction

Geographic Information Systems (GIS) were developed in late 1960s (Yeh, 1991), but installed in only a few places because of expensive hardware and limited software. The rapid price reduction in both computer hardware and software during the 1960's and 1970's has made GIS more widespread in 1980s. Now GIS is becoming more accessible to the potential users in developing countries.

As a new discipline, GIS gets much attention from both scientific and commercial companies. Research into the application of GIS has included fields such as utility networks, rural and urban planning, photogrammetry, and environmental monitoring. Aronoff (1991) showed the diversity of GIS uses, ranging from finding the coincidence of factors, such as locating areas with a certain land resource combination; updating geographic information, such as changing landuse cover; or managing municipal services, such as assigning police patrol areas. The diverse applications of GIS have resulted in many different definitions of GIS. Maguire (1991) compiled eleven definitions from various sources, including the one made by Burrough (1986) '... a powerful set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes'. Similar to Burrough's definition, is that by Guptil (1989) who defines GIS as a computer system designed to allow users to collect, manage and analyze large volumes of spatially referenced data and associated attributes.

In general these definitions bring together computer science, database management systems, and geography. By using GIS, all geographical data (which are usually retained as maps and tables) are converted into a database format and can be utilized via a computer.

Accordingly, GIS should do three main tasks, as stated by Scholten and Stillwell (1990). They are :

- to manage the storage and integration of large amounts of spatially referenced data.
- to provide the tools to carry out analyses especially spatial analysis.
- to develop an organization that maintains large quantities of data which are easily accessible to all users.

This statement of tasks is supported by Nijkamp and Scholten (1993) who say that GIS has four main functions : preparation, analysis, display and management of the data. *Preparation* includes activities such as data collection, data digitizing and editing. This function is primarily building up the database, and good GIS integration depends on this activity which corresponds with the first task stated by Scholten and Stillwell (1990).

The second function is *analysis* - examining the data and creating new data for new information. This function is important for planning activities as it often entails overlaying and buffering maps to produce new maps. In other words, the provision of tools to carry out spatial analysis.

The third function is *display*, which includes all operations that produce graphics or maps as output, and is therefore similar to the main function of geography.

The last function is *management*, which enables efficient data handling, data sharing and data manipulation. Like the previous functions, this function supports the third task which develops an organization to do the data management.

Due to the tasks and functions that must be accomplished, GIS has become an important tool in analysing spatial data. It has the ability is to integrate many different layers of data in a single analysis more quickly than would be possible manually. GIS can also handle complex spatial analyses which may not be possible without such a system. For example, a GIS could be used for analysing a complex database such as a land resource inventory for resource management, or doing simple jobs such as inventories of housing (Edralin, 1991). Aronoff (1991) adds some benefits in implementing GIS; planning scenarios, decision modelling, change detection and analysis become more practical because GIS can do it in a quicker time with relatively low cost. He also emphasises the ability to integrate several data sets from different sources using different operations that distinguishes GIS from other systems such as computer-aided design.

Furthermore, Burrough (1986) explains why GIS is more than a means of coding, storing and retrieving data about aspects of the earth's surface. While GIS uses spatial data, those data could be thought of as representing a model of the real world. The model could be used as a test-bed for studying the environmental processes. When people, especially the decision makers, want to test a scenario about the real world, they refer to a model, which is much simpler than the real world (Aronoff, 1991). The advantage of using a model is that the inputs can be manipulated and the results of the changes monitored. Using a model as a test-bed, people can make mistakes without being afraid of destroying the real world.

From all of these reported benefits and advantages of GIS, it can be concluded that as an analysing tool, GIS is much more powerful than any manual system. It is quicker, easier, less costly and less risky.

**Applications of GIS**

The use of GIS to satisfy the needs of a user is called an application (Smith *et. al.* 1987). It involves some form of geographic or spatial analysis. Applications of GIS can be grouped into three broad elements (Ottens, 1990) : background studies, planning studies, and plan implementation. In the background studies, GIS can be used for nearly all research that involves spatial analysis and modelling. The planning studies need the presentation of maps which can be used for planning and decision making. Plan implementation is more flexible, examples are (Scholten and Stillwell, 1990) :

- traffic and transport planning
- agricultural planning
- environment and natural resource management
- recreation planning
- location/allocation planning
- spatial planning (landuse)
- service planning (education, social services, police, etc)
- marketing

With all of these applications, managers are assumed to deal with two basic activities, planning and control. Newton (1986) specifies planning as an activity to form goals and to guide implementation, while control involves comparing actual implementation and planning. For the decision makers, strategic planning is the kind of planning they usually work with, while the planners do the operational control (Newton, 1986 and Robinette, 1991). Furthermore, Robinette (1991) explains that the kinds of information for both the decision makers and the planners are slightly different because of the different activities. The decision makers whose responsibility is strategic planning need a low level of detail, a small scale map and information summaries. Although they receive global information, they have to be well informed to make long range plans. To do the operational control, on the other hand, planners need more detailed data, which are more site specific and very accurate; and a larger scale map (1 : 50,000 to 1 :10,000).

Cowen and Shirley (1991) have different ideas about planning. According to them, planning is a form of spatial decision making which involves the detailed analysis of a complex set of geographical information. From this statement, it can be said that GIS is a tool to help decision makers and planners complete their jobs. McRae and Cleaves (1986) add that GIS is not just a tool; it can improve the quality of planning and decision making, because GIS is constructed for the most part to help planners and decision makers make decisions. However, as a planning tool GIS will only succeed if supported by good databases and organizations who will manage the technology.

In the planning activity, GIS could be at many different scales, ranging from global scale, such as monitoring the development of rainforest (Nijkamp and Scholten, 1993), to the local scale such as regional or urban planning (Edralin, 1991). GIS has a wide application through all steps in the planning process from data collection, to survey, to monitoring the plan implementation. According to Yeh (1990), the degree of GIS usefulness varies at different stages of the planning process :

- at the formulation stage, GIS could generate a land suitability map for the master plan and area zoning. Using map overlays, problem areas could be identified and planners or decision makers could choose an alternative plan if necessary.

- at the implementation stage, GIS could examine the development proposals and detect the impact of project development.

- at the monitoring stage, landuse and environmental change could be detected and GIS could be used to monitor whether the development's progress is according to the plan or not.

**The Users**

As mentioned before, GIS will run well if is well organized. The institution is important to the success of GIS because it embodies the people, the organization, and the management of GIS. Although this is an important part, many people tend to ignore it when developing the system. It is impossible to expect the system to run well, if one considers only the hardware, the software and the data, without considering the people who will operate the system.

The organization and the user can be classified according to the activity they perform. There are four main types of organization (Scholten and Stillwell, 1990)

- *the research institutions* where research is carried out to find the solution to problems or answers to questions.
- *the administrative institutions* whose objective is to manage the information so that the process of manipulating data is simple.
- *the government agencies* whose objective is to formulate the policy recommendations. They usually use model design and evaluation processes.

- *the commercial enterprises* whose aim is to maximize their profits. They may use the information for establishing new retail outlets.

For each type of organization, the data and the computer hardware and software could be different, depending on the necessity or the function of GIS for the particular organization. Moreover, the occupations of the GIS users in each organization could be quite different.

The table below shows that each user needs a different kind of GIS, and to get the best result the user must specify clearly what kind of GIS (s)he needs.

Table 3. User groups and their demands (Scholten and Stillwell, 1990)

| Type of user | information demand | user demand | type of GIS | development |
|---|---|---|---|---|
| Info specialist | raw data | analysis flexibility | large flexible | links to other packages |
| Researcher | raw data/ pre-treated data | analysis good accessibility | compact manageable | macro languages, interfaces to other packages |
| Management/ decision maker | (strategic) information | good accessibility to users, weighing/ optimization | small and beautiful | user friendly interfaces |
| Target group/ others | information | good accessibility to users | small and beautiful | user friendly interfaces |

The information specialists need a flexible GIS, while the researchers need a more compact GIS. Both could be trained to develop application modules to meet their needs. Yeh (1990) advises that the researchers should be kept informed of the development of GIS so that they can develop the expertise.

The decision makers and planners usually belong to government agencies; they need (strategic) information and prefer an easy-to-use GIS. Their jobs involve translating the information collected from GIS into policy statements or planning actions (Scholten and Stillwell, 1990). Designing a user interface for the last two users is a worthwhile endeavour.

In addition, for a more specific job, such as for soil conservation, the tasks, measures and tools for the decision makers and planners often involve more detail. Hufschmidt *et al.* in Perrens and Trustrum (1985) identified these tasks, measures and tools and they are shown in Table 4.

Table 4. Decision making levels in soil conservation with associated agencies, tasks, measures and tools

| decision making level | agencies | management tasks | specific measures | analytical tools |
|---|---|---|---|---|
| Policy | overall executive, legislative, and national planning bodies | formulation of national or regional land and water management policies | establishment of policies, priorities, and respective roles of cooperating agencies and drawing up of general regulations and incentives | identification and projections of national needs and potentialities |

| decision making level | agencies | management tasks | specific measures | analytical tools |
|---|---|---|---|---|
| Planning | planning agencies at national or state level | develop broad-scale landuse management plans | setting priorities for land development and matching landuse potential to conservation needs | qualitative assessment of land capability and erosion and sediment hazard |

From Table 4, it is apparent that decision makers need a small but user friendly GIS for formulating policies. To achieve this task they must be supplied with small scale maps and data. They only need to know the global resources they have, so that they can generate regulations and incentives. In contrast to the decision makers, planners need more detailed data although they may use the same kind of GIS. They should have a general understanding of data, models and planning processes.

Because the decision makers only need to know the results of any analyses, they only need a display function for showing the maps and tables. The planners, on the other hand, need to do more complicated work. To analyze the data they need to proceed to some overlay analysis which results in new information; and for the planning activity they need to print their maps as well. By knowing the needs and tasks of the decision makers and planners, a correct user interface could be designed specifically for them.

Moreover, before implementing GIS, decision makers and planners should be informed its uses and limitations and the kind of resources they need as well (Yeh, 1990). By knowing this information, they will not be under- or over-estimating the results and they know exactly what kind of output to expect.

**Reasons for Developing the Interface**

Although GIS is best used for planning, there are still some limitations in using GIS as a planning tool. Aangeenbrug (1991) found two kinds of problems in implementing GIS as a planning tool. The first problem was that the commands were too complex and mistakes were easily introduced; and the second was the high level of spatial analysis knowledge required to understand the sequence of tasks used. Actually, these problems exist because of the complexity of the system. If the system can be kept as simple as possible, by developing a user friendly system then these particular problems may be overcome.

While Aangeenbrug discussed GIS limitations in terms of its relationship with the users, Edralin (1991) discussed its limitations in terms of the function of the system itself. These limitations were :

- GIS has little projective capacity. For planning activities, GIS should have the ability to predict the trend of a movement, or to project the changing pattern.

- GIS has no internal evaluative capability, which is useful for evaluating plans before implementation in the field.

- GIS has limited user friendliness

The limited user friendliness has already been discussed, but the first two limitations need to be discussed more detail. These two limitations of Edralin (1991) could be solved by adding further capabilities to the system, however this might make the system more complicated.

Yeh (1991) emphasised Edralin's limitations by mentioning two constraints which reduce the effective use of GIS. GIS was not sufficiently advanced for policy making because of the limitation in analysis, and GIS was not a user friendly program; it was too difficult for the ordinary people who need to use it. The limitations in analyses were the capability to project or to predict the trends of a development, or the ability to evaluate a plan before it is implemented.

The user friendliness of the program is a relative condition, because a user friendly program today might be not as friendly as several years ago. It depends on many factors, and one of them is the language difference. For the non-English speaking users, a user friendly system might be difficult to understand because of the language limitation. Developing a non English user interface for a non English user could eliminate two problems at once, namely, the difficulty with the program and the poor understanding of English commands.

Finally, Yeh (1991) considers that lack of trained staff is another problem, especially planners who understand GIS. To solve this problem, more training for planners must be undertaken. They have to know how to change the data into informative plans, and how to use the data for the planning activity or plan evaluation in order to benefit from using GIS. The implementation of a user interface is one solution, especially if the problem is the user friendliness of the program.

# CHAPTER III

## COMPARISON BETWEEN ARCView AND A PURPOSE-DESIGNED USER INTERFACE

### Overview of ARCView

*Introduction*

ARCView v1.0 is a software package developed by ESRI (Environmental Systems Research Institute) which works under Microsoft Windows 3.0 (or higher). It has the capability to share data with other windows based applications through the use of the clipboard.

In ARC News (Anonymous, 1992), ESRI introduced ARCView as a new software that has capabilities for visualizing data together with existing geographic databases derived from ARC/Info operations. With this user interface, even those with no understanding of ARC/Info could gain access to explore GIS data. According to ESRI, ARCView can be used as a stand-alone application - ARC/Info is not required to run ARCView. This is valuable feature of ARCView, because ARC/Info is costly software. Now an organization could set itself up with a single ARC/Info licence and complement this with several copies of ARCView to provide an excellent environment for planning.

What is a View

During an ARCView session, all of the displays are saved in a **view** file which has the **.av** extension. A view is a file to manage the display and query of the geographic data which was simplified by ARCView (ESRI, 1992). A view contains all information needed by ARCView to manage and display the data. Because it is dynamic, every time the database changes, the view will follow it without having to change it. Since its function is to display the geographic data, removing and deleting the coverages from the view do not mean deleting them permanently, but only remove them from the .av file.

*ARCView Capability*

As a user interface for visualizing ARC/Info data, ARCView is a powerful tool. As well as displaying the data, ARCView has some other capabilities, they are : coverage imports, table operations, plotting and address matching.

Display

With this feature, the users explore the capability of the screen, how the ARC/Info coverages could be presented and analyzed by the users. ARCView has many options for displaying, zooming, displaying selected features only and examining the features on the screen. To make a map more attractive on the screen, ARCView allows the user to specify the way a coverage is displayed. It is suggested that this operation is set up first before any zooming or selection activity.

Zooming allows the user to enlarge or reduce the display window. Features to be drawn may be selected by writing a query (e.g. choosing a particular road by name), or by outlining an area on the screen with a cursor. All features within that area may be shown.

While in the Display mode it is possible to identify and measure certain features. For example, by clicking the mouse on a certain feature, all the information contained in the database on that feature will be displayed. Measurement of distance along a line or the area within a polygon is also available.

ARCView also has the capability to view the database associated with the features on the display. It can also make a map composition and then plot it using several provided layouts and letter fonts. If the printer or plotter is not available at that time, plotting to a file for later execution using a DOS print command is possible.

*ARCView Weaknesses*

As a displaying tool, ARCView does an excellent job, but as a planning tool, combining maps and information from a database it is not adequate. A planning tool should have the capability to manipulate both the maps/coverages and the database as well. Manipulating the database can be done easily under other

Windows-based applications, such as DBASE or Paradox, but it is not so easy for a coverage. Map manipulation includes both the overlay and buffer operations WHICH alter both the maps and the associated databases.

From a planning point of view, ARCView alone would be insufficient. The decision makers might find ARCView appropriate as a tool, since they only want to know the global information. As already mentioned in Chapter II, the decision makers only need to view the result of any analyses, so that they can generate regulations and incentives. The planners, may need to carry out several overlaying activities and should be equipped with another tool such as the purpose-designed user interface described below.

**The Purpose-designed User Interface**

As has already been said the objective of designing this interface was to help people, especially the planners and decision makers, who do not understand GIS, particularly ARC/Info, to explore and manipulate the GIS data. In contrast to ARCView, this interface has the capability to execute the overlay operations, which are often required by the planners.

*User Interface Capabilities*

The interface was designed to operate with either a popup or pulldown interface and in both systems the main menu offers the options of DISPLAYing, ANALYZEing, OVERLAYing or PLOTting the data.

DISPLAY

This operation can be used to show maps of the inventory factors on the screen. Along with the map, more detailed information about each of inventory factors can be displayed.

ANALYZE

This module enables the users to make a query using certain criteria. The selected area is displayed on the screen and can be printed after map composition is created. A statistical analysis is also presented during this operation; the total selected area in hectares and the percentage of the total study area is calculated and displayed.

Extracts from the database pertaining to the selected area are displayed as well. Users are able to choose which items should be displayed, or all items will be displayed (default).

OVERLAY

Overlaying is an operation often used by planners to help them to understand the situation they are studying. Smith *et. al*, (1987) regard overlaying as a fundamental operation that must be performed in GIS.

Six options are available under the OVERLAY menu; they are : buffer, eliminate, intersect, union, update and kill cover. All of these options except kill cover produce a new coverage which is displayed and can then be plotted using the PLOT facility. Kill cover deletes the presently selected coverage.

- Buffer :

    This creates a new output coverage by generating buffer zones around input coverage features (ESRI, 1989). This option is useful for delineating a zone which encircles a particular feature.

- Eliminate :

    Eliminate merges selected polygons with neighbouring polygons by dropping the longest shared border between them (ESRI, 1989). This option is used most often to remove sliver polygons which appear when two polygons are overlaid and the lines do not overlap exactly.

- Intersect :

Intersect overlays two or more different coverages and computes the geometric intersection (ESRI, 1989). The result is a new coverage which preserves only those features in the area common to both coverages.

- Union

Union is similar to intersect, but it preserves all features and attributes of both coverages. (ESRI, 1989). Unlike intersect, both coverages in this operation must contain polygon features.

- Update :

Update replaces areas in a coverage using "cut and paste" operation (ESRI, 1989). This operation is especially useful for updating parts of the coverage.

PLOT

This option gives users the opportunity to see the result of the overlay operation and then print it as a hard copy. Before the map is printed, it is displayed on the screen. If it is suitable for plotting, a hard copy can be produced.

**Discussion**

As a planning tool, a user interface should enable some analytical functions in addition to viewing and plotting of the data. To accomplish these tasks, the user interface should have the capability to display and print maps, and to overlay maps to create new maps. Table 5 shows the comparison between ARCView and the purpose-designed interface as an analyzing tool.

Table 5. Comparison between ARCView and the Purpose-designed User Interface.

| Operation | ARCView | Purpose-designed User Interface |
|---|---|---|
| Display - map | Display all | Display |
| | Display selection | Analyze |
| | Pan and zoom | N/A* |
| | Identify and measure | N/A* |
| Print - map | Display snapshot | Analyze<br>Plot |
| Display - database | Tables | Analyze |
| | Statistics | Analyze |
| Print - database | Save table to a file | N/A* |
| Overlay | N/A* | Overlay |
| Create new coverage | N/A* | Buffer, eliminate, intersect, union and update |
| Delete coverage | N/A* | Kill cover |

* : not available

During the display operation, ARCView has the capability to display either the whole map or the selected map elements. It also has Pan, Zoom, and Identify operations as well, which make it a really good tool for displaying ARC/Info data.

The purpose-designed interface, on the other hand, separates these capabilities into two operations : DISPLAY which just presents the inventory data without offering the option to print or plot them; and ANALYZE, which allows the users to select features according to their own criteria, with the opportunity to plot the result. Unfortunately, the interface does not have pan or zoom capability although this could be added in the future. It does not accomodate identify and measure operations either, but this system can present the extended information for each inventory factor, an operation which needs some effort to do in ARCView.

ARCView produces hard copy using the Display Snapshot option which prints maps at various scales and controls the layout. The maps can be printed to a file, if the printer or plotter is unavailable. The DOS print command, can then be used to send the file to the printer or plotter.

The purposed-designed interface can print maps in two different ways. If the map results from displaying selected map elements, then the map can be printed using ANALYZE, while overlay maps can be printed using PLOT. Neither option supports printing to a file, so users must make sure that a printer is connected, before printing a map.

To display a database, ARCView can present all the database records or just selected records. Statistical calculations can be performed, in either case. Printing the table is very easy using the 'Save into a file' button, which writes the data to an ASCII file. The file can then be printed or read into other applications.

The purpose-designed interface displays database records after performing statistical calculations in the ANALYSE option. In contrast to ARCView, only the selected database records are displayed. The following statistical calculations are performed : calculating the total selected area in hectares and measuring the percentage of the selected area compared to the total area. This system does not yet have the option to print database records. The 'print screen' command can be used for popup interface, because there is no background colour on it, but in the pulldown interface this option is not available as any characters cannot be seen because of the background colour. It seems that every colour in the screen will turn into black in the printer, while any other colour will be converted into black.

With regard to the Overlay operation, ARCView does not have this capability at all. The only way to create a new coverage in ARCView is through Duplicate. This command puts more coverages in the .av file, which makes the users see the copied coverage on the screen but does not copy the database.

In contrast to ARCView, the purpose-designed interface provides five different ways to create a new coverage; they are Buffer, Eliminate, Intersect, Union and Update. To delete a coverage the command is Kill Cover. In the ARCView, like

Duplicate, Remove does not remove a coverage from the directory, but simply deletes it from the .av file. Kill Cover actually deletes all traces of a coverage from the directory.

The inability to manipulate the database in ARCView becomes a major impediment in using ARCView as a planning tool. It allows planners and decision makers to display maps and database records, but as soon as they need to do overlay operations, they have to return to ARC/Info.

In contrast, the purpose-designed interface is designed specially to accomodate planners needs, and provides overlay operations as well as map and database display.

# CHAPTER IV

## DESIGNING USER INTERFACES

### Overview of User Interfaces

An interface is a channel of communication between the user and the application (Kirakowski and Good, 1987), while Helms (1983) defined a user interface as part of a computer program which links the user to the computer and allows the user to control the computer. Illingworth (1990) in the Dictionary of Computing defined a User Interface (UI) as :

> *"The means of communication between a human user and a computer system, referring in particular to the use of input/ output devices with supporting software."*

It can be said then, that a user interface is a tool to help the user to communicate with the computer more easily and operate it more efficiently.

The reason for developing a user interface design is to avoid problems which can occur between the computer and the user. Misunderstandings can arise on both the computer side and the user side. The user's computing skills, background of interest, and native language are all potential problems. Shneiderman (1992) mentions several computer problems, such as inconsistent command languages, confusing operation sequences, chaotic display formats, inconsistent terminology, incomplete instructions, complex error recovery procedures and misleading or threatening error messages. All of these difficulties could be minimised, or avoided by developing a good user interface.

In order to accomplish a good user interface, many factors must be considered, and perhaps most important is knowledge about the users. Rubin (1988) mentioned the importance of understanding the users, because the interface should be designed to satisfy them.

*The Users*

Lea (1988) described three ways to collect information about the user : by direct observation, indirect observation or by employing some form of survey. Direct observation means watching the user as (s)he performs activities at the terminal. According to Lea, the benefit of this approach is that the designer knows exactly the quality of the user, but from the user's point of view, sometimes this activity is very disturbing. Indirect observation, on the other hand, tries to lessen the direct contact between the user and the designer, by using video recording or protocol analysis. The major disadvantage of using this method is, however, that it is very time consuming. The third method, some form of survey, is useful at any stage of the design, and it can provide useful information on the user requirements to be compared with the design objectives.

Once the users are understood it is necessary to group them according to their knowledge or the tasks they wish to perform (Kraak, 1987 and Shneiderman, 1992).

Shneiderman categorizes the users into three groups, i.e. novice users, knowledgeable intermittent users, and frequent users. Novice users are people with little or no experience with computers. The interface designed for them must be simple, with carefully designed manuals and step-by-step on line help. The knowledgeable intermittent users know about computer concepts, but have difficulties in understanding the command language. Screen on line help and well organized manuals will be useful for them. In contrast to the novice, frequent users are very familiar with the system and tend to find shortcuts to complete their work rapidly. A design which allows them to create shortcuts is the one they need.

When a designer must accommodate more than one type of user, the interface must be made with several levels of difficulty. The novices can be taught a simple job, and after gaining confidence they can continue to a higher level. Meanwhile the frequent users could start at a higher level. Likewise the programs, the manuals, screen on line help and tutorials should follow the level of the design.

From Tables 3 and 4 in the previous chapter, it can be assumed that the decision makers and the planners are most often categorized as novice users. For such people the interface should be simple and must provide on line help as frequently as possible.

*The Design Principles*

Shneiderman (1992) considered that designing user interfaces was a complex and highly creative process which involved intuition, consideration, and experience. The real point of designing user interfaces was to ensure clear communication between the user and the computer. Therefore, to design a user interface for an interactive system, the designer must first understand the desired functionality of the system, the capabilities of the users (Bass and Coutaz, 1991), and the heterogeneity of the users (Shneiderman, 1992).

There are many principles of designing a good user interface, because almost every designer has his/her own principles. Sun Microsystems Inc. (1990) for example, has three basic principles for designing a user interface : *simplicity, consistency and efficiency*, while Apple Computer (1988) substitutes *clarity* for efficiency.

Simplicity of the interface is the most important aspect for the beginner and intermittent users. A good visual interpretation contributes to simplicity. A simple visual design will look more friendly and easy to use than a complicated one. Another contribution is a clear command, especially for the infrequent use. Sometimes a very short command, using just a single word is not clear enough, although it is simple. Therefore, a straightforward command is more appreciated.

Consistency will help the novice user to apply his/her knowledge to a new program without much trouble. This transfer of skills is one of the most important benefits of a consistent interface (Apple Computer, 1988). The user should activate the same command after pressing the same button (the mouse buttons or keyboard) every time. An inconsistent pattern of mouse button or keyboard operation will frustrate the user. Like the keyboard, the placement and naming of commands will be better if consistent (Sun Microsystems, 1990). Using a standard convention for both aspects is recommended.

The third principle is efficiency. An efficient application minimizes the number of steps required to perform an operation and provides users with shortcuts (Sun Microsystems, 1990). Fewer steps mean less mouse travel, fewer keyboard presses and less hand movement between mouse and keyboard. Using popup windows or menus is also helpful to the user and makes the design more efficient.

The clarity of the program should not depend only on the picture, sometimes words give a better result. Using animation is the best way to draw the user's attention to a particular place on the screen (Apple Computer, 1988), especially the most important part of the graphic.

By following all of these principles, a designer may be expected to make a good user interface. Users should feel comfortable with the similarities between various applications, and they should use an interface confidently without being afraid of executing a dangerous command.

**Purpose-designed User Interfaces**

By considering the requirements above, two user interfaces for decision makers and planners were designed. These interfaces run under PC ARC/INFO version 3.4D Plus (ESRI, 1990). They were built using the SML (Simple Macro Language) commands available within the PC ARC/INFO system. SML is a high level programming language that can be used to develop user interfaces and to tailor the program itself (Hickin *et. al*, 1991).

Two similar interfaces were designed, one employed a popup interface and the other used a pulldown interface; both used SML commands.

*Popup Interface*

The popup interface is a non-colour menu, often containing some information inside the menu. There are two ways to activate the commands; by choosing an item on the menu using a mouse or cursor, or by typing some numbers or words. During operation, some questions must be answered by typing Y (yes), N (no), numbers, or just pressing <CR> (carriage return) to accept the default to be executed. The main menu of the popup interface is shown in Figure 2.

From the MAIN menu individual commands are executed by highlighting the appropriate word (using the mouse or arrow keys) and then pressing a mouse button or <CR>. Explanations of each command are also given.

**MAIN MENU**

Please choose one of these modules :

DISPLAY

This module enables you to display each of the inventory factors in the Pijiharjo sub-watershed

ANALYZE

This module allows you to create a map showing areas which have been selected according to criteria which you choose

OVERLAY

Overlaying and buffering operations are performed in this module

PLOT

This module is used to create a map composition showing the result of overlaying operation

QUIT

Quit from this system and return to ARC/INFO

Figure 2. The Popup Main Menu

*Pulldown Interface*

This menu uses colour and commands are most easily selected using a mouse. Only commands highlighted in a bright yellow colour are able to be selected. Figure 3 shows the MAIN menu.

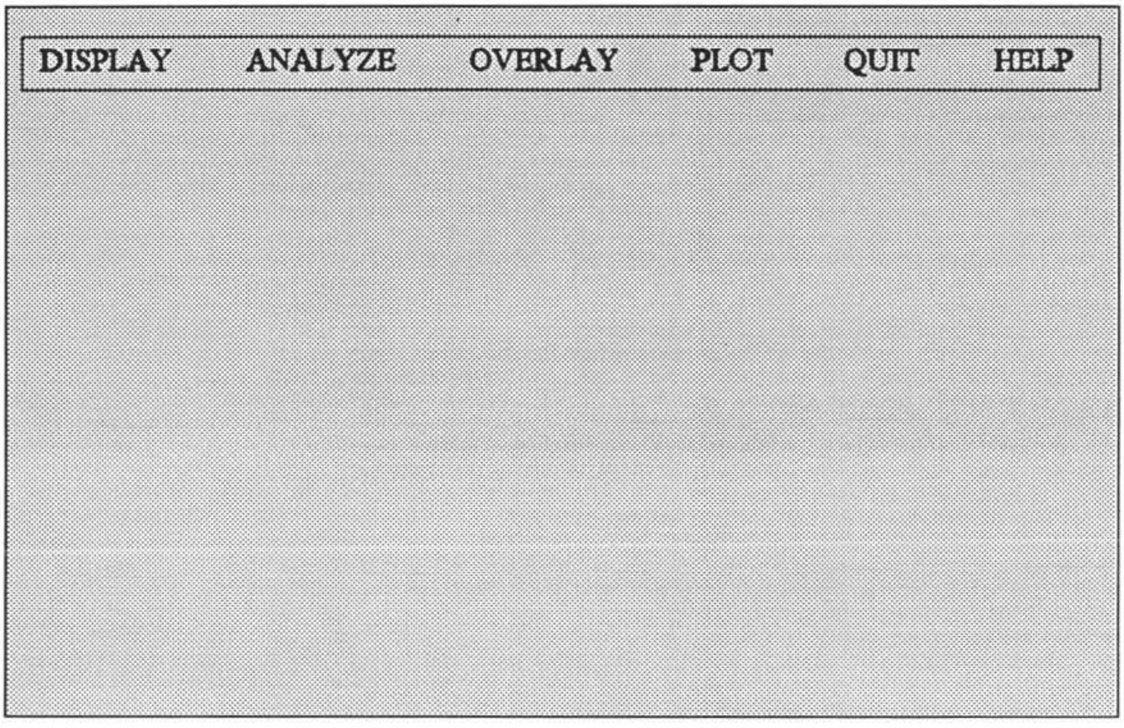


Figure 3. The Pulldown Main Menu

## Discussion

As has already been noted, to design a good user interface, at least three principles must be accomplished; simplicity, consistency and efficiency.

### *Simplicity*

Both interfaces were intended to be simple systems. In the pulldown interface, the user chooses the right procedure by clicking the mouse; there is no need for him/her to do any typing. The popup interface, on the other hand, requires the user to select a command and then type in additional information; this could make a novice user confused. The chance to get a mistype input is possible, while there is no possibility in the pulldown interface. During OVERLAY operations, the user has to input all the arguments asked for by the system. This part of the system could prove confusing to the novice user. To lessen and maybe avoid this problem, a list of coverage names accompanied by a brief explanation should be provided to help the user make a selection.

Compared to the pulldown interface, the popup interface is not as simple, although some of its parts are arguably easier to use. The popup interface sometimes gives the needed information in its menu, which makes these particular parts more understandable than the pulldown interface.

*Consistency*

Compared with popup system, the pulldown system is more consistent. Every time the user clicks on the main menu, a sub menu will appear, and to return to the main menu the user chooses **Return**. In addition DISPLAY, ANALYZE and HELP sub menus have the same structure. They each have three steps and differ only on the third step. DISPLAY menu shows the map, the ANALYZE chooses inventory factors upon which selections are based, and the HELP menu shows extended information about the maps contained in the database. Figures 4 and 5 show the consistent style of the ANALYZE and OVERLAY sub menus.

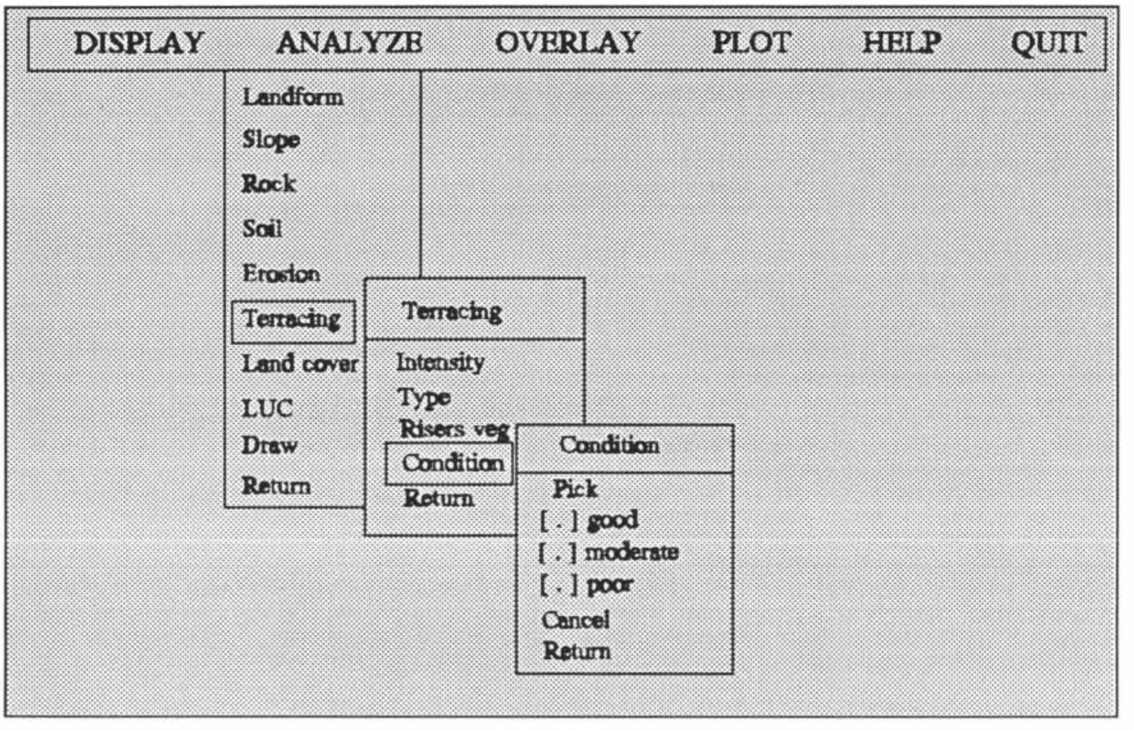


Figure 4. The Pulldown ANALYZE Menu

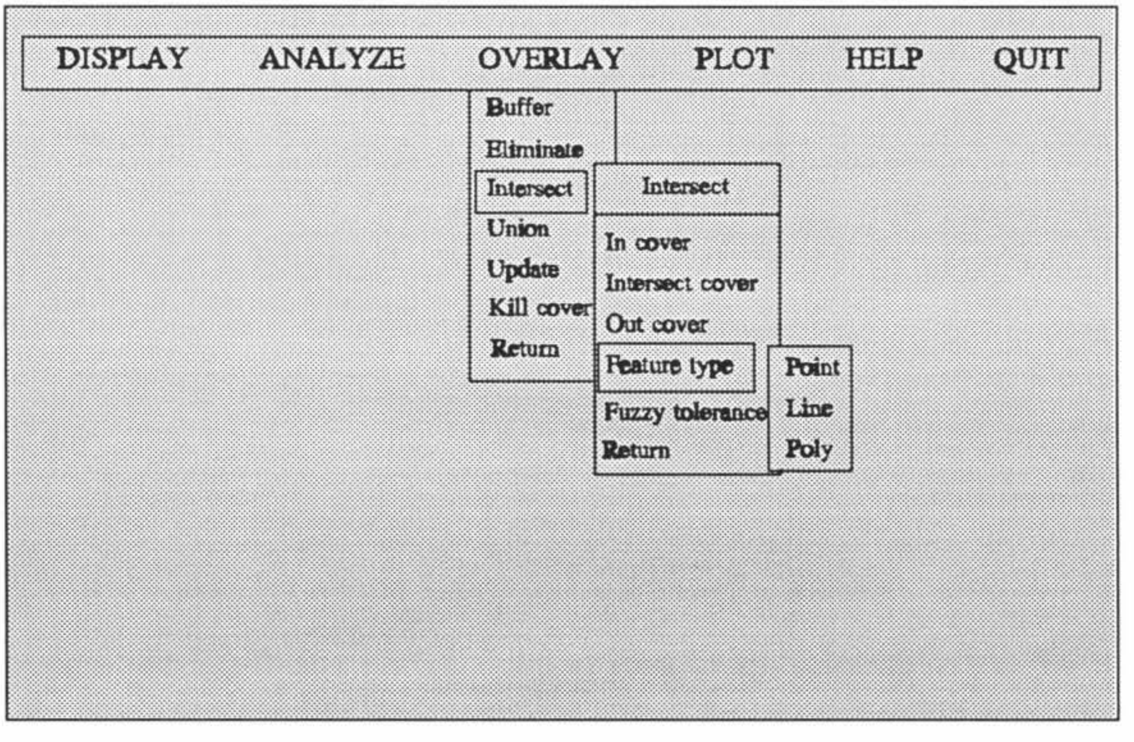


Figure 5. The Pulldown OVERLAY Menu

In contrast, the popup interface has many different entry menus. In the DISPLAY menu, the user first selects an option and then more detailed menus will be shown. The map of terrace type, for example, is found by selecting **terracing** from the DISPLAY menu first; and **type of terracing** from the TERRACE sub menu which is then displayed. Similar sequences occur when selecting the maps of rock, soil, erosion, and LUC that have more detailed inventory data compared to the other inventory factors.

Unlike the DISPLAY operation, the ANALYZE operation has a different menu. It displays all of the sub-items at once instead of separating them under the original items. Figures 6 and 7 show those differences.

All of these displays are for showing you the resources of Pijiharjo area.
Choose one of these maps :

landform
slope
rock
soil
erosion
→ terracing ←
land cover
LUC
recommendation

CANCEL

Figure 6a. The Popup DISPLAY Menu

***** Information about terracing *****

Four maps can be displayed during this session.
Choose one of these maps :

intensity of terracing
→ type of terracing ←
terrace risers vegetated (%)
terrace condition

**********************************

CANCEL

Figure 6b. The Popup Terrace sub-menu

**Pijiharjo Land Inventory Factors**

| | | |
|---|---|---|
| 1. Landform | 7. Soil depth | 13. Type of terrace |
| 2. Slope | 8. Erosion type | 14. Risers vegetated |
| 3. Rock type | 9. Erosion severity | 15. Terrace condition |
| 4. Bare rock | 10 Erosion extent | 16. Land cover |
| 5. Regolith depth | 11 Soil depletion | 17. LUC class |
| 6. Soil class | 12 Intensity of terracing | 18. LUC limitation |

Type the number of the factor you want to analyze :

CONTINUE
CANCEL

Figure 7. The Popup ANALYZE Menu

*Efficiency*

With regard to cursor movement, the popup interface is more efficient than the pulldown interface. The intersect operation in the overlay sub menu, for example, requires many arguments before it is performed. In the popup interface, the user types all of the arguments in one sub menu, whereas in the pulldown interface the user must complete several steps before the command can be executed. The only disadvantage in the popup interface is that the user is assumed to have a greater understanding of the command and to know exactly how to fill in the arguments.

Despite some inefficient in cursor movements, the pulldown interface is definitely easier to operate than popup interface. The user needs to follow the instructions and select from the available options. Figures 8 and 9 show how the UPDATE command is executed from both the popup and the pulldown interfaces respectively.

In the popup interface, the user must type all of the arguments whether (s)he knows what to put in or not, which makes this interface a little bit difficult compared to the other. In the pulldown interface the user just choose one of the item and another sub-menu will appear, and the arguments can be fulfilled just by using cursor to choose the right items.

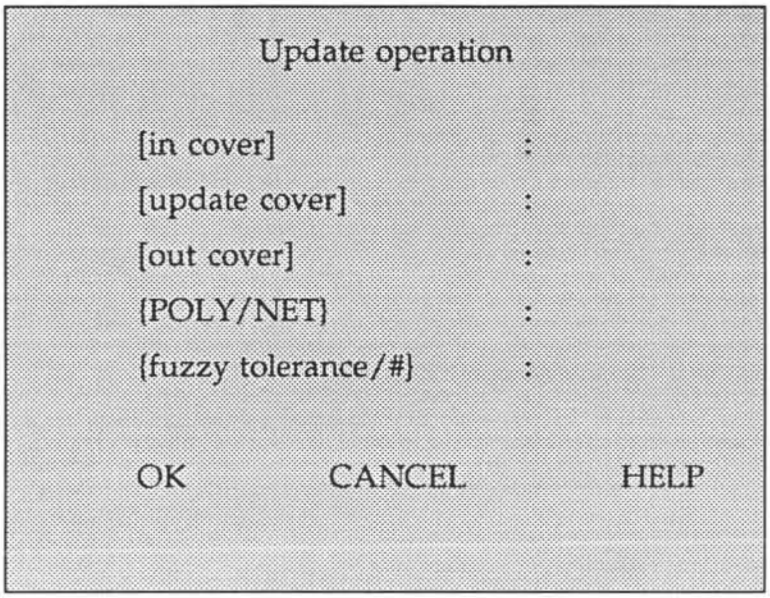


Figure 8. The Popup UPDATE Menu

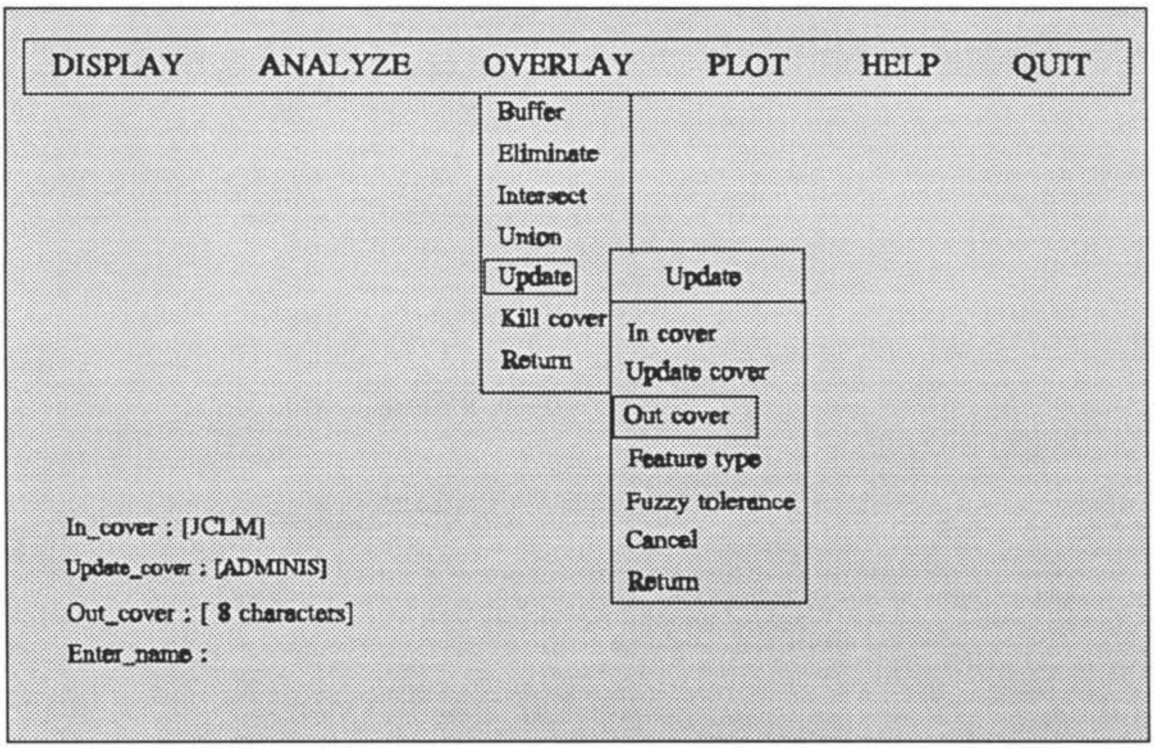


Figure 9. The Pulldown UPDATE Menu

From the discussion above, it seems that the pulldown interface is designed better than the popup interface. The former fulfils all the principles identified as necessary for a good user interface. It is simple, consistent and easier to use, although it may not be as efficient as the popup interface. Because it uses colour, it is more attractive and it is easier to draw the user's attention by using a different colour for important information.

# CHAPTER V

## THE EVALUATION

### Introduction

Evaluation is an essential and integral part of designing and developing a user interface. The user interface generally consists of information displayed on the computer monitor to the user and facilities that allow the user to answer and manipulate the information and to take control of actions.

Ravden and Johnson (1989) said that a user interface provides information about the system, about its capability and about what the user can do. This information could also be found in a user manual or as an on-line help capability. The interface should also provide opportunities for the user to develop a good understanding of the system.

As already mentioned, an interface should be designed to accomplish the user's needs, therefore its design is an important factor. A poorly designed interface will cause many troubles to the user, including frustration and confusion. A good interface, on the other hand, will give many benefits in the long term. Ravden and Johnson (1989) list five benefits of having a good user interface design. They are:

- reduced training time for the user
- reduced support costs due to fewer and less serious difficulties
- reduced need for modifications and revisions after implementations
- increased willingness among the users to use the system effectively
- increased efficiency and utilization of computer resources

To avoid all of the impediments and to achieve the benefits, a user interface must be evaluated before it is released, to make sure that the design is user orientated. As soon as the design is implemented by the users, it is hoped that there would not be many major changes any more.

To achieve a good result in evaluating the interface, a designer must understand the objective(s) of the evaluation and then define a certain criteria for the evaluation.

*The Objective*

Lea (1988) gives three general objectives in evaluating a user interface : 1) the assessment of the capabilities of the design; 2) the assessment of the impacts of design decisions; and 3) the diagnosis of problems with the design.

The first objective is evaluated against the requirements of the users. It can be approached from two points of view; user-orientation and system-orientation. The user-orientation approach assesses the capability in terms of the tasks done by the user using the system, while the system-orientation approach gives more importance to the features of the system and matches it with the feature requirements of the user. The assessment of these capabilities requires familiarity with both the interface and the software system.

The second objective is to identify the effects of an interface design on the user and the user's interaction with the system. In this assessment, the major impact which is usually given most attention is the degree of effort required from the user in order to use the systems capabilities.

The last one is to identify and clarify the scope of specific problems. In contrast to the second objective, this assessment is focused on the interaction failure between the user and the computer, whether the dialogue breaks down or takes an unexpected turn.

It is important to understand these objectives when evaluating a design. There are many approaches to evaluate the design, but the common approach is evaluation through simulation, which is described by Lea (1988) as an important approach which allows the design to be evaluated in advance of its implementation. Evaluation through simulation includes assessing the system's relevance to the jobs to be fulfilled when it is implemented. The method uses a questionnaire, and the accuracy of the simulation can be used to predict how successful the system might be when applied in the real world. Using this approach, changes to the design can be made quickly and are less expensive than evaluating it after implementation.

*The Criteria*

Until now there have been no standard criteria used for evaluation. Shneiderman (1992) suggested five criteria for evaluation : *time to learn,* which means how long the user takes to learn to use the commands; *speed of performance,* means how long the computer takes to carry out the tasks; and *rate of errors by users.* This is a critical point of the design, although the design should be equipped with an error solving problem. The fourth criterion is *subjective satisfaction.* This aspect measures the liking of the user to the design. The last factor is *retention over time,* which means how well the user remembers things after a certain period of time.

Compared to the criteria suggested by Shneiderman, Lea (1988) proposes two criteria; *functionality* and *usability.* Functionality relates primarily to the general objective of assessing the capability of the design, and refers to the tasks that the system enables the user to perform. Usability, on the other hand, relates to the assessment of the impacts of specific design decisions and refers to the ease of use of the interface.

Furthermore, Lea explained that the usability of a system could be assessed from its *effectiveness, learnability, flexibility* and *attitude.* Effectiveness has a correlation with performance of the system in terms of speed and errors. This factor is analogous to the speed of performance together with rate of errors by users as proposed by Shneiderman (1992). It can be said that the effectiveness of a system depends on the speed of a system to execute a job combined with errors made by the users. If a system is excellent in terms of speed, but too complicated so that many mistakes occur, then this interface could not be categorized as an effective system.

Learnability is the performance that can be achieved within a period of time and after a specified amount of training. It is similar to the time to learn presented by Shneiderman. A good interface needs only a little time and training to master it.

Flexibility is the adaptability of the system to the range of variation made by the user. The last factor is concerned with the attitude of the user such as discomfort, frustration or eagerness to continue using the system. Flexibility is not mentioned by Shneiderman, while attitude is already discussed under subjective satisfaction. Both factors relate to the user's reaction in using the interface.

Ravden and Johnson (1989) suggested nine different criteria for evaluating the usability of a system. They are : *visual clarity, consistency, compatibility, informative feedback, explicitness, appropriate functionality, flexibility and control, error prevention and correction and user guidance and support*. Although those criteria look completely different, they are similar to the factors proposed by the previous writers. Table 6 shows the similarities and differences of criteria in evaluating an interface.

Table 6. A Comparison of the Criteria in Evaluating an Interface Proposed by Shneiderman (1992), Lea (1988) and Ravden and Johnson (1989).

| Shneiderman (1992) | Lea (1988) | Ravden and Johnson (1989) |
|---|---|---|
| time to learn<br>retention over time | learnability | consistency<br>informative feedback<br>user guidance and support |
| speed of performance<br>rate of errors | effectiveness | compatibility<br>explicitness<br>error prevention and correction |
| subjective satisfaction | attitude | visual clarity<br>appropriate functionality |
| | flexibility | flexibility and control |

Table 6 shows how the criteria of Ravden and Johnson (1989) compare with those of the previous authors. To evaluate the ease of learning an interface, three detailed criteria are suggested : consistency, informative feedback and user guidance and support.

The way the system looks and works should be consistent. Consistency results in accurate user expectations by maintaining the predictability of the interface at all times enabling the user to learn more quickly and effectively and reducing the likelihood of errors.

A good user interface should also produce good informative feedback. Informative feedback is important in the early stages when the users have to learn how the interface works and how to use it. Moreover, it will help the users in understanding what the system is doing and what to do to complete a task in a particular operation. The amount of feedback is another factor to be considered, because too much feedback will overload the users, while too little will lessen their chance to understand the system. If the system is to be used by a variety of people, a user guide will help to lessen the responsibility of feedback. Novice users can acquire more information from the user guide without irritating the experienced users.

User guidance and support is another important part in evaluating an interface, because it will help the users to understand the system. It should be provided both on the computer as an on-line help and as a user manual. The on-line help facility should be made sufficiently clear, so that the users can find it without difficulty.

To assess the effectiveness of the system, Ravden and Johnson (1989) suggested three criteria : compatibility, explicitness and error prevention and correction. Compatibility is concerned with ensuring that the interface conforms with existing user expectations. This assessment will make the system easier to use, because the user can presume what the system is going to do for a particular operation. As a result, the user is expected to operate the system more effectively and with less error. Introducing a new aspect into the system should be followed by comprehensive guidance and support and information feedback as well.

The explicitness of a system relates on the way the system works or is structured, which should be clear to the users. A clear system will develop a clear and accurate understanding of the interface, of how it is structured and what it does to complete a task. If the interface is good in terms of explicitness, the need for feedback and user guidance might be reduced and less error might be expected.

Error prevention and control is a measure of the flexibility of the system. Since the users will always make errors, the system should be designed to prevent errors wherever possible. Two kinds of error prevention can be implemented : by validating the input before executing an operation and by allowing an action to be cancelled and started over again.

To draw the user's attention to the system, two kinds of measure are proposed, they are visual clarity and appropriate functionality. Visual clarity emphasizes on the screen performance, the ease with which information can be found and read from the screen. A good interface in terms of visual clarity implies a clear and uncluttered screen design, readable font and easily found important information. Good clarity will help the users to understand the system; and an attractive screen performance will encourage the user to choose this system.

Appropriate functionality is another important criterion upon which to assess an interface. It is the information, facilities and options given when the users carry out a task. This information is needed by the users, so that they know what is happening when they execute an action. Without this information the users may experience difficulty and frustration which might reduce their efficiency.

Flexibility suggested by Lea (1988) is similar to the flexibility proposed by Ravden and Johnson (1989). An interface should be sufficiently flexible, particularly if the users are varied. Novice users would like to complete their tasks by following the procedures, while the more experienced would like to make shortcuts. Most of all, the important thing in this assessment is that the users should feel that they are in control of the system.

In general a system should be evaluated according to its attractiveness, easiness, effectiveness, and flexibility. The attractiveness of a system will make the user choose a particular system as much as its ease of use. If the system is effective and flexible, the user will feel that the system is designed specially for his/her usage.

**The Methods**

Other factors should be considered before a user interface is evaluated. They are the system, the application and the types of evaluators available (Ravden and Johnson, 1989). The system refers to how many interfaces will be evaluated. If more than one interface, there are two possibilities; each evaluator has to evaluate each interface, or each evaluator evaluates only one interface. According to Ravden and Johnson (1989) both methods have advantages and disadvantages. The advantage of the first case is the evaluator can compare all interfaces, so that (s)he can choose which interface is the best. The disadvantages are that his/her opinions may be biased, especially if (s)he has to evaluate more than two interfaces; and it takes a longer time to finish the evaluation. With the second scenario, it is possible to evaluate the interface in more detail, but there is the disadvantage of the increased number of evaluators required.

The application used for the evaluation should be similar to the tasks of the interface when it is implemented. The result will indicate problems that might occur when the interface is used for real and the system can be developed further before it is implemented.

The type of evaluator will also affect the result of the evaluation. If the system is designed for certain users then they should be the evaluators, however, a variety of evaluators should be provided if the system is designed for a wide range of users.

After considering all of these factors, an evaluation of the popup and pulldown menus was conducted. The approach used was evaluation through simulation. It meant that the evaluators and the tasks had to be similar to the future users and jobs as well. The criteria used for evaluation were those proposed by Ravden and Johnson (1989).

Since two systems were to be evaluated, it was decided that each evaluator would evaluate only one system since the number of evaluators was limited. There were ten evaluators for each system.

After an initial briefing as to the purpose of the system and the objectives of the evaluation, each participant was required to perform a number of tasks using the interface and then answer questions relating to the criteria discussed in the preceding sections. Details of the evaluators' background and knowledge in computing, soil conservation, GIS and English were also elicited.

Three tasks had to be completed, the first two by following step-by-step instructions and the third without explicit instructions. The first task required the use of DISPLAY and ANALYZE commands to find areas which fulfilled certain criteria and then assign soil conservation practices to these areas. An opportunity to print the resulting map was provided at the conclusion of the exercise.

The second task involved an OVERLAY operation. A river network and administrative boundaries were INTERSECTed and the resulting map displayed. The final task was similar to the first task but instead of selecting areas according to two criteria, four criteria were used. The questionnaire and application tasks are reproduced in Appendices 1 and 2 respectively.

**Results and Discussion**

With each evaluation taking approximately one and a half hours and the limited number of willing evaluators, only twenty evaluations were carried out in total - ten for each system. The small sample size and the wide variation in the replies precluded a meaningful statistical analysis of the results, but the following comments give some indication of just how well the objectives of the project had been achieved.

The evaluators of both systems ranged from novice users to experts, only those who evaluated the popup menu claimed to know at least a little about computers. Only three of those testing the popup menu claimed English as their first language, whereas six of the people evaluating the pulldown menu were native English-speakers (see the accumulated results in Appendix 1).

On the whole, the interfaces were rated moderately to very satisfactory by both sets of evaluators. This was encouraging and indicated that a workable system had been developed. The evaluations did highlight some areas where further development would be worthwhile; these were : user guidance and support, error prevention and correction, and flexibility and control.

Some evaluators assessed the user guidance and support as very unsatisfactory while others rated it satisfactory or better. This variation in assessment can be attributed to the differences in background knowledge in GIS, soil conservation and computing. Those familiar with the computer were more inclined to rank the user guidance and support (the HELP facility) higher than those with a limited understanding of these subjects.

There were three possible reasons why some evaluators gave low rankings or uncertain answers. The first possibility was that they could not find the HELP menu during their exploration of the system. In consequence, they could not answer the questionnaire properly. They might judge that the HELP menu never or seldom appeared, therefore they rated it as very unsatisfactory, or just left the questionnaire without any answer.

The second possibility was that although they noticed a HELP facility was available, they were unable to activate it. They may have assumed that the HELP facility could be assessed by pressing the F1 button like many other systems, but in reality this procedure did not work.

The last possibility was that the HELP menu really was inadequate, especially for novice users. The only way to improve this situation would be to make the HELP menu available as often as possible and producing a better user guide, so that the users would know how to access the HELP facility.

Unlike the user guidance and support, the flexibility and the error prevention sections received less uncertain answers, although the answers still ranged from very satisfactory to moderately unsatisfactory, with the latter being predominant. (see Appendix 1).

These two sections were related to each other, and were about the capability to re-do or un-do an operation. When step-by-step guidance through a task was provided, most of the evaluators did not find any difficulties as long as they followed the instructions exactly. This meant that even though most of the evaluators rated these sections moderately satisfactory (because they did not find any difficulties), it did not imply that the system was excellent. As long as the evaluators followed the instructions, they did not find any problems, therefore they did not know whether there was any possibility to re-do or un-do an operation.

When they started to work out the last problem; which was not detailed by a step-by-step manual, they found that if they made a mistake in the middle of an operation, they could not easily re-do it and had to begin the exercise again.

Input validation is a technique to prevent users from wasting time waiting for an unwanted result because of a wrong selection. Unfortunately, this capability was not always available. Some improvement in the error prevention and correction capabilities would be necessary for novice users, but this must be weighed against the slower operation (especially in the slow computers) that would result and perhaps cause annoyance to more advanced users.

# CHAPTER VI

## THE APPLICATION

### Introduction

As a planning tool, the purpose-designed interface was used to solve a problem and then compared to working with pc ARC/Info directly. Although the resulting maps were similar, this exercise served to demonstrate differences in the ease with which a task could be completed. All of the steps taken and the resulting maps are presented.

The scenario was to find areas outside the watershed protection area (class VIII land), which were eroded but not yet terraced, and then to carry out some activities on those areas to lessen the erosion. Two possible activities could be implemented, constructing terraces, and changing the land cover.

Terrace construction could be applied to those areas which were not too steep (slope less than 25% or classes A to D), and where the soil was sufficiently deep (more than 30 cm). Soil depth was important because after terrace construction, the land between the terraces must have enough topsoil left to allow the farmers to manage the land productively.

Changing the land cover was the alternative on those areas which could not be terraced. If the present land cover was permanent cultivation, such as upland crops, paddy fields or maize, but the soil was already poor, then the recommended land cover would be agro-forestry with restricted food crop. Using this technique, the farmers still could gain some production while decreasing the pressure on the land and helping to improve the soil condition.

Areas which had only scattered trees or were not cultivated, especially the class VII land, would be converted into a forestry system. Such areas are generally not well managed. Changing these areas to forestry benefits both the owner of the land and the soil itself.

From all of these criteria and considerations, three activities were recommended to reduce erosion :

Activity I : **terrace construction** with criteria :

- slope : A - D ( 0 - 25%)
- soil depth : deeper than 30 cm

Activity II : **agro-forestry with restricted food crop** with criteria :

- land cover : upland crops and paddy fields
- soil depletion: soil parent material or bedrock exposed
- soil depth : less then 30 cm

Activity III : **forestry system** with criteria :

- land cover : forestry or others
- LUC class : VII

## Completing the Task Using pc ARC/Info

PC ARC/Info could carry out this task by manipulating the database and then drawing the result during an ARCPLOT session. Before starting, a new item (EXAMPLE) is added to the database, to make selection and drawing easier in the final map.

Table 7. Items Contained in the Pijiharjo Database

| Column | Item Name | Width | Type | N.Dec |
|---|---|---|---|---|
| 1 | Area | 13 | N | 6 |
| 14 | Perimeter | 13 | N | 6 |
| 27 | ICLM_ | 11 | N | 0 |
| 38 | ICLM_ID | 11 | N | 0 |
| 49 | LF | 6 | C | 0 |
| 55 | RO | 8 | C | 0 |
| 63 | RD | 1 | N | 0 |
| 64 | SL | 3 | C | 0 |
| 67 | ER | 9 | C | 0 |
| 76 | SEVER1 | 1 | N | 0 |
| 77 | TYPER1 | 2 | C | 0 |
| 79 | EXTER1 | 1 | N | 0 |
| 80 | SEVER2 | 1 | N | 0 |

continued

| Column | Item Name | Width | Type | N.Dec |
|---|---|---|---|---|
| 81 | TYPER2 | 2 | C | 0 |
| 82 | EXTER2 | 1 | N | 0 |
| 84 | SDL | 1 | N | 0 |
| 85 | TE | 5 | C | 0 |
| 90 | INTTE | 1 | N | 0 |
| 91 | TYPTE | 3 | C | 0 |
| 94 | RISTE | 1 | N | 0 |
| 95 | CONTE | 1 | N | 0 |
| 96 | LU | 12 | C | 0 |
| 108 | LU1 | 4 | C | 0 |
| 112 | LU1GR | 2 | N | 0 |
| 114 | LU2 | 4 | C | 0 |
| 118 | LU3 | 4 | C | 0 |
| 122 | SO | 8 | C | 0 |
| 130 | SD | 1 | N | 0 |
| 131 | BR | 1 | N | 0 |
| 132 | LUC | 6 | C | 0 |
| 138 | CLASS | 1 | N | 0 |
| 139 | SUB | 1 | C | 0 |
| 140 | UNIT | 1 | N | 0 |
| 141 | MU | 11 | N | 0 |
| 152 | HA | 13 | N | 6 |
| 165 | PERCENT | 13 | N | 6 |
| 178 | EXAMPLE | 2 | N | 0 |

The first step was to select all polygons which were not class VIII land (CLASS = 1,2,3,4,5,6,7), not yet terraced (TYPTE = '0'), and were eroded (SEVER1 = 1,2,3). To make the selection easier for the next steps, all of these polygons (34 polygons) received a dummy number, such as 99, in the item EXAMPLE. This number was used to set the colour for each group of selected polygons. Colours were chosen from an ARC/Info shading file (COLOR.SHD) which assigned colours according to numbers. From now on further selection is made from these 34 polygons eroded unterraced areas (EXAMPLE = 99).

To find areas for terrace construction, two more criteria were added; they were the slope classes were less than E (SL < 'E') and the soil depth was deeper than 30 cm (SD > 2). the colour chosen to represent these polygons was yellow brown or number 58.

For the agro-forestry development, similar steps were followed. The only difference was the criteria required. Instead of using slope and soil depth as the limiting factors, the criteria used here were those areas with upland and paddy field (LU1GR < 7), with the soil parent material exposed (SDL = 3), and shallow soils (SD < 3). For these polygons, the number used was 48, which represents green.

The last activity was for class VII land which was to be converted into a more intensive forestry system. The criteria were class VII land (CLASS = 7), with the land cover either forestry or uncultivated (LU1GR = 9,10). These polygons were assigned number 47 which results in a red colour when plotted.

The end result was five values for EXAMPLE : 58 - for terrace construction; 48 - for agro-forestry; 47 - for forestry system; 99 - for the rest of the selected polygons; and 0 - for the unselected polygons. The next step was to start ARCPLOT and draw the map. The commands necessary to plot this map are listed and described in Table 8. To make the map nicer and easier to locate, the roads in red and streams in blue were also added to the map which is then completed with borders, title, legend, north arrow and scale-bar (Figure 10).

Table 8. Commands Used for Plotting the Map

| ARC/Info Commands | Explanation |
|---|---|
| ARCPLOT | *in the ARCPLOT session* |
| **: disp 4** | |
| **: pagesize 29.5 21** | |
| **: maplimit page** | |
| **: pageunit cm** | |
| **: mape box1** | *set the map extent into the same size as the pulldown menu* |
| **: map fig14** | *make a map composition called fig14* |
| **: shadeset color** | *set the shade colour into the proper set* |
| **: polygons iclm poly example** | *draw the polygon shading according to the number given in the EXAMPLE item* |
| **: arcs box1** | *draw the frame of the map completed with the scale-bar and north arrow* |
| **: textsymb 85** | *setting the textset and size* |
| **: textsize 0.5 0.35** | |
| **: move *** | |
| **: text 'MANAGING THE UNTERRACED AREA'** | |
| **: keypos 0.5 0.3** | *setting the legend* |
| **: keysep 0.3 0.3** | |

continued

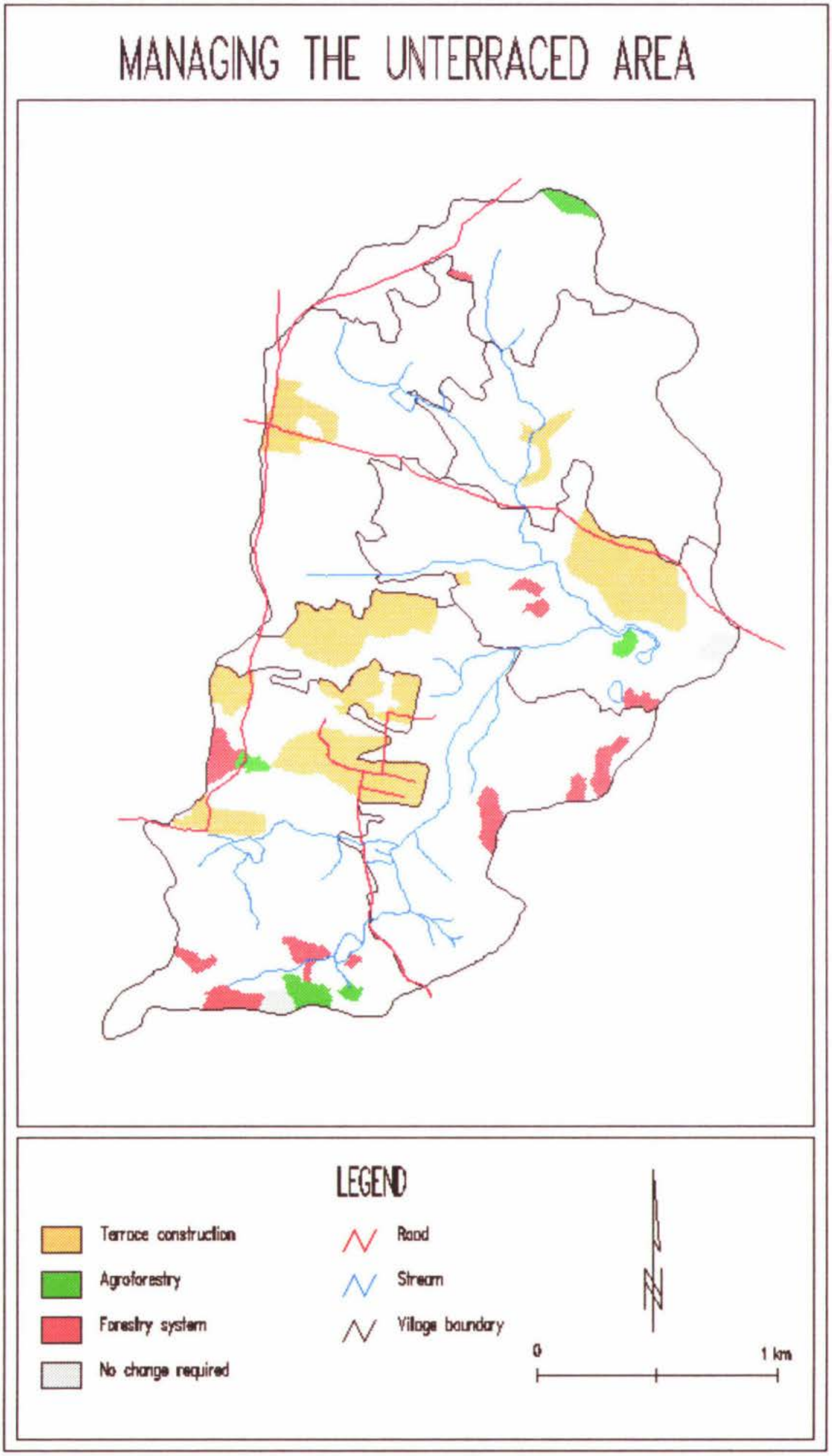


Figure 10. Final Map Created Using PC ARC/Info Directly

| ARC/Info Commands | Explanation |
|---|---|
| **: textsize 0.2 0.1** | |
| **: move *** | |
| **: keyshade terrace.key** | ***terrace.key*** *is already made using a text editor* |
| **: lineset plotter** | *setting the proper lineset* |
| **: keyline hclm 4** | *draw the river's network* |
| **: keyline jclm 2** | *draw the road's network* |
| **: disp 1039** | *copy the map composition into a plot file* |
| **: fig14.plt** | *a name of the plot file* |
| **: plot fig14** | |
| **: q** | *quit form ARCPLOT* |
| **ROTPLOT fig14 fig14r 270** | *rotate the plot file 270 degrees* |
| **DRAW fig14r 2** | *print the rotated-plot file* |

Figure 10 shows all the areas that were not yet terraced. Each colour shows the different activities recommended to be done. The two grey polygons are actually parts of the unterraced area but since these two polygons did not fall into any of the other categories, they were left unchanged.

### Completing the Task Using the Purpose-designed Interface

Instead of having to know the syntax of ARC/Info commands and the names of all items in the database, the task can be performed using the interface. Simply pointing and clicking the mouse within the ANALYZE module executes all the necessary commands - see Table 10

Table 10. Comparison between ARC/Info Commands and the Purpose-designed Interface Complete with Explanations. (**bold** shows all commands to be typed in ARC/Info, underline shows all items to be selected from the user-defined menu)

| ARC/Info commands | Explanation | Purpose-design interface |
|---|---|---|
| **Selecting the standard criteria (eroded but not yet terraced)** | | |
| ARC | *go to the right location* | ARC |
| Tables | | @go |
| | | ANALYZE |
| **sel iclm.pat** | *select the standard requirement* | LUC - class : III - VII |
| **resel class in {1,2,3,4,5,6,7}** | | terracing - type : unterraced |
| **resel typte = '0'** | | erosion - severity : slight, |
| **resel severl in {1,2,3}** | | moderate and severe |
| **ca example = 99** | *assign a dummy number to make the next selection easier* | |
| | *draw the map* | Draw |
| | *make a map composition* | choose YES |
| | *create map title* | title **'MANAGING THE UNTERRACED AREA'** |
| | *make a hard copy* | choose YES |

| AREAS for terrace construction | | |
|---|---|---|
| **sel iclm.pat** | *select the standard requirements* | LUC - class : III, IV, V, VI, VII |
| **resel example = 99** | | terracing - type : unterraced |
| | | erosion - severity : slight, moderate and severe |
| **resel sl in {'A','B','C','D','A+B','A+C', 'B+C','C+B','C+D','D+C'}** | *select the appropriate slope classes and soil depth* | slope : A, B, C, D, A+B, A+C, B+C, C+B, C+D, D+C |
| **resel sd > 2** | | soil - depth : 3, 4, 5 |
| **ca example = 58** | | Draw |
| | *draw the map* | choose YES |
| | *make a map composition* | title **'TERRACE CONSTRUCTION'** |
| | *create map title* | choose YES |
| | *make a hard copy* | |

| AREAS for agro-forestry development | | |
|---|---|---|
| **sel iclm.pat** | *select the standard requirement* | LUC - class : III - VII |
| **resel example = 99** | | terracing - type : unterraced |
| | | erosion - severity : slight, moderate and severe |
| **resel lu1gr < 7** | *choose the upland crop and paddy field* | land cover : pl-dp-pl; pl-pl-pl; pl-pl-br; pl-dp-br; rainfed paddy; irrigated paddy |

| | | |
|---|---|---|
| **resel sdl = 3**<br>**resel sd < 3** | *choose the soil depletion and the soil depth* | erosion - depletion : soil parent material exposed<br>soil - depth : 0, 1, 2 |
| **ca example = 48** | | |
| | *draw the map* | Draw |
| | *make a map composition* | choose YES |
| | *create map title* | title **'AGROFORESTRY DEVELOPMENT'** |
| | *make a hard copy* | choose YES |
| | **AREAS for forestry** | |
| **sel iclm.pat** | *select the standard requirement* | terracing - type : unterraced |
| **resel example = 99** | | erosion - severity : slight, moderate and severe |
| **resel class = 7** | | LUC - class : VII |
| **resel lu1gr in {9,10}** | *choose the forestry and other land cover* | land cover : forestry and others |
| | *draw the map* | Draw |
| | *make a map composition* | choose YES |
| | *create map title* | title 'FORESTRY' |
| | *make a hard copy* | choose YES |
| **ca example = 47** | | |
| **q** | *quit from the tables* | |

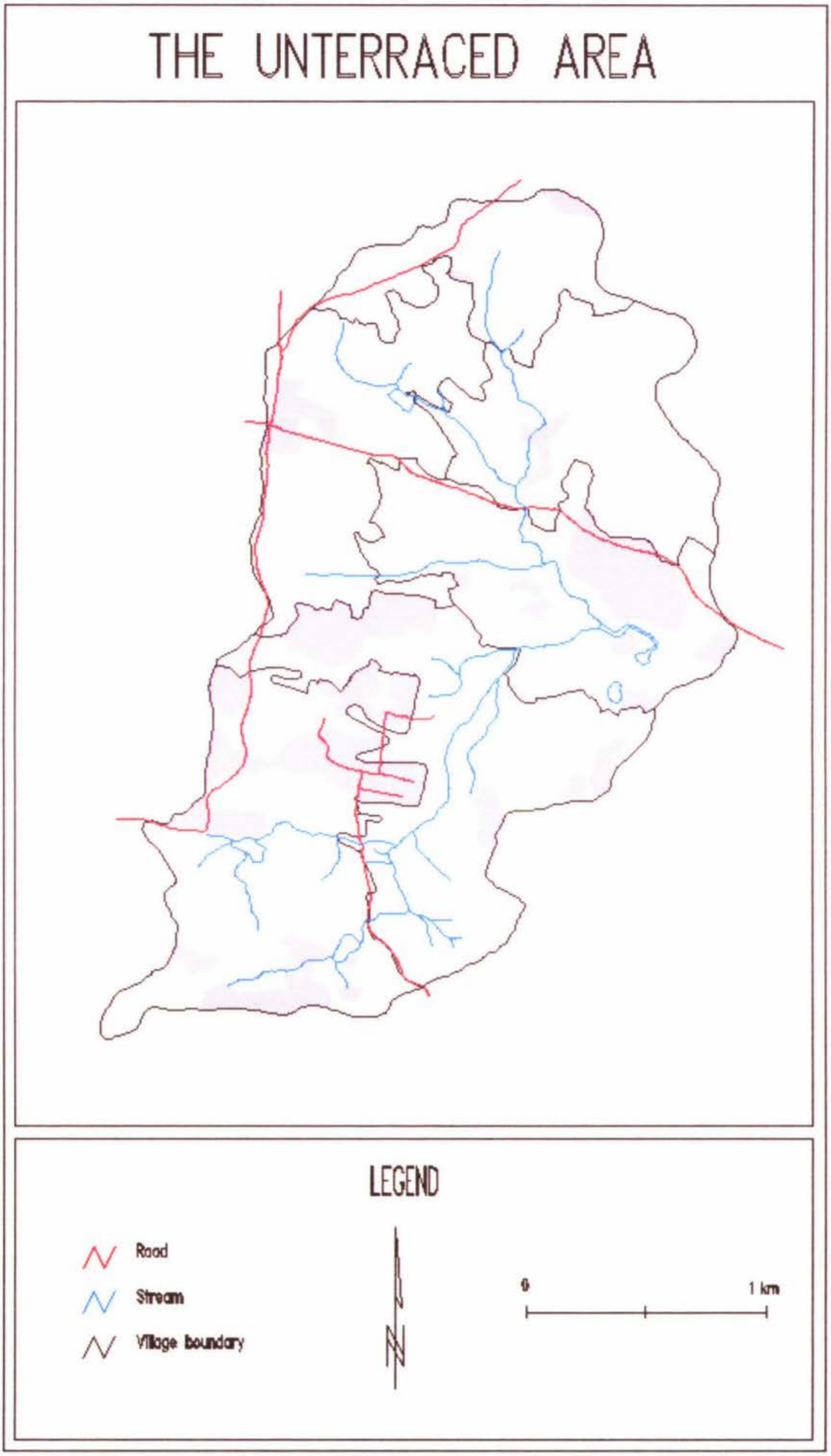


Figure 11a. Map Produced Using the Purpose-designed Interface - 'The Unterraced Area'

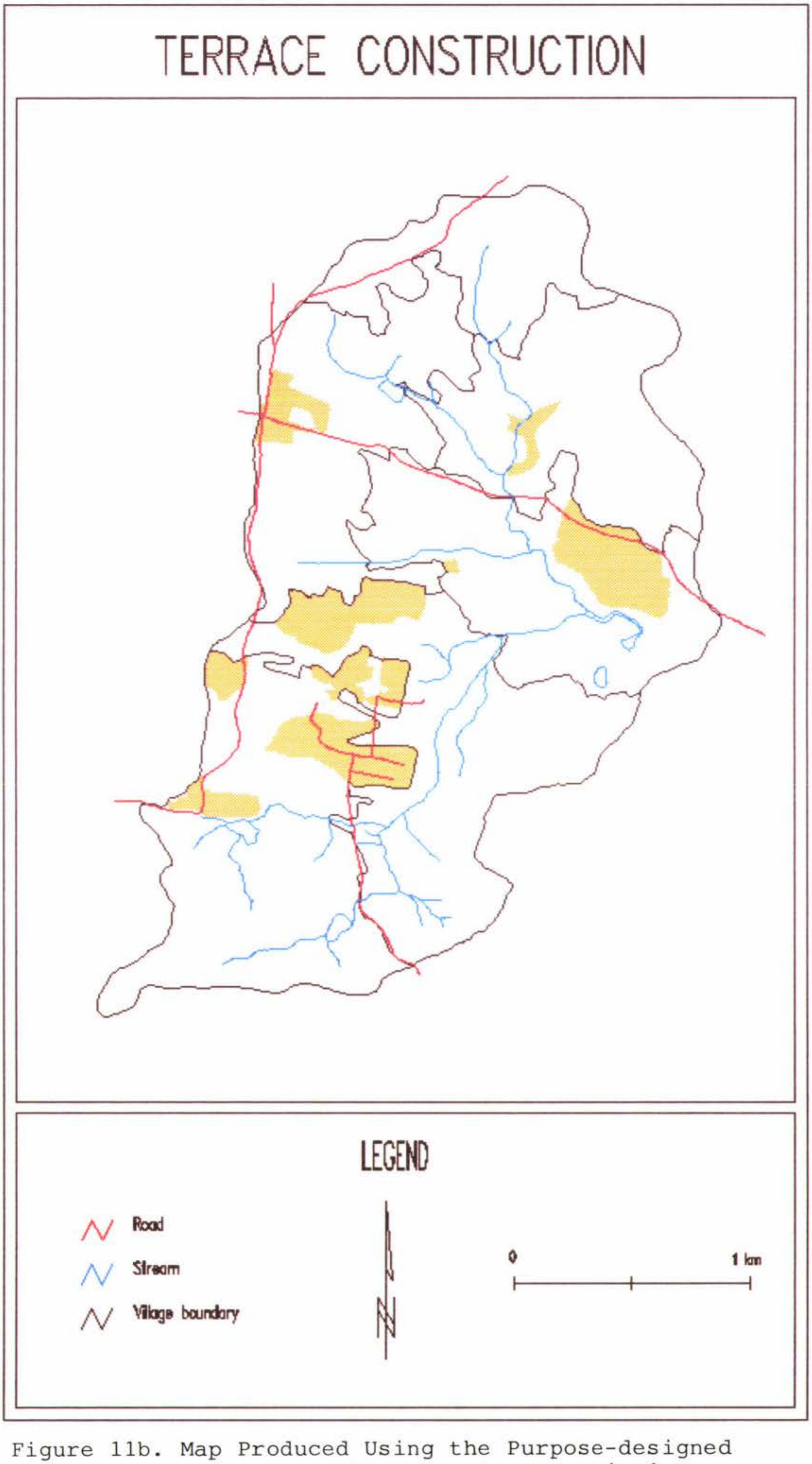


Figure 11b. Map Produced Using the Purpose-designed Interface - 'Terrace Construction'

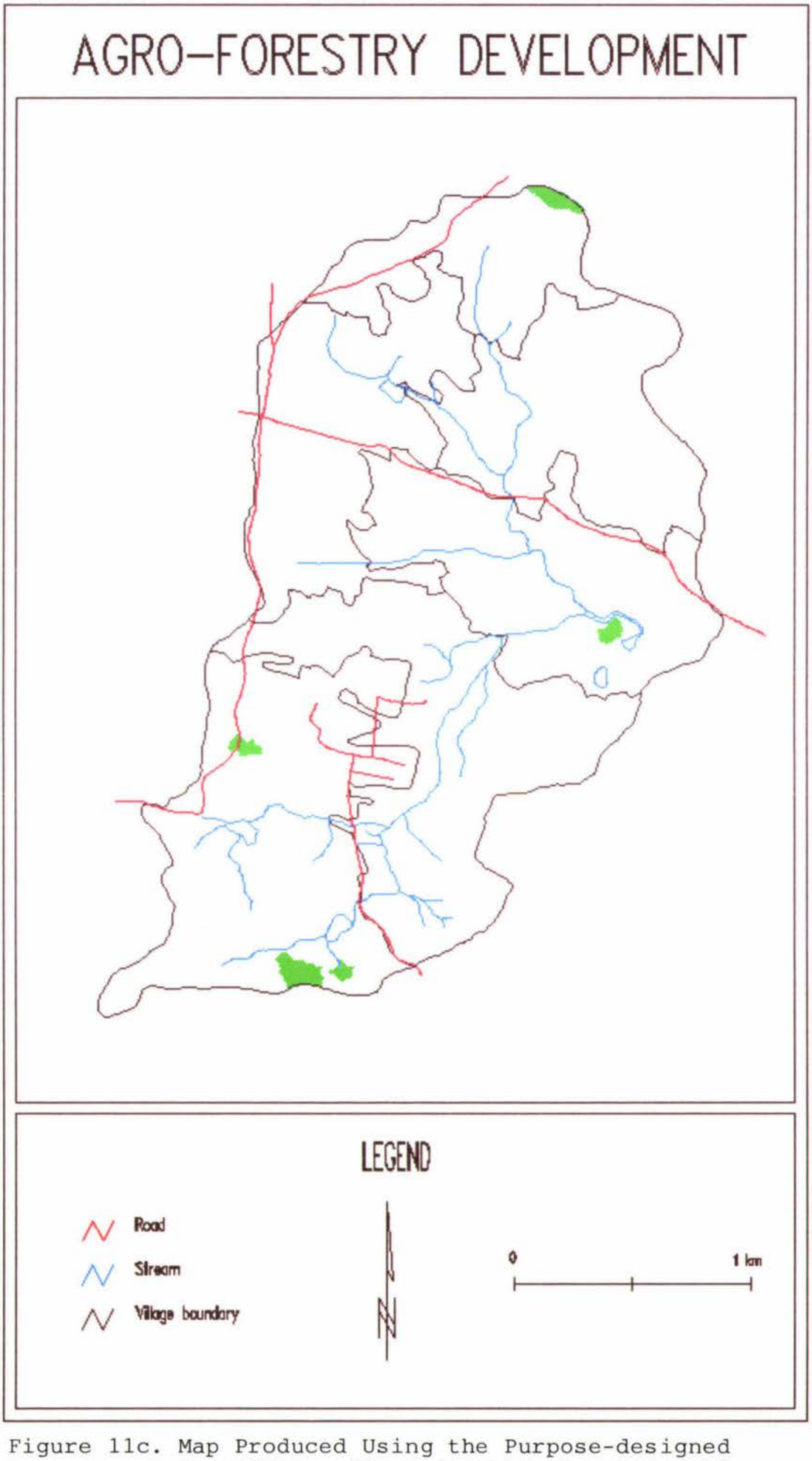


Figure 11c. Map Produced Using the Purpose-designed Interface - 'Agro-forestry Development'

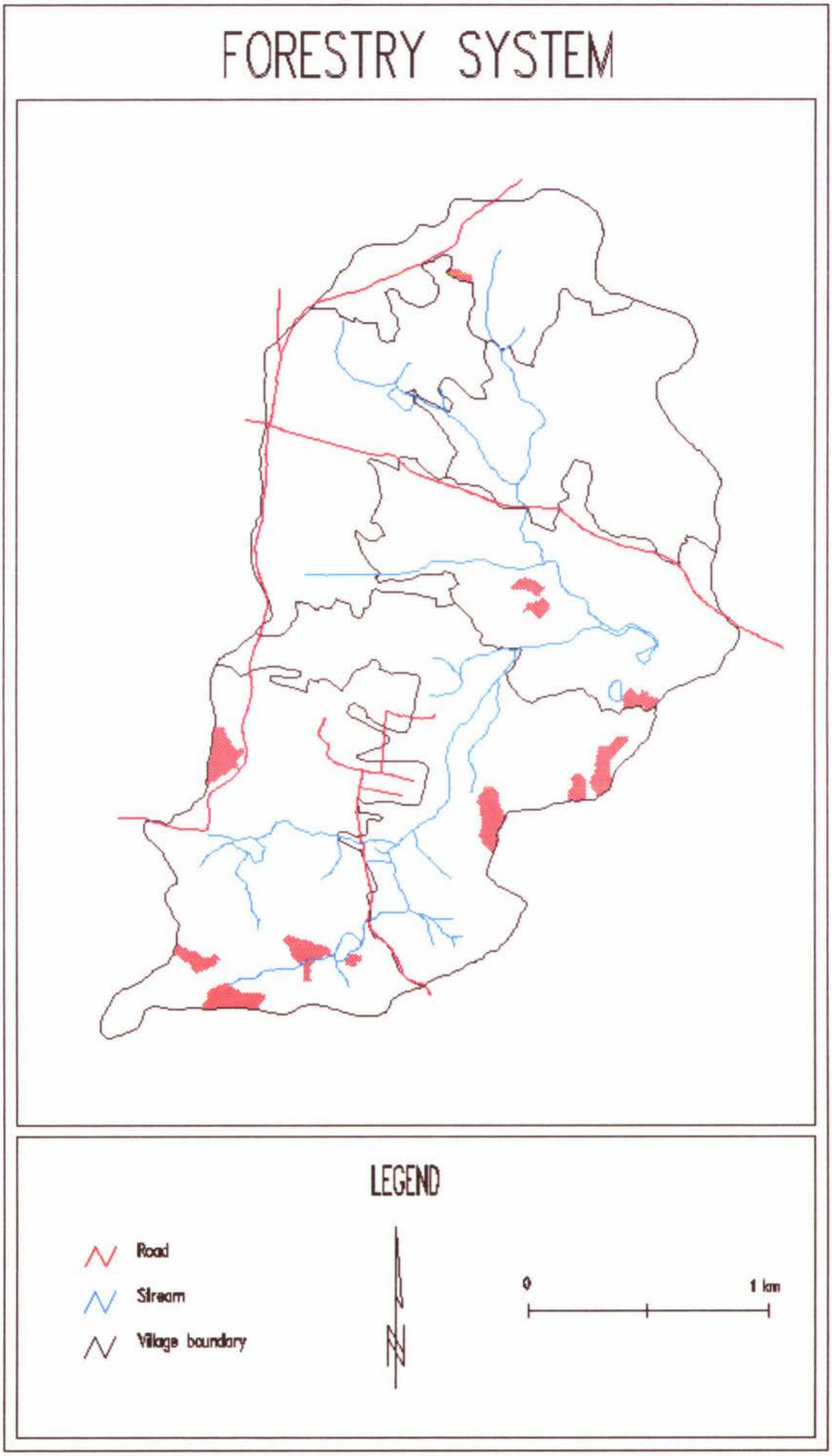


Figure 11d. Map Produced Using the Purpose-designed Interface - 'Forestry System'

Unfortunately the system is not yet equipped with the capability to draw a single map with more than one colour. Different maps for each activity are easily produced, however, as is a map showing all the unterraced, eroding areas.

### Discussion

Although it might not look simple, using the interface is definitely easier, because the user can choose the criteria more easily. When operating ARC/Info manually the user must know the syntax of writing a query and (s)he must understand all abbreviations in the database (Table 7) as well. Another task which is not trivial is the construction of the layout of the output. This particular activity is difficult and time consuming.

Using the interface, those two complicated activities are hidden behind the program, the user only follows the instructions. The selections are easy to carry out, because the user chooses from the screen using a mouse. The items themselves are easy to understand because instead of using codes and abbreviations, common words are used.

The one disadvantage of this system is the lack in ability to make a map with multiple criteria and colour. When this impediment is overcome, then this system will be more useful for the planners and decision makers.

Two grey polygons appear in Figure 10 (the ARC/Info method) do not come out on all of the maps using the interface. This situation could be explained as follows, using the ARC/Info method these two polygons were selected because they fall into the first criteria. For the next selection, they were never selected any more, because they could not meet the next criteria. For example, the terrace development requires not too steep slope with a deep soil, but these polygons do not have a deep soil. They could not be categorized into agro-forestry development either, because the soil parent material is not exposed yet.

Using the interface, this situation could be avoided because the map is made for each criteria. It means that every selected polygons matched with the criteria. Moreover, using the interface, it would not give wrong selections and wrong calculations to the users.

# CHAPTER VII

## CONCLUSION AND FUTURE DEVELOPMENT

### Conclusion

The use of GIS as a tool for decision makers and planners will improve the quality of their work. Unfortunately GIS programs are not always easy and simple, most of them are not user friendly. The use of a friendly user interface will really help both the planners and the decision makers.

A user interface is a tool to help the user to communicate with the computer more easily and operate it more efficiently. Because of its function, a user interface must be designed according to the user's need, therefore the designer needs to know his/her users. (S)he has to know their background and their tasks. This information could be gathered in many ways; such as conducting a survey or observing the users either directly or indirectly. Any design should be based on this information.

As soon as the design is ready, an evaluation should be conducted. The objective should be to judge whether the design is appropriate for the users or not. The benefit of evaluating the design before releasing it, is that if the design still needs to be changed, it is easier and cheaper to fix it at this stage. Another benefit is that the evaluators' comments could be used as a reference to update the design. To achieve a good result, the evaluators and the tasks created should resemble the users and their jobs.

The result of the evaluation in this study showed that the purposed-designed user interfaces, the popup and pulldown menus, were simple and easy to learn. The pulldown menu was especially attractive because it used a colourful menu. Although some parts of this system still needed to be developed, such as the **cancel** and the HELP operations, in general it was agreed that this design should accommodate the planners' needs.

As a planning tool, the popup and pulldown menus were compared to ARCView Version 1.0. ARCView is a user interface which can be used to display ARC/Info coverages as well as the associated databases.

For displaying both the coverages and database, ARCView is a good interface, but it does not have the capability to manipulate the database. It cannot do the OVERLAY and BUFFER operations, because these operations will alter the database. This is the major weakness of using ARCView as a planning tool.

The popup and pulldown interfaces, on the other hand, give the opportunity to the users to do such things. Both interfaces have six options : BUFFER, ELIMINATE, INTERSECT UNION, UPDATE, and KILL COVER. All of those options except KILL COVER produce a new coverage and new database automatically, while KILL COVER deletes the coverages which are no longer required.

**Future Development**

Since the pulldown interface is more attractive and also probably easier to use, this system should be developed further, as there are still several things to be improved. Many suggestions and comments were gathered during the evaluation; some of them could be implemented, but not all. Improvements would include :

- Using hot keys such as F1, Esc, and spacebar.
  Actually those hot keys are convenient, because they are used by many software programs and the users are already familiar with them. Unfortunately the SML program which is used to write this interface, does not have the capability to use hot keys. All key strokes are treated as a <CR> key. It only understands that every key stroke is for the item where the cursor is, and it converts the chosen item into an uppercase letter.

- Using the first letter of each item to be selected
  This suggestion is difficult to implement as well, since SML does not have the capability to understand such a selection. In the SML program, any button or words pushed from a menu is always returned in uppercase and then used to make the selection. Like the previous case, all key strokes are treated as a <CR> key. Therefore it does not matter what button is pushed, the result is the same. This condition limits the ability to make a selection more versatile.

- Separating the input and output coverages.

  The idea of separating the input and output coverages is good, because it will enable the important coverages to be kept in a safe place. To accommodate this suggestion, the output coverage should receive a different path and be saved it in a different sub directory. For KILL COVER operation, the files displayed should be only from the output (sub)directory. For overlay and buffer operations the coverage's presented for the first and second cover could be gathered from both the input and output (sub)directory. This would give the opportunity to use the result of the previous overlay operation for the input coverage. Users would still be able to use the input coverages for these operations but would not be able to delete them.

Apart from the suggestions and comments received from the evaluators, there should be other minor changes for the next version. As this system will be used in other areas as well as Pijiharjo, the opening menu needs to be changed.

There should be an option to choose other watersheds which have the same database structure as the Pijiharjo database. The introductory readings could become optional. The user could choose to read this information, but could go straight to the MAIN MENU if they chose. Such information is only useful to those whose are unfamiliar with the area and the data and could be bypassed by the experienced planners.

Another thing that should be added, is the capability to analyze the coverage at a larger scale, such as for village planning. This capability will encourage the planners to do bottom up planning which is more useful to the farmers.

In conclusion, for the next version, it is hoped that the pulldown interface will accompanied with the ability :

- to separate the input and output coverages
- to be used in other watersheds
- to be used by the village level planning agency.

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# Appendix 1. The Questionnaire

*Adapted from Ravden, S. J. and G. I. Johnson. 1989. Evaluating Usability of Human-Computer Interfaces. A Practical Method. Ellis Horwood Limited. Chichester.*

The evaluators were asked to complete the following questionnaire. The figures quoted here are the accumulated results (**bold = popup**; normal = pulldown)

**Background Information**

| | nothing at all | a little bit | a lot |
|---|---|---|---|
| 1. What do you know anything about GIS (Geographic Information Systems) | **7**<br>3 | **1**<br>6 | **2**<br>1 |
| 2. What do you know about soil conservation | **3**<br>2 | **5**<br>4 | **2**<br>4 |
| 3. How much do you know about computer and computer softwares | **-**<br>1 | **6**<br>6 | **4**<br>3 |
| 4. Is English your first language (yes/no)<br>If no, what is your first language | **3 - yes; 7 - no**<br>6 - yes; 4 - no | | |

**Evaluating the system**

1 : always
2 : most of the time
3 : some of the time
4 : never

A. Visual clarity

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Is each screen clearly identified with an informative title or description ? | **8**<br>5 | **2**<br>5 | | |
| 2. Is the information on the screen easy to see and read? | **5**<br>5 | **5**<br>5 | | |
| 3. Is it easy to find the required information on a screen | **6**<br>6 | **4**<br>3 | **-**<br>1 | |

Any other comments you wish to add regarding the above issues ?

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How would you rate the system in terms of visual clarity ?

| Very satisfactory | Moderately satisfactory | Neutral | Moderately unsatisfactory | Very unsatisfactory |
|---|---|---|---|---|
| **7**<br>3 | **2**<br>7 | **1**<br>- | | |

| 1 : always | 3 : some of the time |
| --- | --- |
| 2 : most of the time | 4 : never |

B. Consistency

| | 1 | 2 | 3 | 4 |
| --- | --- | --- | --- | --- |
| 4. Is the same type of information (e.g. instruction, menus, messages, titles) displayed in the same location on the screen ? | **7**<br>3 | **2**<br>7 | | |
| 5. Is the method of entering information consistent throughout the system ? | **5**<br>4 | **4**<br>6 | **1**<br>- | |
| 6. Is the method of selecting options (from the menu) consitent throughout the system ? | **4**<br>6 | **5**<br>4 | **1**<br>- | |

Any other comments you wish to add regarding the above issues ?

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How would you rate the system in terms of consistency ?

| Very satisfactory | Moderately satisfactory | Neutral | Moderately unsatisfactory | Very unsatisfactory |
| --- | --- | --- | --- | --- |
| **7**<br>6 | **2**<br>4 | **1**<br>- | | |

1 : always
2 : most of the time
3 : some of the time
4 : never

C. Compatibility

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 7. Where the user makes an input movement in a particular direction (using a mouse), is the corresponding movement on the screen in the same direction ? | **6**<br>8 | **2**<br>- | **1**<br>1 | |
| 8. Does the organization and structure of the system fit the user's perception of the task ? | **6**<br>6 | **4**<br>4 | | |
| 9. Does the sequence of activities required to complete a task follow what the user would expect ? | **6**<br>5 | **4**<br>5 | | |

Any other comments you wish to add regarding the above issues ?

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How would you rate the system in terms of compatibility ?

| Very satisfactory | Moderately satisfactory | Neutral | Moderately unsatisfactory | Very unsatisfactory |
|---|---|---|---|---|
| **5**<br>4 | **4**<br>5 | **1**<br>1 | | |

1 : always
2 : most of the time
3 : some of the time
4 : never

D. Informative feedback

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 10. Do instructions and prompts clearly indicate what to do ? | **5**<br>4 | **4**<br>4 | **1**<br>1 | |
| 11. Is it clear what the user needs to do in order to take a particular action ? (e.g. which options to select, which key to press) | **3**<br>3 | **7**<br>5 | **-**<br>1 | |
| 12. When the user enters information on the screen, is it made clear what this information should be ? | **5**<br>4 | **4**<br>5 | **1**<br>- | |

Any other comments you wish to add regarding the above issues ?

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How would you rate the system in terms of informative feedback ?

| Very satisfactory | Moderately satisfactory | Neutral | Moderately unsatisfactory | Very unsatisfactory |
|---|---|---|---|---|
| **5**<br>3 | **5**<br>5 | **-**<br>1 | | |

1 : always 3 : some of the time 
2 : most of the time 4 : never

E. Explicitness

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 13. Is it clear what the user needs to do in order to complete a task ? | **4**<br>3 | **5**<br>6 | **1**<br>1 | |
| 14. Is it clear why the system is organized and structured as it is ? | **4**<br>1 | **5**<br>7 | **1**<br>1 | |
| 15. Is the system well-organized from the user's point of view ? | **3**<br>3 | **6**<br>7 | **1**<br>- | |

Any other comments you wish to add regarding the above issues ?

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How would you rate the system in terms of explicitness ?

| Very satisfactory | Moderately satisfactory | Neutral | Moderately unsatisfactory | Very unsatisfactory |
|---|---|---|---|---|
| **3**<br>2 | **7**<br>6 | **-**<br>2 | | |

1 : always
2 : most of the time

3 : some of the time
4 : never



F. Appropriate functionality

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 16. Does each screen contain all the information which the user feels is relevant to the task ? | **4**<br>3 | **5**<br>7 | **1**<br>- | |
| 17. Can the user access all the information which they feel they need for their current task ? | **5**<br>5 | **4**<br>4 | **1**<br>1 | |
| 18. Do the contents of help facility make use of realistic task data and problem ? | **4**<br>5 | **4**<br>2 | **-**<br>2 | |

Any other comments you wish to add regarding the above issues ?

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How would you rate the system in terms of appropriate functionality ?

| Very satisfactory | Moderately satisfactory | Neutral | Moderately unsatisfactory | Very unsatisfactory |
|---|---|---|---|---|
| **3**<br>3 | **5**<br>7 | **1**<br>- | | |

1 : always
2 : most of the time
3 : some of the time
4 : never



G. Flexibility and control

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 19. Is there an easy way for the user to 'undo' an action, and step back to a previous stage or screen ? (e.g. if the user makes a wrong choice, or does something unintended) | **4**<br>5 | **3**<br>2 | **2**<br>3 | **1**<br>- |
| 20. In menu-based systems, is it easy to return to the main menu from any part of the system ? | **6**<br>5 | **2**<br>4 | **2**<br>1 | |
| 21. Can the user choose whether to enter information manually or to let the computer generate information automatically ? (e.g. where there are defaults) | **5**<br>2 | **2**<br>3 | **2**<br>2 | **-**<br>2 |

Any other comments you wish to add regarding the above issues ?

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How would you rate the system in terms of flexibility and control ?

| Very satisfactory | Moderately satisfactory | Neutral | Moderately unsatisfactory | Very unsatisfactory |
|---|---|---|---|---|
| **2**<br>4 | **6**<br>4 | **-**<br>- | **2**<br>2 | |

1 : always
2 : most of the time
3 : some of the time
4 : never



H. Error prevention and correction

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 22. Does the system validate user inputs before processing, wherever possible ? | **3**<br>1 | **3**<br>2 | **2**<br>2 | **1**<br>2 |
| 23. Are users able to check what they have entered before it is processed ? | **4**<br>1 | **4**<br>5 | **1**<br>1 | **1**<br>1 |
| 24. Is there some form of cancel (or 'undo') key for the user to reverse an error situation ? | **1**<br>3 | **6**<br>4 | **1**<br>2 | **2**<br>- |

Any other comments you wish to add regarding the above issues ?

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How would you rate the system in terms of error prevention and correction ?

| Very satisfactory | Moderately satisfactory | Neutral | Moderately unsatisfactory | Very unsatisfactory |
|---|---|---|---|---|
| **3** | **5** | **-** | **1** | **1** |
| 2 | 1 | 5 | - | - |

I. User guidance and support

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 25. If there is some form of **help** facility (or guidance) on the computer to help the user when using the system, can the user request this easily from any point in the system ?<br>Is the **help** information presented clearly, without interfering with the user's current activity ? | **3**<br>4 | **1**<br>3 | **2**<br>1 | **1**<br>- |
| 26. When using the **help** facility, can the user find relevant information directly, without having to look through unnecessary information ? | **2**<br>3 | **4**<br>3 | **1**<br>1 | |
| 27. Does the **help** facility allow the user to browse through information about the other parts of the system ? | **1**<br>1 | **3**<br>2 | **-**<br>- | **3**<br>2 |

Any other comments you wish to add regarding the above issues ?

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How would you rate the system in terms of user guidance and support ?

| Very satisfactory | Moderately satisfactory | Neutral | Moderately unsatisfactory | Very unsatisfactory |
|---|---|---|---|---|
| **2**<br>2 | **2**<br>4 | **2**<br>- | **-**<br>1 | **1**<br>- |

## General Questions on system usability

| | no problems | minor problems | major problems |
|---|---|---|---|
| 1. Lack of guidance on how to use the system | **3**<br>3 | **7**<br>7 | |
| 2. Understanding how to carry out the tasks | **4**<br>7 | **6**<br>3 | |
| 3. Information which is difficult to read clearly | **7**<br>8 | **3**<br>2 | |
| 4. System response times that are too quick for you to understand what is going on | **8**<br>9 | **1**<br>1 | **1**<br>- |
| 5. Having to remember too much information while carrying out a task | **6**<br>8 | **4**<br>2 | |
| 6. Information which does not stay on the screen long enough for you to read it | **9**<br>8 | **-**<br>2 | **1**<br>- |
| 7. System response times that are too slow | **3**<br>5 | **4**<br>4 | **3**<br>1 |

8 What are the best aspects of the system for the user ?

9 What are the worst aspects of the system for the user ?

10 Are there any parts of the system which you found confusing or difficult to fully understand ?

11 What changes would you make to the system to make it better from the user's point of view ?

12 Is there anything else about the system you would like to add ?

# Appendix 2. The Application Tasks

## POPUP MENU

Display, Analyze and Plot

Soil conservation measures are to be undertaken on all steep eroded areas : slope is 25% or greater, erosion is moderate or severe. Your task is to identify these areas and produce a map which shows them clearly.

Solution

Criteria : - slope is 25% or greater, means classes E or higher
- moderately or severely eroded, means erosion severity is 2 or 3

Ensure that ARC/Info is running and you have the **[ARC]** prompt. If it is not present, simply enter **arc**.

To activate the menu, enter **@GO** and then **1** for the **popup menu.**

1 Read all of the information by first pressing **enter** with **Continue** highlighted. Then, as with all the following menus, choose the task you wish to execute using the arrow keys and press **Enter**.

2 In the main menu, choose **DISPLAY** to see whether all of the criteria we need are there

3 Choose **slope** and read the further information by typing **y** and pressing **Enter**.

4 Enter **y** in answer to the query "draw another factor (Y/N)" (the default [Y] will result by simply pressing **Enter**)

5 This time display the **erosion severity** after first choosing **erosion** from the initial list.

6 Enter **n** in answer to the query "draw another erosion factor ? (Y/N)"

7 Enter **n** in answer to the query "draw another factor ? (Y/N)"

You have now seen the data from which the steep eroded areas will be selected. The following steps show how this done

1 Choose **ANALYZE** and read the information about how this system works

2 Enter **2** for slope and then **CONTINUE**

3 Enter **4** (the maximum number) for the number of codes you will use

4 Enter **E, F, G, and H** using an uppercase letters

5 Enter **y** in answer to the query "do you want to analyse another inventory factor (Y/N)"

6 Repeat step two and type **9** for erosion severity. Now you only use two codes, moderate and severe. Enter **2** for the number of codes, and **2** and **3** for erosion severity. Conclude this step by selecting **CONTINUE**

7 Now enter **n** in answer to the query "do you want to analyse another inventory factor (Y/N)"

8 The computer will show all of your selections. If you agree with them, enter **y**, otherwise **n** and you must start your selection again.

9 On the screen, there will be 15 colours shown, choose one of them for your polygon colouring by pressing the number and then enter. Remember that the roads are drawn in red and streams in dark blue

10 The computer will measure those polygons matching the criteria in terms of the total area and the percentage. A map will then be displayed with the shaded polygons those which match the criteria.

11 After drawing the map, you can then go on creating a map composition by entering **y** to the query "do you want to create a map composition ? (Y/N)"

12 Type the name of the map, for example **erosion**

13 Type the title **'erosion map in indonesia'**. You have to type the **apostrophe (')** before you start to type the titles

14 Position the title in the upper box - put the cursor nearly in the middle of the box

15 The next menu will show a table extracted from the database, which gives details on all the selected land parcels. Choose **CONTINUE** to go out from the database.

16 Choose **YES** if you want to make a hard copy, otherwise **NO**

Overlay and Plot

1 Choose **overlay** and **intersect**. After union, there are still two options, update and kill cover

2 In the intersect menu, type the following names for each argument

| | |
|---|---|
| In_cover | HCLM |
| Intersect_cover | ADMINIS |
| Out_cover | ADMINHYD |
| Feature_type | line |
| Fuzzy_tolerance | # |

You have to remember these names, because you will be asked to type the name of the coverage in the **Plot** operation

5 Choose **OK**, and **cancel** to go back to the main menu

6 To check the result, choose **plot**, and **drawing**

7 Type the name of the out_cover you've create and choose **draw**. You will see the result of intersect operation

8 Select **cancel** from the overlay menu, and **No** in answer to the query "Do you want to make a hard copy"

Now try to solve this problem.

You are asked to find locations for **terrace development**. The criteria are

- not yet terraced (terrace type = unterraced)
- soil depth must greater than 30 cm (classes 3 - 5)
- percentage bare rock is less then 10% (class 0 and 1)
- the priority is for those areas with erosion (erosion severity classes 1-3)

Before you finish, choose **OVERLAY** and **kill cover**, and delete the file you've just create, and then select **QUIT** to go out from this system.

Please answer this questionnaire afterwards

# PULLDOWN MENU

Display, Analyze and Plot

Soil conservation measures are to be undertaken on all steep eroded areas : slope is 25% or greater, erosion is moderate or severe. Your task is to identify these areas and produce a map which shows them clearly.

Solution

Criteria : - slope is 25% or greater, means class E or higher
- moderately or severely eroded, means erosion severity is 2 or 3

Ensure that ARC/Info is running and you have the **[ARC]** prompt. If it is not present, simply enter **arc**.

To activate this menu, enter **@GO** and then **2** for the **pulldown menu.**
Use the arrow keys to highlight your selection and then press enter.

1 Read all of the information by first pressing **enter** with **Continue** highlighted. Then, as with all the following menus, choose the task you wish to execute using the arrow keys and press **enter**.

2 In the main menu, choose **display** and then **slope**. Press any key to return from the map to the menu. If you want to read more about the slope map, press the **help** button and choose **slope**, choose **Return** to go back to the previous menu.

3 Using the same steps, display the **erosion severity** map, which is under **erosion** sub menu. These are the two maps you need to know about for this exercise

You have now seen the data from which the steep eroded areas will be selected. The following steps show how this done

1 Choose **slope** in the **ANALYZE** menu and tick the slope classes E, F, G and H and then press **return**. Notice that this [√] sign will change into [X] if you click twice in the same choice. A third click will change it back to [√] [√] means you choose it, and [X] means you do not want to choose it.
2 Choose **erosion - severity** : **moderate** and **severe** and then select **return** and **return** again
3 From the **ANALYZE** pulldown menu select **Draw**
4 On the screen, there will be 15 colours shown, choose one of them for your polygon colouring by pressing the number and then enter. Remember that the roads are drawn in red and streams in dark blue
5 The computer will measure those polygons matching the criteria in terms of the total area and the percentage. A map will then be displayed with the shaded polygons those which match the criteria.
6 Choose **yes** if you want to plot it, otherwise **no** and skip to 11
7 Make the titles by clicking on **titles** and type the title **'Erosion Map in Indonesia'**. Don't forget to put an apostrophe (') in front and at the end of your titles.
8 Choose **plot**, position the title in the box - put the cursor nearly in the middle of the box
9 You will be shown a table about the database from which you should choose the items you are interested in, then press **return** and **continue**
10 If the printer is on, you will get your printed map by choosing **YES**, otherwise **NO**.

Overlay and Plot

1 Choose **overlay** and then **intersect** and make the following selections for each item in the menu and choose **Return** afterwards

| | |
|---|---|
| In_cover | HCLM |
| Intersect_cover | ADMINIS |
| Out_cover | ADMINHYD |
| Feature_type | line |
| Fuzzy_tolerance | # |

2 To check the result, return to the main menu, choose **plot**, and then **draw**

3 Choose **Coverage**, select the name of the intersect coverage (**adminhyd**) and **draw** to see the result of this operation

4. Select **Return**, **Return** again and **No**

Now try to solve this problem.

You are asked to find locations for **terrace development**. The criteria are

- not yet terraced (terrace type = unterraced)
- soil depth must greater than 30 cm
- percentage bare rock is less then 10%
- the priority is for those areas with erosion (choose all erosion severity classes **other than negligible**)

Before you finish, choose **OVERLAY** and **kill cover**, and delete the file you've just create. Select **QUIT** from the main menu to go out from this system. Please answer this questionnaire afterwards

# Appendix 3. The Purposed-design User Interface User Manual

### Introduction

This manual will help you understand the user interfaces more easily. Before you activate the menus, check that the coverages and database are available and in ARC/Info format.

To load the program into your computer insert the disk and then type **a:install [your preferred drive]:**, for example a:install d:. ARC/Info must be installed on your computer for this program to work.

Two kinds of menu are available : popup and pulldown. Both menus are similar, in that they activate ARC/Info commands and give similar output; but they are different in screen performance. The popup menu is a non-colour menu, which requires the use of the keyboard for typing and the mouse/cursor for selecting from the menu. The pulldown menu, on the other hand, is in colour and needs only a mouse or cursor to select from the menu. These menus are discussed together and only when you have to choose a different action, will they be discussed separately.

Four main operations are supported by these interfaces : DISPLAY, ANALYZE, OVERLAY, and PLOT. Each operation will be described separately.

To activate either menu, type **@GO** in the ARC session, and then choose the system you are more interested in. Before you come to the MAIN MENU, the system gives an introductory reading about the background of the area. When you finish reading that information, put your cursor on **CONTINUE**, which is on the bottom line, and press **Return**, and you will proceed to the MAIN MENU. The designs of the popup and pulldown menus are shown in Figures 1 and 2 respectively.

**MAIN MENU**

Please choose one of these modules :

DISPLAY

This modules enables you to display each of the inventory factors in the Pijiharjo sub-watershed.

ANALYZE

This module allows you to create a map showing areas which have been selected according to criteria which you choose.

OVERLAY

Overlaying and buffering operations are performed in this module.

PLOT

This module is used to create a map composition showing the result of overlaying operation.

QUIT

Quit from this system and return to ARC/INFO.

Figure 1. The Popup Main Menu

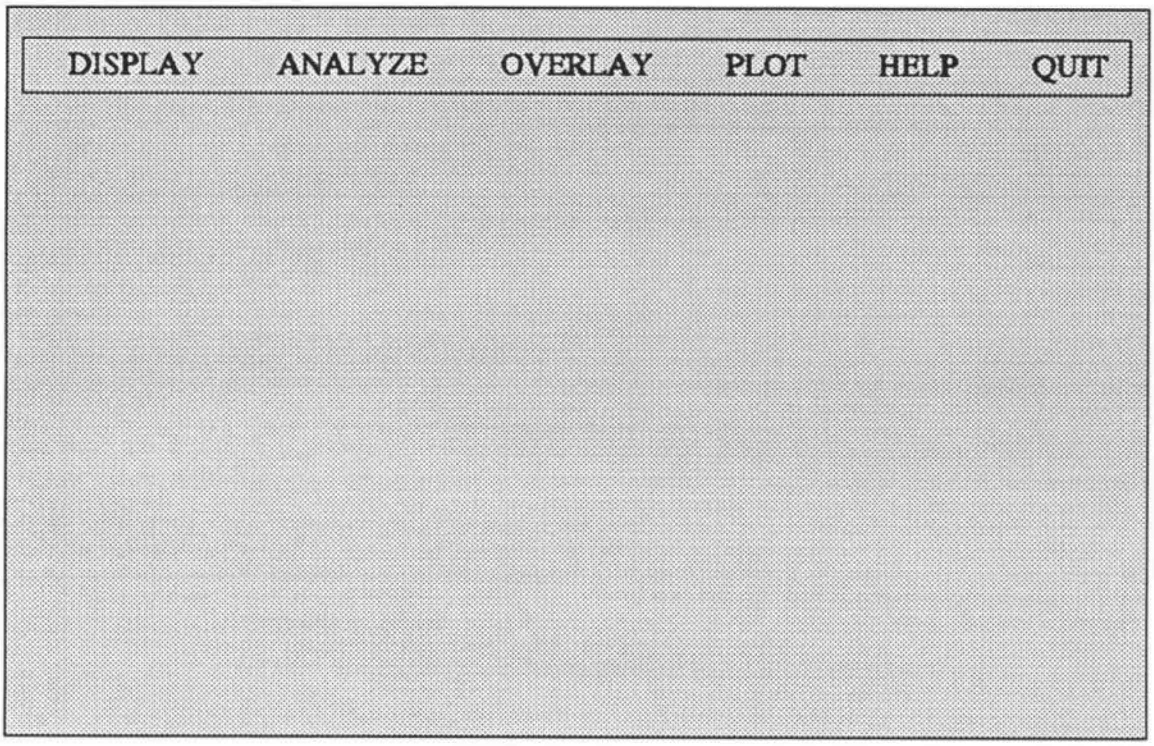


Figure 2. The Pulldown Main Menu

DISPLAY

The first module enables you to display all of the maps of land resource inventory factors in the Pijiharjo sub-watershed. Nineteen maps are available together with the extended information. They are :

- landform
- slope
- rock :
    - rock type
    - % bare rock
    - regolith depth
- soil :
    - soil class
    - soil depth
- erosion :
    - erosion type
    - erosion severity
    - % erosion extent
    - soil depletion

- terracing : - intensity of terracing
  - type of terracing
  - terrace risers vegetated
  - terrace condition
- land cover
- LUC : - LUC
  - LUC class
  - limitation

The extended information about the inventory factors can be gathered by typing **Y** for the query or selecting HELP and the appropriate topic. By choosing HELP, you also have the chance to browse through all the information without displaying the maps.

The maps are to give you general information about the area and before you carry out any planning activities, make sure that you are familiar with inventory factors available in the database. It is a waste of time for you develop a model which is not applicable because one of your criteria is not present in the database. Therefore it is important to examine the inventory factors carefully.

In some maps, there are map units that are labelled **more than one type**, which means that they are complex polygons containing more than one item. A polygon is characterized as a complex polygon if it contains more than one code. For example, if the slope code is A+B, it means that this polygon has two slope classes : A and B.

The DISPLAY menus of the popup and the pulldown system can be seen in Figures 3 and 4 respectively.

All of these displays are for showing you the resources of Pijiharjo area.

Choose one of these maps :

landform
slope
rock
soil
erosion
→ terracing ←
land cover
LUC
recommendation

CANCEL

Figure 3a. The Popup DISPLAY Menu

*****Information about terracing*****

Four maps will be displayed during this session :

Choose one of these maps :

intensity of terracing
type of terracing
terrace riser vegetated (%)
terrace condition
********************************

CANCEL

Figure 3b. The Terracing-Display sub menu

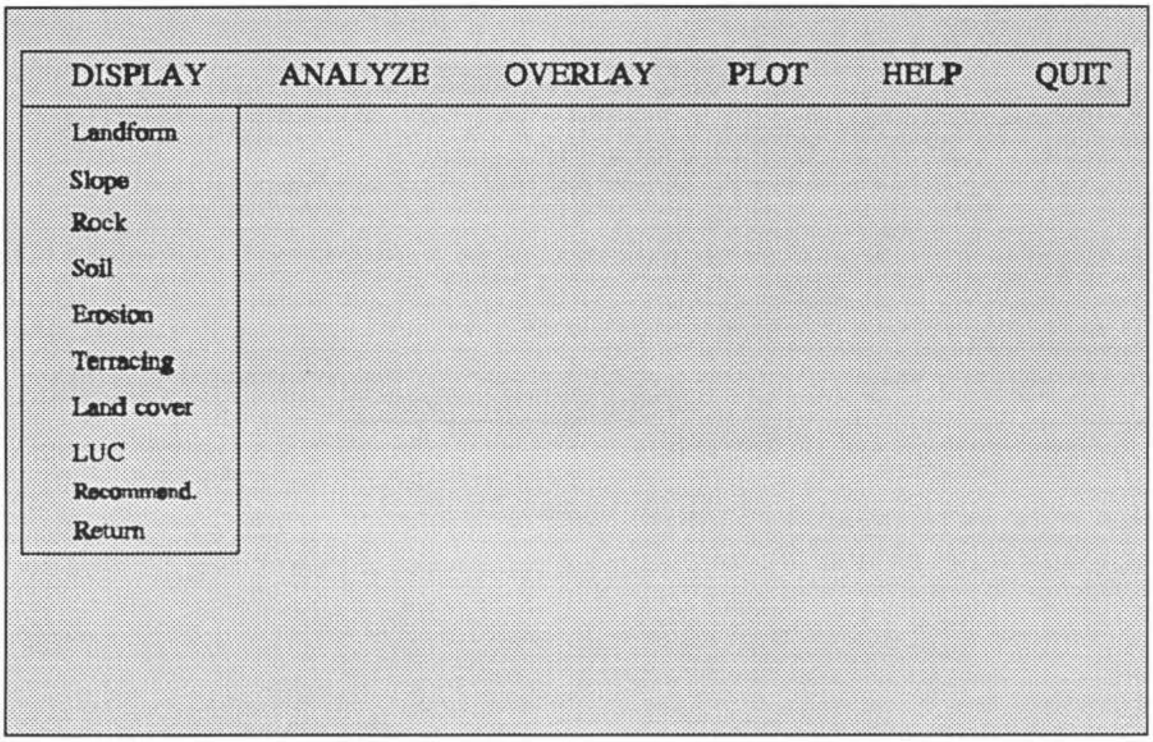


Figure 4. The Pulldown DISPLAY menu

If you want to display the terrace condition, for example, by choosing **terracing** you will be presented the Terracing-Display sub menu (Fig. 3b.) and you can choose the terrace condition item.

Choosing one of the inventory factors from the DISPLAY menu will cause a map to be shown on the screen. In the pulldown menu, you just press any key to return to the DISPLAY menu and perhaps view other maps. The popup menu, in contrast, will show both the map and the extended information together. If you want another map to be drawn, enter **Y** or just press **enter** at the query **draw another factor**, because the default is **Y**, and the DISPLAY menu will be presented for you once again.

**ANALYZE**

The ANALYZE menu allows you to create a map of areas selected according to certain criteria. The system will select all areas which meet the criteria you choose and then display them complete with their area in hectares and the percentage of the total area. The selection procedure is different for each system.

*Popup menu*

After you choose ANALYZE from the MAIN MENU, some information about how this system works is displayed. By pressing CONTINUE in this display, you will see the ANALYZE menu, which is presented in Figure 5a.

Every time you want to make a selection according to some factors, you just type the number of the inventory factor you require, and then press CONTINUE. The next menu is the Inventory Factor sub menu. You have to type the number of codes you will use (the maximum number is four) and then type the codes in the right place. Figure 5b shows the Landform-Analyze sub menu as an example.

If you want more than one factor as criteria for your selection, type **Y** in answer to the query **do you want to analyze another inventory factor** and you will return to the ANALYZE menu again. To finish the selection, type **N** to the above query, and the computer will show all of your selections. If you agree with them, enter **Y**, otherwise **N** and you start the selection again.

*Pulldown menu*

In contrast to the popup menu where the maximum number of inventory codes that can be chosen is limited, there is no such limitation in the pulldown menu. Furthermore you are not required to type the codes you choose, you just use the cursor or mouse to make the selection. Notice that the [√] sign will change into [X] if you click twice in the same choice. A third click will change it back to [√]. [√] means you choose it, otherwise [X]. When you finish your selection, return to the ANALYZE menu by pressing **Return** until the first ANALYZE menu is highlighted (in bright-yellow colour) and select **Draw.**

**Pijiharjo Land Inventory Factors**

| | | |
|---|---|---|
| 1 →Landform← | 7. Soil depth | 13.Type of terrace |
| 2. Slope | 8. Erosion type | 14.Risers vegetated |
| 3. Rock type | 9. Erosion severity | 15.Terrace condition |
| 4. Bare rock | 10.Erosion extent | 16.Land cover |
| 5. Regolith depth | 11.Soil depletion | 17.LUC class |
| 6. Soil class | 12.Intensity of terracing | 18.LUC limitation |

Type the number of the factor you want to analyze :

CONTINUE
CANCEL

Figure 5a. The Popup ANALYZE Menu

LANDFORM SELECTION MENU

The landform codes to be selected are :

| | | | |
|---|---|---|---|
| river valley | : A2v | karstic plateau | : K16 |
| alluvium colluvium | : A3c | karstic slopes gentle | : K2a |
| rounded hillcrest- and knob | : H1k | karstic alluvium- colluvium fan | : K2b |
| hill < E slopes | : H1h | karstic slope-steep | : K3 |
| steep hill E-I slopes | : H1s | karstic depression | : K6 |

How many codes do you want to use :

Write your selections using the codes above :
first code :
second code :
third code :
fourth code :

CONTINUE
CANCEL

Figure 5b. Landform Inventory Factor sub menu

Figure 6 shows the ANALYZE menu; the Terrace-condition sub menu is presented as an example. If you want to select locations which have a good terrace condition, just click the cursor on the appropriate item and the computer will make the selection for you.

From now on the steps for both menus are the same.

On the screen, 15 colours will be displayed, choose one of them for your polygon shading by typing the number and **enter**. Remember that the roads are drawn in red and streams in dark blue, therefore avoid those colours. The computer will only draw polygons matching all of your criteria. While drawing the polygons, it also measures the area selected and its percentage of the total study area.

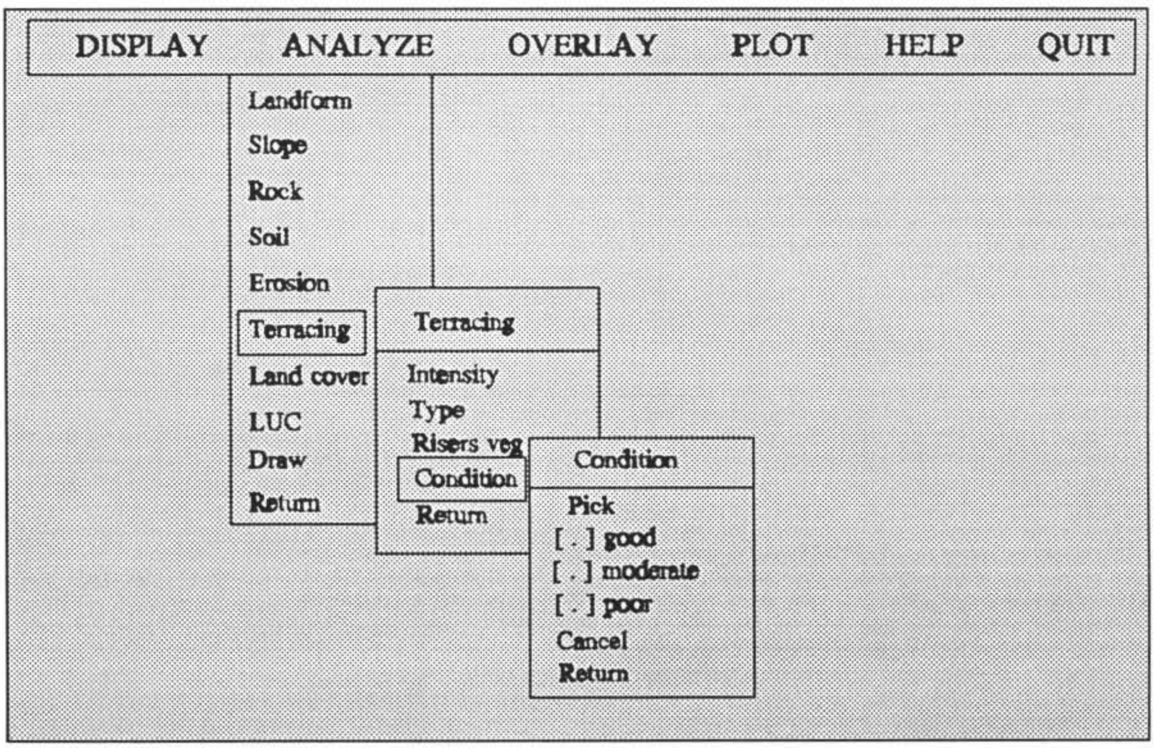


Figure 6. The Terrace-Condition sub menu

And once again, the computer reminds you of the criteria you set by presenting them on the screen after the map has been drawn. You, then are asked to make a map composition (in the popup menu) or to plot your map (in the pulldown menu). By typing **Y**, you proceed to map composition menu.

The map composition operation enables you to create your own titles. Remember that you must put an apostrophe (') in front of your title to tell the computer if you wish type more than one word; otherwise the computer only keep the first word. Choose **plot** after completing the plot title and then position your title on the top of the map (see Figure 7). Mark the lower left corner of the box with the cursor and you will see your title written in the chosen place.

Before you can get your print out, a table showing the database of the selected polygons will be presented. In the pulldown menu you could choose the items you are interested in, but not with the popup menu. The abbreviations and class descriptions can be found in Appendix 4. If the printer is on, you can print your printed map by choosing **YES**, otherwise **NO**, and return to the MAIN MENU.

## OVERLAY

This module allows you to perform the overlaying and buffering coverages. When you make an overlay, you combine at least two coverages to produce a new coverage. The database which accompanies the new coverage is derived from the database of both the old coverages.

Six available options under this menu are : BUFFER, ELIMINATE, INTERSECT, UNION, UPDATE AND KILL COVER. All of them except KILL COVER produce new coverages which could be checked and then printed using the PLOT facility. KILL COVER works like the erase command in DOS, which means delete the coverage that is no longer required. The OVERLAY menus of popup and pulldown systems are presented in Figures 8 and 9 respectively.

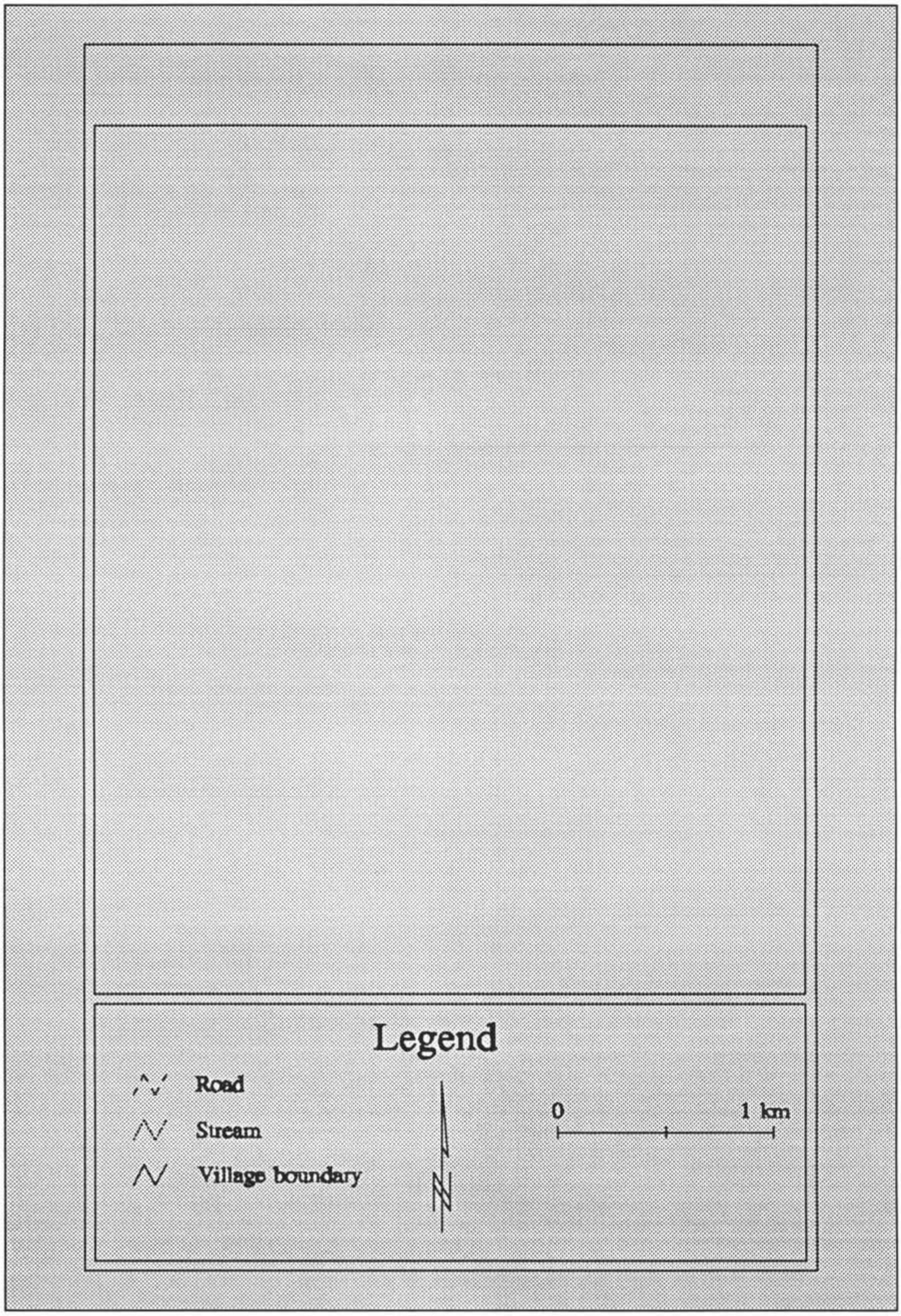


Figure 7. The Frame of the Map

**OVERLAY OPERATIONS**

Six options are available : buffer, eliminate, intersect union, update and kill cover.

*Buffer*

creates buffer polygons around selected coverage features

*Eliminate*

merges selected polygons with neighbouring polygons by dropping the longest shared border between them

*Intersect*

computes the geometric intersection of two coverages. Only those feature in the area common to both are preserved

*Union*

computes the geometric intersection of two polygon coverages. All features and attributes of both coverages are preserved

*Update*

replaces areas in a coverage using "cut-and-paste" operation

*Kill_cover*

erases any coverages that no longer required

CANCEL

Figure 8. The Popup OVERLAY Menu

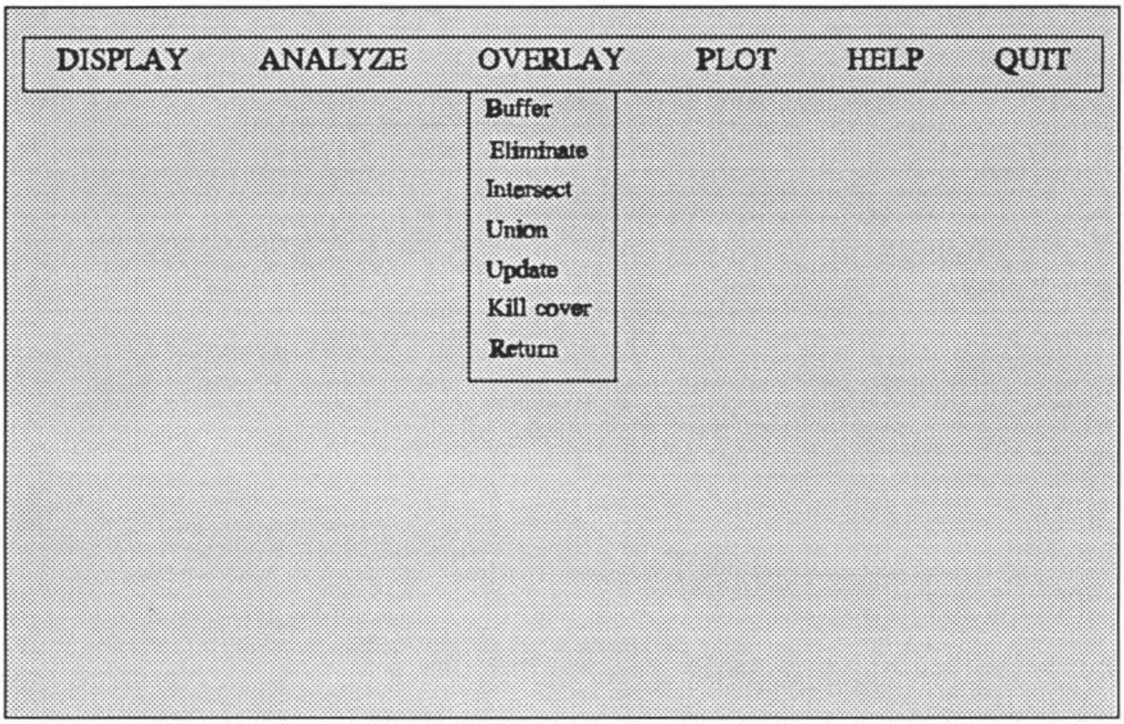


Figure 9. Overlay menu of Pulldown Menu

*Buffer*

Buffer creates a new output coverage by generating buffer zones around input coverage features (ESRI, 1989). This operation is useful for delineating a zone which encircles a particular feature such as an area prone to flooding around rivers and dams; or a hazard zone around a waste dump.

To run buffer, several arguments must be assigned :

- **In cover** is the coverage containing the features (polygons, lines or points) to be buffered.
- **Out cover** is the new coverage created by this operation
- **Buffer item** is one of the items in the input coverage to be buffered.
- **Buffer table** is worked simultaneously with buffer item. Buffer table and buffer item must be mentioned if you want to make a different distance for different kinds of feature.

The last two arguments are not yet available in these interfaces, therefore you are advised to skip them by typing #.

- **Buffer distance** is the distance used to create a buffer zone around the feature type specified in the input coverage. The distance unit is in metres.
- **Fuzzy tolerance** or map resolution is the minimum distance which separates all arc coordinates in an input coverage. The value of fuzzy tolerance depends on the map scale, the larger the map scale the smaller the value. For example, if the map scale is 1 : 50,000 and the fuzzy tolerance is 2.5 metres, then the value of fuzzy tolerance is 0.005.
- **Feature type** specifies the features in the input coverage to be buffered. They are either lines, points or polygons.

For example, if you want to make a buffer which includes everything within 10 metres of the road, then the steps are :

| | |
|---|---|
| - in cover | : JCLM |
| - out cover | : [type a new name] |
| - buffer distance | : 10 |
| - fuzzy tolerance | : 1 (default) |
| - feature type | : lines |

*Eliminate*

Eliminate merges selected polygons with neighbouring polygons by dropping the longest shared border between them (ESRI, 1989). This option is used most often to remove **sliver polygons**. They appear when two polygons are overlaid and the arcs do not overlap correctly. By selecting polygons which have an area smaller than a certain number, they can be removed. It is suggested that you should check coverages resulting from UNION, UPDATE, and INTERSECT operations in the DRAW menu before using this command.

The arguments for eliminate are :

- **In cover** is the coverage whose polygons or arcs will be eliminated
- **Out cover** is the new coverage created using eliminate operation
- **SML file** is the name of a file which contains appropriate input responses to the dialogue needed by this operation.

  An SML file has already been formulated and using this file, polygons with areas are smaller then 0.1 hectares will be eliminated. If the sliver polygons still remain after this operation, it is suggested that they be removed manually.

*Intersect*

Intersect overlays two or more different coverages and computes the geometric intersection (ESRI, 1989). The result is a new coverage retaining only those features in the area common to both coverages.

This operation is valuable for adding information within a certain area, especially if the features are different. For example, intersecting the road network with administrative boundaries will result the road network for each district able to be identified and then perhaps, measured.

The arguments for intersect are :

- **In cover** is the first coverage which contains one of the feature types; lines, points and polygons.
- **Intersect cover** is a coverage which contain polygons.
- **Out cover** is the new coverage created using the intersect operation.
- **Feature type** is the feature class of the input coverage and will be the feature class of the output coverage as well. If the feature type of the input is line, the new coverage will be a line coverage.
- **Fuzzy tolerance** or map resolution is the minimum distance which separates all arc coordinates in an input coverage.

*Union*

Union is similar to intersect, but it will preserve all features and attributes of both coverages. (ESRI, 1989). Unlike intersect, both coverages in this operation must contain polygon features.

This operation is worthwhile if you have two different coverages, such as socio economic, health or environmental coverages. By combining two kinds of information from two different coverages, a new coverage with all the information will be produced.

Union's arguments are :

- **In cover** is the first coverage
- **Union cover** is the second coverage
- **Out cover** is the result of the overlaying
- **Fuzzy tolerance** or map resolution is the minimum distance which separates all arc coordinates in an input coverage.

*Update*

Update replaces areas in a coverage using a "cut and paste" operation (ESRI, 1989). This operation is especially useful for updating parts of a coverage. If the polygons are to remain unaltered, then updating the database is sufficient. However, if the polygons are to change, such as making a subdivision, then this operation must be used. By executing this operation, the database will be changed automatically.

The arguments are :

- **In cover** is the old coverage containing polygons to be updated
- **Update cover** is the coverage with updated polygons which must have a polygon topology
- **Out cover** is the new coverage to be created

- **Feature type** is the feature classes to be updated. Two options are available, **poly** and **net**. Poly is the default; which makes the output coverage a polygon. Net could create both polygons and lines as long as both the input coverage and the update coverages have similar topology.
- **Fuzzy tolerance** or map resolution is the minimum distance which separates all arc coordinates in an input coverage.

Before executing this operation, you must make sure that the items both in the input and update coverages are exactly the same, otherwise this operation will be terminated.

**PLOT**

This module enables you to check and then draw the coverages resulting from the OVERLAY operation. Two options are available : **draw** and **plot**. The difference between these operation is the output device; **draw** means showing the map on the screen, while **plot** means printing the selected map after executing the map composition. If, after drawing you decide the map is worth printing, then choose **plot** and you will proceed to the map composition procedure. To print it, choose **YES** to the query : **do you want to make a hard copy** and your map will be printed immediately. The plot menu of both the popup and pulldown systems are presented in Figures 10 and 11 respectively. As in the previous menus, the popup menu always gives a brief description about the operation you choose while the pulldown menu does not.

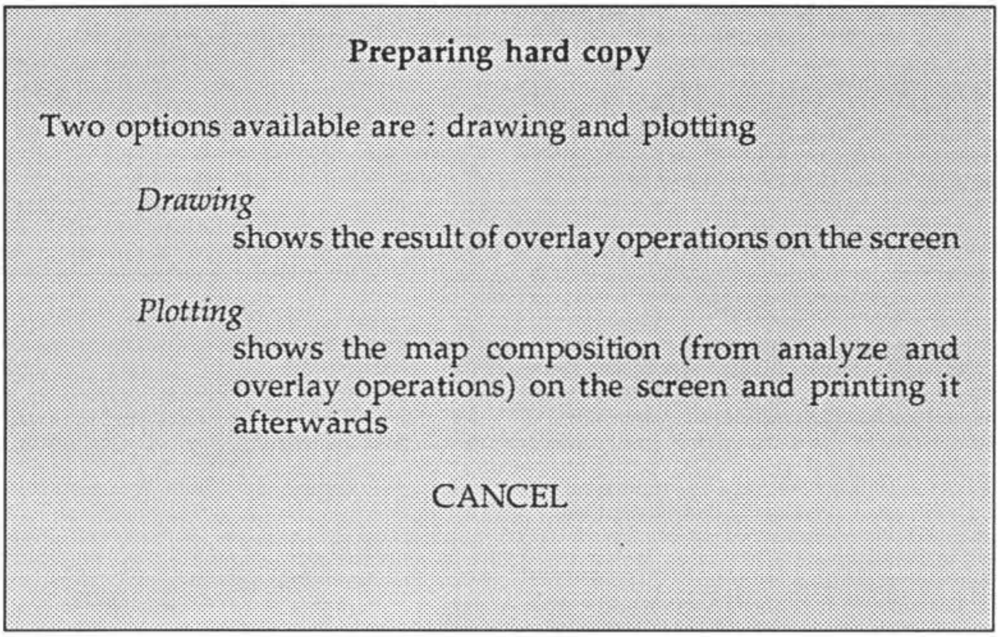


Figure 10. The Popup PLOT menu

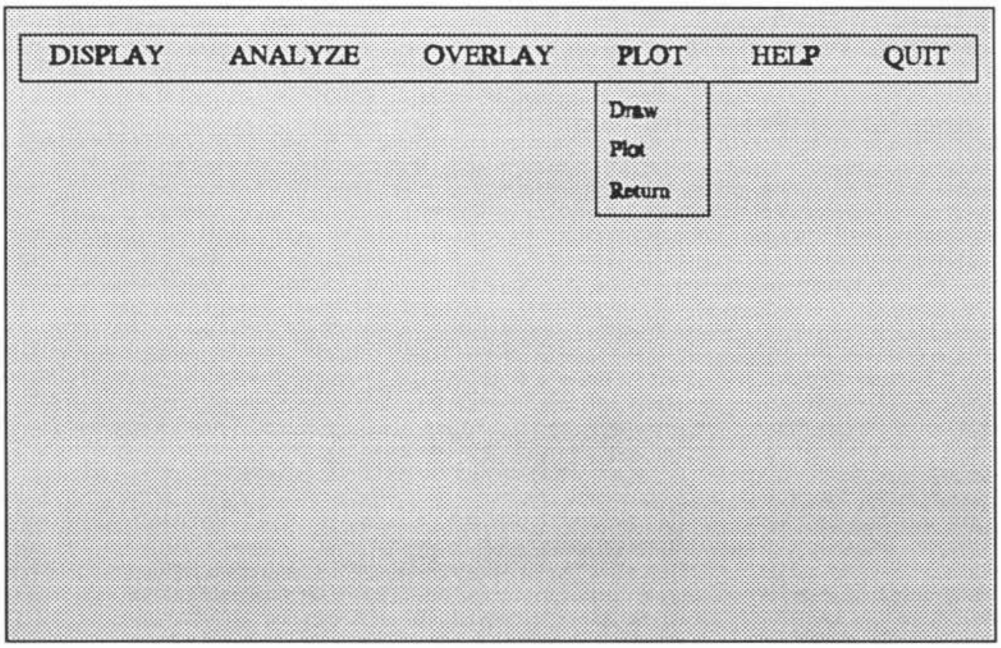


Figure 11. The Pulldown PLOT menu

*Draw*

As has already been said before, the use of this operation is to check maps resulting from the OVERLAY operation. The next operation chosen depends on this operation. If the map makes sense, then print is the next step; if many sliver polygons appear, then you have to choose ELIMINATE to delete those sliver polygons; but if the map is really useless, then KILL COVER should be used to delete that coverage.

In the popup menu, after typing the name of the coverage to be drawn choose **draw** for drawing the map or **return** to go back to the PLOT menu. Inputting the coverage name could be done by typing the coverage's name (in the popup menu), or just selecting a name from the given list ( in the pulldown menu). You can choose either system, but in the popup menu it is assumed that you know exactly which coverage should be displayed.

*Plot*

This operation is similar to the **plot** operation under the ANALYZE menu. The difference is that you do not need to choose the colour, because there will be no polygons selected. Your map will be drawn complete with red roads and blue streams. In this operation you are asked to complete some arguments; they are :

- **coverage(s) name** is the name of the coverage you want to display. In the popup menu, once again, you should type the name, while in the pulldown menu you can choose the coverage's name from the given list.
- **title**. You are allowed to type a long single title for your help, where the maximum number is 25 characters. If you have more than one word for your title, do not forget to put an apostrophe (') in the beginning and at the end of your title. By doing this, you tell the computer that you have more than one word.

- **plot** is chosen after you finished with the title activity. In this section you will be shown the frame of the map composition, and you should put your title on the top of the box. The layout of this map is similar to the frame used for plotting the result of the ANALYZE operation (see Fig. 7).
- the HELP button will give similar information to this user's guide.

You will get your printed map if you choose YES to the query **Do you want a hard copy**. As soon as the map is finished printed you will return to the MAIN MENU. If you want to go out from this system, choose QUIT and type **Y** afterwards.

## Appendix 4. Abbreviations and Class Descriptions Used in the Database

| Land Resource Inventory | Abbr. | Class | Description |
|---|---|---|---|
| **Landform** | LF | A | Alluvial system |
| | | A2v | River valley |
| | | A3c | Alluvium colluvium |
| | | H | Hilly system |
| | | H1k | Rounded hillcrest and knob |
| | | H1h | Hill < E slope |
| | | H1s | Steep hill (E-I slopes) |
| | | K | Karst system |
| | | K1 | Karstic plateau/hillcrest and knob |
| | | K2a | Karstic gentle (A-D slopes) |
| | | K2b | Karstic alluvium/colluvium fan (A-D slopes) |
| | | K3 | Karstic steep (E-I slopes) |
| | | K6 | Karstic depression |
| **Slope** | SL | A | 0 - 4 % |
| | | B | 4 - 8 % |
| | | C | 8 - 15 % |
| | | D | 15 - 25 % |
| | | E | 25 - 35 % |
| | | F | 35 - 45 % |
| | | G | 45 - 65 % |
| | | H | 65 - 85 % |
| | | I | > 85 % |

continued

| Land Resource Inventory | Abbr. | Class | Description |
|---|---|---|---|
| **Rock** | | | |
| - Rock Type | RO | Sf | Yellowish brown to grey clay, silt and sand |
| | | Is | Tuffaceous sandstone, pumice breccia, minor tuff and shale |
| | | Sl | Calcarenite and calcirudite |
| | | Sc | Calcareous sandstone, non calcareous sandstone and siltstone |
| - Bare Rock (%) | BR | 0 | nil |
| | | 1 | 1 - 10 |
| | | 2 | 10 - 20 |
| | | 3 | 20 - 40 |
| | | 4 | 40 - 60 |
| | | 5 | 60 - 80 |
| | | 6 | > 80 |
| - Regolith Depth (cm) | RD | 0 | < 10 |
| | | 1 | 10 - 20 |
| | | 2 | 20 - 40 |
| | | 3 | 40 - 60 |
| | | 4 | 60 - 80 |
| | | 5 | 80 - 100 |
| | | 6 | 100 - 200 |
| | | 7 | > 200 |

continued

| Land Resource Inventory | Abbr. | Class | Description |
|---|---|---|---|
| **Soil** | | | |
| - Soil Class | SO | KEFA | Lithic ustorthents |
| | | KEFB | Vertic ustorthents |
| | | KEFF | Typic ustorthents |
| | | JCCA | Lithic ustropepts |
| | | JCCB | Vertic ustropepts |
| | | JCCE | Fluventic ustropepts |
| | | JCCF | Typic ustropepts |
| | | EDAE | Typic chromuterts |
| | | EDBE | Typic pellusterts |
| | | ICFB | Vertic paleustalfs |
| | | ICFO | Ultic paleustalfs |
| - Soil Depth (cm) | SD | 0 | < 10 |
| | | 1 | 10 - 15 |
| | | 2 | 15 - 30 |
| | | 3 | 30 - 60 |
| | | 4 | 60 - 90 |
| | | 5 | > 90 |
| **Erosion (ER)** | | | |
| - Erosion Type | TYPER | 0 | Negligible to no erosion |
| | | S | Sheet erosion |
| | | vS | Village sheet erosion |
| | | R | Rill erosion |
| | | rR | Roadside rill erosion |

continued

| Land Resource Inventory | Abbr. | Class | Description |
|---|---|---|---|
| | | G | Gully erosion |
| | | Gh | Gully erosion (with distinct head) |
| | | rG | Roadside gully erosion |
| | | Sb | Streambank erosion |
| - Erosion Severity | SEVER | 0 | Nil to negligible |
| | | 1 | Slight erosion |
| | | 2 | Moderate erosion |
| | | 3 | Severe erosion |
| - Erosion Extent (%) | EXTER | 1 | 1 - 10 |
| | | 2 | 10 - 20 |
| | | 3 | 20 - 40 |
| | | 4 | 40 - 60 |
| | | 5 | 60 - 80 |
| | | 6 | > 80 |
| - Soil Depletion | SDL | 0 | Little to no topsoil lost |
| | | 1 | Little topsoil remains |
| | | 2 | Much subsoil lost |
| | | 3 | Soil parent material or bedrock exposed |
| **Soil Conservation Measures** | | | |
| - Intensity of Terracing (%) | INTTE | 0 | Unterraced |
| | | 1 | 1 - 10 |

continued

| Land Resource Inventory | Abbr. | Class | Description |
|---|---|---|---|
| | | 2 | 10 - 20 |
| | | 3 | 20 - 40 |
| | | 4 | 40 - 60 |
| | | 5 | 60 - 80 |
| | | 6 | > 80 |
| - Type of terracing | TYPTE | 0 | Unterraced |
| | | Bl | Bench level |
| | | Br | Bench reverse |
| | | Bo | Bench outward |
| | | Bm | Bench mixed |
| - Terrace risers Vegetated (%) | RISTE | 1 | 0 - 20 |
| | | 2 | 20 - 50 |
| | | 3 | > 50 |
| | | 4 | Risers of stone |
| - Terrace condition | CONTE | g | good |
| | | m | moderate |
| | | p | poor |
| **Land Cover** | LU1GR | 1 | Upland crop : pl - dp - pl[*)] |
| | | 2 | pl - pl - pl |
| | | 3 | pl - pl - br |
| | | 4 | pl - dp - br |

continued

| Land Resource Inventory | Abbr. | Class | Description |
|---|---|---|---|
| | | 5 | Rainfed paddy |
| | | 6 | Irrigated paddy |
| | | 8 | Mixed and homestead garden |
| | | 9 | Forestry system |
| | | 10 | Others |
| **Landuse Capability** | | | |
| - Limitation | LULIMIT | e | Erosion |
| | | c | Climate |
| | | s | Soil |

*) pl : palawija
dp : dry paddy
br : uncultivated (during dry season)