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MANUAL FOR SPATIAL COMPUTERIZED LAND EVALUATION SYSTEM

WITH SPECIAL REFERENCE TO THE
HIGHLANDS OF ETHIOPIA

VOL. 3 :

GILES

GEOGRAPHICAL INFORMATION AND LAND EVALUATION SYSTEM

USER MANUAL

by

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MINISTRY OF AGRICULTURE
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ABSTRACT

This Field Document forms a component part of a three-volume manual on a computerized land evaluation system for Ethiopia based on the principles of the FAO Guidelines on Land Evaluation for Rainfed Agriculture (FAO 1983). It constitutes volume III of the Manual and describes the computer aspects of the land evaluation, the software package GILES. Volume I explains the land evaluation methodology (FAO 1987 b), while volume II (1987 c) deals with the influence of environmental conditions on crop growth and crop development.

The software package GILES: Geographical Information and Land Evaluation System was especially developed to fulfill the required tasks of project ETH/82/010 and ETH/87/006: 'Assistance to Land Use Planning', to execute agricultural suitability assessments, to define soil conservation measures, to estimate carrying capacities on a spatial basis (1:50000 and 1:250000 scale) and to deliver cartographic information in an integrated, multidisciplinary approach.

After finalizing, GILES functions now in a wider context as a database carrier on national, regional and subregional level to perform above mentioned duties and additional features of computerized mapping and information retrieval on spatial basis.

Part A (Chapter 1) is addressed to **decision makers**, politicians, government bodies, planners (particularly land-use planners), supervisors, managers, NGOs etc. to be able to **make efficient use of the output of GILES** and to stimulize their request for data provided by GILES.

Part B (Chapter 2 and 3) is for **users** to know about the facilities of GILES and how to retrieve maps and statistics. Land evaluation specialists, physical resource experts, soil conservation specialists, technicians, statisticians etc. will be guided through the **'User's Manual'** with step-by-step explanations and references.

Part C (Chapter 4 and Appendices) is a mere **reference strictly for system analysts** to install, establish and understand the system and to enter, change or modify data.

GILES is transferable to any area, but main fields of applications will remain the assessment and interpretation of natural resources in developing countries at low cost level. It r[illegible] IBM-compatible microcomputer with DOS operating system.

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LIST OF ABBREVIATIONS

BS	- Base saturation
CEC	- Cation exchange capacity
DMBS	- Database management system
DD	- Double density (disk specification)
DEM	- Digital elevation model
DOS	- Disk operation system
DS	- Double sided (disk specification)
DTM	- Digital terrain model
EC	- Electrical conductivity
ESC/P	- Epson standard code for printer
FAO	- Food and Agriculture Organization
GILES	- Geographical Information and Land Evaluation System
GIS	- Geographical Information System
HD	- High density (disk specification)
HPGL	- Hewlett Packard graphics language
k	- Kilobyte (1024 bytes)
kB	- Kilobyte (1024 bytes)
LE	- Land evaluation
LUPRD	- Land Use Planning and Regulatory Department
LUT	- Land utilization type
MB	- Megabyte (1048576 bytes)
PA	- Peasant Associations
PC	- Personal Computer
PET	- Potential Evapotranspiration
PS	- Personal System
SIS	- Soil information system
UTM	- Universal Transverse Mercator Grid System
3D	- 3 dimensional (display)

Trademarks not listed.

THE FIRST TIME ?

Before you do anything else:

- Have a look in Chapter 3 of this Manual
- Make a back up copies of GILES (see App.1, p.189)
- Install GILES in your system (see App.1, p.189)
- Proceed with 'How to start the first time' (Section 3.3.21; p.137)

G I L E S

PART A:

For Decision Makers, Politicians, Planners

Chapter 1) Aspects of Computerized Information and Evaluation System of Natural Resources

1. ASPECTS OF A COMPUTERIZED INFORMATION AND EVALUATION SYSTEM OF NATURAL RESOURCES

This chapter describes the need for GIS in general and for GILES in particular, their advantages in form of large data handling, quality, output, speed, updating, and how politicians and planners can make use of these advantages.

1.1 NEED FOR ESTABLISHMENT OF NATURAL RESOURCE DATA BASE

Ever-increasing population leads to pressures on the available resources of the land that exceed its carrying capacity. Resulting overutilization leads to resource degradation: Soil erosion, changes in flow regimes of rivers, changes in precipitation regimes due to deforestation, development of gullies, scarcity of fuelwood, to name only a few phenomena in Ethiopia. This results again in a stronger overutilization and worse degradation.

Effective land-use planning is necessary if this degradation of natural resources is to be stopped and optimal use to be made of the land for sustained and increased agricultural production to support the population.

This requires **comprehensive information** on land resources so that development strategies can be assessed in terms of all relevant environmental relations, such as climate, soil, land form, water etc. to define physical resources, but as well as of population, infrastructure, agricultural activity to define demand and activities. The generally accepted response to this process is the establishment of a management structure for natural resources.

The lack of adequate information, accessible to decision makers and planners, on which natural resources management is based has been identified as one of the reasons for - up to now - limited impact on the definition of appropriate land use plans and activities. It is in relation to this point that set up and development of information systems to support resource management had to be initialized.

Politicians, policy and decision makers, planners, supervisors, managers, development agencies require more and better resource information !

The need to match the land requirements for producing food and supporting populations to the resources of climate, soil, water, and available technology led to the assessment of the suitability of the land for agricultural purposes, a powerful- and essential - tool in the hand of decision makers and land use planners.

Thematic mapping of earth resources prepared by the concerned specialists (soil scientists, climatologists, hydrologists, geologists, ecologists, land-use specialists) gave partly the answer for those questions. They have been - and are - a source of useful information for resource exploitation and management.

But the need for spatial data and spatial analysis has not been restricted only to earth scientists. Additionally to informations about physical resources, decision makers need detailed information about the land and its rather economic and infrastructural characteristics.

In the past, data were collected and then documented in hardcopy form as tables or maps. Indeed, the rapidly increasing population and environmental changes result in a fast change of data and high need for fast, updated interpretation of those data. Formulation of essential actions and plans therefore require faster, more and better data than in the past to handle - and hopefully to solve - the problems of land degradation and population support.

But ultimate goal of resource monitoring must be to go one step further: to analyze not only the supply but also the demand and the accessibility of the resources.

1.2 INTRODUCTION OF COMPUTERIZED DATA BASE

a) In the past, examples abounded of data collection exercises that got stuck in their own abundance of data which at one side was necessary to assess the resources - and potential - of the land, on the other side could not be handled manually anymore. This need for **handling large data quantities** of the environment for rather detailed assessments can highly be met by a new technology developed in the past and applicable on a wide scale only in the past 10 years: The electronic processing of digital data by 'computer' !

The increasing capability and availability of computer and its technologies and experiences have a revolutionary effect upon the techniques available to those responsible for the assessment and management of natural resources. This development was encouraged by progressively cheaper, more user-friendly and better performing computer facilities.

Various attempts were made on global basis as well as on national levels in different countries to develop and to install a computerized data base system of the resources inventory (CDC 1986; Nag 1987; Shupeng 1987; Bellamy 1986, to name only a few). Until now, much emphasis has been put on information systems as data bases providing facilities to store and retrieve these data.

b) It is not only the size of the data collected and interpreted, but often the prompt demand for information which can not be delivered rightly in the traditional, manual way. Most of the requests by land use planners, governments, implementation agencies etc. are in high urgency. An important objective of a data-processing system is to provide a rapid and comprehensive response to ad hoc requests for data retrieval and interpretation.

Computerized storage encourages a wide range of available, **immediate retrieval** operations of the requested information - processed, modified, manipulated or raw, in the required way of presentation.

c) It is not only one subject which allows the definition - the need and the potential - of natural resources, but a number of parameters, being in a dependent interrelation with each other. One influences the other. These interactions are difficult to assess and were in the past the cause for misplanning, misinvestment and damage of the nature, even for many disasters caused by 'wrong planning', i.e. planning based on wrong information supplied by the resource data base which might not have considered the interactions.

The fact that the environmental data recorded by individual surveys are stored and available in digital and computer compatible form from the very beginning enhances this possibility of allowing computers to complement man for an optimal use of the data (Hellden 1987).

The more complex transformation of data into adequate information and the need for system's analysis of the complex 'man-environment' interaction, involving huge amounts of data from different sources, calls for computer support.

Computerized **modeling** to simulate the environment takes - and particularly will take in the future - these interactions into considerations.

Relatively simple examples are the assessment of the agricultural potential for specific crops, as done in the land evaluation incorporated into GILES (see Section 1.4 and 2.3.1; p.7/29), or the calculation of the erosion hazard (see Section 2.3.2; p.32).

Development of spatial models of land use may be a way towards the ultimate monitoring system, where supply, demand and accessibility of resources are assessed in an integrated way. Combined models describing supply and demand are defined and applied (e.g. carrying capacity models).

d) Many of the parameters used for land resource management and essential for land use planning, are highly variable in space and time.

Spatial variability when inventorying and surveying the environment is normally accommodated by appropriate sampling density. Procedures for these are more (e.g. present land use) or less (e.g. climate) established.

But inventoried variability depends on scale, timeframe of the survey and objectives of the study. More detailed survey can bring better results (maps, data) than previous exercises.

Temporal variability in environmental factors can be very high. The methodology to handle this variability is not well established.

Changes of climate, land use patterns, hydrological regimes, population, political boundaries can modify the characteristics - and the need and the potential of the land.

A reliable resource information system should always be up-to-date and corrected with the latest available figures. Changes, **updatings and corrections** should be entered into the archives ('data base') as soon as they are available.

This chance is given through computerized storing and handling of data.

But updating is rather more than just modifying an aging data base; it implies resurvey and processing new information. The updating modifications will result in always new, corrected, improved assessments of the agricultural potential and need for - eventually new - actions and plans the land requires.

e) Often resource data are collected, but stored and organized in different institutions and in different formats. This intransparency does not lead to a high efficiency to support Government and planners with the requested information. Established **links to other natural resources data bases** are to permit easy exchange of data between databanks. E.g. setup of a National Soil Survey databank of Ethiopia specialized on soil data was made in conformation with GILES; meteorological data are gathered and organized by the National Meteorological Service Agency NMSA, statistical data (census figures, yield estimates) by the Central Statistical Office CSO of Ethiopia; proposal is made for a Sahelian natural resource database (CDC 1986).

If computerized compatibility is given, these data can - after being made available - be inserted into the present geographical information system.

f) Conclusions:

Establishment of a computerized database is not necessarily a capital intensive activity requiring mainframe computing facilities with high costs any more. Recent developments in computer hardware and software have placed the computer power required to run a GIS within the scope of any average size office, as it is demonstrated in this Manual (for requirements, see Section 2.6; p.37).

Beside the fact that large data can be stored in a compact, organized manner, the most fundamental and the most significant advantage of computerized processing is, that data may be **'rapidly retrieved in a wide variety of formats, aggregations' and manipulations** (WMO 1985).

1.3 SPATIAL INFORMATION: GIS

Any land resources data base should be site specific ! Long term land use planning objectives require the identification of locations suitable - or not suitable - for a particular land use.

For planning and modeling purposes, it is not only the data being important, but rather the **spatial distribution of the environmental data in form of maps**, which gives the essential information where actions have to be taken. It is evident, that land users require more and better mapping information (Cunningham et.al.1984).

Presentation of environmental information in map form is a necessary tool for the planning and management of natural resources, as well as for for research on the distribution and allocation of resources. Maps can be seen as a means for communication between researchers, decision makers and planners. The amount of information that can be presented in map form is tremendous. Both status, trends and projections can be presented in a conceptually simple way. To keep pace with the increasing capacity to collect environmental - and structural - data through surveying and the increasing demands of supplying data to users of all categories, the conventional data handling methods should be supplemented by modern computer assisted techniques.

Any resource data base and interpretation on spatial distribution has to combine various maps with different mapping units and to process their parameters. The mapping units of those maps might be similar (if based on the same inventory, e.g. aerial photographs), but maybe they are not at all (e.g. administrative boundaries compared with physiographic units, watershed management with vegetation units). This can only be solved by more or less small resolution mapping systems which can be adjusted to all these different boundaries.

This can be offered by computerized means - with all the possibilities described above - through so-called **'Geographical Information System'**: GIS. The principle of any GIS is to store spatial information as different information layers in a grid system, enabling further processing and retrieval.

The major advantage of a GIS is the possibility to integrate and analyze very large amounts of data from different sources and with different themes for computer based generation of new information layers, maps and statistics for planning purposes. The information available can be presented in optional combinations.

In review of the present state-of-art, it is apparent that there is a high, but still unsatisfied need for low-cost, easily usable GIS software running on readily available, cheap hardware that emulate the capabilities of larger specialized systems. This need tries to be satisfied by the present GILES system.

1.4 GIS FOR LAND EVALUATION : G I L E S

The present computerized data base of natural resources on spatial basis gives the possibility to assess land performance when used for specified purposes.

The assessment is directed towards the following objectives:

a) **identify land suitable** for arable and perennial cropping, livestock grazing and fuelwood production, based on assessment of soil erosion hazard, present land degradation and wetness limitations

b) **identify suitable crops**, areas where they can be grown, and estimating yields under different levels of inputs and technology

c) assessing the land resource balance relative to present and projected population numbers (population support capacity) to **identify areas of particular** need and **areas most likely to benefit from additional investment**.

The results of this land evaluation will provide a rational basis for decisions on land use which can be taken in accordance with national and regional development priorities.

Exploration and exploitation of new resources, new techniques and new input levels in agriculture can increase the agricultural potential considerably. Steady change in environment, land use, economic parameters and economic evaluation makes the land evaluation timevariable. As soon as change in environment etc. is inventoried and assessed, it can be brought into the system for land evaluation.

That results in the pronounced need for new, fast executed land evaluation assessments. High need exists for fast incorporation of these eventual changes of land use into the land evaluation procedure for immediate checking of the potential of new land use practices.

As in reliable evaluation systems with applicable results many parameters (land characteristics and land qualities) have to be incorporated, there is the understanding that such a system should operate under computer assistance. This is even more true if such a database has to show spatial distributions, i.e. thematic maps.

As larger the scale, e.g. moving from 1 Mio. to 1:50000 scale, as more data are gathered and need to be processed for the different, in more detail defined objectives of land use planning studies, which are rather for implementation than for project identification.

Generally it can be said, that as larger the scale is, as more reliable are the results of the land evaluation and recommendations, which goes up to the level of giving site specific information, but as more complex are the models and more parameters ('land qualities') **have** to be considered.

This large amount of data can be processed only by computerized means, otherwise a tremendous loss of information will lead to misrecommendations and misplanning.

This is the main objective of GILES.

Land evaluation exercises were executed by GILES in various areas of Ethiopia (see App.10; p.257). Several land evaluation reports with accompanying atlases are published by the 'Land Use Planning and Regulatory Department' of the Ministry of Agriculture of Ethiopia (assisted by FAO/UNDP project ETH/82/010 and ETH/87/ 006): FAO 1987 d; 1988 a; 1988 b; 1988 c; 1988 d.

1.5 SUMMARY OF ADVANTAGES AND LIMITATIONS OF A COMPUTERIZED INFORMATION AND EVALUATION SYSTEM (GILES)

1.5.1 Advantages

a) **Possibility to store large amount of data:**

In GILES, it is possible, to store, integrate and analyze very large amounts of data derived from different sources (e.g. different maps from different agencies), with different themes, different scales and different level of detail for computer based generation of new information layers, maps and statistics for planning purposes.

A standard computer storage medium (40 Mb hard disk; 1988) can store more than 1500 different maps (map sheets).

b) **Possibility to store all original data:**

In conventional mapping systems it was necessary, to reduce the original data greatly in volume (or to classify) in order to make them understandable and representable. Consequently, many local details were often filtered away and lost. GILES makes it possible to organize the data storage without generalization, i.e. loss of data, and to generalize them only when retrieved according to request.

Each map stored in GILES can have up to 700 different mapping units (e.g. soil types shown on the map). For soil and administrative units up to 50 parameters ('attributes') can be entered and retrieved (e.g. drainage, texture, depth, population density, population support etc.).

c) **Selection of level of detail:**

The level of detail shown on the map produced by GILES can be selected by the user. The degree of map generalization can be chosen, depending on the scale and the purpose.

d) **Flexibility of scale:**

GILES enables print or plot of the requested map within a wide scale range (e.g. thematic maps of Ethiopia at a scale of between some 1:500000 and 1:6 Mio).

e) **Combination of maps with other maps (spatial data):**

GILES' maps can be overlaid and combined with other maps or map overlays (!). It is possible to consider the interactions between different ecological parameters or between physical and administrative units.

Maps can be shown with requested attributes of up to 10 different base maps. Up to 5 crop suitability assessments (maps) can be overlaid to form a crop mix ('farming system') suitability assessment.

f) **Combination of maps with non-spatial data**
('attributes', 'parameters'):

Maps can be retrieved in combination with entered non-spatial data in a specified content through translation tables (e.g. 'parametric maps', see Glossary; p.267).

Out of the soil map e.g. 50 individual parametric maps can be retrieved with the translation table 'soil type characterization'.

g) **Correction and updating facilities:**

Printed maps are static, qualitative documents, almost impossible to be changed. 'It is extremely difficult to attempt quantitative spatial analysis within the units delineated on a thematic map without resorting to collecting new information for the specific purpose in hand' (Burrough 1986).

In GILES, corrections due to a better survey, more reliable data base, updating on a monitoring basis, changes in the environment, new delineation of administrative units etc. can be easily inserted and hereby corrected maps or statistics can be printed.

Not only the data are continuously to be checked and corrected, it is also the interpretation of the data, the modeling, which can be revised due to new requests, new approaches or new purposes (e.g. different scales, different requirements).

h) **Facility of modeling:**

Many advantages accrue when emphasis is placed on manipulation, analysis and modeling of spatial data in an information system.

This potential for dynamic simulation and modeling is offered by GILES. A number of options and scenarios can be easily modeled and compared with each other (e.g. what is the quantitative advantage to drain a certain area). 'What if ?' analyses can be executed.

To overlay various spatial data with the incorporation of models ('algorithms') to assess the agricultural potential and the environmental interactions is the main activity of GILES. A large number of varieties of modeling is possible (the assessment of agricultural potential, its need to sustain productivity etc.).

i) **Speed of map print:**

Processing of a map is faster than manual drawing of a map.

j) **Error quality:**

In any manual and computerized mapping system, it is impossible to avoid systematic errors completely. Advantage of GILES is that these errors can relatively easy be checked and corrected.

Random errors (e.g. 'human errors') as they always might occur on hand-drawn maps, will be avoided by GILES.

k) **Wide range of output forms:**

GILES offers a wide range of different output forms: Maps plotted with boundaries of the units, colored or black & white maps on plotter, maps on matrix printer with font symbols or with grey scale, maps on computer storage media for later outprint, only legends of maps on screen, printer or in spreadsheets. These maps can be retrieved for the entire area or only for selected parts or small windows (see Section 3.2.3; p. 98).

1.5.2 Limitations

a) **Necessity of computer facility**:

At least one Personal Computer with peripherals ('hardware') is required, as listed in App.4 (p.200). Costs for the purchase of one hardware set is in the range of 1500 - 4000 US$ (1989, with tendency to be less in the future; see Section 2.1; p.17).
Power supply (electricity of 220 V or 120 V) is essential.

b) **Know How of personnel**:

To run any kind of computer equipment, manpower trained in the use and maintenance of computer is essential. For the application of GILES, interactive manuals and help menus offered during information request can train users within a few days time (see Section 2.6.2; p.39).

More difficult is the installation, maintenance and repair of computer. For this, expertise at the level of good basic understanding of technics and electrics is required.

In many developing countries, service is not offered by computer dealers or manufacturers. In Ethiopia, most computer hardware service is done by individuals getting acquainted with computer hardware at various levels.

c) **Data entry of base maps**:

Before retrieval or processing of maps or data, base maps (e.g. topography, soils etc.) have to be entered ('digitized') into GILES.

Even though particular emphasis was given to efficient and user-friendly way of map digitizing, this can still be a bottleneck of the system. Digitizing, in spite of modern table digitizers, is time-consuming and enervating work: a drudge (Burrough 1987).

E.g. to enter a relatively detailed map of Ethiopia at a scale of, lets say, 1:1 Mio. might take some 20-70 man hours (see Section 2.5.1; p.36).

d) **Unawareness of clients**:

The Government, ministries, development agencies and other potential clients are not fully aware of the advantages of a fast computerized information system providing the essential information within hours time. Thus, the necessary structural changes in work and information flow and practices that would allow the advantages did not take place yet (see Section 2.1.4; p.19).

e) **Limited output graphics**:

In the present GILES version (2.2) automated cartography is not fully established yet and therefore output quality can not always be considered equal to well performed manual cartography.

1.6 SUPPORT OF PLANNING ACTIVITIES

'Only the use of the information produced by information systems can justify their existence: information systems have to support decision making.' (de Meijere/van de Putte 1987).

The assessments of the agricultural potential with and without improvements will **guide the formulation of land use plans** through which this potential can be realized.

Beside the evaluation of areas or of crops being suitable, the planner can, based on political priorities, define rules for the identification of the areas with the highest potential or with the highest needs for soil conservation and for an estimation of the cost/benefit relationship in each of the areas selected. The characteristics selected to identify the areas might be any combination of a high population density, a low available land/capita ration, a high, but not increasing annual crop yield, a high precipitation variability, a medium or high soil loss or a specified slope.

Because planning is concerned with the future, the essence of planning is making projections of developments over a certain time period. The first projection that must be made in any planning exercise is the 'autonomous' development situation ('the *"without" situation*'). This reflects the development of processes as they will take place without (new) actions being taken.

A plan indicates a set of actions to steer the process in the desired action, with assumptions made and changes of the environment. The **new scenarios can be evaluated**. This can be done easily if the assumed actions are integrated into an information system and characterize a new, improved situation ('the *"with" situation*').

To be able to make projections for a proposed set of actions, it must be possible to indicate in quantitative terms what the effects will be. The elaboration of scenarios used to be a very laborious task and therefore only a limited number of alternatives were used for decision making. Computer analysis facilitates this process and therefore enlarges the scope of information available for decision making - and improves the quality of the output and reduces the chances of misplanning.

Because these data can be accessed, transformed, and manipulated interactively in a geographical information system, they can serve as a test bed for studying environmental processes or for analyzing the results of planning decisions. By using GILES in a similar way that a trainee pilot uses a flight simulator, it is, in principle, **possible for planners and decision-makers to explore a range of possible scenarios and to obtain an idea of the consequences of a course of action** before the mistakes have been irrevocably made in the countryside itself.

It would be a tremendous and practically impossible task to carry out such operations manually by combining and comparing map sheets, with different themes, scales and ages, with each other.

It is only when the system has been made 'dynamic' that it can be used for making projections and therefore for planning, but it is also the dynamic aspect that is difficult to quantity. This emphasizes the importance for planners to have a tool which enables them to test the effects of various alternative actions and to assess the impact of the sensitivities on the assessment criteria related to the objectives.

Specialized GIS systems 'are emerging as the major spatial data handling tool for solving complex natural resource planning problems' (Nystrom 1986).

But development 'continued so fast that it outstripped the ability of managers to keep up. Under these circumstances it was difficult for them to remain objective and to think of how the new technology was really addressing the fundamental problems of mapping.' (Burrough 1986). At the present, GIS systems are not being used as effectively nor as widely as possible for natural resource assessments.

It was shown in this chapter that microcomputers have the potential to become a standard tool for resource managers in decision-making, but the most important is that resource managers are aware of the powerful tool they have in their hand and know how to use it in the most efficient way.

With further development and higher acceptance of decision makers it can be assumed that GILES will lead to considerable improvements in agricultural and environmental management and control in Ethiopia in the future.

G I L E S

PART B:

For Users, Experts, Technicians

2. GILES

The present geographical information system GILES was developed particularly for the assessment of the potential of the land for agriculture and its need for conservation measures to sustain agricultural productivity in developing countries and additionally to establish a land resource database.

There was a pronounced need of a computerized, fast, flexible system, capable of a high level of detail, for multipurpose map retrieval and overlay to fulfill above mentioned requirements.

This led to the development of GILES: GILES now presents an interactive, grid-cell based, low-cost, easy-to-handle GIS system with strong emphasis on map overlay, particularly for agricultural planning purposes, for the output of raster or plot maps and transfer of maps and statistics via translation files into other software systems. Printer for various scales outprint, plotter and digitizing tablet are supported, less attention is given in the present version to automated cartography. It runs on any 'compatible' micro-computer with DOS system and with a harddisk. GILES is completely menu-driven and supported by help mains; queries by users will be responded immediately.

GILES as any GIS is scale independent (see App.10 for areas and scales in Ethiopia where GILES is applied; p.257). But main advantage of GILES is the answer for improvement and sustaining of agricultural productivity, the land evaluation aspects of GILES, which can be carried out better at a medium (detailed or semidetailed) scale than at small scale.

Part of GILES is this Manual with the general description of GILES and its main facilities, a user's manual with a tutorial that leads through the sample evaluation, background information on land evaluation, instructions for installing and for interfacing to commercial databases.

Computer, GIS and land evaluation system brought with them a considerable amount of jargon. For these not familiar with these new technologies, two Glossaries of terms used in this Manual, are given at page 279-289.

GILES facilities consist of two components:

a) '<u>G</u>eographical <u>I</u>nformation System component', for thematic map retrieval, entry, modification and (general) manipulation of spatial data. The theoretical background and some technical aspects are discussed in: see Section 2.2 (p.20)

b) '<u>L</u>and <u>E</u>valuation <u>s</u>ystem component', for specific processing of physical environmental maps for the assessment of agri-cultural suitability and of conservation need for planning the most appropriate land use: see Section 2.3 (p.29).

Before use can be made of the advantages of a computerized geographical information and land evaluation system, some change of the methodology applied and some investment in hardware and training have to be done: see Sections 2.4-2.6 (p.33).

2.1 COMPONENTS OF GILES

Four components make up any kind of computerized processing such as GILES (see App.5; p.203):

a) Computer hardware
b) Software: GILES
c) Trained personnel
d) Institutional context

2.1.1 Computer Hardware

In order to fulfill the above mentioned tasks, an information system should be:

- relatively inexpensive,
- limited in the demand on highly skilled technology and manpower,
- the best technology affordable,
- robust and easy to maintain.

Therefore, emphasis at the selection of computer hardware to execute GILES was put on low cost equipment with low maintenance requirements to give highest performance under difficult environmental conditions (high temperature, extreme air humidity, dust, irregularity of power supply), supply and maintenance difficulties. THe relatively young generation of micro-computers: PC or PS/2 match these requests the best. Basically, they consist of four parts:

a) The CPU ('central part of the computer') is linked to information and storage units (RAM, ROM, harddisk, disk drives) providing space for storing programs, map and general data.

b) Enhanced graphic facilities ('EGA' or 'VGA' screen and adapter) show by far better maps at the screen than colored graphics equipment ('CGA') or black & white equipment.

c) Printer or plotter will present the maps and other kinds of processed data on paper (see App.4 for supported printers and plotters; p.200).

d) A digitizing tablet will convert data in map form into digital form (see App.4 for supported digitizing tablets; p.200).

Required hardware and costs are briefly in Section 2.6.1 (p.39) and 2.6.3 (p.40), in detail in App.4 (p.200). Further explanations on computer processing are given in App.5.A (p.203).

2.1.2 Software

GILES includes most of the important GIS processing techniques. Major capabilities include:

- Entry and verification of maps
- Non-spatial data base of attributes ('parameters', DBMS)
- Vector / raster conversion
- Storage of maps/data
- Retrieval of maps/data
- Overlay of maps
- Feature extraction of maps/data
- Manipulation of maps/data
- Display of data and maps on screen, printer, plotter
- Transfer of data and maps to other systems
- File utilities

The main options are explained in detail in the 'User's Manual' in Chapter 3 (in particular, Sections 3.2.1 and 3.3; p.47/105).

The software package GILES is stored on six DS/DD diskettes (if HD, two disks). (For listing of all files, see App.6; p.208). Before using, GILES must be installed in the system: See App.1 (p.184).

2.1.3 Trained Personnel

Experience with GILES can be made via context-sensitive on-line help on screen, with the references of this Manual or in training courses.

Similar to most software, first output can be produced within few hours time for an experienced user. To get highly familiar with GILES and thus to make use of all facilities might take 1-3 weeks of intensive training (see Sections 2.6.2 (p.39) and 2.6.3b (p.41).

2.1.4 Institutional Context

'Management is just as important as technology'!

The wider use of GILES should not be inhibited by unawareness among potential users, resistance to new technology and management problems.

In order to be used effectively, GILES has to be placed in an appropriate institutional context: This tool can only be used effectively if it is properly integrated into all planning procedures and all clients are aware of the facilities of this planning instrument, in particular of the fast access to the immense natural database and the chance of modeling.

Different methods of data collection and processing, different kinds of products and far-reaching effects on the way land use planning is performed require its full institutional establishment.

Only then GILES can perform as a fast and powerful planning tool.

Further reference is made to de Man (1984) recommending a series of guidelines to be followed relating mostly to the organizational and managerial aspects of GIS systems.

2.2 GIS ASPECTS OF GILES

A Geographical Information System (GIS), as part of the present GILES, is a multipurpose computer based information system for retrieval, administration, processing, integrated analysis and cartographic and statistical presentation of any kind and combination of information which can be defined in space.

In principal, a geographical information system has to answer:
a) What do I find on a given location ?
b) Where can I find a given object/condition/potential ?

GIS represent a rapidly developing field lying at the intersection of many disciplines - among them cartography, computing, geography, photogrammetry, remote sensing, statistics, surveying and other disciplines concerned with handling and analyzing spatially-referenced data. They are of interest to a wide and increasing range of users, such as land and resource managers, market researchers, planners and those responsible for utilities, to say nothing of administrators and policy makers at all levels.

2.2.1 Development

The study of the spatial distribution of resources and of the characteristics of the land started in a qualitative way. As in many new sciences, the first aim of many surveys was inventory - to observe, classify, and record. Qualitative methods of classification and mapping were unavoidable given the huge quantities of complex data that most environmental surveys generated - and which are essential for a reliable assessment of the reality, of the potential and of the need of the land.

But with the large volume of data the problem of handling these data arose. Further, there was a lack of appropriate mathematical tools for describing spatial variation and interrelation in a quantitative way.

Comparing and even combining spatially-referenced data from different sources, different scales, different topics is extremely difficult, especially within the time constraints imposed on policy and decision makers. It was the advent of computer in the past 20 years that was the key element in making effective GIS with rapid response times practical possibility. Only with the availability of computerized processing and particularly of low-cost Personal Computers in less developed countries (where the need for such assessments is the highest) it was possible, that:

- both the conceptual methods for spatial interpretation of the resources: the land evaluation aspects of GILES,
- and the actual possibilities for quantitative thematic mapping and spatial analysis, the geographical information system aspects of **GILES** have been able to blossom.

With computerized processing facilities of GILES it is now possible for all those responsible for collecting and presenting statistics of various kinds to automate the handling of such data and thereby speed and make more flexible both production and analysis.

The increasing interest in spatial characteristics of data collected by various surveys and for various purposes can be fulfilled in an effective way only by computerized mapping means. In the past, applications of computing to cartography was first concentrated on the production of relatively simple thematic maps of statistical data for smaller administrative units. Only recently it was possible to shift to more complex mapping and overlay methodologies.

As it was one of the largest requests to relate different categories of information for the purpose of a fast retrieval and compilation for resources assessment and agricultural productivity improvement, appropriate concepts and software for storing and handling the data were developed in the present GILES.

In summary, GILES was developed due to:

- need of transparent system which can be modified by trained staff
- need to define and integrate models for agricultural planning (e.g. suitability assessments)
- need to be operated by those with no previous knowledge of computers (no query language)
- need to overlay map with interaction relations
- high costs of specialized systems
- need for relatively low demand on highly skilled technology and manpower
- need for low-cost, insensitive output devices
- need for standard languages, operating systems and microcomputers to allow portability
- production philosophy underlying commercial software

GILES is the design of a GIS around the need for spatial analysis and handling geographical models rather than an enforcement of data and models into existing data structures (Clarke 1986; Tomlinson 1978).

GILES is operating in the 'Land Use Planning Department' (LUPRD) for the last three years. Its outputs were applied for planning in various areas of Ethiopia (see App.10; p.257).

2.2.2 Structure of GILES

A functional GIS of the new generation, such as GILES, should be able to **process attributes referring to a spatial distribution**. Thus, part of the GILES modules consist of routines for handling spatial distribution (coordinate systems, classically understood by "GIS") and one for the handling of the data base with the parameters ('attributes'; classically understood by "DBMS"): This is called a 'hybrid' system. These two components are linked by a 'pointer' (Aronson and Morehouse, 1983) or 'identifier', which is done in GILES by the mapping unit number.

```
Map retrieval   <——>  Pointer,  <——>  Database
    system            identifier
       |                                  |
      Map                         Parameter, attribute
                                  ('characteristic')
```

(modified from Schaller 1987)

GILES is an 'integrated hybrid system', as the soil map and administrative map (and further maps on request) can be retrieved 'directly' (see Section 3.2.1.1; p.48) as well as can be handled as pointers (pointer maps) where the soil mapping units or administrative units 'point' to a particular, selected parameter ('attribute', 'land characteristic') which can be retrieved or processed.

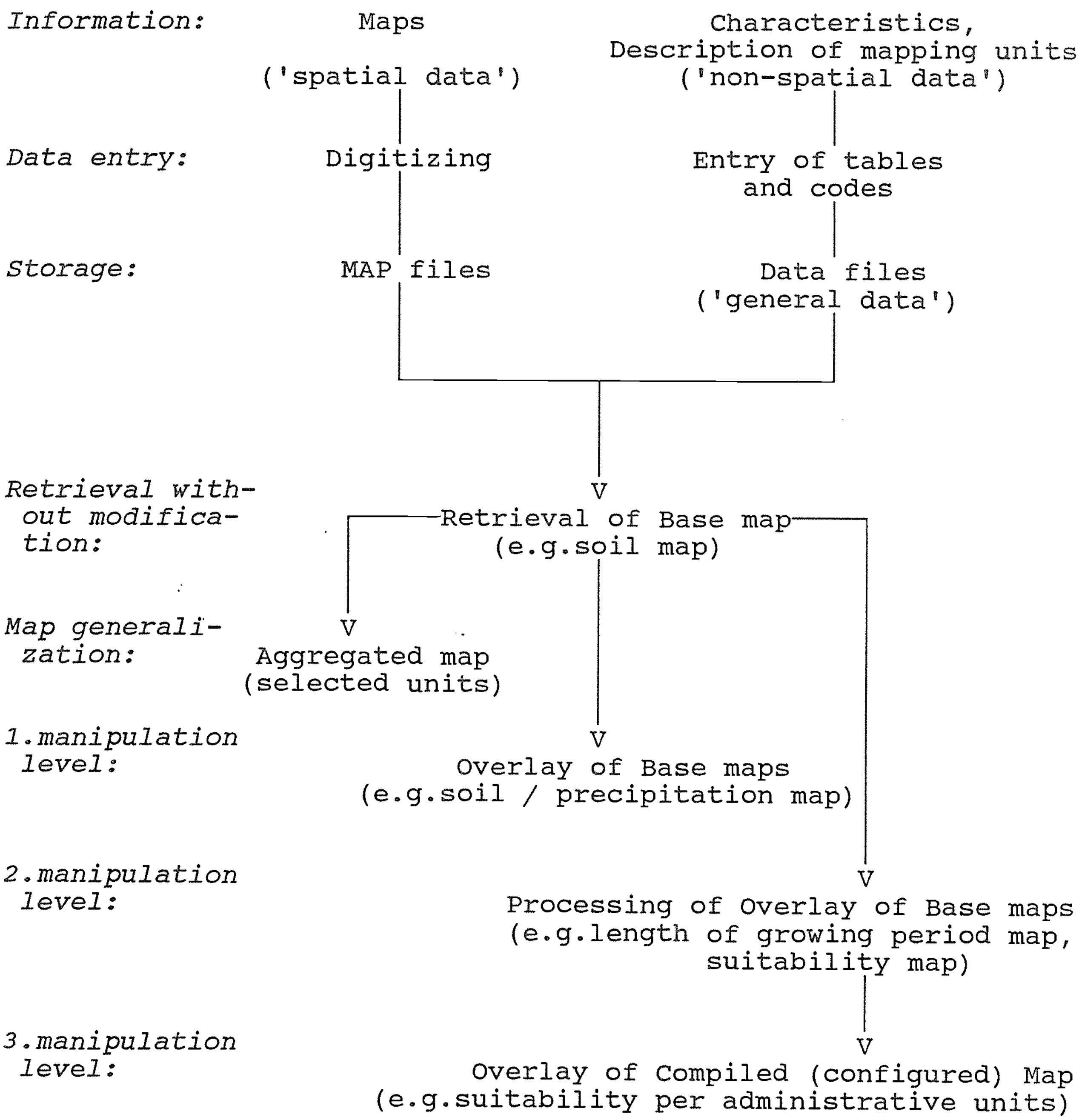
2.2.3 Map Overlay

2.2.3.1 Concept:

Because more and more detailed information concerning the environment is needed, and because our environment is very complex, it is impossible for any one individual to acquire sufficiently detailed knowledge and understanding of all aspects of the environment. Experts of various specializations therefore participate in the information or data handling which will result in the output, which may be presented maps, suitability assessments in form of maps or tables or plans for better and more appropriate use of the land.

Previously, land evaluation started with integrated, multidisciplinary surveys, where attempts were made to 'find "naturally occurring" environmental units being relatively homogeneous and which can be recognized, described and mapped in terms of the total interaction of the attributes' (Gestalt method; Burrough 1986).

But soon it was shown that the level of these surveys was too general and that it was impossible to retrieve specific information from them about particular attributes. This is particular the case when new objectives, e.g. for the development of a specific area, were defined and previous, multidisciplinary inventories had to give the information for newly defined purposes.


Information:
Maps
('spatial data')
Characteristics,
Description of mapping units
('non-spatial data')
Data entry:
Digitizing
Entry of tables
and codes
Storage:
MAP files
Data files
('general data')
Retrieval without modification:
Retrieval of Base map
(e.g.soil map)
Map generalization:
Aggregated map
(selected units)
1.manipulation level:
Overlay of Base maps
(e.g.soil / precipitation map)
2.manipulation level:
Processing of Overlay of Base maps
(e.g.length of growing period map,
suitability map)
3.manipulation level:
Overlay of Compiled (configured) Map
(e.g.suitability per administrative units)

With better understanding of the interactions of the various ecological parameters and with the need for better assessment and estimates of the potential as well as of the needs of the land, combined with the tendency to work for more applicable, practical results rather than small-scale inventories only, the high demand arose to **have relatively detailed, monodisciplinary resource surveys and to combine and integrate them in a later stage by overlaying.**

Thus, a ready market for the more conventional, monodisciplinary surveys remained, such as those of geology, landform, soil, vegetation, land use, economy. This is executed in the 'Land Use Planning and Regulatory Department' (LUPRD) where GILES was developed: Monodisciplinary surveys were carried out for physical and economic data collection in various areas of Ethiopia where agricultural productivity is to be improved and land degradation has to be stopped at semi-detailed scale (1:50,000) or small scale (1:250,000):

soils	inventoried	by	soil scientists,
topography	"	"	soil scientists and geographers,
climate	"	"	(agro)climatologists,
vegetation	"	"	ecologists,
land use	"	"	ecologists,agronomists, and (agro)economists,
economy	"	"	(agro)economists,
social attributes	"	"	(agro)economists.

All those data gathered in monodisciplinary approaches can be used for a wide range of purposes and will serve for a long time as excellent individual databases.

The very essential - "essential" for the combined effort of the land use planning - task of land evaluation is the combination of those relatively independently working and information gathering work outputs. By this, it is the integration, or re-aggregation, of all the factors, influencing the environment, to determine the potential (suitability) of land for a specific, appropriate kind of land use.

A good and useful information system must provide links among all those various fields and enable the experts to produce useful syntheses - although it is often difficult to find a common language for people with such different backgrounds.

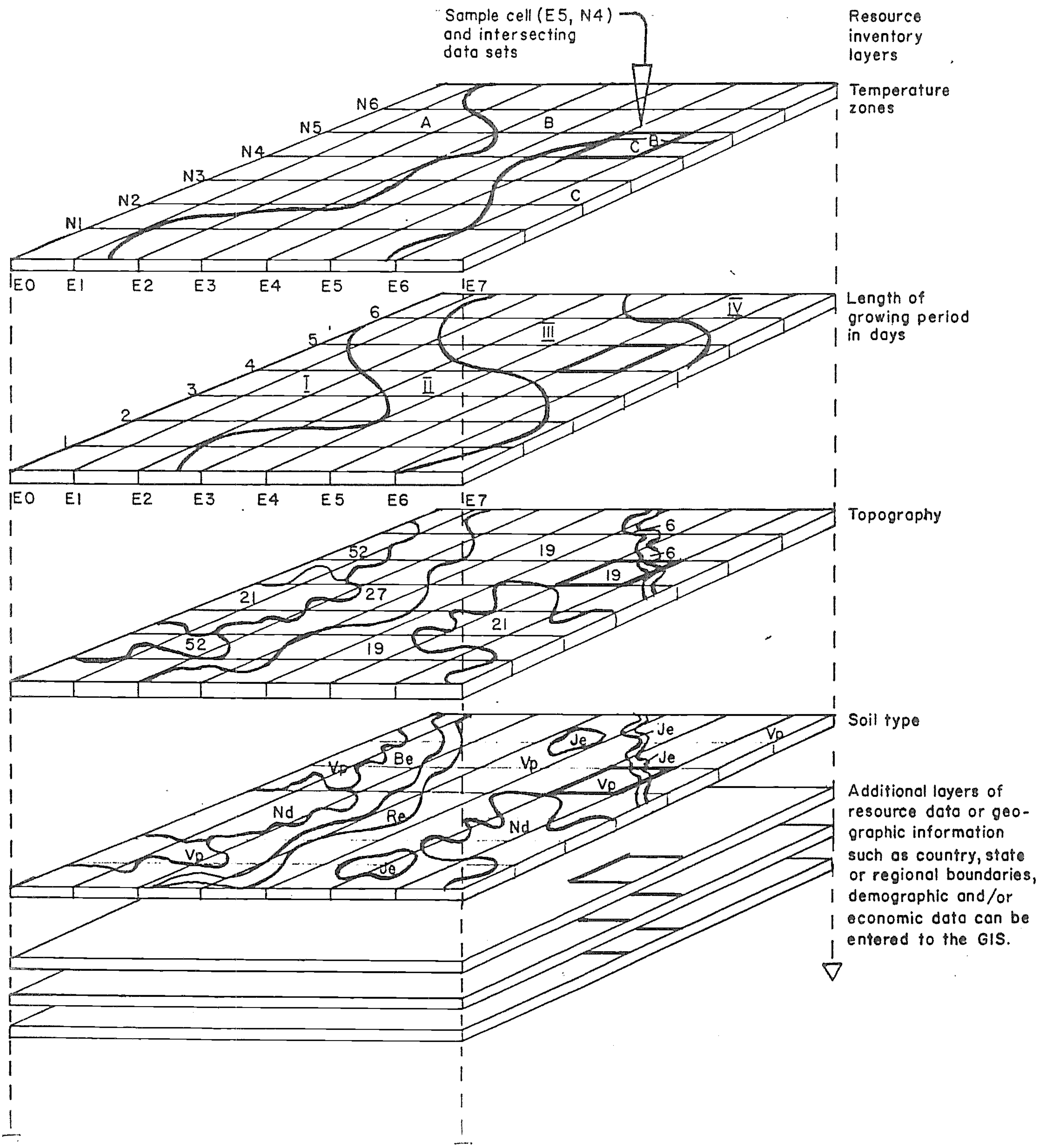
2.2.3.2 Technique:

A computer can store and process a large number of digital maps containing all possible information on soils, altitude, climate, agricultural productivity, topography, cultural attributes, water resources and so on.

Each map is converted into an integer data, two dimensional array. Different maps are handled as different files (arrays). Core of the system is the formation and recall of a set of a spatially registered data layers, which are the various thematic maps.

In its simplest form, the overlay concept is realized in raster data structures by stacking two-dimensional arrays. This results in a three-dimensional structure as shown above. This overlay concept is fundamental to most raster image processing.

Each thematic map (each layer) can be analyzed independently (without modification or generalization) or in combination with a number of other maps (layers). In the latter case direct reference is made to each overlay, not each cell.



2.2.4 Principles of Map Digitizing and Storing

2.2.4.1 Concept of Grid Cell:

To store and to overlay different location specific informations, they have to be in a form processable by computer. As computer can work only in a digital manner, any area specific processing, i.e. any kind of maps, have to be in matrix form. There are two fundamental ways of handling topological data: Raster form or vector form.

- The **raster** system is based on a rectangular array of cells, e.g. like a graph paper, splitting up each 'map' into a large number of tiny grid cells ('pixels'). The location (within the system) is given by coordinates of the horizontal x-axis and the vertical y-axis. Thus, each grid cell is referenced by a row and column number and it contains a number presenting the number of the mapping unit and serving as a 'pointer' to the database (DBMS).

  Through the x- and y-coordinates each location, i.e. each cell, can easily be - independently - addressed and all its geographical informations, e.g. soil type, altitude etc., can easily be recalled.

  Advantages of raster based systems are a computer congruent concept enabling direct access to data arrays for processing and to storage media and therefore high speed, easy overlay of maps (direct overlay of the pixels; see p.23), direct display and outprint facility, easy access to neighborhood and 'island' processing. They require a relatively simple data structure and are executable on cheap hardware. The primary output is a 'raster map' which requires, if output on a printer, additional cartographic work to finalize the map. Strong emphasis is given in these systems to area coverage and processing and easy spatial analysis rather than to topological line and point features.

- **Vector** based systems consist of mapping units with their boundaries defined by a set of points and lines ('vectors') between these points. Their primary output are 'polygon maps' with elegant and accurate graphics.

  Although they might provide better quality output, require sometime less storage capacity of the computer and give better support to line features, they do not show the above described advantages of raster systems. Overlays of several polygon maps, in particular for modeling, are difficult.

The most obvious and effective matrix system is a space grid cell system following a coordinate system. Many digitized computer systems use therefore this system. Thus, preference is given in **GILES to raster system** rather than vector system.

Although GILES handles and manipulates maps internally in a raster system, raster/vector conversion and vice versa are installed for digitizing (map entry through digitizing tablet) and for plotting.

The application of a raster implies the careful decision of the size of the raster. The pixel size determines the resolution at which the resource information is represented. It is of fundamental importance for:

a) Accuracy (quality of results)
b) Outlook of the output maps
c) Time required for data entry and processing
d) Storage required

Any kind of selected grid cell size will be a compromise between acceptable detail and a manageable time effort for data entry and processing.

With those considerations and for the ease of map entry, it is highly recommended to use a **5x5 mm grid cell raster as standard for map entry into GILES**. This pixel size still allows manual handling. With this, it is even possible to raster thematic maps manually and then input into the computer through the numeric keypad (recommended only in exceptional cases). It corresponds to the area of 0.25 cm^2 which is seen as the smallest area capable of being represented and described by observations (Bridges 1982; Vink 1963).

The mapping unit with the largest area within a grid is assumed to be representative for the grid. According to Ankum (1986) the loss of information of one particular grid cell is 15-40 %. This potential loss of information which is a disadvantage of grid cell systems, can efficiently be avoided by reducing the area a pixel represents, through:

- Reduction of the grid cell size at map entry; indeed, this is limited because data entry with smaller units than 5x5 mm is very tedious for the operator and can not easily be checked and corrected; or:
- **Enlargement of the scale for map entry**, in which case the only disadvantage is the intermediate process of (photographical) enlargement of the map. With the use of FX printers, a factor of 2.36 was found to be very useful. See Section 3.3.15 (1) (p.122) for selection of map scale for entry.

The average loss of information on a scale of 1:50,000 when a 5x5 mm input grid pattern is used (250 x 250 m) is calculated to be 0.94 - 2.50 ha, on a scale of 1:250,000 with the same 5x5 mm input grid pattern by using the above mentioned 'scale enlargement technique' 4-11 ha.

In the present land resource inventory, land evaluation and land use planning project (LUPRD) some 300,000 ha were covered at a scale of 1:50,000 annually, or some 2,000,000 ha at a scale of 1:250,000. Thus, a pixel size of 5x5 mm implies an allover amount of 50,000-70,000 pixel per map of the area surveyed in one year, which can be entered in between 2 days and 3 weeks (see Section 2.5.1; p.36). One thematic map of one study area takes some 100-200 kB storage on disk. For many project sites, soil, altitude, and land use/land cover maps of one study area can be stored on one disk (360 k drives of IBM-PC).

2.2.4.2 <u>Technique</u>:

For easy handling each map sheet is divided into four vertical strips called 'runs'. Each run is covered by 28 columns (5 mm wide) and 111 rows (5 mm high). Thus, a map sheet is covered by a raster with 112 x 111 cells (see Section 3.2.2; p. 97). Each run is stored in a separate data file (binary, random access, no use is made of map compensation techniques, run length coding or quadtrees, as computer storage is a minor constraint and in order to improve execution speed of detailed maps).

2.2.5 Future System Enhancements

It is shown that the integration of computer technology and spatial data for land evaluation purposes can provide a user with a powerful tool for environmental analysis that greatly extends the capabilities of conventional maps.

With hardware prices still declining in terms of processing power and storage capacity available and demand increasing, there seems certain to be a trend towards small, decentralized systems (Burrough 1986) to make a system like GILES accessible for any institution concerned with natural resource inventories and land use planning.

Although it would be a mistake to let our focus to become too narrow. Data base technology is rather new and not fully developed. Practically and conceptually, there are still a lot of problems. But perspectives for the future can be very optimistic.
In general, positional and graphic output forms will be very much improved, ease of retrieval and especially of entry will be improved in higher performances both in hard and in software.

In particular, following additional options are not implemented in GILES, but envisaged, partly developed and will be available in the next GILES version:

- Wider/continuous scale range for printouts on matrix printer
- Menu-driven modification of land evaluation
- Support of slope maps and aspect maps (at large scale)
- Advanced plot facilities with topographic features
  (fully operational automated cartography)
- Flexibility of scale for map entry
  (overlay/comparison of maps entered at different scales)

2.3 LAND EVALUATION ASPECTS OF GILES

Among the reasons why previous GIS systems were not effectively used is that the complex nature of many natural phenomena is poorly captured by conventional GIS methods (Hogg/Stuart 1987). It was a major objective of GILES to overcome this problem by defining quantitative or semiquantitative interrelations, as set by the land evaluation methodology.

The principle objective of land evaluation is to select the optimum land use, taking into account both physical and socio-economic considerations and the conservation of environmental resources for future use (FAO 1983).

Main emphasis to land use recommendations under the conservation point of view and to soil conservation recommendation is given in Section 2.3.2 (p.32). The more detailed agricultural potential assessment will be carried out crop-specifically and gives yield estimates, as described in Section 2.3.1 (p.29). Social and economic parameters are considered to show the balance between potential and need of the land in Section 2.3.3 (p.32).

Thus, land evaluation is installed in GILES to:

a) assess the land suitability for crops and crop mixtures at defined levels of inputs and management
b) derive recommended land use based on assessment of erosion hazard and wetness limitations
c) assess the ability of the land resources of the area to support current and future levels of population

2.3.1 Land Suitability Assessment

The 'agricultural potential' is defined in terms of five different 'crop suitability' classes with approximately expected yields as a percentage of the maximum obtainable yield (see Table A7.24; p.238):

a) Highly suitable ('S1'):
Potential production is high and sustainable from year to year.
Average yields: 80-100 %of the 'maximum obtainable yield'.

b) Moderately suitable ('S2'):
Potential production may be moderate or high, but is variable from year to year.
Average yields: 60-80 % of the 'maximum obtainable yield'.

c) Marginally suitable ('S3'):

Potential production is variable from year to year with considerable risks or difficulties in maintaining continuity of output. In some years there may be failure to establish the intended crop.

Average yields: 40-60 % of the 'maximum obtainable yield'.

d) Very marginally suitable ('S4'):

In many years there will be failure to establish the intended crop.

Average yields: 40-60 % of the 'maximum obtainable yield'.

e) Not suitable ('N'):

Environmental conditions do not allow a continuous growth of the crop.

Average yields: Nil or less than 20 % of the 'maximum obtainable yield'.

The essential procedure of land evaluation is one of matching the resources of land with the requirements of specific types of land use. 'Land' is taken to include all relevant features of the land use environment, including climate and vegetative cover in addition to surface and soil features.

Emphasis is given to land suitability assessments for single crops. At the present, 42 crops occurring in the highlands of Ethiopia (see Section 4.2.19; p.180) are defined with their ecological requirements and allow a crop specific assessment. Similar evaluations are possible for forestry.

Single crop evaluations can be combined to assess the viability of existing and proposed farming systems. Bearing in mind the influence of the level of inputs and management on crop suitability, four levels of inputs were defined as follows:

a) a low level of inputs, corresponding to local unimproved crop varieties, no fertilizers or pesticides, no soil conservation measures
b) an intermediate input level of inputs, corresponding to limited use of improved seeds, fertilizers and pesticides and some minor soil conservation measures.
c) a high level of inputs, in which improved seeds are used and at which fertilizer and pesticides are used near optimum levels. Land preparation is mechanized and physical conservation is carried out.
d) a high level of inputs, with mechanization, in which all farming operations, including harvesting, are fully mechanized.

Various minor and major land improvements can be incorporated to show the potential of the land under improved conditions. A few examples of this modeling are shown in Section 3.2.1 (p.47).

The ecological environment (soils, climate, present land utilization types, agronomic practices) is inventoried by field surveys and described in form of 'land characteristics' (e.g. slope, drainage, altitude, precipitation, frost hazard). These land characteristics strongly interact in their influence on crop growth and are combined in the definition of 'land qualities' (e.g. oxygen availability, growing period). Land qualities are then compared ('matched') with the specific 'crop requirements' of the particular crop. Details of land quality/ crop requirement models are given in volume 2 of this Manual (FAO 1987 c).

Land qualities are grouped and crop suitabilities are retrieved at three intermediate stages of the evaluation to show:

- The **climatic suitability**, based on the land qualities *temperature, moisture availability* and *frost hazard*
- The **soil suitability**, based on the land qualities *oxygen availability, nutrient availability, nutrient retention, rooting conditions, flood hazard, sodicity* and *salinity*
- The final **land suitability** class is based on the combination of climatic and soil suitability, with additional consideration of the land qualities *workabilities* and *erosion hazard.* The above intermediate crop suitabilities are useful in identifying the source of constraints.

Detailed assessments are very useful for the suitability assessment of new crops and after implementation of higher input farming systems or of certain land improvement(s). GILES enables the mapping of the areas with the various suitability assessments.

Computerization of land evaluation is as more important, as greater the scale, because a greater scale involves a higher level of detail and therefore more calculation (matchings) which are time consuming as well as very attractive for errors. The map overlay functions go far beyond pure Boolean algorithms.

Any land evaluation approach has to be continuously tested and corrected. Field checks are required for both methodology as well as for crop requirements checking. Modifications of land evaluation models can be easily inserted into GILES.

The entire methodology of land suitability assessment is explained in general in FAO 1986, 1983, in detail in volume 1 of this Manual (FAO 1987 b), summarized in App.7 (p.211).

2.3.2 Recommendations for Conservation Based Land Use and Conservation Measures

a) **Sheet erosion intensity** ('erosion hazard'), expressed in t/ha/yr, can be calculated using an erosion estimate model, adapted from the Universal Soil Loss Equation (USLE) by Wischmeier/Smith (1978), modified to the conditions in the Ethiopian highlands by Hurni (1985). This assessment is based on environmental conditions, such as rainfall, soil type, slope gradient, slope length, as they occur in the area. Detailed explanation is given in App.7.1 (p.211). The loss is grouped quantitatively in four classes of < 10 / 10-30 / 30-75 / > 75 t soil loss/ha/yr.

b) **Recommendations for appropriate land use** can be made for land use strategies and associated physical conservation works to minimize further degradation of the land resources. They are based on the assessment of sheet erosion hazard, gullying status and several soil characteristics. Land use intensity, annual/perennial cropping, livestock production, production/conservation forestry are recommended based on the conservation point of view (see App.7.2; p.215).

Through GILES, it is possible to assess these estimates and recommendations, to map the individual units and to calculate their sizes per administrative unit.

2.3.3 Population Support Capacity

Population support capacity is determined by matching the potential productivity of land resources with the food requirements of the population (and the forage requirements of livestock in areas with a high livestock population) which form an essential component of the farming systems. The results of this assessment indicate areas (e.g. administrative units) which are particularly critical with respect to supporting their population, and also areas with potential for surplus production.

Although GILES does not actually execute the matching between the potential and the food requirement, it can supply all data for the population support capacity models, in particular the quantitative assessment of the agricultural potential e.g. in suitability terms or in tons grain per planning zone or per PA. Further explanations of the population support capacity model can be found in Appendices in FAO 1988c, 1988d, 1989a.

Interfacing of the agricultural potential and existing farming systems is supported by GILES through assessment of the suitabilities per agroecological zone and matching them with the results of the socio-economic farming system survey, as it is done in the present FAO project in LUPRD.

2.4 DATA STRUCTURE REQUIREMENTS

A computer system - essentially an unintelligent, industrious slave - forces people, when implementing tasks within it, to plan very carefully and to clarify all principles and operations. This has resulted in the need for a precise structure and definition of data.

Data collection is the fundamental data operation, as its reliability governs the utility of all the subsequent operations. The values should be sufficiently representative of the element or parameter in space. The observation network density governs the representation in space. The aspect of computerized processing should already be incorporated **when monitoring and surveying** is done at field work. Aspects of feasibility and reliability of data under the aspect of data processing have to be considered.

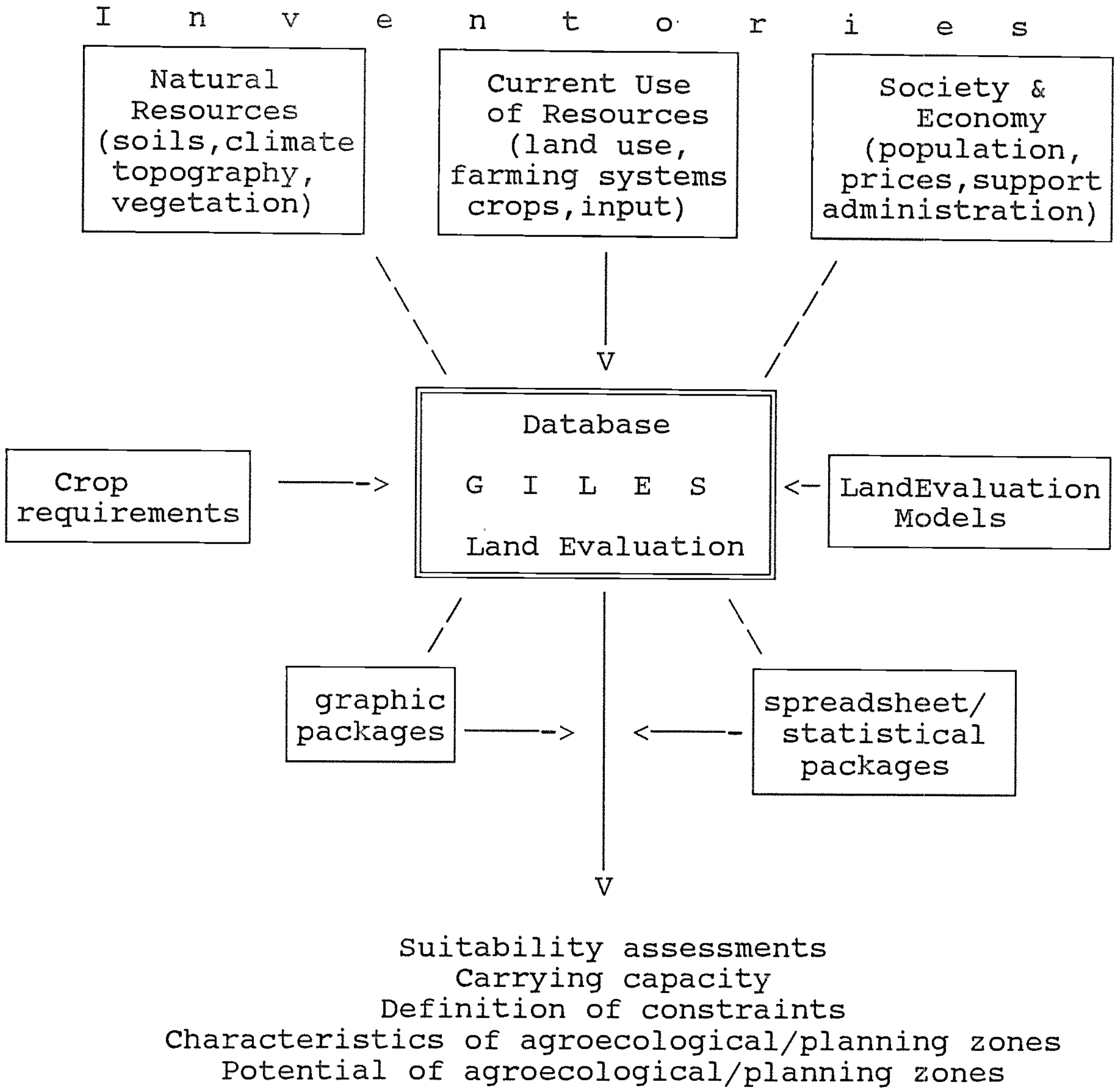
Soil surveyors should be aware about the level of detail, e.g. processed spatial detail (28 ha at 1:250,000 inventory resolution with scale enlargement technique). A grid storage system requires some means of 'interpolating' randomly located survey data to a fixed grid (Giltrap 1983); eventually the sampling design has to be redefined. Under the digital point of view a grid sampling (stratified grid or stratified random) has many advantages at medium or large scale surveying.

The preparation of the data comprises the operations necessary to convert data from the format in which it is received to a format suitable for input to the computer. This includes the need to **reorganize the data before entry**: standardization of measurement units, grouping of all available and necessary data into classes (described and listed in Section 4.2, p.153), additional levels of coding for storage purposes, and the estimation of derived parameters, e.g. estimation of temperature and Penman evaporation from climatological data.

For agricultural planning purposes, **three groups of data** are required for a system to give the entire information set to allow decision making:

a) data on natural resources and agricultural potential:
 soils, climate, water, topography, vegetation etc.
b) data on the use of the resources by the population:
 present agricultural activities, crops, input,
 farming systems etc.
c) data on the social and economic environments in which this
 use of resources take place:
 population, population growth, prices, supply, demand,
 social infrastructure etc.

Aspect (a) is the main part of the GIS and land evaluation facilities of GILES, (b) and (b) can be entered and retrieved on a spatial basis and overlaid with other data sets. A detailed list of data essential for land evaluation is given in Volume 1 of this Manual (FAO 1987 b), a summary of the considered physical land characteristics in Section 4.2.16 (p.176).



These data are inventoried by remote sensing, field surveys, farm and crop surveys, secondary data sources (statistics) etc. Particularly 'dynamic' data, such as population, management level, infrastructure data, need special attention. Very often they can change considerably within shortest time. GILES is the tool to update the data set and perform updated calculations and assessments.

At each step of resource data processing and mapping **errors** will occur: Delineation of units depends on judgment of surveyor, transition zones of concrete phenomena have to be expressed by chloropleth maps, maps are rasterized, raster output maps have to be delineated etc. Most of these errors can be minimized by careful checking, but complete avoidance is impossible. Computers cannot intelligently ignore non-logical errors.

At each stage there should be necessary and proper data verification and checking procedures to ensure that the resultant database is as free as possible from error. Only if the collected, entered, stored and processed data are sufficiently reliable and 'error-free', GILES can give the requested information and thus justify the system.

Another, more severe problem of data validity arises when interpreting and modeling. Because this implicitly assumes that all information encoded is absolutely correct and contains no error components: One of the weakest points of modeling.

The whole land evaluation approach and all applied models have to be **continuously tested** and corrected. This requires field check for both resource data as well as for methodology, crop requirements, current and potential farming systems.

For further description of handling data in GILES, see Chapter 4 (p.150).

2.5 DATA INPUT AND OUTPUT

2.5.1 Input

Two aspects of the data need to be considered separately for GILES: These are first the geographical data ('maps') necessary to define the locations, and second, the associated attributes ('parameters', DBMS) that record what the cartographic features represent.

2.5.1.1 Map entry:

Maps do not usually lend themselves to direct placement on an automated device for entry into digital form. Most of them are cluttered or loaded with colors, polygon-fill and labels. Automatic scanning is therefore impossible (Fleet 1986).

Some options which are used to digitize maps are stereo digitizers with zoom-transfer scopes, optical scanners that replace the digitizer in some applications, and remotely sensed data from airplanes to satellites that can be converted to maps (Consoletti 1986). But none of them are applicable and can be recommended for use on PCs within the cost range and technology input presented here.

GILES gives the offer to enter maps through an interactive way of digitizing from existing maps, aerial photographs or satellite images via digitizing tablet.

No experience or knowledge is required for map digitizing. (In some other GIS the operator is required to build the topological links into the database while digitizing the line pattern or to stop at each node or intersection). The whole procedure is menu-driven; entered units are displayed with their shape and area size on on-line display: WYSIWYG.

The basic principle is to surround the mapping unit by following its boundary with the stylus till the starting point is reached. Depending on the size of the tablet, the starting point will be read automatically (on tablets larger than one map run) or has to be entered with its x and y coordinates by the operator (on smaller tablets). No device buttons have to be pressed, no limitation of speed. This simplicity of operation as well as feedback is provided in order to minimize errors, because these errors are usually tedious and expensive to correct.

Immediate check is made for 'dead ends' of line entry (area not closed), 'double assignments' (assignment of the area to a different unit before), correct vector/raster conversion, correct labeling of the unit, digitizing within the active area of the tablet and proper function of interface and tablet. Filling of the polygon is made automatically. Following the 'predominance method' cells at the edge of the units covered by two or more units, are assigned to the unit predominating within the cell.

The procedure of map entry is explained in Section 3.3.18 (3) (p.125). For explanation of error messages see App.3 (p.192).

The only preparation before map digitizing concerns the - eventual - enlargement of the map (see Section 3.3.15 (1), p.122), cutting into various sheets and defining the map index (see Section 3.3.15 (2) and 3.3.17; p.125).

Several digitizing utilities can be used, such as automatic replacement of units, individual or selective replacement, boundary checking of the total area, 'cutting', filling of blank areas, check for completeness (listing of blank, unassigned areas) or shifting parts of the map into the four main directions.

Previous experiences in the LUPRD showed that entering a map of 1-3 m^2 takes between 2 days and 3 weeks, depending mainly on the level of detail, i.e. size of the individual mapping units (see Section 1.5; p.9). Average speed of entering is 30-50 linemeters per hour.

Maps of different input scales can not be compared and overlaid yet (see Section 2.2.5; p.28).

In exceptional cases, for very small areas or for correction work maps can be entered by overlaying a transparent raster and following the boundary with the numeric keypad (up, right, down, left).

The presented way of digitizing is faster, cheaper and easier than of most other GIS systems because it does not require attention of details of topology, attribute-assignment or operation of hardware and hardly any of software. Therefore, the time effort is almost equal to 'redrafting maps' (which is seen as a faster way of map entry into complicated GIS system than the conventional way of digitizing (Fleet 1986)).

The best way to check that the spatial data have been correctly digitized is to get the computer to plot them, preferably on transparent or thin paper, at the same scale as the original. The two maps can then be placed over each other on a light table and compared visually, working systematically from left to right and up and down across the map. Missing data, locational errors, and other errors should be clearly marked on the printout and corrected in GILES either grid cell by grid cell (for minor corrections) or by overwriting the existing, old values (with 'ALLN' option; see Section 3.3.18; p.126).

2.5.1.2 Non-spatial data:

Non-spatial data ('parameters','attributes') are stored in DBMS, which forms part of GILES. All data can easily be input following the option 'Database' at the Main Menu.

Most of the data can be entered directly into GILES as well imported from spreadsheet files (through DIF format), e.g. from Lotus 1-2-3 (see Section 3.3.22; p.133). This gives the possibility to manipulate the data through spreadsheet or database software packages and to integrate and use them in GILES. In particular, this is applied for precipitation data (eventually from other sources, such as the National Meteorological Survey Agency) or for comprehensive soil mapping unit composition tables.

Non-spatial data are checked during entry and program execution for syntactical errors, but that does not imply that careful checking of data does not need to be made after entry.

2.5.2 Output

All operations for retrieval of any kind of information ('output') are carried out in an interactive environment through a continuous, self-explanatory dialogue between the user and the computer ('menu-driven').

Maps can be displayed on screen in scrolling or high-resolution image mode, printed directly through GILES or through screen dump utilities on printer or plotter or stored on disks in various formats for further processing.

Experiences in LUPRD showed that font printing on matrix printer is the most preferred output mode for large size maps. But it should be noted that it requires - like all rastermaps of GIS systems - a considerable amount of 'afterwork' to finalize the maps: sticking the individual print sheets together, to delineate and to label the units.

On small size maps (e.g. text maps) it is recommended to print the resolution map display of the screen through screen dump utility.

Numeric data can be displayed on screen, printed or transferred to spreadsheet or graphic packages for presentation as tables, graphs or charts or for statistical calculations.

The various output forms are discussed in Section 3.2.3 and in all 'Output' Paras. of Sections 3.2.1 (p.47).

2.6 REQUIREMENTS

Requirements of GIS systems were very high in the past. Only the development, mass production and inexpensive sale of microcomputers (PC) and the introduction of user-friendly software did lead to a break-through in GIS applications. Moreover, in the past GIS systems required professional software engineers to run them and were extremely hardware dependent and hence could not readily be transferred from one system (computer) to another.

GILES' data can be easily transferred from one system to another (by disks, communication cable, or modem; 6 seconds per map sheet at 9000 bps rate). The user-acceptance of the system can be compared with the one of commercial spreadsheet software, thus, no software engineers are required anymore.

2.6.1 Hardware

The package will run on any DOS operating system based microcomputer (PC) **with a harddisk**. But recommendation is given to 'IBM-compatible' computers with high speed (if possible, 20 MHz or faster), fast hard disk access (if possible, 20 ms or faster) and extended memory (some 2 MB).

The system was developed on IBM-PC/AT equipped with CGA and EGA facilities, Epson FX printers and HP and Roland plotters as output devices and Summasketch and Houston Instrument tablets as input device. The program is written in Quickbasic Compiler language.

The detailed hardware requirements are listed in App.4 (p.200) with one version for the minimum (1500 US$) and one for the optimum configuration (4000 US$; prices of July 1989).

Technical support for Personal Computer in Ethiopia like in many other developing countries is still rather poor and less satisfactory. But - a great advantage of the present system - the components of the required hardware are rather inexpensive and easy to exchange. E.g. malfunctioning of a board simply means to replace it.

2.6.2 Training

Personnel has to be trained to apply the system and to make use of all potential products. They have to be able to retrieve all requested information, to enter the data and to contact, to offer and advise the clients about the facilities of GILES.

Education of personnel is divided into two different level:

a) Level **'users, experts, technicians'** should know how to retrieve data (maps, statistics, tables) and to continue with and to interpret these data for the individual purposes. Additionally, technicians and cartographers should be able to enter data.

Training can be autodidactic or in form of training courses or workshops of a few days. Knowledge of operating system, programming or electronics is not required.

This chapter ('GILES') and Chapter 3 ('Users Manual') is in particular addressed to these users.

b) Level **'system analysts'**: One or two staff members should be completely familiar with the entire system to set up or modify GILES on request, to make and organize back up copies and to give advise to users.

Hardware maintenance (cleaning, checking hardware functions, replace spare parts) should be done by the 'system analyst' (see App.4; p.200).

This experience can be gathered by working with GILES for a few weeks or by an intensive training course. Knowledge about DOS and computer hardware is advisable.

Chapter 4 ('Data structure') and Appendices are addressed to the 'systems analysts' explaining the details of GILES, including the option (not a necessity) to change the programs (source code and current compiler must be available).

2.6.3 Costs

Four separate elements of costs have to be considered. They will be discussed here and compared with large, purely commercially oriented GIS systems:

a) **Purchase**: As GILES is designed to run on small PCs and the computing power of these smaller machines increases rapidly, some 1500 US$ (minimum configuration) - 4000 US$ (optimum; prices of July 1989) are sufficient for one hardware system being able to run GILES (see App.4; p.200).

Commercial GIS software in midrange systems require hardware of 25,000 to 150,000 $, large systems for major GIS applications up to half a million dollar (Devine/Field 1986).

b) **Personnel**: Training new personnel to use the system is very essential !

Even though GIS are 'complicated by their nature', attempt was made to make GILES as user friendly as possible with explanations in the menus, on-line Help menus, use of standard commands of commercial software and with this manual (see Help facilities in Section 3.1.2; p.45).

It will take a person having some experience with spreadsheet processing between a few hours and a day to produce the first output, one or two weeks to run most of the facilities of GILES.

'The more you spend on the system, the more your training costs rise.' For expensive systems, access to a computer programmer and often to a maintenance technician is essential (Devine/Field 1986).

c) **Digitizing**: The main disadvantage of GILES experienced in the LUPRD, as well as of all GIS systems is the time delay and/or costs caused by the entry of maps into the system.

Data entry of one thematic map of, to say, 1-2 m^2 with a medium level of detail (i.e. mapping units with an average size of some 5 cm^2) takes some 2-4 days. But with a higher level of detail (with units of 1 cm^2 or even less, e.g.many soil maps) it might take 1-4 weeks to enter such a map.

This is a common experience of GIS systems: 'Digitizing dwarfs every other cost of GIS'. There can be only argued that this procedure has to be done only once for every map, the entered map can be retrieved as many times and in as many versions as requested.

d) **Maintenance and support**: Maintenance for PC is rather uncomplicated. Care has to be taken mainly for cleaning the system, particular in dusty environments (see App.4.4 for hardware maintenance; p.202).

In case of a break down, the malfunctioning components (e.g. boards) have to be identified and replaced. This is not expensive, but might bring some delay, if spare parts are not available in the country.

Large GIS systems require a software maintenance fee. 'Costs of software - and hardware - maintenance rise with the purchase price of the system' which is in the order of 1 % of the purchase price per month (for hardware) or more (for software).

3 USER'S MANUAL

This chapter is addressed to the '**user**' who wants to derive (or enter) any kind of maps or data handled by GILES. No computer or GIS experience is required.

Section 3.2.1 (p.47) presents the **main options** of GILES. It is worthwhile to have at least a look in the main features and to see what GILES can execute.

Sections 3.2.2 - 3.2.5 (p.97) explain how to define a number of settings for the retrieval of maps or calculations, which are **specification of the area or of the output, setup of the hardware and transfer to other packages.**

Section 3.3 (p.105) illustrates how to perform the most import tasks in an easy step-by-step **(menu-by-menu) description**.

. More detailed information is given in Chapter 4 and the Appendices for the 'system analyst' who wants to set up or modify GILES. Information is given concerning the structure and syntax of data files and programs.

The land evaluation approach is explained in App.7 (p.211).

3.1 INTRODUCTION

3.1.1 Setup of Menus

When you start GILES, your screen appears as shown below:

```
                    'Status Bar'
                         ||
                         ||
                         V

                 M A I N        M E N U

==> BaseMap (complete/aggregating/selective/parametric)\
    Overlay of base maps                                 > Maps
    Overlay/reprint of Previously Configured Map(s)     /
    Area Sizes                                          \
    site specific Information                           / Tables
    Climatic Suitability                                \
    Soil Suitability                                     > Suitab.
    Land Suitability                                    /
    Erosion hazard                                      \
    Conservation Based Land Use Recommendations         /  Erosion
    Length of Growing Period

    Database (DBMS)                                     \
    Entry of Base Map                                   / Data entry
    Systematic Change of Base Map                       \
    Chaining of Various Procedures                      / Utility
    File Operation                                      \
    Shell to DOS                                         > DOS
    out (exit to system)

F1=Help F2=PreviousMenu F10=MainMenu Up Down(or1.letter)ENTER=Select
                         ^
                         ||
                         ||

                   'Command Bar'
```

Every GILES menu shows several options in different lines with the *'Command Bar'* at the bottom and the *'Status Bar'* at the top.

The indication arrow and the highlighting of the option can be moved **up** and **down** with the numeric keypad on the right handside of the keyboard. To select an option, move the cursor to the requested option, or press the first letter of the option, and press <**Enter**>.

Additional features of the menus are:

a) the call of a Help screen with context specific explanations: pressing **F1**
b) the repetition of the previous menu: pressing **F2**
c) the new start at the Main Menu: pressing **F10**

A sequence of menus will be displayed to define all parameters for the requested task.

No query language is installed, all menus are request-specific: The user should not worry about query language syntax or about internal processing details, e.g. raster/vector conversions or 'calculation of the length of the border of a quadtree' (as it was seen in another GIS).

When all parameters for the requested map are defined, the map will be displayed and, if requested, printed, plotted or stored in the computer.

3.1.2 Help Facilities

GILES has three kinds of help to offer. Two of them are on-line, one is given with the reference to this manual.

3.1.2.1 Help for menu commands:

It consists of a brief description of the menu's current choices and of the selections made so far. You don't have to press any keys or make any menu choices to get this description; it appears in form of:

- the **command bar** at the bottom of the screen which shows all currently active choices: commands which can be executed (e.g. move cursor up and down)
- the **status bar** at the top of the screen which shows abbreviations of the options selected until now: status of the selection procedure
- additional information is given in the menus to non-selfexplicatory options

3.1.2.2 Context-sensitive Help:

Context-sensitive help answers the questions about the various options in GILES' menus. To use context-sensitive help, press **F1** function key and see a synopsis of the present menu. Exit the Help description ('Help Menu') by pressing the Space bar. There are 102 different Help Menus installed.

At the Main Menu, the help answers are option specific. Thus, place the cursor on the option you want to know about, then press F1 function key to see the explanation help of the requested option.

3.1.2.3 Manual:

The present Manual gives further details about the options offered in each menu.

3.2 FACILITIES

The abundant facilities of GILES will be explained in this paragraph.

3.2.1 Main Options

The Main Menu offers the access to the retrieval or the processing of:

- Geographical information system facilities,
  such as map retrieval, overlay, combinations;
  in line 1 - 5 (Section 3.2.1.1-3.2.1.5; p. 48-64)

- Land evaluation facilities
  such as erosion hazard and land suitability assessment;
  in line 6 - 11 (Section 3.2.1.6-3.2.1.11; p.65-79)

- Data entry,
  such as map entry and data base management
  in line 12 and 13 (Section 3.2.1.12/3.2.1.13; p.80-92)

- Utilities,
  such as map correction, file copy etc.;
  in line 14 - 16 (Section 3.2.1.14-3.2.1.17; p.93-96)

Each option is explained at the following pages with its functions, requirements, output forms and references for further explanations.

Next page:

Table 3.1

Main Options

3.2.1.1 'Base map (complete/aggregating/selective/parametric)':

Functions:

This main module of GIS facilities is for retrieval (display, print, plot or computer storage) of 'base maps' with their entire area, one sheet, one run or one window in following versions:

- "complete map": Retrieval of all units in the form they were entered,
  Example: Altitude units (see p.50); all PAs

- "aggregating map":Retrieval of ('new') units which are aggregations of previous ('old') units; form of map generalization,
  Example: Altitude units 1000-1600 m aggregated into one unit, 1700-2400 m into one. > 2400 m into one (see p.51); all mapping units with vertic properties grouped together into a 'Vertisol' unit

- "selective map": Retrieval of selected units only,
  Example: one planning zone (see p.52); only wetland units

- "parametric map": Retrieval of units in their content through translation table(s),
  Example: slope map, drainage map out of soil map, population density map out of administrative map.

  Parametric maps can be:

  "parametric-complete"
  Example: Complete drainage map(see p.53); complete slope map

  "parametric-aggregating"
  Example: Slope map with only three slope classes)

  "parametric-selective"
  Example: Slope map indicating areas with >25% only

For explanation and listing of 'basemaps' see p.124; for further explanations of terms, see Glossary (p.267).

Requirements:

Map (MAP files)
Mapping unit codes (MUC file)
Study area names (STAREA file)
For 'parametric maps': Translation table(s)
(e.g. soil mapping unit composition and soil type characterization (MCP and TCH files), or administrative unit composition (ACH file)

Output:

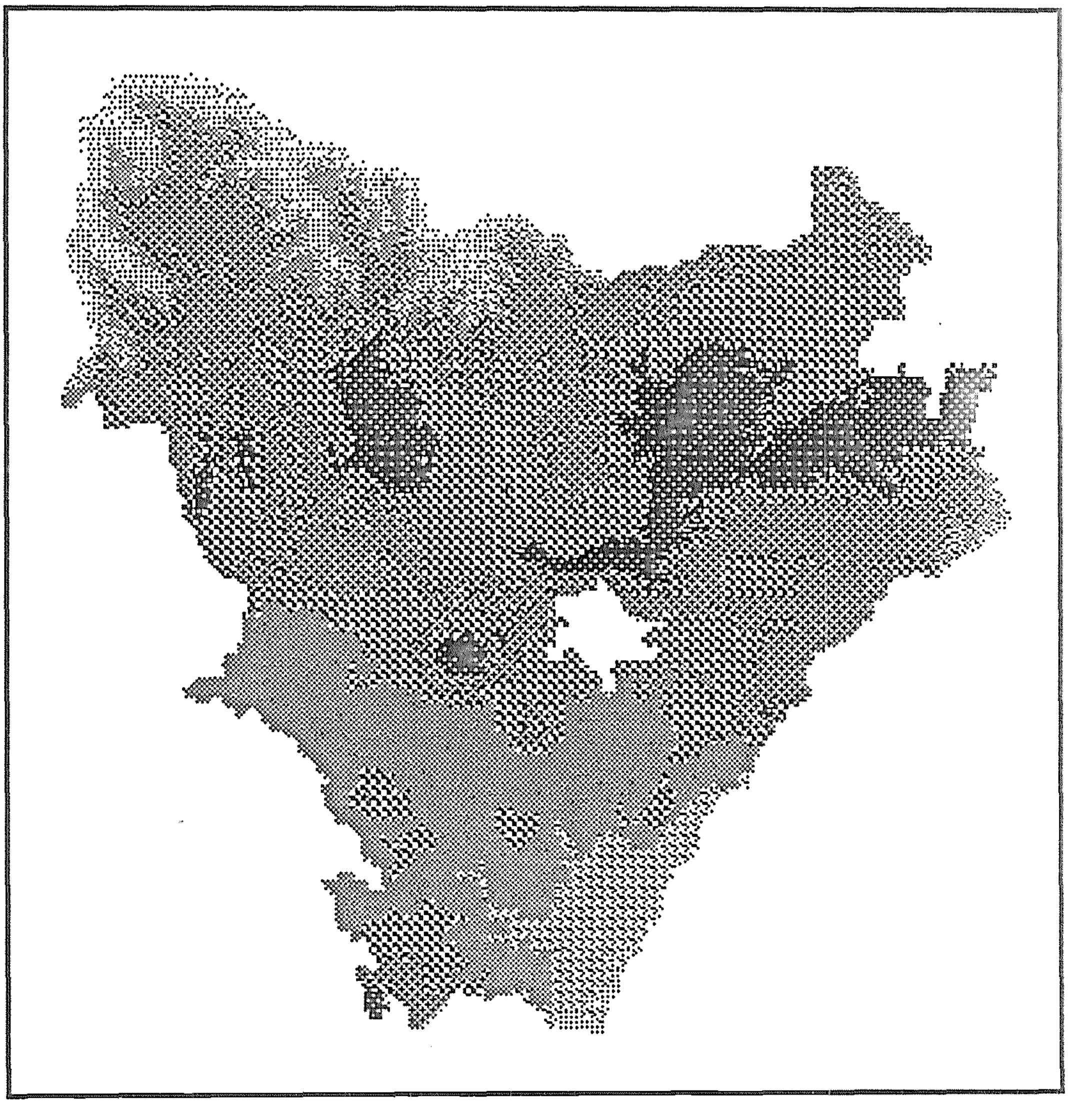
Maps scrolling on screen, as high resolution image on EGA/VGA screen, printed on matrix printer or plotter, or stored on disk as GILES file
('C:\INTERM\DGpCMPmn.MAP' with 'DGpCMP.NAM')
or as ASCII file (DG0CMPmn.PRN'); or printed through screen dump utility
Area size tables on screen or printer

References:

Selection procedure: Section 3.3.3 and 3.3.4 (p.108/109)
Program structure: App.8.12 (p.245)

Map 3.1

Complete Base Map (Example)

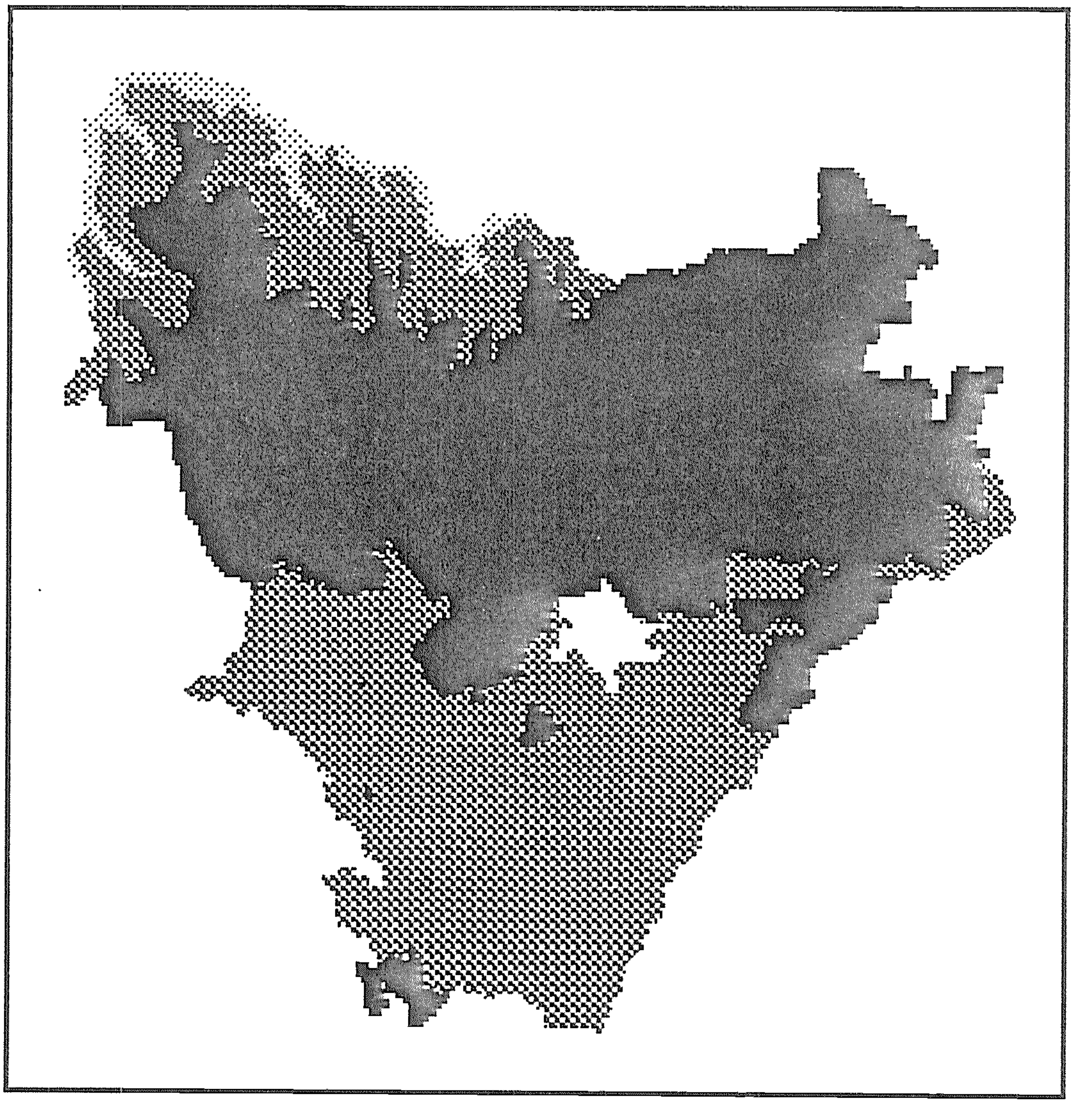


Altitude Zones in Menagesha

1:1 000 000

Map 3.2

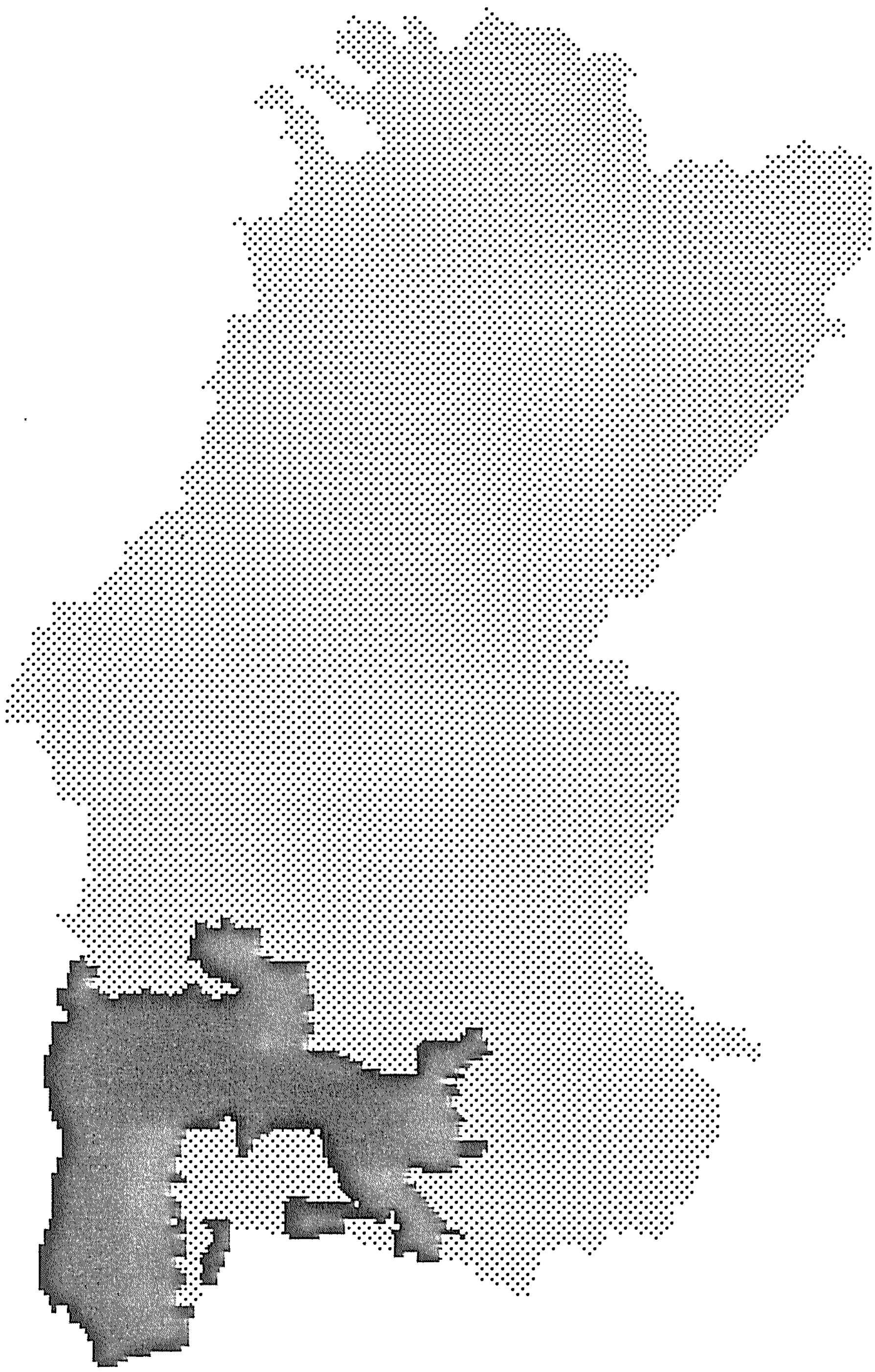
Aggregating Base Map (Example)



Grouped Altitude Zones in Menagesha
1:1 000 000

Map 3.3

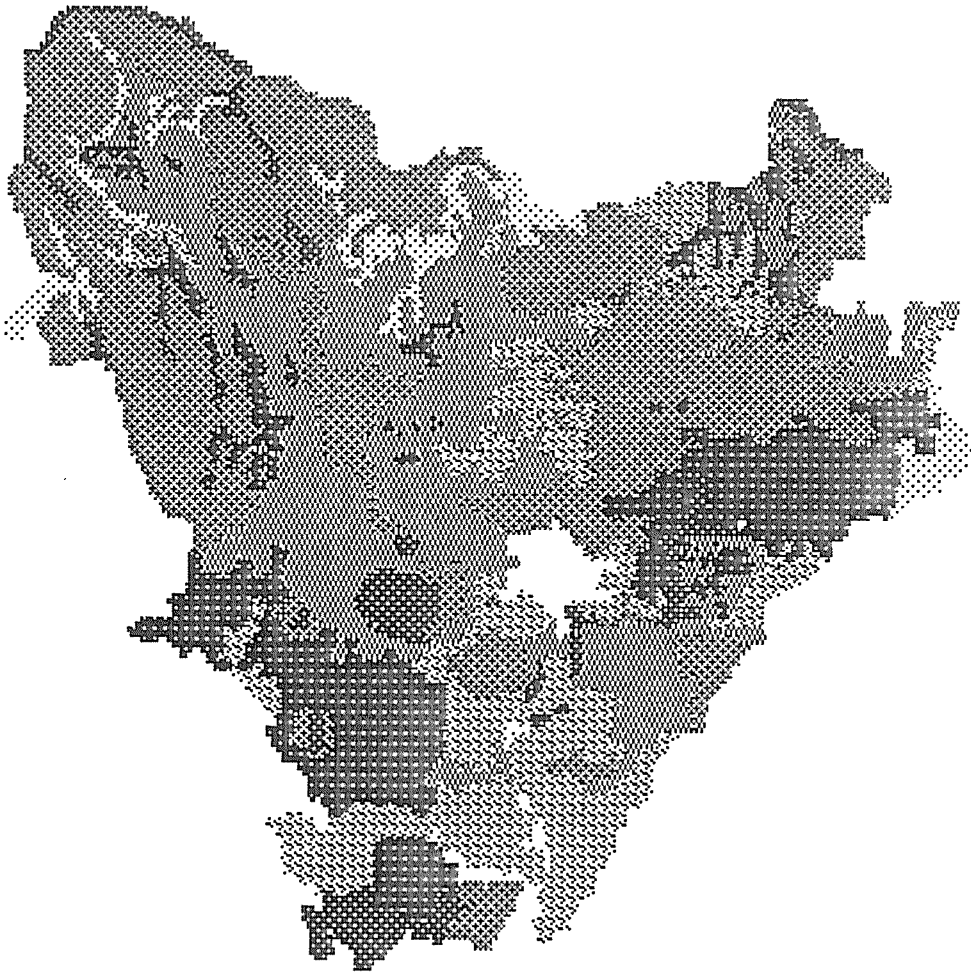
Selective Base Map (Example)



Planning Zone 7: Alaba Plain, in Haykoch & Butajira
1:1 000 000

Map 3.4

Parametric Base Map (Example)



Drainage Conditions in Menagesha
1:1 000 000

3.2.1.2 '<u>Overlay of base maps</u>':

Function:

This program shows all areas fulfilling defined requirements.

Up to 10 maps can be overlaid, for each map up to 30 mapping units can be defined as required, following Boolean algorithm:
(unit 1 and/or unit 2 and/or ... and/or unit 30 of map A) AND (unit 1 and/or unit 2 and/or ... and/or unit 30 of map B) AND ..... AND (... of map J) for display of unit I
(unit 1 and/or unit 2 and/or ... and/or unit 30 of map A) AND (unit 1 and/or unit 2 and/or ... and/or unit 30 of map B) AND ..... AND (... of map J) for display of unit II etc.etc.

Areas which do not fulfill any of the required conditions in one or more of the overlaid maps are displayed as blank (grey).

Example: A1-1 soil units in altitude of 1300 (± 100 m) (see p.55)

Requirements:

Maps (MAP files)
Mapping unit codes (MUC file(s))
Study area names (STAREA file)
For 'parametric maps': Translation table(s)
(e.g. soil mapping unit composition and soil type characterization (MCP and TCH files), or administrative unit composition (ACH file)

Output:

Maps scrolling on screen, as high resolution image on EGA/VGA screen, printed on matrix printer or plotter, or stored on disk as GILES file
('C:\INTERM\DG<u>p</u>CMP<u>mn</u>.MAP' with 'DG<u>p</u>CMP.NAM')
or as ASCII file (DG0CMP<u>mn</u>.PRN'); or printed through screen dump utility

Area size tables on screen or printer

References:

Program structure: App.8.13 (p.247)

Map 3.15

Overlay of Base Maps (Example)

Vertisols units in 1400-1600 m asl in Yerer & Kereyu

3.2.1.3 'Overlay/reprint of previously configured map(s)':

Functions:

Beside the option 'Base map', this is the core of the geographical information facilities of GILES. Overlays can be processed within this module, with the condition that the overlaid maps were processed and stored beforehand through another module (e.g. through 'Base map').

Principally, there are 4 options:

- **Reprint** of one previously stored map
- **Overlay of a 'main map' with a map 'selected areas map'** with selected areas,
  e.g.overlay of a suitability map with an administrative map, to analyze the suitability per administrative unit.
  Area crosstabulations can be transferred to Lotus-1-2-3 for further processing and presentation.

  If more than 70 mapping units ('selected areas') occur, the original map has to be split into two (or more) selective base maps with mapping units 1-70, 71-140....

- **Comparison of two (suitability) maps**, in order to show the impact of land improvement

  Example: see next page

- **Combination of various crop suitability maps** to produce a crop mix suitability map

  Up to 5 crops can be overlaid by taking the lowest suitability of any of the selected crops ("law of the minimum") into consideration. This gives the overall suitability for this crop mixture.

If the 'main map' does not have **more than 10 different units** and the overlaid 'selected areas map' not **more than 20** 'selected areas', the overlay's result can be stored and overlaid again with another 'selected areas map'.

Requirements:

Prepared ('previously configured') maps
('C:\INTERM\DGpCMPmn.MAP' with 'DGpCMP.NAM' files)
Study area names (STAREA file)

Output:

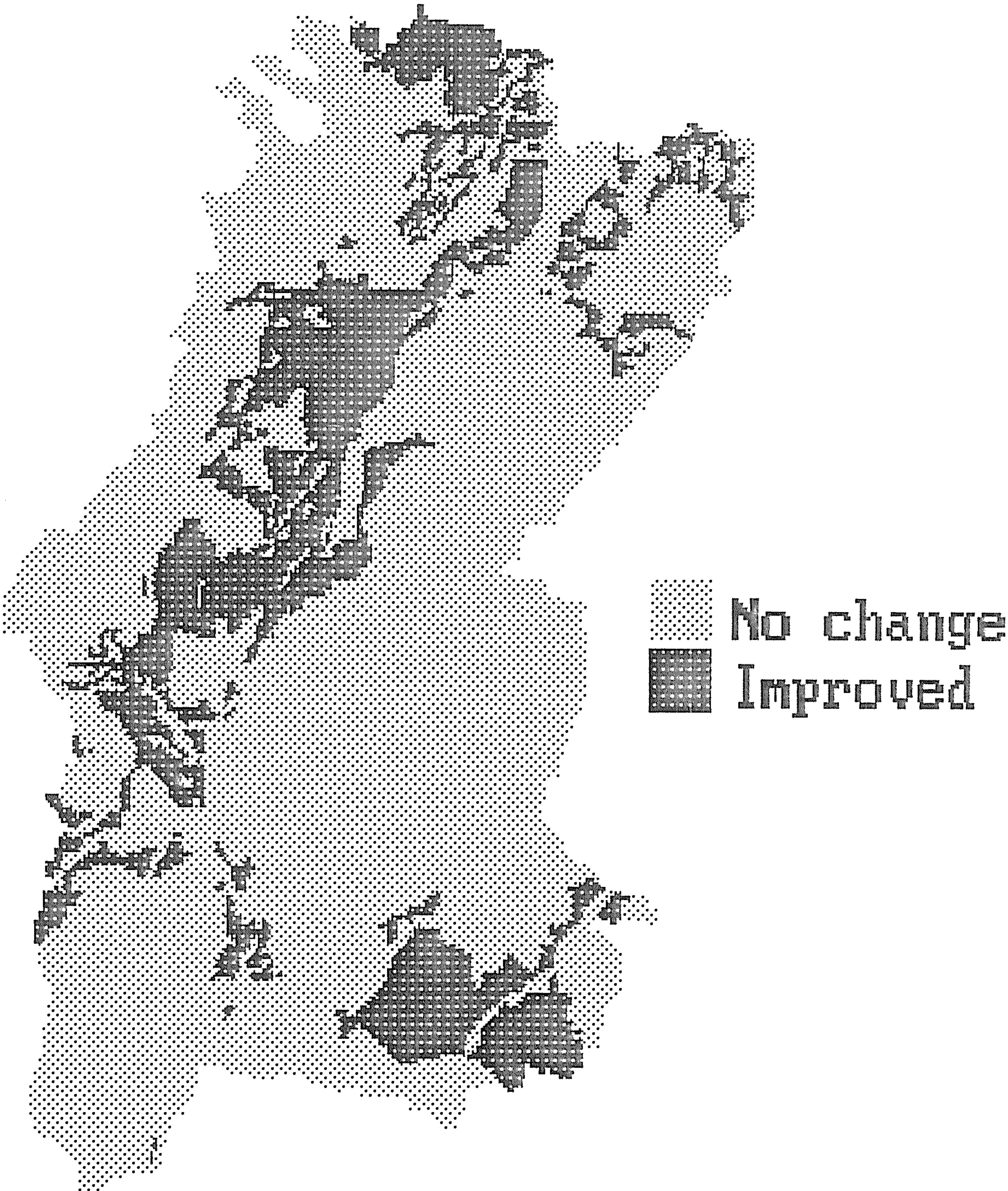
Maps scrolling on screen, as high resolution image on EGA/VGA screen, printed on matrix
printer or plotter, or stored on disk as GILES file
('C:\INTERM\DGpCMPmn.MAP' with 'DGpCMP.NAM')
or as ASCII file (DG0CMPmn.PRN'); or printed through screen dump utility
Area size tables on screen or printer or stored on disk
as ASCII file (C:\INTERM\GIL2LOTa.PRN) for further processing

===> If the ASCII file extends a length of 240 symbols, continuation is given in file GIL2LOTZ.PRN, then in GIL2LOTY.PRN, then in GIL2LOTX.PRN

References:

Selection procedure: Section 3.3.8 (p.113) and 3.3.9 (p.115)
Program structure: App.8.14 (p.247)

Map 3.6
Land Improvement Base Map (Example)



Suitability for Maize: Improvement due to Bunding
1:1 000 000

Table 3.2

Crosstabulation of Overlay of Main Map with Selected Areas
(Example)

Suitability for Sorghum
under intermediate input level
in Haykopch & Butajira

in hectares

	S1	S2	S3	S4	N
Planning Zone 1	0	3992	2844	6306	42893
Planning Zone 2	0	174	400	7710	23595
Planning Zone 3	2415	12063	12626	27156	25147
Planning Zone 4	807	6687	12366	16362	32619
Planning Zone 5	6537	22435	38356	12429	28406
Planning Zone 6	19066	60754	80562	12401	60878
Planning Zone 7	0	18322	75969	26306	39993
Planning Zone 8	266	2592	80042	17780	45182
Planning Zone 9	0	0	32324	14487	127008
Planning Zone 10	0	156	8953	4438	11119

3.2.1.4 'Area sizes':

Function:

Area sizes can be retrieved of mapping units of a selected map either for the total area, for an individual sheet or for one run of one map sheet.

Area size files as the basis for these calculations can be created during performance of this option.

Example: Areas of PAs and of altitude units in Hosaina with hectarages and percentages; hypsographic curve of Ethiopia (see next page).

Requirements:

Area size files (ARS files); or:
Maps (MAP files) and
Mapping unit codes (MUC file)
Study area names (STAREA file)

Output:

Area size tables on screen, printer or disk as ASCII file
('C:\INTERM\GIL2LOTa.PRN') for further processing in Lotus

References:

Selection procedure: Section 3.3.13 (p.120)
Program structure: App.8.10 (p.245)

Table 3.3

Area Sizes (Example)

Area Sizes of Administrative Units (PAs) of Borkena

0101	3293 ha	1.1 %
0102	4306 ha	1.4 %
0103	3512 ha	1.2 %
0104	4337 ha	1.4 %
0105	1837 ha	0.6 %
0106	3131 ha	1.0 %
0107	1056 ha	0.3 %
0108	3200 ha	1.0 %
0109	4800 ha	1.6 %
0110	3125 ha	1.0 %
0111	6687 ha	2.2 %
0112	5193 ha	1.7 %
0113	4262 ha	1.4 %
0114	3050 ha	1.0 %
0115	4475 ha	1.5 %
0201	1075 ha	0.4 %
0202	2900 ha	1.0 %
.	.	.
.	.	.
.	.	.

Altitude Distribution in Hosaina

1000-1200 m asl	0 ha	0 %
1200-1400 m asl	0 ha	0 %
1400-1600 m asl	875 ha	0.4 %
1600-1800 m asl	24706 ha	10.8 %
1800-2000 m asl	48456 ha	21.1 %
2000-2200 m asl	67093 ha	29.2 %
2200-2400 m asl	33975 ha	14.8 %
2400-2600 m asl	21300 ha	9.3 %
2600-2800 m asl	13668 ha	6.0 %
2800-3000 m asl	9762 ha	4.3 %
3000-3200 m asl	6943 ha	3.0 %
3200-3400 m asl	2825 ha	1.2 %
3400-3600 m asl	0 ha	0 %

3.2.1.5 'Site specific information':

Function:

Selection of this option will display any information stored in the system of a particular location (grid cell) in tabular form.

The mapping unit and its explanation of the requested location (pixel) will be shown for all entered 'base maps'.

Additionally, further information is given for the occurring soil type(s), soil characteristics (drainage, texture, slope, chemical parameters etc.), monthly and annual precipitation at various reliability levels, monthly and annual temperature and potential evapotranspiration, administrative characteristics (population density, livestock population density, population support capacity, access to roads etc.) as far as they were entered into GILES.

Example: Location in Borkena project area (see next pages)

Requirements:

Maps (MAP files)
Mapping unit codes (MUC files)
Soil mapping unit composition ('aSOIL.MCP' file)
Soil type names ('aSOIL.STN' file)
Soil type characterization ('aSOIL.TCH' file)
Altitude correlation ('aALT.COR' file)
Administrative unit characterization ('aADM.ACH' file)
Expected precipitation values ('aPREC.RLV' file)
Land characteristics names ('LCHAR.NAM' file)
Land characteristic classes names ('LCHATN.NAM' file)
Structural characteristic classes names ('aATN.NAM' file)
Study area names (STAREA file)

Output:

Listings on screen or printer

References:

Program structure: App.8.11 (p.245)

Table 3.4

Site Specific Information (Example)

INFORMATION ABOUT Borkena

Sheet 3 (Degaga) / Run 3 / x 10 / y 10		
Latitude:	10:46:12-10:46:21 N	
Longitude:	39:38:51-39:38:59 E	
UTM grid	EB 708 906-EB 711 908	
Administrative unit:	0111	
Woreda (District)	Albuko	(coded as 1)
Awraja (Province)	Kalu	(coded as 5)
Region	Welo	(coded as 2)
Population	6000-7000	(coded as 11)
Present population density	75-100 /km2	(coded as 5)
TLU	6000-7000	(coded as 11)
TLU density	100-150 /km2	(coded as 6)
AGH (Arable+grazing land/household)	1.5-2 ha	(coded as 7)
Planning zone:	1C	
Agroecological zone:	(no)	
Altitude unit :	2500 +- 100 m	
Soil mapping unit:	B5-1	
Soil type of appr. 50 % :		
Soil type:	41	
Drainage	somewhat excess.drained	(coded as 6)
Texture (tops.)	L + cL	(coded as 20)
Texture (subs.)	L + cL	(coded as 20)
Min.fragm. (tops.)	frequent (15-40 %)	(coded as 3)
Min.fragm. (subs.)	n.a.	(coded as 9)
Depth	shallow (25-50 cm)	(coded as 3)
Topsoil depth	deep (appr.30 cm)	(coded as 4)
Ponding	none-slight (< 1 day)	(coded as 1)
Flash flooding	none	(coded as 1)
Flooding	none	(coded as 1)
Surface stoniness	very stony (3-15 %)	(coded as 4)
Surface rockiness	2 - 10 %	(coded as 3)
Erosion/gully/badland status	moderate sheet/rill	(coded as 3)
Nec.f.gully measures	no eros.measures neces.	(coded as 1)
Mean slopes	25 - 40 %	(coded as 8)
Mean max.slopes	40-55%	(coded as 9)
Topography	sideslope	(coded as 8)
Microrelief	moderate	(coded as 3)
Slope shape	complex	(coded as 1)
Slope length	< 50 m	(coded as 1)
Groundwater level	> 300 cm	(coded as 8)
Permeability	rapid	(coded as 5)
Consistence	hard/non-sticky	(coded as 2)
Structure (tops.)	fine	(coded as 5)
Surface sealing	none to slight	(coded as 1)
Bulk density	medium	(coded as 2)
Organic matter	high (3 - 5 %)	(coded as 3)
N (t) (tops.)	medium (0.1-0.15 %)	(coded as 2)
N (t) (subs.)	n.a.	(coded as 9)
P (avail) (tops.)	medium (5-15 ppm)	(coded as 2)
Ca (exc)	very high (> 10 me)	(coded as 4)
Mg (exc) (tops.)	very high (> 5 me)	(coded as 4)
Mg (exc) (subs.)	n.a.	(coded as 9)
K (exc) (tops.)	very high (> 0.5 me)	(coded as 4)
K (exc) (subs.)	n.a.	(coded as 9)
pH (tops.)	slightly acid (6-6.6)	(coded as 4)
pH (subs.)	n.a.	(coded as 9)
CEC (tops.)	high (> 20 me)	(coded as 4)
BS (tops.)	medium (50-75 %)	(coded as 3)
BS (subs.)	n.a.	(coded as 9)
Na (exc) (tops.)	low (< 6 %)	(coded as 1)
Na (exc) (subs.)	low (< 6 %)	(coded as 1)
EC (tops)	non-saline (< 2 mmhos)	(coded as 1)
Erodibility (kc)	kc 0.10	(coded as 2)

Soil type of appr. 50 % :		
Soil type:	62	
Drainage	excessively drained	(coded as 7)
Texture (tops.)	variabel	(coded as 19)
Texture (subs.)	variabel	(coded as 19)
Min.fragm. (tops.)	Very frequent (40-75 %)	(coded as 4)
Min.fragm. (subs.)	n.a.	(coded as 9)
Depth	very shallow (10-25 cm)	(coded as 2)
Topsoil depth	lim.byrootingdepth(<15 cm)	(coded as 1)
Ponding	none-slight (< 1 day)	(coded as 1)
Flash flooding	none	(coded as 1)
Flooding	none	(coded as 1)
Surface stoniness	very exceedingly stony	(> 50 %)
Surface rockiness	50 - 90 %	(coded as 6)
Erosion/gully/badland status	slight sheet/rill	(coded as 2)
Nec.f.gully measures	no eros.measures neces.	(coded as 1)
Mean slopes	40 - 55 %	(coded as 9)
Mean max.slopes	40-55%	(coded as 9)
Topography	sideslope	(coded as 8)
Microrelief	strong	(coded as 4)
Slope shape	complex	(coded as 1)
Slope length	< 50 m	(coded as 1)
Groundwater level	> 300 cm	(coded as 8)
Permeability	moderate	(coded as 4)
Consistence	loose/non-sticky	(coded as 1)
Structure (tops.)	massive or weak	(coded as 1)
Surface sealing	none to slight	(coded as 1)
Bulk density	medium	(coded as 2)
Organic matter	medium (1 - 3 %)	(coded as 2)
N (t) (tops.)	medium (0.1-0.15 %)	(coded as 2)
N (t) (subs.)	n.a.	(coded as 9)
P (avail) (tops.)	low (< 1 ppm)(< 5 ppm)	(coded as 1)
Ca (exc)	very high (> 10 me)	(coded as 4)
Mg (exc) (tops.)	very high (> 5 me)	(coded as 4)
Mg (exc) (subs.)	n.a.	(coded as 9)
K (exc) (tops.)	very high (> 0.5 me)	(coded as 4)
K (exc) (subs.)	n.a.	(coded as 9)
pH (tops.)	slightly acid (6-6.6)	(coded as 4)
pH (subs.)	n.a.	(coded as 9)
CEC (tops.)	high (> 20 me)	(coded as 4)
BS (tops.)	medium (50-75 %)	(coded as 3)
BS (subs.)	n.a.	(coded as 9)
Na (exc) (tops.)	low (< 6 %)	(coded as 1)
Na (exc) (subs.)	n.a.	(coded as 9)
EC (tops)	non-saline (< 2 mmhos)	(coded as 1)
Erodibility (kc)	kc 0.10	(coded as 2)
Precipitation unit:	4A	
Land use/cover unit:	C2T.G5-G	
Linear Features	IN	
Annual temperature	15 C	
Temperature of Jan.	14 C	
Temperature of Feb.	15 C	
Temperature of March	15 C	
Temperature of April	17 C	
Temperature of May	17 C	
Temperature of June	17 C	
Temperature of July	16 C	
Temperature of Aug.	15 C	
Temperature of Sept.	16 C	
Temperature of Oct.	14 C	
Temperature of Nov.	14 C	
Temperature of Dec.	13 C	
Annual evapotranspiration	1159 m	
PET of Jan.	84 mm	
PET of Feb.	93 mm	
PET of March	111 mm	
PET of April	110 mm	
PET of May	124 mm	
PET of June	111 mm	
PET of July	85 mm	
PET of Aug.	83 mm	
PET of Sept.	85 mm	
PET of Oct.	99 mm	
PET of Nov.	87 mm	
PET of Dec.	82 mm	

3.2.1.6 'Climatic suitability':

Function:

This option assesses the suitability of the climate of the requested area for the specific soil/landscape situation **or** for an 'average' soil situation (with 100 mm moisture holding capacity).

Following 'land qualities' are considered:

- Length of the growing period (moisture conditions)
  considering: precipitation at a specified reliability level, potential evapotranspiration; if soil-specific: soil moisture holding capacity and drainage; crop characteristics for transpiration and moisture uptake, annual or perennial crop
- Temperature
  considering: altitude,
- Frost hazard
  considering: altitude, topographic situation.

With the assumption of land improvement: irrigation, moisture constraints will be overcome.

These three environmental parameters are matched with the crop requirements to assess the climatic suitability at the requested location for a crop. The suitability is expressed in terms of s1 ('highly suitable'), s2 ('moderately suitable'), s3 ('marginally suitable'), s4 ('very marginally suitable') or n ('not suitable'). This is the basis for the land suitability assessment.

The individual suitability ratings can be printed for testing.

Examples: Suitability at probability level of 75 % (dark pattern indicates high suitability et v.v.) with high suitabilities (p.67) and at probability of 90 % with high risk avoidance and therefore lower suitabilities (p.68)

Requirements:

Precipitation map ('DGPRECmn.MAP' files)
Altitude map ('DGALTmn.MAP' files)
For site-specific assessment: Soil map ('DGSOILmn.MAP'files)
Precipitation data ('aPREC.TWY' file)
Altitude-temperature correlation ('aALT.COR' file)
Soil mapping unit composition ('aSOIL.MCP' file;
Soil type characterization ('aSOIL.TCH' file;
Crop requirements (CREQo files)
LUT/crop names ('LUT.NAM' file)
Mapping unit codes (MUC files)
Study area names (STAREA file)

Output:

Maps scrolling on screen, as high resolution image on EGA/VGA screen, printed on matrix printer or plotter, or stored on disk as GILES file ('C:\INTERM\DG1CMPmn.MAP' with 'DG1CMP.NAM') or as ASCII file (DG0CMPmn.PRN'); or printed through screen dump utility

Area size tables on screen or printer

Individual suitability ratings on screen or matrix printer

Examples: s1 for 50 % reliability level with high risk acceptance (left), s3 for 75 % reliability (right), see below

References:

Selection procedure: Section 3.3.5(1) (p.110)
Function: App.7.4 (p.227)
Program structure: App.8.18 (p.251)

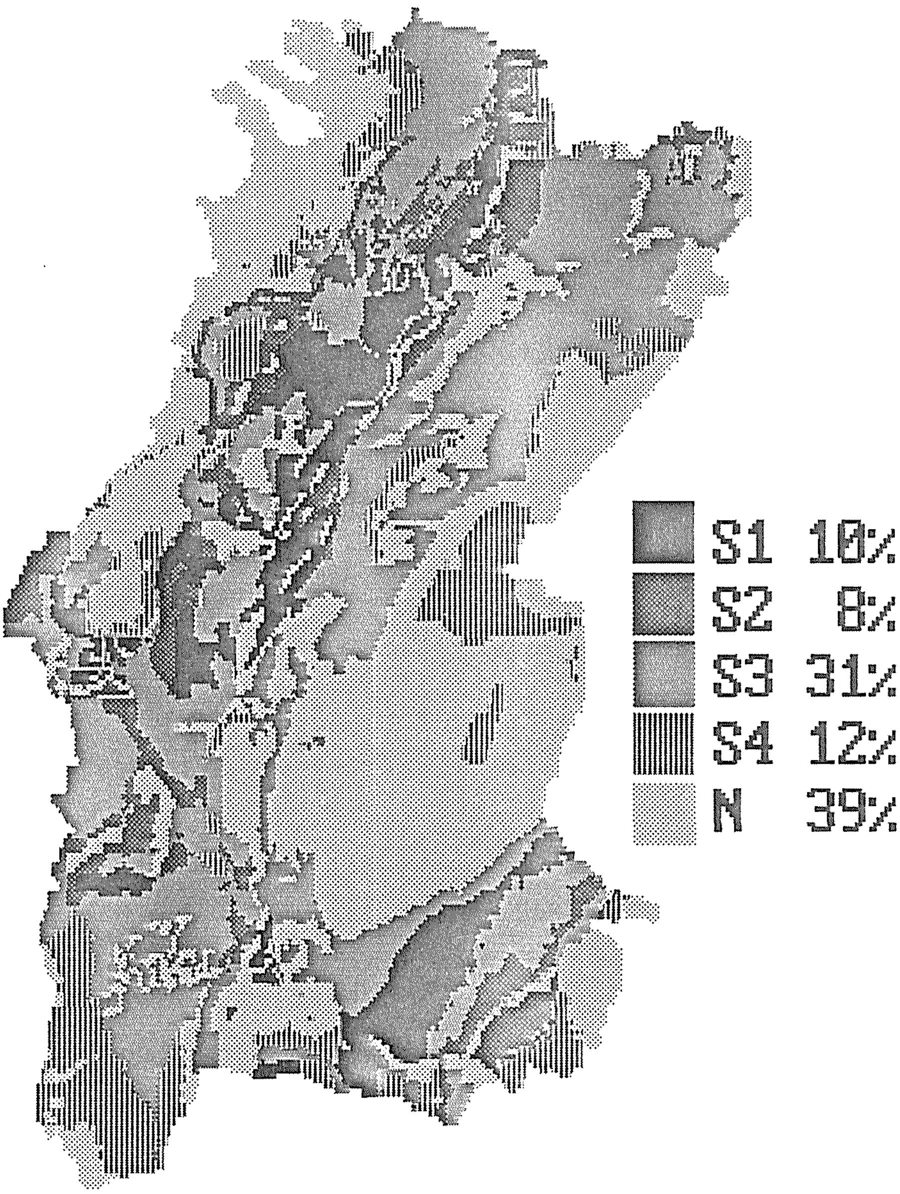
Table 3.5

Individual Climatic Suitability Ratings (Example)

```
 Estimated AWHC:  46 mm
 Considered AWHC: 50 mm

   .XXXWWXXXXXXXXXXXXXWWWWWWWXXXWWWWXX..
   x....xXXXXXXx....XWWWWWWWWXXxXXXX...
   ..................XXWWWWWXXXXx......
   ........XWWWWXXx..XXXWWWWWWXXx..xx..
   X.....xXXXWWWWWXXXXWWWWWWWWWXXX..XX.
   Xx.............xXXWWWWWWWWWXXXxxXXx
   ......xXXXXWWWWXXXXWWWWWWWWWXXx.....
   .....XXXXWWXXXx..XXWWWWWWWWWWWXXxxXX
   .......XxX......XXWWWWWWWWWWXXX.....

LGP:  120-216) days at requested reliability level

LQ moisture:            n
LQ temperate:           s3
LQ frost:               s3
```

Map 3.7

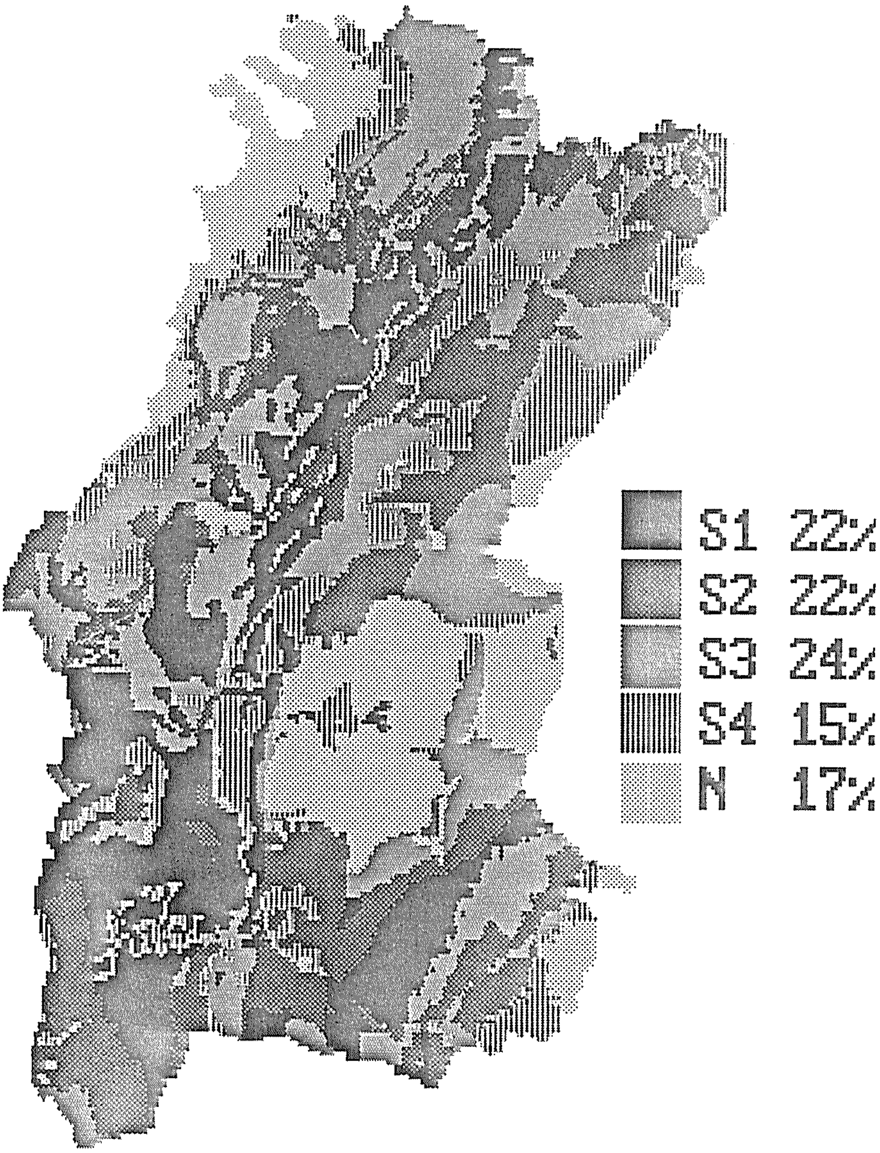
Climatic Suitability at 75 % Reliability (Example)



Climatic Suitability for Sorghum in Haykoch & Butajira

Map 3.8

Climatic Suitability at 50 % Reliability (Example)



Climatic Suitability for Sorghum in Haykoch & Butajira

3.2.1.7 'Soil suitability':

Function:

This option assesses the suitability of the soil of the requested area for a specified crop.

Following 'land qualities' are considered:

- Oxygen availability
  considering: drainage
- Nutrient availability or retention
  considering: N, P, CEC, pH, bulk density
- Rooting conditions
  considering: soil depth,mineral fragments, consistence, bulk density
- Flood hazard
  considering: flash flooding, ponding
- Sodicity / salinity:
  considering: sodicity, salinity

With the assumption of land improvement: minor or major drainage measures, flood protection, stone clearance, constraints will be partly or totally overcome.

These five environmental parameters are matched with the crop requirements to assess the soil suitability at the requested location for a crop. The suitability is expressed in terms of s1 ('highly suitable'), s2 ('moderately suitable'), s3 ('marginally suitable'), s4 ('very marginally suitable') or n ('not suitable'). This is the basis for the land suitability assessment.

The individual suitability ratings can be printed for testing purposes.

Example: "Without" (Map 3.9) and with improvement - scenarios.
It is shown that that drainage measures (Map 3.10) will increase the potential of PA 1139 by up to 310 t wheat, additional flood protection (Map 3.11) by another 320 t wheat. Major conservation measures (Map 3.12) will not improve the situation (see p.71/72).

Requirements:

Soil map ('DGSOILmn.MAP'files)
Soil mapping unit composition ('aSOIL.MCP' file)
Soil type characterization ('aSOIL.TCH' file)
Crop requirements (CREQo files)
LUT/crop names ('LUT.NAM' file)
Mapping unit codes (MUC file)
Study area names (STAREA file)

Output:

Maps scrolling on screen, as high resolution image on EGA/VGA screen, printed on matrix printer or plotter or stored on disk as GILES file

('C:\INTERM\DG2CMPmn.MAP' with 'DG2CMP.NAM')
or as ASCII file (DG0CMPmn.PRN'); or printed through screen dump utility
Area size tables on screen or printer

Individual suitability ratings on screen or printer
Examples: Without major land improvement ("without"situation): Not suitable (left); with flood protection: S2 (right), see below

References:

Selection procedure: Section 3.3.5 (2) (p.110)
Function: App.7.5 (p.226)
Program structure: App.8.19 (p.251)

Table 3.6

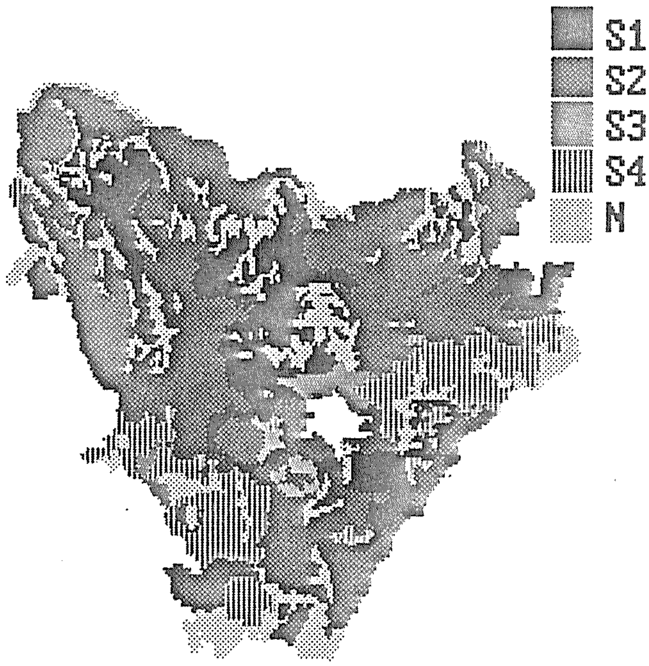
Individual Soil Suitability Ratings (Example)
(without / with land improvement; here: flood protection)

```
without flood control:

     Soil type: 14

         LQ drainage:           s1
         LQ nitrogen:   s1
         LQ phosphorus: s1
         LQ nutrients:          s1
         LQ foothold (depth):   s3
         LQ flooding:           n
         LQ sodicity/salinity:  s1

           SOIL SUITABILITY:          n

 with flood control:

     Soil type: 14

         LQ drainage:           s1
         LQ nitrogen:   s1
         LQ phosphorus: s1
         LQ nutrients:          s1
         LQ foothold (depth):   s3
         LQ flooding:           s1
         LQ sodicity/salinity:  s1

           SOIL SUITABILITY:          s3
```

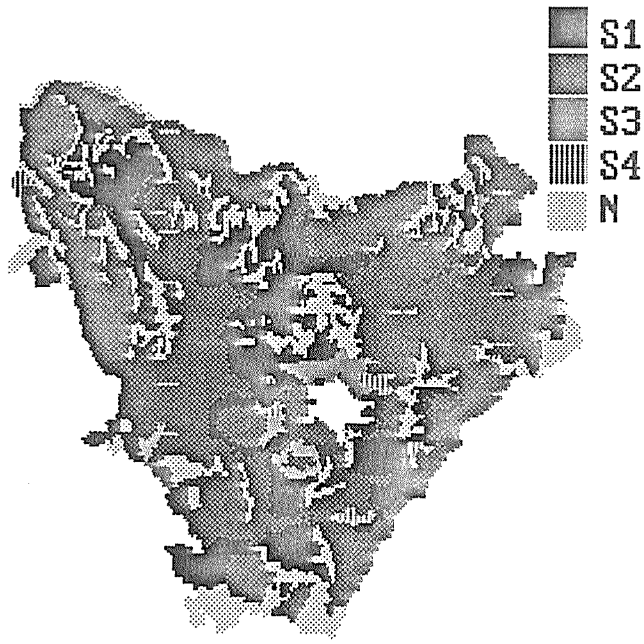
Map 3.9 and 3.10

Soil Suitability Maps (Example)

a) Suitability for sorghum in Menagesha, without land improvement:

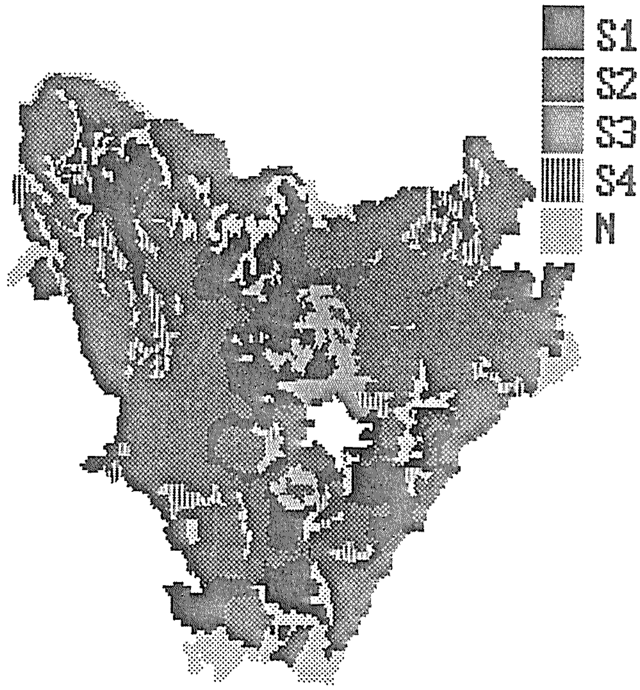


b) With minor drainage measures:

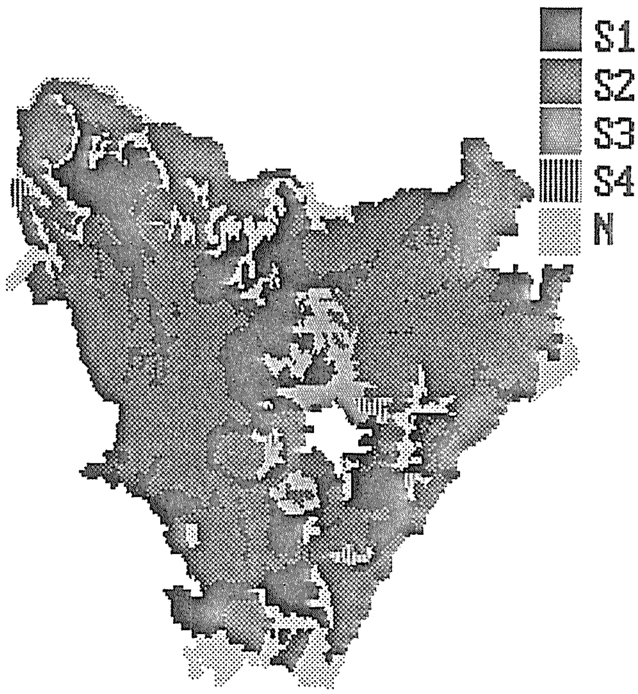


Map 3.11 and 3.12
Soil Suitability Maps (Example)

c) With minor drainage measures and flood protection:



d) With drainage measures, flood protection, major conservation:



3.2.1.8 'Land suitability':

Function:

This option assesses the suitability of the land of the requested area for a specified crop, based on the climatic and soil suitabilities. Thus, these two intermediate suitabilities have to be assessed first and stored beforehand.

Following 'land qualities' are considered for the final land suitability assessment:

- Erosion hazard

    considering: sheet erosion hazard (see Para.3.2.1.9), based on mean annual rainfall, soil erodibility, slope length, mean maximum slope, land cover (with crop characteristic: erosion resistance); and soil depth, present gully status

- Workability

    considering: slope, surface stoniness, rockiness,consistence

With the assumption of land improvement: minor or major conservation measures, stone clearance, constraints will be partly or totally overcome.

The climatic and soil suitabilities are combined and the two mentioned, additional environmental parameters are then matched with the crop requirements to assess the land suitability at the requested location for a crop.

The - final - suitability is expressed in terms of S1 ('highly suitable'; 80-100 % of maximum obtainable yield), S2 ('moderately suitable'; 60-80 % of maximum obtainable yield), S3 ('marginally suitable'; 40-60 % of maximum obtainable yield), S4 ('very marginally suitable'; 20-40 % of maximum obtainable yield) or N ('not suitable'; 0-20 % of maximum obtainable yield) and can be converted into potential yields (ton/ha). For 100% yield figures ('maximum obtainable yield'), see Table A7.24 (p.239).

The individual suitability ratings can be printed for testing purposes.

Example: Suitability for wheat at 75 % LGP reliability (see p.75)

Requirements:

Climatic suitability map ('DG1CMPmn.MAP' with 'DG1CMP.NAM' file)
Soil suitability map ('DG2CMPmn.MAP' with 'DG2CMP.NAM' file)
Precipitation map ('DGPRECmn.MAP' files)
Soil map ('DGSOILmn.MAP'files)
Precipitation data ('aPREC.TWY' file)
Soil mapping unit composition ('aSOIL.MCP' file)
Soil type characterization ('aSOIL.TCH' file)
Crop requirements (CREQo files)
LUT/crop names ('LUT.NAM' file)
Study area names (STAREA file)

Output:

Maps scrolling on screen, as high resolution image on EGA/VGA screen, printed on matrix printer or plotter, or stored on disk as GILES file ('C:\INTERM\DG3CMPmn.MAP' with 'DG3CMP.NAM') or as ASCII file (DG0CMPmn.PRN'); or printed through screen dump utility

Area size tables on screen or printer

Individual suitability ratings on screen or printer

Example: annual soil loss (t/ha/yr), erosion observation, erosion suitability, workability suitability, see below

References:

Selection procedure: Section 3.3.5 (p.110) and 3.3.6 (p.111)
Function: App.7.6 (p.237)
Program structure: App.8.20 (p.252)

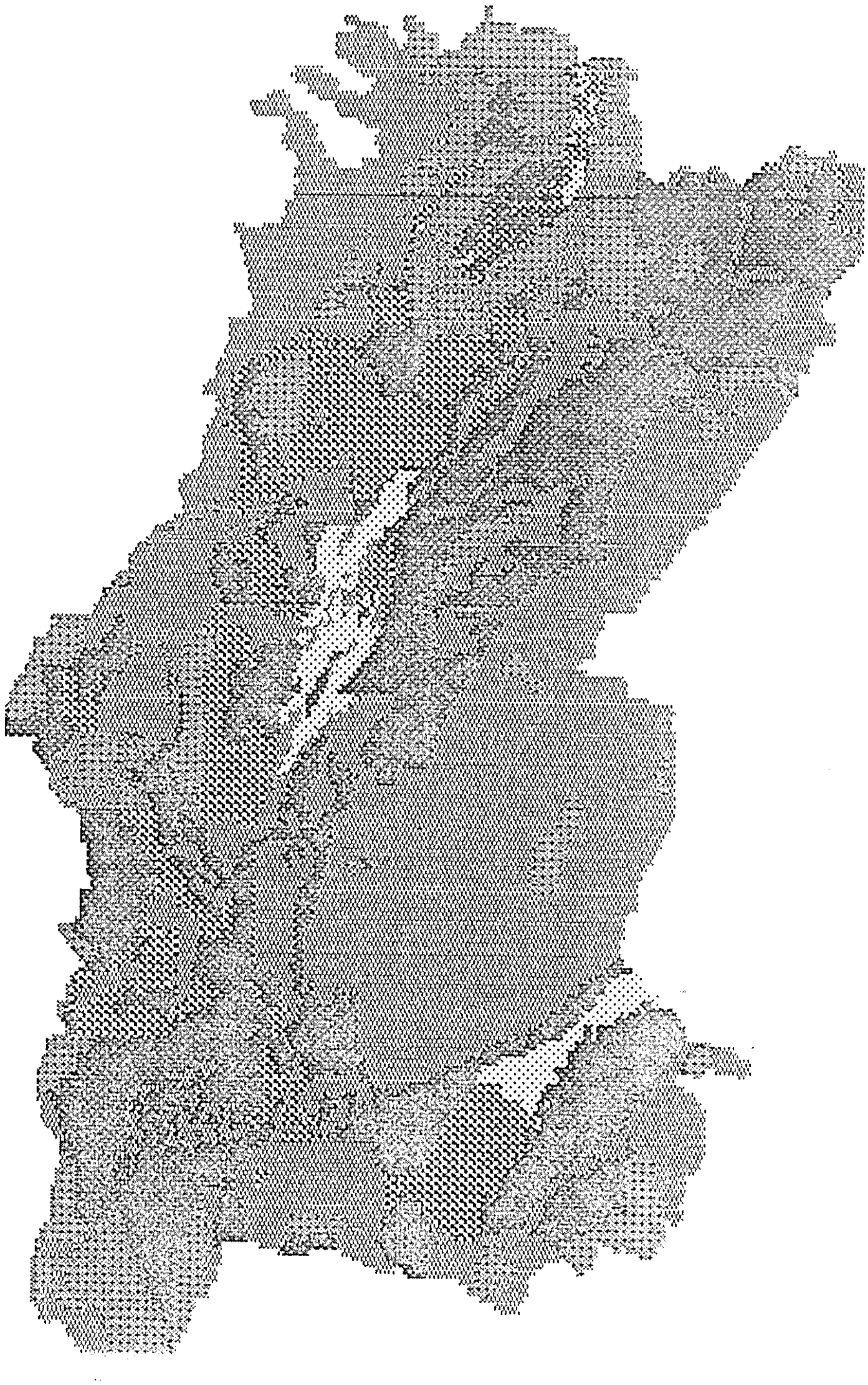
Table 3.7

Individual Land Suitability Ratings (Example)

```
Precipitation mapping unit:      4
Soil mapping unit:                51
   Soiltype:                      41 (3.column)
        ANNUAL SOIL LOSS:            25 t/ha/yr
   Erosion observation:          3. class (203)
        EROSION SUITABILITY:        s4
        WORKABILITY SUITABILITY:    s3
```

Map 3.13

Land Suitability (Example)



3.2.1.9 'Erosion hazard':

Function:

The sheet erosion loss (expressed in tons soil loss per ha per year) can be calculated and mapped based on environmental factors (such as rainfall erosivity, soil erodibility, slope gradient, slope length and land use). Use is made of USLE/Wischmeier formula, specifically modified and tested for Ethiopian conditions.

Additional attention can be paid to gully erosion hazard in the neighborhood of gullies.

Example: Sheet erosion hazard (see next page)

Requirements:

Precipitation map ('DGPRECmn.MAP' files)
Soil map ('DGSOILmn.MAP'files)
Soil mapping unit composition ('aSOIL.MCP' file)
Soil type characterization ('aSOIL.TCH' file)
Study area names (STAREA file)
Precipitation data ('aPREC.TWY' file)

Output:

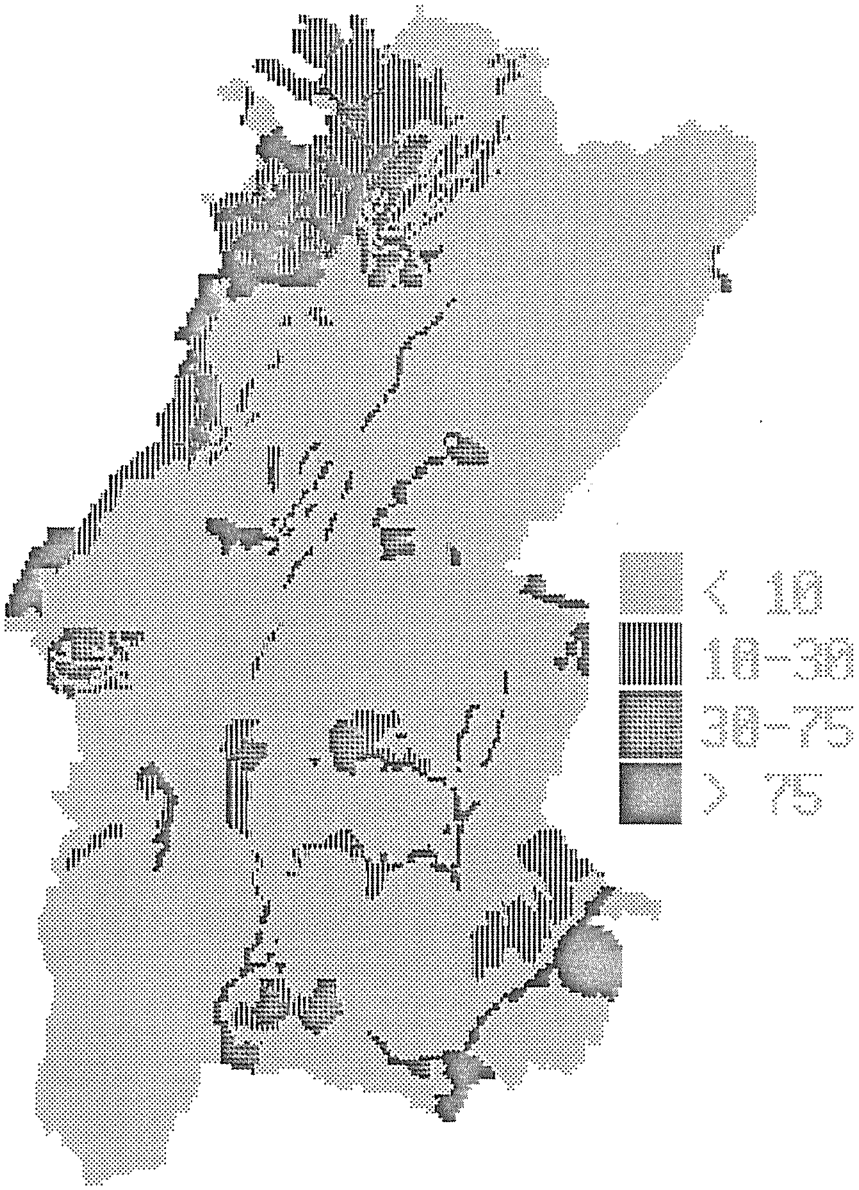
Maps scrolling on screen, as high resolution image on EGA/VGA screen, printed on matrix printer or plotter, or stored on disk as GILES file ('C:\INTERM\DGpCMPmn.MAP' with 'DGpCMP.NAM') or as ASCII file (DG0CMPmn.PRN'); or printed through screen dump utility
Area size tables on screen or printer

References:

Function: App.7.1 (p.211)
Program structure: App.8.15 (p.248)

Map 3.14

Erosion Hazard Map (Example)



Sheet Erosion Hazard in Haykoch & Butajira (ton soil loss/ha/yr)

3.2.1.10 'Conservation based land use recommendations':

Function:

Recommendation for soil conservation measures and appropriate land use (major kinds of land use) are defined on the basis of ecological conditions, such as erosion hazard (see 3.2.1.9), slope, soil depth, erosion status, flooding, vertic properties.

Example: see next page

Requirements:

Precipitation map ('DGPRECmn.MAP' files)
Soil map ('DGSOILmn.MAP'files)
Soil mapping unit composition ('aSOIL.MCP' file)
Soil type characterization ('aSOIL.TCH' file)
Precipitation data ('aPREC.TWY' file)
Study area names (STAREA file)

Output:

Maps scrolling on screen, as high resolution image on EGA/VGA screen, printed on matrix printer or plotter, or stored on disk as GILES file ('C:\INTERM\DGpCMPmn.MAP' with 'DGpCMP.NAM') or as ASCII file (DG0CMPmn.PRN'); or printed through screen dump utility
Area size tables on screen or printer

References:

Function: App.7.2 (p.215)
Program structure: App.8.16 (p.249)

Map 3.15

Conservation Based Land Use Recommendations (Example)

(For description of units, see Table A7.2; p.215)

3.2.1.11 'Length of growing period':

Function:

Moisture conditions of the location are expressed by the length of the growing period. The 'LGP' is calculated for a number of years (e.g. 20 years, or less)
either: for a specified crop, or
for an 'average' crop; and
either: for the specific soil/landscape situation, or
for an 'average' soil situation (with 100 mm AWHC).

The LGP calculation is based on a decadal soil moisture balance considering actual and effective precipitation , potential and actual evapotranspiration, soil moisture holding capacity, drainage, and if crop-specific: crop characteristics for transpiration and moisture uptake, annual or perennial crop. Decadal matching of the soil moisture with the crop requirement gives decadal declaration as:

Table 3.8

Definition	LGP Considerations	Chart	Lotus
dry	no LGP	.	0
moist	strong constraints, but accepted as LGP	x	1
humid	optimum LGP conditions	X	2
wet	wetness constraints, but accepted as LGP	W	3

The LGP assessment is calculated out of the LGP of the individual years, with consideration of the specified reliability level.

The quantitative moisture balance per year and the growing period charts can be printed for testing purposes or transferred into spreadsheets (e.g. Lotus 1-2-3) for further processing or to graphic packages (e.g. 'Boeing Graph') for 3D display.

Example: Non-soil specific LGP for an average crop at 75 % reliability level (see p. 82)

Requirements:

Precipitation map ('DGPRECmn.MAP' files)
Altitude map ('DGALTmn.MAP' files)
For site-specific assessment: Soil map ('DGSOILmn.MAP'files)
Precipitation data ('aPREC.TWY' file)
Altitude - PET correlation ('aALT.COR' file)
For site-specific assessment: Soil mapping unit composition ('aSOIL.MCP' file;
For site-specific assessment: Soil type characterization ('aSOIL.TCH' file)
For crop-specific assessment: Crop requirements (CREQo files)
For crop-specific assessment: LUT/crop names('LUT.NAM'file)
Mapping unit codes (MUC files)
Study area names (STAREA file)

Output:

Maps scrolling on screen, as high resolution image on EGA/VGA screen, printed on matrix printer or plotter, or stored on disk as GILES file ('C:\INTERM\DGpCMPmn.MAP' with 'DGpCMP.NAM') or as ASCII file (DG0CMPmn.PRN'); or printed through screen dump utility
Area size tables on screen or printer

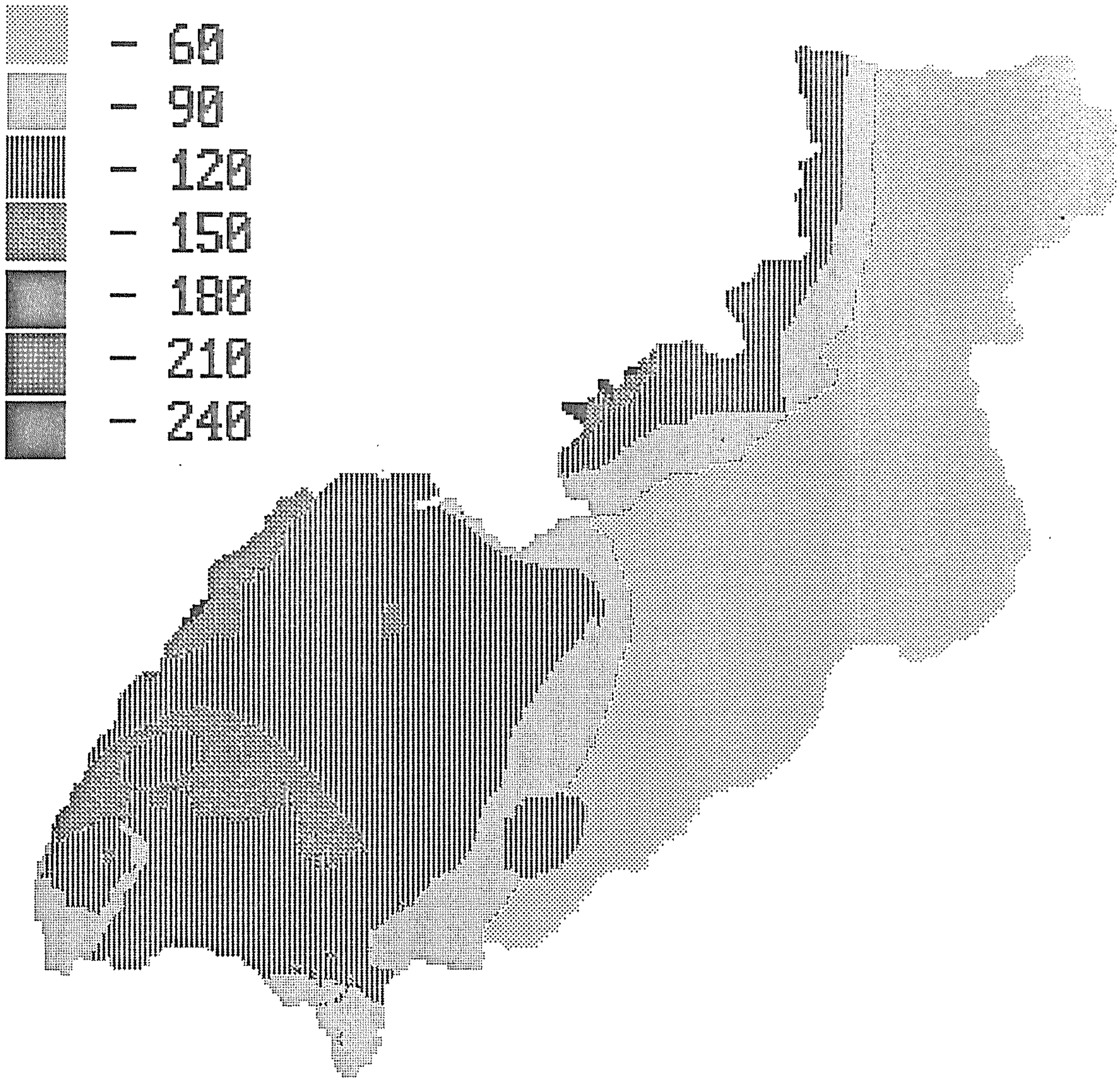
Growing period charts on screen, printer or on disk as ASCII file ('C:\INTERM\GIL2LOTa.PRN') for further processing in Lotus or for 3D display
Example for 20 years, see Table 3.9 (p.83)
Soil moisture balance dynamic on screen or printer
Example for 36 decades of 1.year, see Table 3.10 (p.84)

References:

Function: App.7.3 (p.216)
Program structure: App.8.17 (p.249)

Map 3.15

LGP Map (Example)



Length of mean growing period in Yerer & Kereyu

Table 3.9

Growing Period Charts (Example)

Growing Period for Consecutive Years

.=dry, x=moist (30-60%rel.SM), X=humid (60-99%rel.SM),W=wet (100%)

Assumed AWHC: 100 mm
LGP for root.depth: 100 cm
Depletion ability: 50 %
Transpiration: .75

JanFebMarAprMayJunJulAugSepOctNovDec	Belg	Krmt	End
......x.xXXXWWXXXWWWWWWWWWXXx.XXx...	70	210	33
.XXXXx..xXXXWXWXXWWWWWWWWWXXXWWXXx..	50	260	34
....xXXXXXXXXXxxXXWWWWWWWWWWWXXx....	110	280	32
.XXXXxxXXXXXXXXXXXWWWWWWWWWWXWXXx..X.	140	310	35
...x..X..xXXx.xXXXXWWWWWWXXXXx......	40	160	30
......XXWXWXXXx..XXWWWWWXWWXXx......	90	130	30
xx..xx..xXXXXXXXXWWWWWWWXXXXXXXXXx..	70	260	34
..XXXx..xXx..XWXXWXWWWWWWWWXXXXx....	40	180	31
.............xXXXXXWWWWWWXXXx.......	20	160	29
.........XX.XXx.XxXWWWWWWWWWXXXXx...	30	140	30

Mean Kremt: 209 days
at given reliability: 165 days

Table 3.10

Soil Moisture Balance Dynamic (Example)

Yr	Dec	Soil moisture beg mm	Soil moisture end mm	Topsoil moisture beg mm	Topsoil moisture end mm	c inf	Prec 10d mm	Prec 10d eff mm	GW mm	kPET eff	kPET crp	PET 10d mm	PET 10d eff mm	Soil moist. %	top %	LGP
1	1	0	0	0	0	0.8	0	0	0	0.6	0.8	36.4	27.3	0	0	.
1	2	0	0	0	0	0.8	0	0	0	0.6	0.8	36.9	16.6	0	0	.
1	3	0	0	0	0	0.8	0	0	0	0.6	0.8	36.9	16.6	0	0	.
1	4	0	0	0	0	0.8	0	0	0	0.6	0.8	36.9	16.6	0	0	x
1	5	0	4	0	4	0.8	26	21	0	0.6	0.8	36.9	16.6	4	21	.
1	6	4	0	4	0	0.8	0	0	0	0.6	0.8	39.1	17.6	0	0	.
1	7	0	2	0	2	0.8	26	21	0	0.6	0.8	41.4	18.6	2	11	.
1	8	2	0	2	0	0.8	4	3	0	0.6	0.8	43.6	19.6	42	100	X
1	9	0	42	0	20	0.8	76	61	0	0.6	0.8	42.6	19.2	18	0	x
1	10	42	18	20	0	0.8	2	1	0	0.8	0.8	41.7	25.0	0	0	.
1	11	18	0	0	0	0.8	0	0	0	0.6	0.8	40.7	18.3	0	0	.
1	12	0	0	0	0	0.8	0	0	0	0.6	0.8	40.5	18.2	0	0	.
1	13	0	0	0	0	0.8	7	6	0	0.6	0.8	40.2	18.1	0	0	.
1	14	0	0	0	0	0.8	8	6	0	0.6	0.8	40.0	18.0	0	0	X
1	15	0	58	0	20	0.8	94	75	0	0.6	0.8	38.3	17.2	58	100	X
1	16	58	37	20	20	0.8	8	6	0	1.0	0.8	36.5	27.4	37	0	X
1	17	37	35	20	20	0.8	24	19	0	0.8	0.8	34.8	20.9	35	0	X
1	18	35	74	20	20	0.8	74	59	0	0.8	0.8	33.5	20.1	74	100	W
1	19	74	100	20	20	0.8	79	63	0	1.0	0.8	30.9	24.2	100	100	W
1	20	100	100	20	20	0.8	77	62	0	1.0	0.8	31.0	23.2	100	100	W
1	21	100	100	20	20	0.8	62	50	0	1.0	0.8	31.2	23.3	100	100	W
1	22	100	100	20	20	0.8	42	34	0	1.0	0.8	31.3	23.4	100	100	W
1	23	100	100	20	20	0.8	93	74	0	1.0	0.8	31.5	23.5	100	100	W

3.2.1.12 'Database':

Functions:

This option is for input, change, display or printout of all data files of the 'general data' (DBMS, non-spatial data, i.e. all data except maps). (The spatial data (maps) can be entered and changed through option 'Base map entry').

Output and modifications of data files can be handled in several versions. It is possible to :

- declare a new data file
- change/modify the size (dimensions) of an existing data file
- import a data file (one column) from Lotus file
  (C:\INTERM\LOT2GILc.DIF, numbered between A and E)
- change/modify data
- see the data on screen
- outprint the data
- transfer the data set to a Lotus file
  (C:\INTERM\GIL2LOTc.DIF, numbered between A and E)

Before entering or importing data into a file, it has to be first declared (1.option) and the dimensions have to be defined (2.option).

Requirements:

Concerned file(s)
Study area names (STAREA file)

Output:

Storage on disk

References:

Selection procedure: Section 3.3.22-28 (p.134-142)
Data structure: Section 4.2 (p.150)
Program structure: App.8.8 (p.244)

Out of the 14 data sets which can be accessed through 'Database' option, 3 shall be discussed in more detail:

Suboption a: 'Crop requirements'

Functions:

This DBMS option is for input, change, display or printout of the 40 crop requirements and characteristics which are handled by GILES for the crop suitability assessments either per crop or per land quality/ requirement:

Minimum temperature requirements)
Maximum temperature requirements) for S1 / S2 / S3 / S4
Minimum LGP requirements) suitability classes
Maximum LGP requirements)
Increase for minimum LGP requirement with altitude
Increase for maximum LGP requirement with altitude
Rooting depth for moisture uptake
Evapotranspiration rate
Ability to uptake not readily available soil moisture
Average uptake of available water holding capacity
Annual / perennial plant
Frost sensitivity
Drainage sensitivity
Ponding and flooding sensitivity
Requirements on N uptake
Requirements on P uptake
Requirements on K uptake/fertilizer response
Required rooting depth
Germination requirement
Flash flooding sensitivity
Sodicity sensitivity
Residual moisture plant
Requirements for workability
Salinity sensitivity
Resistance to erosion

Requirements:

Crop requirements (CREQo files)
LUT/Crop names ('LUT.NAM' file)
Study area names (STAREA file)

Output:

Storage on disk (CREQ files)
Listing on screen or printer
Example: wheat (see p.87); drainage (see p.88)

References:

Selection procedure: Section 3.3.12 (3) (p.119)
Data structure: Section 4.2.20 (p.182)
Program structure: App.8.7 (p.244)

Table 3.11

Crop Requirements per Crop (Example)

Crop Requirements for Maize at medium input level:

T min	(1-40 C)	s1	16
		s2	15
		s3	14
		s4	12
T max	(1-40 C)	s1	26
		s2	30
		s3	34
		s4	38
LGP min	(1-365 days)	s1	140
		s2	120
		s3	100
		s4	90
LGP max	(1-365 days)	s1	265
		s2	310
		s3	355
		s4	365
LGP min regression (0-20 days/100m)			10
LGP max regression (0-20 days/100m)			8
Rooting depth for moist.uptake (50/100/150 cm)			150
kc (evapotranspiration) (1-150 %)			70
Not readily available soil water (1-100 %)			40
AWHC uptake (1:100 mm/2:150 mm)			2
Perennial plant			0
Frost sensitivity (1:tol/2:mod.tol/3:mod.sens/4:sens)			3
Drainage sensitivity (1:tol/2:mod.tol/3:mod.sens/4:sens)			3
Ponding/flooding sensit. (1:tol/2:mod.tol/3:mod.sens/4:sens)			4
N requirements (1:v.low/2:low/3:med./4:high/5:v.high)			4
P			4
K			4
Rooting requirements (1:>0/ 2:>10/ 3:>25/ 4:>50/ 5:>100/ 6:>150 cm)		s1	5
		s2	4
		s3	4
		s4	3
Germination requirement (1:low/2:medium/3:high)			2
Flash flooding sensitivity (1:low/2:medium/3:high)			2
Sodicity sensitivity (1:low/2:medium/3:high)			3
Residual moisture plant			0
Workability requirement (1:low/2:medium/3:high)			2
Salinity sensitivity (1:tol/2:mod.tol/3:mod.sens/4:sens)			3
Erosion resistance (1-100 %)			10

Table 3.12

Crop Requirements per Land Quality (Example)

Crop requirements of Frost Sensitivity:

Sorghum	sensitive
Maize	moderately sensitive
Rice	sensitive
Wheat	moderately tolerant
Barley	tolerant
Teff	moderately sensitive
Oats	tolerant
Field Peas	moderately tolerant
Haricot Beans	sensitive
Horse Beans	tolerant
Chick Peas	moderately sensitive
Lentils	moderately tolerant
Vetch	moderately tolerant
Soybeans	moderately sensitive
Coffee	sensitive
Tea	moderately sensitive
Banana	sensitive
Citrus	sensitive
Sugarcane	sensitive
Pepper	sensitive
Shallot	moderately tolerant
Tomato	sensitive
Irish Potato	moderately tolerant
Sweet Potato	sensitive
Cabbage	tolerant
Pineapple	sensitive
Sisal	sensitive
Niger seed	sensitive
Sesame	sensitive
Sunflower	moderately sensitive
Safflower	tolerant
Flax (linseed)	tolerant
Tobacco	sensitive
Cassava	sensitive
Cotton	sensitive
Groundnut	sensitive
Pearl Millet	moderately sensitive
Finger Millet	moderately sensitive
Grape	sensitive
Ensete	tolerant
Cow Pea	sensitive
Maize (short LGP variety)	moderately sensitive

Suboption b: '<u>Study areas</u>'

Functions:

Each study area is defined by following parameters:

- Name
- Working abbreviation (3 or 4 letters)
- Scale of data entry
- Number of soil types
- Individual sheets with
  - -- names
  - -- working abbreviations (3 or 4 letters)
  - -- relative position of sheet to previous sheet
  - -- N,S,W,E coordinates (latitude and longitude)
- Additional maps (in addition to soil, altitude, precipitation, land use/cover, administration, agroecological ng zone)

Requirements:

Study area names (STAREA file)

Output:

Storage on disk (CREQ files)
Listing on screen or printer

References:
Selection procedure: Section 3.3.15 (p.122)
Data structure: Section 4.2.19 (p.180)

Suboption c: '<u>Precipitation data</u>'

Functions:

It allows the entry of (monthly or decadal) precipitation data through keyboard or from Lotus files (LOT2GIL<u>a</u>.DIF), their correction and retrieval, and their processing and transfer into GILES internal precipitation data files (<u>a</u>PREC.TWY) for GILES land evaluation processes.

Table 3.13

Calculation of Precipitation Values (Example)

****

Station 1 Motta

mon	m mm	s mm	n	m0 mm	s0 mm	n0	cm mm	cs mm	cm0 mm	cs0 mm	p0 %	cCV %	cCV0 %
1	12.0	12.9	7	16.8	12.1	5	6.9	11.5	10.7	10.8	0.29	167	101
2	23.0	25.2	6	34.5	23.0	4	24.2	25.0	35.5	22.7	0.33	103	64
3	44.1	26.2	7	44.1	26.2	7	35.3	19.5	35.3	19.5	0.00	55	55
4	47.0	36.3	7	47.0	36.3	7	35.9	35.0	35.9	35.0	0.00	97	97
5	86.5	33.2	6	86.5	33.2	6	79.7	44.1	79.7	44.1	0.00	55	55
6	119.7	68.5	6	119.7	68.5	6	109.5	53.8	109.5	53.8	0.00	49	49
7	358.3	110.7	7	358.3	110.7	7	341.8	106.6	341.8	106.6	0.00	31	31
8	313.9	81.4	8	313.9	81.4	8	290.3	70.1	290.3	70.1	0.00	24	24
9	157.5	23.3	8	157.5	23.3	8	158.5	22.9	158.5	22.9	0.00	14	14
10	69.8	69.0	8	93.0	63.8	6	87.9	74.9	108.0	72.1	0.25	85	67
11	24.6	28.3	8	28.1	28.7	7	57.6	57.2	64.0	56.7	0.13	99	89
12	4.1	3.9	7	4.8	3.8	6	11.6	8.2	11.1	6.9	0.14	71	62
							1239		1280				

****

Station 2 Felege Berhan

mon	m mm	s mm	n	m0 mm	s0 mm	n0	cm mm	cs mm	cm0 mm	cs0 mm	p0 %	cCV %	cCV0 %
1	7.6	10.0	4	10.1	10.5	3	8.7	17.6	14.7	19.1	0.25	202	130
2	15.5	28.9	4	31.1	39.2	2	23.3	31.5	41.2	41.6	0.50	135	101
3	26.3	24.9	3	26.3	24.9	3	37.0	63.4	37.0	63.4	0.00	171	171
4	54.2	38.8	3	54.2	38.8	3	40.8	25.6	40.8	25.6	0.00	63	63
5	87.2	19.2	3	87.2	19.2	3	78.7	13.9	78.7	13.9	0.00	18	18
6	140.8	55.5	3	140.8	55.5	3	135.1	48.5	135.1	48.5	0.00	36	36
7	315.7	29.3	4	315.7	29.3	4	408.3	28.0	408.3	28.0	0.00	7	7
8	251.4	81.5	5	251.4	81.5	5	248.9	60.5	248.9	60.5	0.00	24	24
9	144.1	101.5	5	180.1	71.3	4	168.9	163.6	211.1	115.0	0.20	97	54
10	45.5	35.4	5	56.9	28.4	4	69.4	38.5	73.1	31.7	0.20	55	43
11	13.7	9.9	4	13.7	9.9	4	25.2	14.0	28.0	14.2	0.00	56	51
12	5.4	6.3	3	8.2	6.0	2	10.4	9.7	13.9	8.1	0.33	93	58
							1255		1331				

****

Station 3 Finote Selam

mon	m mm	s mm	n	m0 mm	s0 mm	n0	cm mm	cs mm	cm0 mm	cs0 mm	p0 %	cCV %	cCV0 %
1	2.3	2.9	9	4.1	2.7	5	1.8	2.3	2.8	2.2	0.44	128	79
2	5.2	8.2	9	11.7	8.8	4	6.8	8.7	14.0	9.0	0.56	128	64
3	45.7	26.1	9	45.7	26.1	9	35.9	20.1	35.9	20.1	0.00	56	[illegible]
4	38.7	30.4	9	38.7	30.4	9	36.2	28.5	36.2	28.5	0.00	[illegible]	
			9	95.8	36.2	9	116.7	35.3	116.7	35.3	0.00		
				[illegible]	43.5	9	127.0	42.2	127.0	42.2	0		
					53.1	10	236.2	60.5	236.2	60.5			
					[illegible]	11	201.0	67.8	201.0	67			
						9	103.3	54.6	114.8				
							82.3	42.6	[illegible]				

Table 3.14

Generation of Precipitation Data and their Calculation (Example)

exp.rainf.at reliab.of 90% mm	80% mm	75% mm	66% mm	50% mm	25% mm	years with prec.	w/o	mean expected mm	sd mm	P %	mean calculated mm	sd mm	P %	mean mm	sd mm
								0	0	0	0	0	0		
M O N T H L Y V A L U E S O F P M U 1															
0	0	0	24	73	181	143	57	17	16	26	17.2	15.0	29	12.3	14.9
0	24	27	32	38	49	169	31	43	15	13	42.8	18.2	16	36.2	22.7
61	69	73	78	86	101	193	7	89	22	2	86.5	22.8	4	83.5	27.4
37	44	47	52	60	75	199	1	64	21	2	63.5	22.3	1	63.2	22.6
83	93	97	102	112	128	199	1	115	23	2	113.8	26.3	1	113.2	27.5
83	93	97	102	112	128	195	5	115	23	2	111.7	29.2	3	108.9	33.7
189	208	215	226	245	277	200	0	250	47	0	243.5	59.6	0	243.5	59.6
152	167	172	181	196	221	200	0	200	37	0	200.3	46.7	0	200.3	46.7
83	93	97	102	112	128	198	2	115	23	2	113.2	27.4	1	112.1	29.3
61	69	73	78	86	101	197	3	89	22	2	86.9	20.5	2	85.6	22.9
8	14	16	20	26	39	193	7	32	19	5	31.8	20.7	4	30.7	21.1
0	4	12	30	70	170	159	41	15	16	17	15.9	18.0	21	12.7	17.2
A N N U A L V A L U E S O F P M U 1															
summation through the years :															
757	877	925	1028	1216	1598						1102.1	107.2	0	1102.1	107.2
summation through the months :															
						196					1127.1			1102.2	

****

exp.rainf.at reliab.of 90% mm	80% mm	75% mm	66% mm	50% mm	25% mm	years with prec.	w/o	mean expected mm	sd mm	P %	mean calculated mm	sd mm	P %	mean mm	sd mm
								0	0	0	0	0	0		
M O N T H L Y V A L U E S O F P M U 2															
13	20	23	27	34	48	187	13	40	20	5	39.2	17.2	7	36.7	19.1
		49	54	62	76	189	11	66	20	5	65.6				
			-	5	5	193	7	89	17	2					

3.2.1.13 'Entry of base map':

Function:

This is the option to enter maps ('base maps') in digitized form into the computer. In particular, it is possible to:

- enter mapping units,
- display maps on screen,
- highlight uncovered (blank) areas (grid cells),
- print uncovered (blank) areas (grid cells),
- correct single locations (single grid cell),
- enter data (mapping units) by latitude/longitude,
- fill all blank areas in a specified window with a mapping unit,

and to store them as map files.

Additionally, it is possible to measure areal units (areas) or linear units (lines).

Requirements:

Mapping unit codes (MUC file)
Study area names (STAREA file)
Original map
Recommended: 29-112-transparent overlay

Output:

Storage on disk (MAP files)
Printed list of blank pixels

References:

Selection procedure: Section 3.3.18 (3) (p.126) and 3.3.17 (p.125)
Program structure: App.8.5 (p.243)

3.2.1.14 'Systematic change of base maps':

Functions:

This module serves as a utility to modify base maps, to:

- overlay and check two maps, if they are identical in covering the same total area (with automatic assignment on request, 'cutting')
- replace ('substitute') mapping units (not more than 700)) to form a modified / new
- aggregate mapping units (not more than 700)) 'base map'
- shift (move) parts of a map
- define corridors along roads (only for 'LIN' maps)
- compare two mapping units of two different maps for their identity, with eventually new assignment

Example: Corridor map (see next page)

Requirements:

Maps (MAP files)
Mapping unit codes (MUC files)
Study area names (STAREA file)

Output:

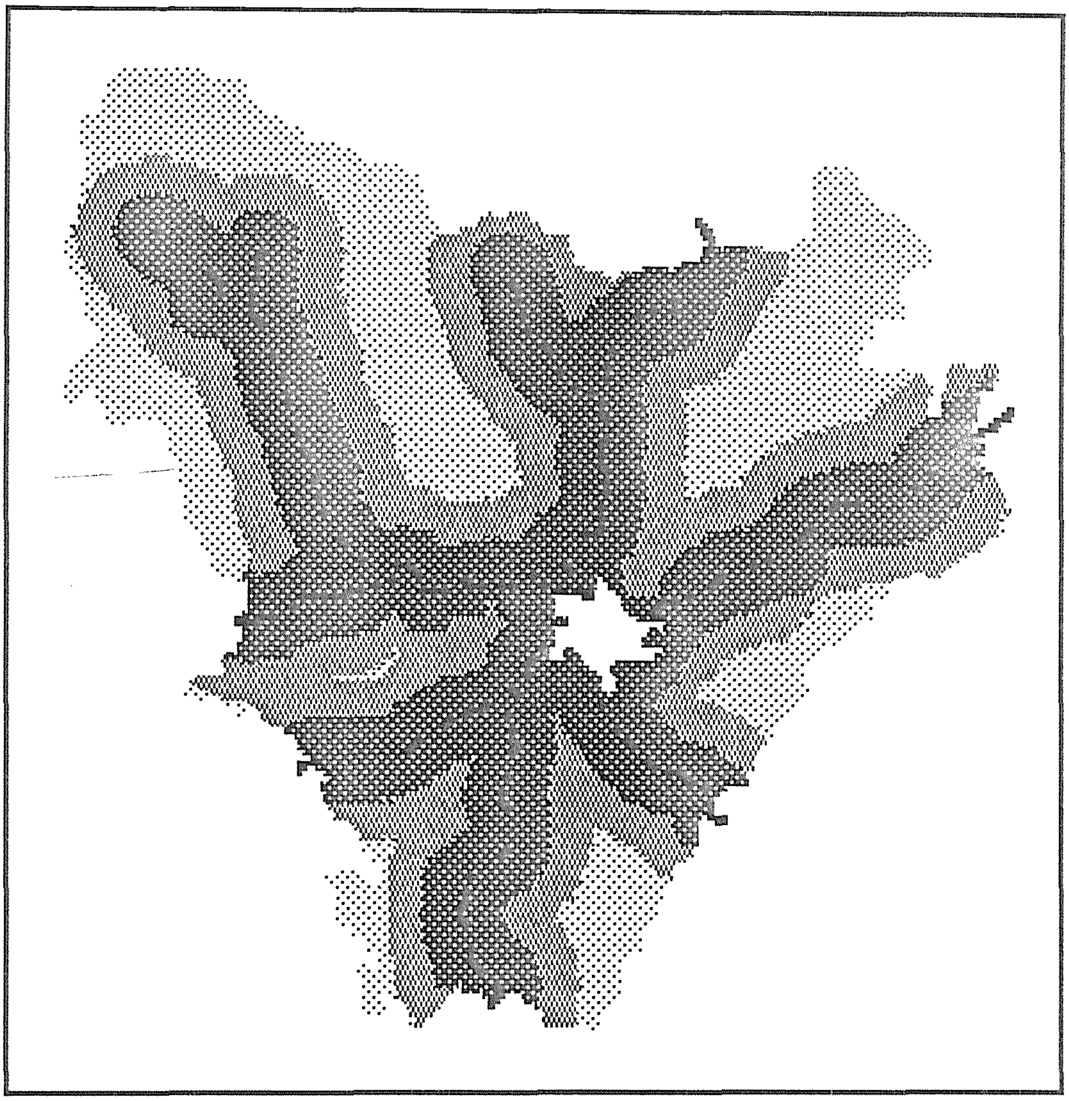
Maps (MAP files)
Print list of pixels showing discrepancies

References:

Selection procedure: Section 3.3.18 (6) (p.127)
Program structure: App.8.6 (p.243)

Map 3.15

Overlay of Base Maps (Example)



Roads and 'Corridors' in Menagesha

3.2.1.15 'Chaining of various selections':

Functions:

Chaining of following GILES procedures can be stored in a queue and processed one after the other:

- climatic suitability assessment
- soil suitability assessment
- land suitability assessment
- map overlay of 2 maps
- DOS copy operation

Crop, input level, land improvement(s) for suitability assessments, specification of source and target for file copying, map specification for map overlays will be entered for each chained procedure. All processes will be made for the entire study area; definition of windows is not possible.

Requirements:

as requested by the individual processes
Study area names (STAREA file)

Output:

Queue (C:\INTERM\CONTFILE.DAT' file), requesting the individual processes

References:

Selection procedure: Section 3.3.14 (p.121)
Program structure: App.8.4 (p.242)

3.2.1.16 'File operation':

Functions:

With this option, it is possible to:

- copy files,
- erase files,
- show the content of an ASCII file,
- list directories.

Thus, DOS commands are supported.

Requirements:

Concerned files
Study area names (STAREA file)

Output:

(DOS processing)

References:

Program structure: App.8.3 (p.242)

3.2.1.17 'Shell to DOS':

Function:

Shelling to DOS is possible. Return to GILES is made by typing 'EXIT' at the DOS prompt.

It is not recommended to load resident programs such as 'Inset' in shell mode.

3.2.1.18 'Exit to DOS':

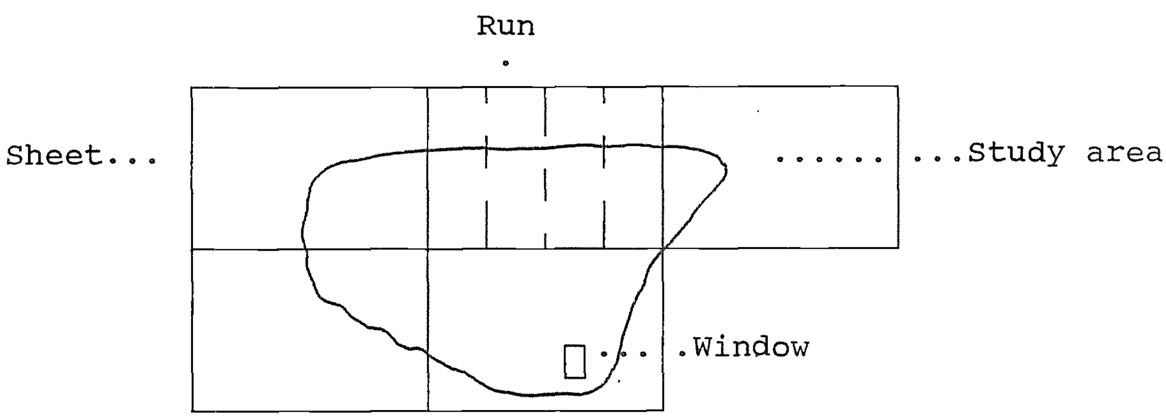
Function:

By this option, GILES will be left and return is made to the operating system.

3.2.2 Specification of retrieved area

The retrieval of maps can be defined for a specified area:

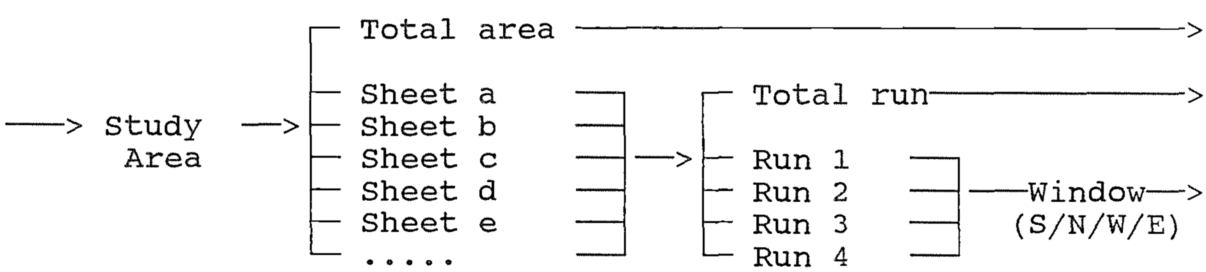
- for the entire study area, or:
- for one, individual (entire) map sheet
  (Sheet is one part of the study area defined in the map index (see Section 3.3.15 (p.121) and App.10 (p.259), or:
- for one run (quarter) of one sheet
  (Run is a vertical strip covering one quarter of one map sheet), or:
- for a part of one run ('window')
  ('Window' is a rectangular part of a run defined by its N, S, W, E margin; see 'How to define a window", Section 3.3.7; p.112).



The definition will be set in 2 - 4 steps (study area/sheet/ run/window selection). As smaller the requested area is, as more menus (selection steps) have to be passed:

Table 3.15

Area Retrieval



3.2.3 Specification of output

Output of maps and tables can be:

- display on screen: - scrolling mode (with fonts/letters)
  - high resolution image mode
- hardcopy on paper: - matrix printer (through GILES)
  printer (through screen dump utility)
  - plotter (through GILES)
- storage on disk: - GILES format (extension MAP)
  - ASCII format (extension PRN)

For **display** on CGA or MDA screen, only scrolling of the grid cells at the monitor in 'scrolling mode' (showing letters/fonts) is possible (raster map). Fonts can be changed to give a gradual shading pattern (either only for the requested map or permanently; see Section 3.3.11; p.118 and App.9, p.255).

High resolution images display either the entire area or one map sheet in up to 16 colors. This is only possible in EGA, VGA or PGA mode.

Zooming during or after display is not possible. If zooming is requested, it has to be set through window definition (see Section 3.2.2. p.97).

Through GILES it is possible to **print** large size maps for all map version either on printer or plotter. A matrix printer (Epson FX, EX, LX, RX, MX, LQ or compatible) prints raster maps showing a font for each grid cell. Fonts can be changed (see above).

If a high resolution display is installed, it is recommended to use screen dump and edit utility software for printout of small size text maps. Good experience is made with 'Inset' (by MicroPro), somehow less, but still satisfying results can be made with 'Grab' (by WordPerfect), 'Egaprint' (public domain) or similar packages (see 'How to dump a screen', Section 3.3.31; p.147).

The advantages of matrix printers for map print are high speed, low costs (paper, ribbon), and easy handling. The disadvantages are the lower quality, the relatively small width of the paper (at 132 column paper print width is 28 cm) making it necessary to stick the various runs together manually, and the limited range of scale: Only 9 different outprint scales are supported in the present version:

Table 3.16

Outprint Scales on Matrix Printer

Ratio outprint scale / map entry scale	E.g. input of 1:50,000 results in output scale of	1:106,000	
1.00	1: 50,000	1:106,000	
1.18	1: 59,000	1:125,000	
1.50	1: 75,000	1:159,000	*
1.70	1: 85,000	1:180,000	
2.00	1:100,000	1:212,000	
2.36	1:118,000	1:250,000	
2.50	1:125,000	1:265,000	*
3.00	1:150,000	1:318,000	*
3.92	1:196,000	1:415,500	

Plotting of maps by **plotter** requires more care for handling, is more expensive and slower, but quality is better, has more manipulation options and can produce colored maps.

At HP or Roland plotter, outplot maps can have a scale of:

Table 3.17

Outprint Scales on Plotter

Ratio outprint scale / map entry scale	E.g. input of 1:50,000 results in output scale of	1:106,000
(0.50)	(possible, but not recommended)	
0.70	1: 35,000	1: 74,000
.	.	.
.	.	.
10.00	1:500,000	1:1,060,000
(20.00)	(possible, but not recommended)	

At map plotting, it is possible to overlay the plot of various maps by leaving the paper in the plotter and "run" the next map.

Labels can be plotted with full length, with short form or can be omitted. They are automatically centered, but individual character placement can be selected by omitting and then plotting the labels individually at the requested spot. Label size is adjusted to the scale within a certain range.

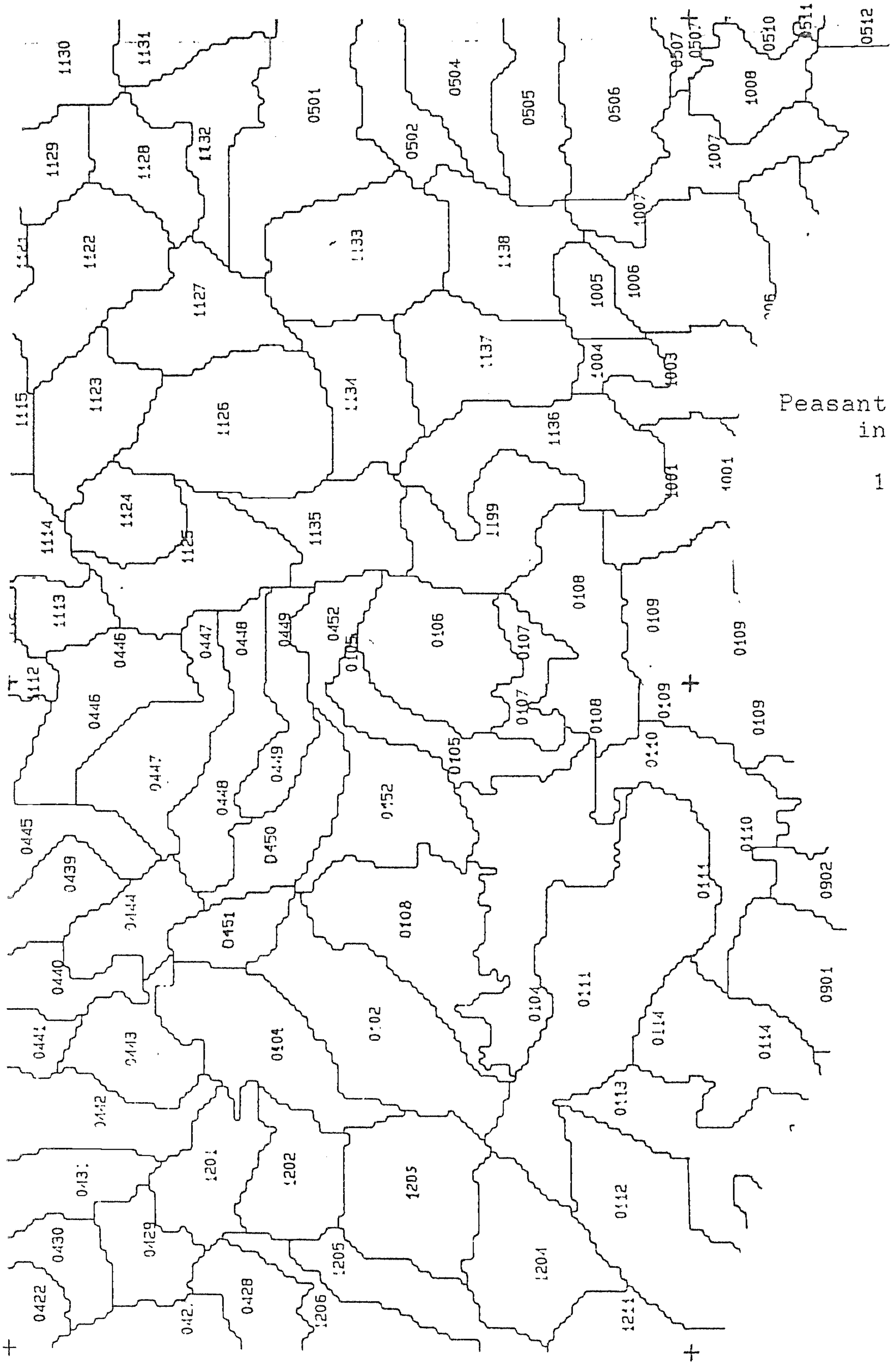
Tables can be printed with any kind of printer. It is possible to print the legend at the end of the map or only the legend with the area sizes (without map).

No direct support is given to manipulate tables or to produce graphs or charts out of numeric data, but data can be transformed in to specialized spreadsheet or graphic packages for manipulation and presentation.

Processed maps and tables can be stored on **computer storage** media, i.e. disks. The only accepted drive/subdirectory specification for storing is C:\INTERM\.... From there the configured GILES files (maps: 'DGaCMPmn.MAP' with 'DGpCMP.NAM' files) or ASCII files (maps: 'DG0CMPmn.PRN' files or tables: 'GIL2LOTc.PRN' files for processing in Lotus) can be copied to other disks or subdirectories using GILES utilities or DOS commands. DIF map files can be translated from ASCII files using Lotus environment (see Section 3.3.28 (3); p.143).

Map 3.19

Plotted 'Boundary Map' (Example)

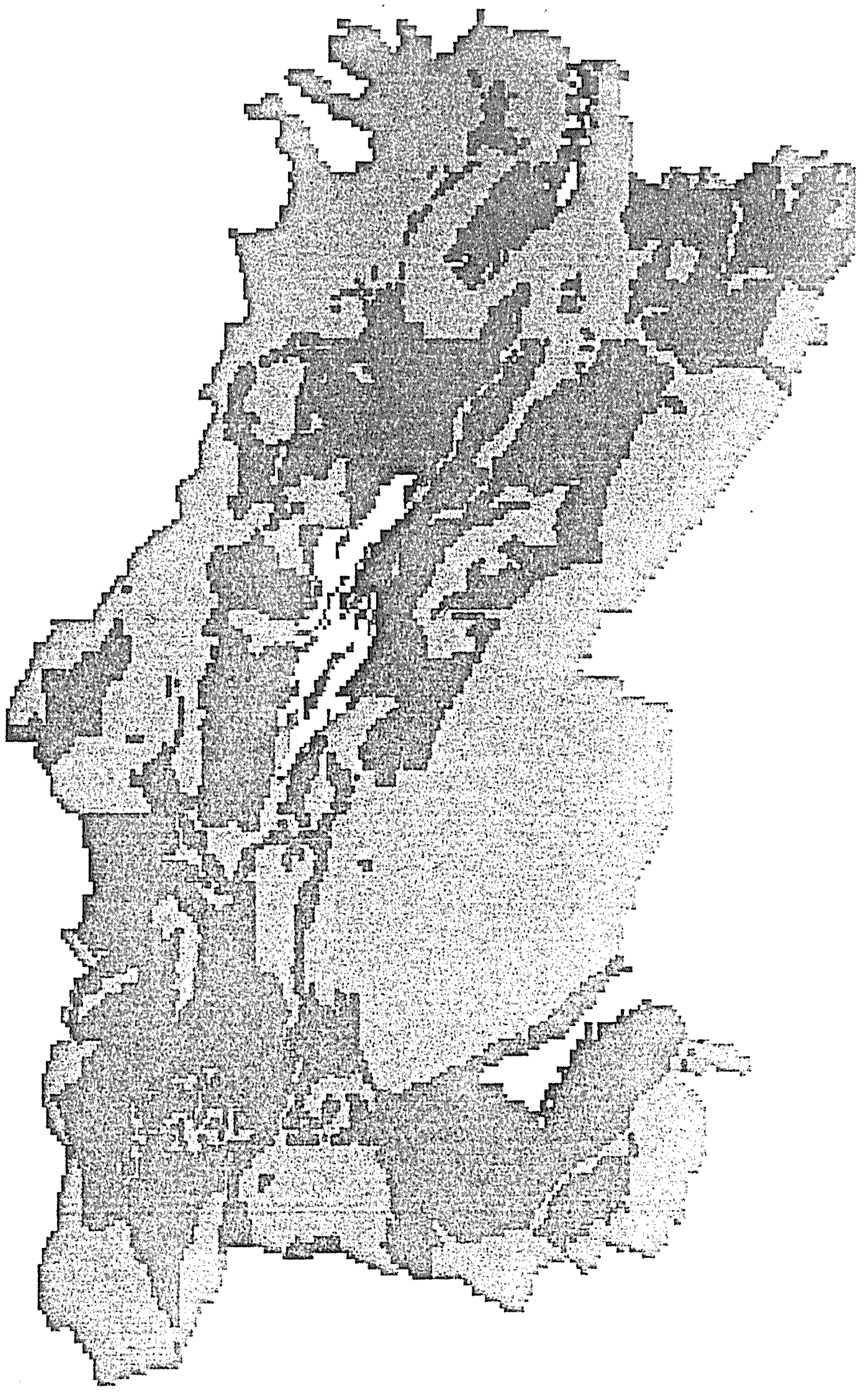


Peasant Associations
in Borkena

1:250 000

Map 3.20

'Colored hatched Map' (Example)



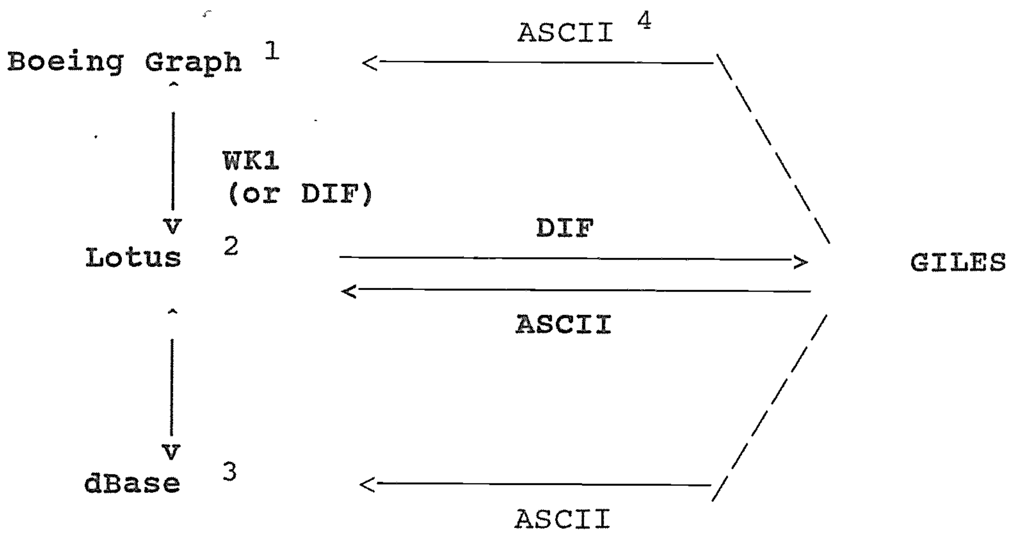
3.2.4 Setup of hardware

The hardware is set up automatically (selection of screen and graphic adapter). Software and 'general data' must be installed in drive C:, subdirectory '\LANDEV\'.

The default drive for maps is C:, subdirectory \aDG\ (where a is the working abbreviation of the area), but can be modified through menu. If a virtual disk (e.g. D:) with at least 250 kB is installed, retrieval can be accelerated by copying the map(s) (MAP files) to the virtual drive and to retrieve from there (see 'How to speed up map retrieval', Section 3.3.30; p.145).

3.2.5 Transfer

Transfer to and from other software packages is made in following formats:

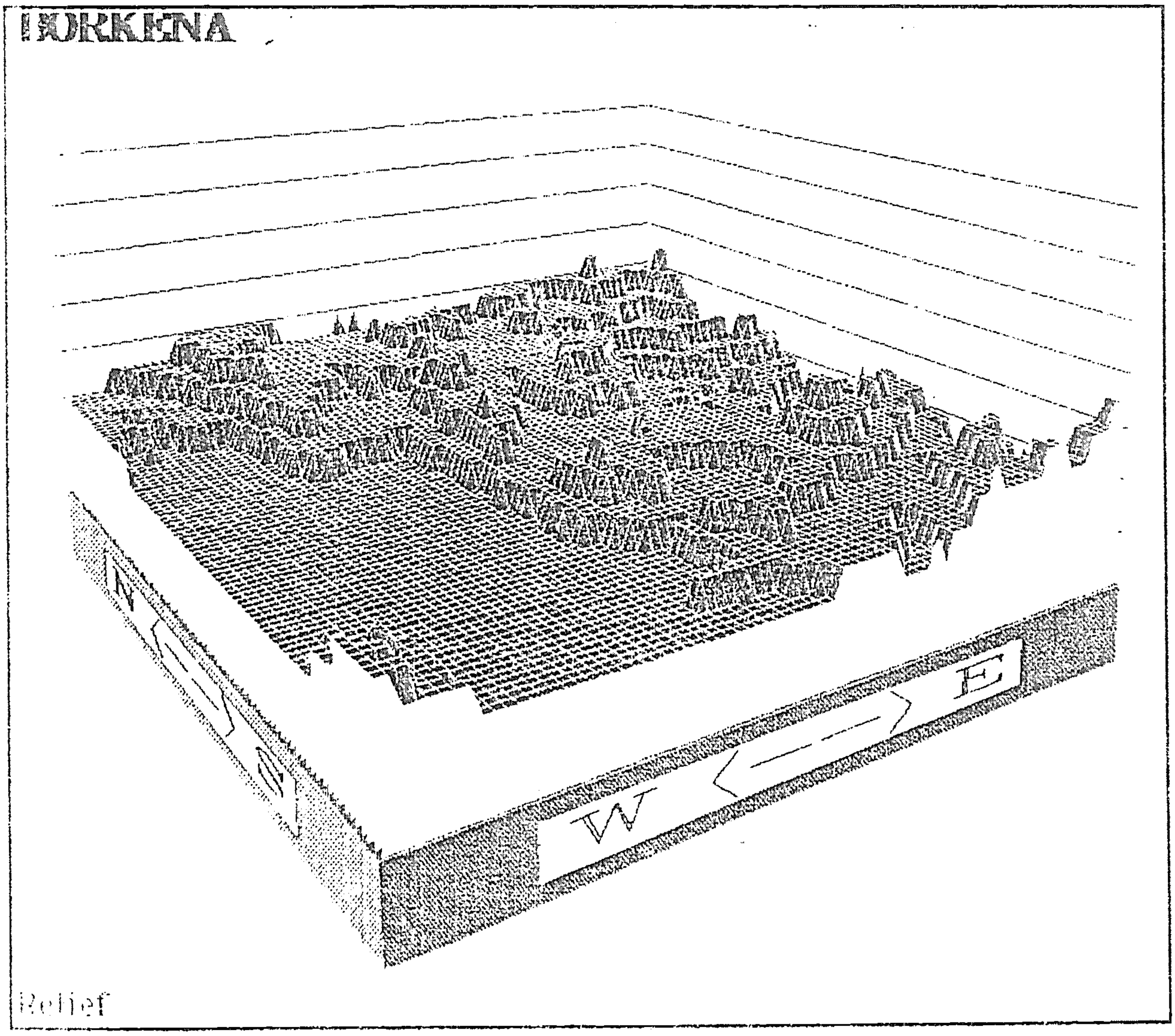


Recommended is the process through Lotus 1-2-3 if available.

[1] or similar 3D graphic packages
[2] or similar spreadsheet packages
[3] or similar database packages
[4] with extension .DAT

Map 3.21

3 D Map (example)



3.3 HOW TO ...

In this chapter various procedures are described step-by-step ('menu-by-menu') in their default versions. The selected options can be modified, e.g. instead of retrieving the 'whole study area' it is possible to ask only for one sheet, or can be combined. Various other output forms, not listed here, can be selected. Following functions are explained:

Table 3.18

Sample Procedures

3.3.1 How to Start

Make sure the C> prompt is on screen indicating that the default drive is C: at root directory level. Type

GILES <Enter>

and the first GILES display will appear on screen prompting for the Main Menu.

If problems occur during execution and Quickbasic version 4.0 is installed, GILES has to be started by:

\QUICKB4\QB /RUN \LANDEV\SELE1

3.3.2 How to Exit GILES

1) Press F10 function key
   (unless you are already in the Main Menu)

2) Main Menu: Select 'out (Exit to system)' and return to DOS

3.3.3 How to Retrieve a Complete Base Map

'Complete' means non-aggregating, without (map) generalization.

1) Select area and map

- 1.1) Main Menu: Select 'Base map (complete/selective/aggregating/parametric)'
- 1.2) Select study area
- 1.3) Select 'Whole study area'
- 1.4) Accept 'C:<--- default'
- 1.5) Accept the default subdirectory
- 1.6) Select map
- 1.7) Select 'Complete map'

2) Select output form

- 2.1) Select 'Map/data on screen only' for display
- 2.2) With high resolution mode:
  Select 'High resolution image'
  Select: 'No'
  Select: 'Right column' and <Enter>

3.3.4 How to Retrieve a Parametric Map

A parameter is a land characteristic read out of the soil (e.g.drainage, slope), altitude (e.g.temperature range) or precipitation map, or a structural characteristic (e.g.population density, access situation) read out of the administrative map through translation tables. It is possible to retrieve a specific map of one characteristic:

1) Select area and map

- 1.1) Main Menu: Select 'Base map (complete/selective/aggregating/parametric)'
- 1.2) Select study area
- 1.3) Select 'Whole study area'
- 1.4) Accept 'C: <--- default'
- 1.5) Accept the default subdirectory
- 1.6) Select 'Parametric map'
- 1.7) Select 'Complete map'
- 1.8) Select considered parameter ('Land/structural characteristic', e.g.drainage)

2) Select output form

- 2.1) Select 'Map/data on screen only' for display
- 2.2) With high resolution mode:
  Select 'High resolution image'
  Select: 'No'
  Select: 'Right column' and <Enter>

3.3.5 How to Assess the Land Suitability for a Crop

1) Assess the **suitability of the climate** for the requested crop

1.1) Main Menu: Select 'Climatic suitability'
1.2) Select study area
1.3) Select 'Whole study area'
1.4) Accept 'C:<--- default'
1.5) Accept the default subdirectory
1.6) Select '75 %'
1.7) Select 'With consideration of occurring soils'
1.8) Select crop and input level
1.9) Select 'No'
1.10) Select 'As (1) with storage.....'
1.11) With high resolution mode: Select 'High resolution'
1.12) Accept the default storage number 1
1.13) With high resolution mode: Select: 'No' and 'Right column' and <Enter>
After retrieval of the map:
1.13) Press Space to return to Main Menu

2) Assess the **suitability of the soil** for the requested crop

2.1) Main Menu: Select 'Soil suitability'
2.2) Process through all menus with the selection of the area, considered crop, input level and land improvement(s), as above
-- *which has to be equal with the previous selection*
2.3) Select 'As (1) with storage ...'
2.4) With high resolution mode: Select 'High resolution'
2.5) Accept the default storage number 2
2.6) With high resolution mode: Select 'No' and 'Right column' and <Enter>
After retrieval of the map:
2.6) Press Space to return to Main Menu

3) Combine the climatic suitability with the soil suitability and take management and conservation factors into consideration

3.1) Main Menu: Select 'Land suitability'
3.2) Process through all menus with the selection of the area, considered crop, input level, land improvement(s), as above
-- *which has to be equal with the previous selections*
3.3) Select 'Map/data on screen only' for display
3.4) With high resolution mode: Select 'High resolution'
3.5) Select 'no'
3.6) With high resolution mode: Select: 'No' and 'Right column' and <Enter>

After retrieval of the map:
3.6) Press Space to return to Main Menu

3.3.6 How to Combine Crop Suitabilities to Form a Crop Mix Suitability Assessment

1) Assess the crop suitability for the first crop

1.1) Process the crop suitability map as described under
'How to assess the land suitability for a crop' (Section 3.3.5; p.110), **but:**
1.2) Select 'As (3) with storage of ...'
1.3) Select #3

After retrieval of the map:
1.4) Press Space to return to Main Menu

2) Repeat step 1 for each crop of the crop mix,
but store the map(s) **under different number(s)**,
(e.g. in step 1.3 #4 for the second crop,
#5 for the third crop etc.)

3) Overlay these maps to form the crop mix suitability map

3.1) Main Menu: Select 'Overlay/reprint of previously configured map(s)'
3.2) Select study area
3.3) Select 'Whole study area'
3.4) Accept 'C: <--- default'
3.5) Accept the default subdirectory
3.6) Select 'Map/data on screen only' for display
3.7) With high resolution mode:
Select 'High resolution image'
Select: 'No'
Select: 'Right column' and <Enter>
3.8) Select the option with the number of suitability maps
3.9) Select the line with the 1.suitability map
3.10) Repeat step 3.9 for the other suitability maps

After retrieval of the map:
3.11) Press Space to return to Main Menu

3.3.7 How to Define a Window at Map Retrieval

A window is defined as a **rectangular** part of the map of the project area (see Glossary: window, irregular window)

1) Start with the selection of the required map as described in the other 'How to ... ' Sections

2) At the selection of the area, proceed as follows:

   2.1) Define the window at the map using the 29-112-transparent: (see p.125)
   Write down the x and y coordinates
   2.1) Select study area
   2.2) Select the map sheet of the window
   2.3) Select the run (quarter of a sheet) of the window
   2.4) Enter:
   southern margin of the window: 1-111
   (y/row number of the 29-112-transparent)
   northern margin of the window: 2-112
   (y/row number of the 29-112-transparent)
   western margin of the window: 1-28
   (x/column number of the 29-112-transparent)
   eastern margin of the window: 2-29
   (x/column number of the 29-112-transparent)

3) Continue with the selection of the required map as described
   in the other 'How to ...' Sections

3.3.8 How to Define an Irregular Window and to Print Thematic Maps of This Window

An **irregular window** is the area defined by one homogeneous characteristic (e.g. the area of a Peasant Association or the area of a valley) having an irregular (not rectangular) shape.

1) Define the irregular window

1.1) Main Menu: Select 'Base map (complete/selective/aggregating/parametric)'
1.2) Select study area
1.3) Select 'Whole study area'
1.4) Accept 'C:<--- default'
1.5) Accept the default subdirectory
1.6) Select the map by which the window is defined
1.7) Select 'Selective/aggregating map'
1.8) Enter '1'
1.9) Select 'Enter right now'
1.10) Select the unit
It is possible to add another mapping unit(s) !
When finished, select 'Not more in this unit'
1.11) Select 'As (1) with storage ...'
1.12) With high resolution mode: Select 'High resolution image'
1.13) Choose one of the proposed numbers (e.g. #9)
1.14) With high resolution mode:
Select: 'No'
Select: 'Right column' and <Enter>

After retrieval of the map:
1.15) Press Space to return to Main Menu

2) If the total number of mapping units of the 'main map' is not known:

2.1) Main Menu: Select 'Database'
2.2) Select study area
2.3) Select 'Mapping unit codes'
2.4) Select map
2.5) Select 'See the data'
2.6) Note the number of the last unit **(except 'OUT')** and press any key
2.7) Select 'Return to Main Menu'
2.8) Press Space to return to Main Menu

3) Prepare the 'main map'

3.1) Main Menu: Select 'Base thematic map' (or any other map option)
3.2) Select study area
3.3) Select 'Whole study area'
3.4) Accept 'C: <--- default'
3.5) Accept the default subdirectory
3.6) Select map
3.7) Select 'Complete map'
If more than 70 mapping units occur at the 'main map', see Section 3.2 (3)
3.8) Select 'As (1) with storage ...'
3.9) Choose one of the proposed numbers, but not the one chosen under step 1.10 (e.g.4)
3.10) Continue as described in the other 'How to ...' Sections

After retrieval of the map:
3.11) Press Space to return to Main Menu

4) Make the overlay for the irregular window

4.1) Main Menu: Select 'Overlay/reprint of previously configured map(s) '
4.2) Select study area
4.3) Select 'Whole study area'
4.4) Accept 'C: <--- default'
4.5) Accept the default subdirectory
4.6) Select 'Map/data on screen only' for display
4.7) With high resolution mode: Select: 'High resolution image'
4.8) Select 'No'
4.9) With high resolution mode:
Select: 'No'
Select: 'Right column' and <Enter>

4.10) Select 'Overlay of main map with selected areas'
4.11) Select the main map, as defined under step 3.9
4.12) Select the select area, as defined under step 1.13

After retrieval of the map:
4.13) Press Space to return to Main Menu

3.3.9 How to Define 'Selected Areas' and to Retrieve Crosstabulation Statistics

'Selected areas' are defined by homogeneous characteristics (e.g. PAs). Any map can be overlaid with those 'selected areas' (e.g. suitability assessment = 'main map', PAs = 'selected areas').

1) Define the 'selected areas'

1.1) Main Menu: Select 'Base map (complete/selective/aggregating/parametric)'
1.2) Select study area
1.3) Select 'Whole study area'
1.4) Accept 'C: <--- default'
1.5) Accept the default subdirectory
1.6) Select the map by which the selected areas are defined
1.7) Select 'Complete map'
1.8) Select 'As (1) with storage ...'
1.9) With high resolution mode: Select 'High resolution image'
1.10) Choose one of the proposed numbers (e.g. #9)
1.11) With high resolution mode:
Select 'No'
Select 'Right column' and <Enter>

After retrieval of the map:
1.12) Press Space to return to Main Menu

2) If the total number of mapping units of the 'main map' is not known:

2.1) Main Menu: Select 'Database'
2.2) Select study area
2.3) Select 'Mapping unit codes'
2.4) Select map
2.5) Select 'See the data'
2.6) Note the number of the last unit (except 'OUT') and press any key
2.7) Select 'Return to Main Menu'
2.8) Press Space to return to Main Menu

3) Prepare the 'main map'

3.1) Main Menu: Select 'Base thematic map' (or any other map option)
3.2) Select study area
3.3) Select 'Whole study area'
3.4) Accept 'C:<--- default'
3.5) Accept the default subdirectory
3.6) Select the map
3.7) Select 'Complete map'
If more than 70 mapping units occur at
the 'main map', see Section 3.2 (3)
3.8) Select 'As (1) with storage ...'
3.9) Choose one of the proposed numbers, but
not the one chosen under step 1.10 (e.g.4)
3.10) Continue as described in the other 'How to ...' Sections

After retrieval of the map:
3.11) Press Space to return to Main Menu

4) Create the crosstabulation 'main map' - 'selected areas'

4.1) Main Menu: Select 'Overlay/reprint of previously configured map(s) '
4.2) Select study area
4.3) Select 'Whole study area'
4.4) Accept 'C:<--- default'
4.5) Accept the default subdirectory
4.6) Select 'Map/data on screen only' for display
4.7) With high resolution mode: Select: 'High resolution image'
4.8) Select 'Yes', if you want to transfer the table to Lotus
Select one of the five 'GIL2LOTa.PRN' files
4.9) With high resolution mode:
Select: 'No'
Select: 'Right column' and <Enter>

4.10) Select 'Overlay of main map with selected areas'
4.11) Select the main map, as defined under step 3.9
4.12) Select the 'selected areas', defined under step 1.10

After retrieval of the map:
4.13) Press Space to return to Main Menu

3.3.10 <u>How to Plot</u>

1) Prepare the map

1.1) Select the map to be plotted
(This can be any map offered by GILES,
e.g. map overlays, LGP map, suitability map etc.)
But due to the limitation of color pens, it is recommended not to select maps with more than 8 different units !

1.2) Select 'As (1) with storage of ...'

1.3) Select the number of storage (e.g. #4)

After retrieval of the map:

1.4) Press Space to return to the Main Menu

2) Initiate plotting

2.1) Main Menu: Select 'Overlay/reprint of previously configured map(s)'

2.2) Select study area

2.3) Select 'Whole study area'

2.4) Accept 'C:<--- default'

2.5) Accept the default subdirectory

2.6) Select 'Map/data on screen and map on paper by plotter (4)'

2.7) With high resolution mode:
Select: 'No'
Select: 'Right column' and <Enter>

2.8) Enter the scale

2.9) Select '1 map, previously produced and stored'

2.10) Select the map to be plotted, defined under step 1.3

3) Install the plotter and give the required parameters

3.1) Load the pen holder with the pens:
1: black 0.7 mm
2: black 0.3 mm
3...: any color 0.3 mm

3.2) Load the plotter paper against the left rail (close and parallel, but not too tight !) and align with the rear guide (small white line)

3.3) Select 'no'

3.4) Select 'Mapping unit name'

3.5) Select 'Black 0.3 mm'

3.6) Select 'Black 0.3 mm'

3.7) Select 'Solid lines'

After plotting:

3.9) Enter 'N' for no title outprint

3.10) Press 'N' for no additional symbols

3.3.11 How to Change Fonts (Mapping Unit Outprint Symbols)

At line printers, each grid cell is printed with a symbol characteristic for the occurring mapping unit. These outprint symbols can be changed (e.g. to make them darker or brighter), either **permanently** through this procedure or temporarily. See App.9 (p.255) for a list of recommended fonts and ASCII codes.

1.1) Main Menu: Select 'Database'
1.2) Select study area
1.3) Select 'Mapping unit codes'
1.4) Select map
1.5) Select 'See the data'
1.6) Note the number (left column) of the mapping unit(s) which outprint symbol(s) are to be changed and press any key
1.7) Select 'Mapping unit codes'
1.8) Select the map
1.9) Select 'Enter/change part of the data'
1.10) Enter the number of the mapping unit (see step 1.6)
1.11) Press <Enter> to leave the mapping unit,
then enter the number of the new symbol (font) (see App.9; p.255)
1.12) Enter "n"
1.13) Save ("Y", then "YY")
1.14) Select 'Return to Main Menu'

3.3.12 How to Add a Crop

At the present, 43 crops (mainly those being used and/or have a potential in the highlands of Ethiopia) are entered into GILES with their requirements to allow suitability assessments. The list of these crops is found in Section 4.2.19 (p.181).
Additional crops can be entered by:

1) If the total number of crops is not known:

1.1) Main Menu: Select 'Database'
1.2) Select any project area
1.3) Select 'LUT/crop names'
1.4) Select 'See the data'
1.5) Press <Enter> two or three times, till you reach the last page note the number of the last crop and press any key
1.6) Select 'Return to Main Menu'
1.7) Press Space to return to Main Menu

2) Enter the crop name (in 'lut.nam' file):

2.1) Main Menu: Select 'Database'
2.3) Select any project area
2.4) Select 'LUT/crop names'
2.5) Select 'Enter/change part of the data'
2.6) Enter the number of the first blank line (number of crops + 1, see step 1.5)
2.7) Enter the name
2.8) Save it and return to Main Menu
("Y", then "YY" and 'Return to Main Menu')

3) Enter the crop requirements (in 'creqo.dat' file):

3.1) Main Menu: Select 'Database'
3.2) Select any project area
3.3) Select 'Crop requirements'
3.4) Select 'no'
3.5) Select the (new) crop
3.6) Select 'Low'
3.7) Enter the crop requirement for the specific quality in integer numbers (accepted ranges are indicated)
Or: Press <Enter> to leave the previous code.
3.8) Repeat step 3.7 for all qualities
To scan through all requirements, hold <Enter>
F2 function key brings you back one line.
3.9) Repeat step 3.1-3.8 for 'intermediate' input level
3.10) Repeat step 3.1-3.8 for 'high' input level
3.11) Press Space to return to Main Menu

3.3.13 How to Calculate Area Sizes

1.1) Main Menu: Select 'Area sizes'
1.2) Select study area
1.3) Select 'Whole study area'
1.4) Accept 'C: <--- default'
1.5) Accept the default subdirectory
1.6) Select the map
1.7) Indicate if you want outprint on paper or only display on screen
1.8) Select 'no' (if you do not want the figures transferred into Lotus worksheet file)
1.9) Select 'yes' (if the area size files are already prepared)
1.10) Press Space to return to Main Menu

3.3.14 How to Chain Processes

Time consuming processing can be stored in a chain file ('C:\landev\contfile.dat') which executes the requested procedures one after the other.

1) Create chain file

1.1) Main Menu: Select 'Chaining of various procedures'
1.2) Select study area
1.3) Select the procedure which should be processed first/next
1.4) Select crop
1.5) Select input level
1.6) Select land improvement
1.7) Select 'No' for map outprint
1.8) Select 'No' for legend outprint
1.9) Enter if you want to store the map and eventually the storage number (1-9)
1.10) Enter 'No' for transfer of output tables to Lotus

2) Repeat step 1.3 - 1.10 for each selected procedure to be next in the chain file

3) Leave the entry mode and start processing

3.1) Select 'End and START'

3.3.15 How to Start With a New Area

If this is the first area, see under 'How to start first time':
Section 3.3.21 (p.133)

1) Select the scale for map entry

The scale of map entry into GILES can vary.

It is recommended to have the map entry scale being 2-4 times greater than most of the output maps or inventory maps by **enlarging the base maps photographically** by this factor. This will smoothen the curves of the mapping units and make map entry easier.

The map entry scale should by no means be smaller than the output maps !

Particularly, the factor **2.36** is highly recommended because that allows the outprint of maps on matrix printer in the same scale as the base thematic maps (unmodified scale).

E.g. at inventory scale of 1:250,000, it is advisable to enlarge the maps to the scale of
1:250,000 * 2.36 = approx. 1:106,000

As more the map scale will be enlarged, as smaller will be the area covered by one individual pixel and as more detailed will be the information.

$$\text{Area size of one pixel (ha)} = \frac{(\text{scale (in thousands)} * 5)^2}{10000}$$

Eg.: Entry Scale	Pixel Coverage	Pixel Size
1: 50,000	250 x 250 m	6.25 ha
1:106,000	530 x 530 m	28.09 ha
1:250,000	1250 x 1250 m	156.25 ha

2) Define the map sheets of the area

Split the map of the whole area into 55.5 x 56.0 cm (HxW) sheets, eventually photographically enlarged.

If an adjacent map was entered into GILES before, it is recommended to extend the sheet frame to the new area.

Otherwise, you start with a reference point in the central part of the project area being the junction of either latitude/longitude or UTM grid system. This reference point should be the corner of the four adjacent map sheets. Then process from these four sheets into all directions.

This is the setup of the '**map index**', i.e. the definition of the relative location of the map sheets (Example, see App.10; p.257). There are 4 runs on each map sheet: Each 55.5 cm x 14 cm (HxW) (see Section 3.2.2; p.97 and 3.3.17; p.125).

3) Enter required parameters into GILES (in 'starea.nam' file):

3.1) Main Menu: Select 'Database'
3.2) Select any area
3.3) Select 'study areas'
3.4) Select 'Change the size (dimension) of the data set'
3.5) Enter: 1 ('add additional area')
3.6) Enter the name of the new project area (up to 15 letters; e.g. Ethiopia)
3.7) Enter the working abbreviation (3 or 4 letters; e.g. ETH)
3.8) Enter the scale (as defined under step 1)
3.9) Enter the number of soil types in the project area
[1] (not: soil mapping units)
3.10) Additional maps **can** be entered by giving:
[1] - map theme (map name; e.g. Evapotranspiration)
- working abbreviation (3 or 4 letters; e.g.PET)
If no (or not more) additional maps shall be indicated, press <Enter>
3.11) For all map sheets of the area, there **must be** entered:
- all sheet names
- working abbreviation of all sheets (one letter or one digit; <Enter> for proposed default: 1..)
- relative position to the previous sheet:

1 one to the right	6 down and one to the left
2 two to the right	7 down and two to the left
3 three to the right	8 down and three to the left
4 four to the right	9 down and four to the left
5 one down	

- N,S,W,E coordinates of sheet frame (in latitude and longitude, with decimals)
3.12) Save, return and exit to DOS

[1] Not essential

3.3.16 How to Define an Additional Map

Following maps are predefined and already installed:
- Soil map
- Altitude map
- Precipitation map
- Land use/land cover map
- Administrative map
- Agroecological zones map
- Planning zones map

For these 7 maps the following procedure can be omitted.

Up to 9 additional new maps can be specified:

1) Define the new additional map

1.1) Main Menu: Select 'Database'
1.2) Select project area
1.3) Select 'Study areas'
1.4) Select 'Enter/change part of the data'
1.5) For the first additional map, give: 101;
for the second additional map, give: 102 etc.
1.6) Enter the title of the specific map (up to 15 letters; e.g. trifolium map)
1.7) Enter working abbreviation (3 or 4 letters; e.g. TRI)
1.8) Save and return to Main Menu

2) Enter the mapping unit codes

See Section 3.3.18 (2); p.126.

3.3.17 <u>How to Prepare a Map For Entry</u>

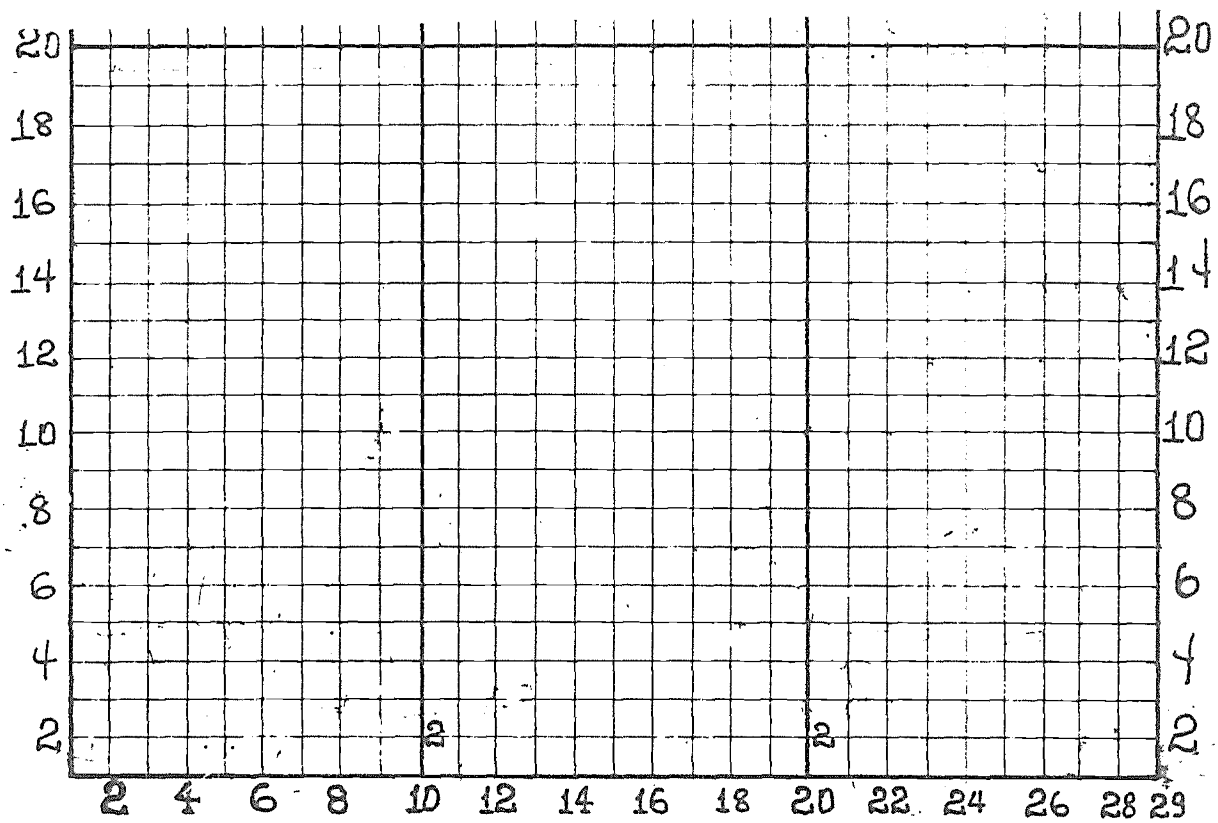
1) If the scale is not chosen yet, decide on the scale for map entry (see 'How to enter a new area', 3.3.15(1); p.122).

2) If the area is not divided into various map sheets, follow the criteria given under step 2 of 'How to start with a new area' (Section 3.3.15; p.122) to decide on map sheet divisions and mark them at the map(s) of the area.

3) Prepare a transparent with 29-112 grid cell system, with:
   - 28 columns: vertical line no.1 as the left margin of the leftmost column, line no.29 as the right margin of the rightmost column,
   - 111 rows: horizontal line no.1 as the bottom margin of the bottom row, line no.112 as the top margin of the top row.

   Each grid cell is addressed by the coordinates of its left bottom corner !

This 29-112-transparent covers one 'run'. Four runs cover one map sheet:



4) Cut the map in such a way that a row of 2 or 3 'map sheets' form one piece.

5) Cut holes along the margins and mark **precisely** the margins of each sheet and each run **VERY ACCURATELY** !

6) Overlay the 29-112-transparent form and check each run.

7) Write sheet and run number on all runs.

3.3.18 <u>How to Enter a Map</u>

1) If the map is not prepared yet, split it into different map sheets as described under 'How to prepare a map' (see previous page).

2) Enter the mapping unit codes of the map (if the codes are not entered yet)

2.1) Main Menu: Select 'Database'
2.2) Select project area
2.3) Select 'Mapping unit codes'
2.4) Select the map
(If the map is not defined yet: See 'How to define an additional map'; p.124)
2.5) Select 'Declare a new data set' and confirm with "YY"
2.6) Enter the number of mapping units of this map
(Number of units = number of different units)
2.7) Enter the code (label) of the first mapping unit
2.8) Enter the ASCII code (36-126) for the font (outprint symbol) of the first mapping unit
(e.g. 36: $),
but keep ASCII symbol 46 reserved for the last mapping unit ('OUT') !
See App. 9 for recommended ASCII codes !

2.9) Repeat step 2.7 and 2.8 for each mapping unit

2.10) Save ("Y", then "YY") and return to Main Menu

3) Enter one run of the map

3.1) If a digitizing tablet is available, connect the tablet through its communication (serial) cable to the serial port of the computer and (if necessary) the power supply cable to the transformer unit of the tablet.

3.2) Place the map on the digitizing tablet in such a way that the margins of the map are
ABSOLUTELY PARALLEL TO THE FRAME OF THE TABLET !
Small holes along the map sheet division are useful help.

3.3) Main Menu: Select 'Entry of base map'
3.4) Select project area
3.5) Select sheet
3.6) Select run
3.7) Accept 'C:<— default'
3.8) Accept the default subdirectory

3.9) Select map
3.10) Choose 'digitizing tablet'
3.11) Only with large tablets:
Place the cursor exactly at position 1/1
(left bottom corner of the run) and press <Enter>
3.12) Press <Enter>
3.13) Select 'Enter a unit'
3.14) Select one mapping unit at the map and enter the code (label) of this unit.
3.15) Only with small tablets:
Select one point of the boundary of the selected mapping unit, read its coordinates from the 29-112-transparent and enter them.
3.16) With small tablets:
After beep, place the stylus
exactly at the crossing of vertical and horizontal
lines of the given coordinates,
With large tablets: After beep, place the stylus anywhere at the boundary of the mapping unit,

then follow the unit boundary with the stylus pressed down or with the cursor and surround the entire unit.
It is possible to go back, to form 8-shape-like units or to go beyond the margin of the run.
At any place it is possible to lift the stylus off, then press <Enter>, 'C' and continue with the keypad or with the stylus.
3.17) When reaching the starting point, lift the stylus off and press <Enter>.
3.18) For checking purposes, give the unit code, eventually the x and the y coordinates again.
3.19) The unit shall be displayed at the screen, the area calculated and return to the entry menu. Continue with step 3.13.

If the entered area or parts of it were previously assigned to another mapping unit, a message will appear and ask for the correct unit of this grid cell. Enter:
'N' if the current ('new') assignment is correct for the indicated pixel
'P' if the previous assignment is correct for the indicated pixel
'ALLN' if the current ('new') assignment is correct for the indicated pixel and all following
'ALLP' if the previous assignment was correct for the indicated pixel and all following
'SP' if only one particular mapping unit shall be replaced with the new assignment, but all others remain unchanged
'C' if neither the current nor the previous assignment is correct for the indicated pixel.

For any error message, see App. 3 (p.192) for trouble shooting.

3.20) Mark the unit as entered (e.g with a tick mark)
3.21) Repeat step 3.13-3.19 for all mapping units.

After entering all mapping units:
3.22) Check properly the whole map; corrections of single grid cells can be made through:
Select 'Correct a single grid cell'

Press <Enter> if the code is correct

3.23) Select 'See the area on screen and highlight the blank areas' to check for full coverage.

If there are pixels not entered yet, enter them in any of the above described way (either step 3.13-3.20 or 3.22).

3.24) If there are many blank pixels:
Select 'See the area and print the blank areas'

After checking:

3.25) Select 'Save (and/or exit)'

4) Repeat step 3 for each run of each map.

5) Check the boundary of the project area

The 'outside' boundary of the project area of all maps have to be identical. Therefore, it is recommended to have one reference map (e.g.altitude map or soil map) the other input maps refer to.

5.1) Turn the printer on
5.2) Main Menu: Select 'Systematic change of base maps'
5.3) Select project area
5.4) Select 'Whole study area'
5.5) Accept 'C:<--- default'
5.6) Accept the default subdirectory
5.7) Select map
5.8) Select 'Check the outer boundary of the map with a reference map'
5.9) Enter the reference map (3 or 4 letters, e.g. ALT)
5.10) Select 'Assignment of pixels being outside to OUT ('cutting') and outprint of the pixel(s) if the map is too small'
5.11) Select 'same name'
5.12) Return to Main Menu

6) Run the area sizes (for creation of area sizes files)

6.1) Main Menu: Select 'Area sizes'
6.2) Select project area
6.3) Select 'Whole study area'
6.4) Accept 'C:<--- default'
6.5) Accept the default subdirectory
6.5) Select map
6.6) Select 'Map/data on screen only'
6.7) Select 'No'
6.8) Select 'No'
6.9) Return to Main Menu

3.3.19 How to Change Mapping Units of Base Maps

1) It is recommended to have a listing of the mapping units first:

1.1) Turn the printer on
1.2) Main Menu: Select 'Database'
1.3) Select project area
1.4) Select 'Mapping unit codes'
1.5) Select map
1.6) Select 'See and outprint the data'
1.7) Without saving, return to Main Menu
('N', 'Return to Main Menu')

2) Mark the units to be changed on this list

3) Enter the changes

3.1) Main Menu: Select 'Systematic change of base maps'
3.2) Select project area
3.3) Select 'Whole study area'
3.4) Accept 'C: <— default'
3.5) Accept the default subdirectory
3.6) Select map
3.7) Select 'Replace/aggregate old units with new'
3.8) For each replacement:
Enter the old mapping unit number (not unit)
-to replace what?-
and the new mapping unit number
- to replace with what?-
and press <Enter>
3.9) In case of wrong entry, press 'N' instead of the last
<Enter> and enter the **previous** change again
3.10) After entry of all changes, give "000"

After modification of the map:
3.11) Select 'No'
3.12) Enter 'N' and return to Main Menu

4) Check the mapping unit codes if they are still valid

4.1) Main Menu: Select 'Database'
4.2) Select project area
4.3) Select 'Mapping unit codes'
4.4) Select map
4.5) Select 'See and outprint the data'
4.6) Return to Main Menu

3.3.20 How to Aggregate Mapping Units to Form a New Base Maps

1) Before entering GILES use DOS to produce a temporary dummy 'mapping unit code' file with the old mapping units:

1.1) Type at C: prompt:

```
COPY \aDG\am.MUC \aDG\an.MUC
```

where: a abbreviation of study area , e.g.HOS
m abbreviation of theme of old map, e.g.ADM
n abbreviation of theme of new map, e.g.PLZ

2) It is recommended to have a listing of the mapping units:

Proceed as in step 1 of 'How to change mapping units of base maps', Section 3.3.19 (p.130)

3) Give each unit the new unit number on this list

4) Enter the aggregations

4.1) Main Menu: Select 'Systematic change of input maps'
4.2) Select project area
4.3) Select 'Whole study area'
4.4) Accept 'C:<--- default'
4.5) Accept the default subdirectory
4.6) Select map
4.7) Select 'Replace/aggregate old units with new'
4.8) For each replacement:
Enter the old mapping unit **number** (not unit)
-to replace what?-
then the new mapping unit **number**
- to replace with what?-
then press <Enter>
4.9) In case of wrong entry, press 'N' instead of the last
<Enter> and enter the **previous** assignment again
4.10) After entry of all assignments, 'OUT' has to be given:
Enter the old mapping unit number for 'OUT'
(total number of old units + 1)
then the new mapping unit for 'OUT'
(total number of new units + 1)
4.11) After entry of all changes, give "000"

After modification of the map:
4.12) Select 'yes' and give the abbreviation,
same as n in step 1, e.g. 'PLZ'
4.13) Enter 'N' and return to Main Menu

5) Run the area size and check that no unit with a number greater than the last unit of the aggregated list occurs

Proceed as in step 6 of 'How to enter a map' (Section 3.3.18; p.129)

6) Enter the new mapping unit codes of the map

6.1) Main Menu: Select 'Database'
6.2) Select the project area
6.3) Select 'Mapping unit codes'
6.4) Select map
6.5) Select 'Declare a new data set' and enter 'YY'
6.6) Enter the total number of mapping units of this map
(Number of units = number of different units + 1)(see step 4.9)
6.7) Enter the code (label) of the first mapping unit
6.8) Enter the ASCII code (36-255) for the font (outprint symbol) of the first mapping unit
(e.g. 36: $), See App. 9 (p.255) for recommended ASCII codes !

6.9) Repeat step 6.7 and 6.8 for each mapping unit

6.10) Enter 'OUT' as the code (label) of the last unit
6.11) Enter ASCII code '46' as outprint symbol of mapping unit 'OUT' (.)
6.12) Save (Y, then YY) and return to Main Menu

7) Run the area sizes again: See above (step 5)

If error message 'Calculated unit does not fit to mapping unit codes' occurs, one or more units were forgotten: See for trouble shooting in App.3: 'Calculated ....' (p.192)!

3.3.21 How to Start the First Time

1) Select the scale for map entry

The scale of map entry into GILES can vary.

Read and follow step 1 of 'How to start with a new area' (Section 3.3.14; p.121)

2) Define the map sheets of the area

Read and follow step 2 of 'How to start with a new area' (Section 3.3.14; p.121)

3) Enter required parameters into GILES (in 'starea.nam' file):

3.1) Main Menu: Select 'Database'
3.2) Select any area
3.3) Select 'Study areas'
3.4) Select 'Declare a new data set'
3.5) Enter the number of project areas (e.g. 1)
3.6) Enter the maximum number of map sheets covering the project area
3.7) Enter the name of the project area (up to 15 letters; e.g. Ethiopia)
3.8) Enter the working abbreviation (3 or 4 letters; e.g. ETH)
3.9) Enter the scale (as defined under step 1)
3.10) Enter the number of soil types in the project area
[1] (not: soil mapping units)
3.11) Additional maps **can** be entered by giving:
[1] - map theme (map name; e.g. Evapotranspiration)
- working abbreviation (3 or 4 letters; e.g.PET)
If no (or not more) additional maps shall be indicated, press <Enter>
3.12) For all map sheets of the area, there **must be** entered:
- all sheet names
- working abbreviation of all sheets (one letter or one digit; <Enter> for proposed default: 1..)
- relative position to the previous sheet:

1 one to the right	6 down and one to the left
2 two to the right	7 down and two to the left
3 three to the right	8 down and three to the left
4 four to the right	9 down and four to the left
5 one down	

- N,S,W,E coordinates of sheet frame (in latitude and longitude, with decimals)
3.13) Save, return and exit to DOS

[1] Not essential

3.3.22 How to Import a Lotus 1-2-3 File

1) Create a Lotus worksheet file

Following criteria for the structure of the Lotus spreadsheet have to be considered:

A) For the import/aggregation of mapping unit codes:

aa) It can contain 2 or 3 or more columns:
Column A : mapping unit label (as string)
Column B : number (as value) (e.g. number of newly assigned mapping unit)
Column C : label for newly assigned mapping units

ab) Blank rows or rows with another content,
e.g. a label not being a mapping unit label
in column A, are allowed, but ignored by GILES

B) For the import of characterization tables:

ba) It can contain 2 or 3 or more columns:
Column A : number of soil type/administrative unit (as value)
Column B or C or .. : class number (as value)

bb) All columns must contain a value !
No labels are allowed, no blanks !

2) Translate this file into a DIF file

2.1) Save this file under the name 'LOT2GIL<u>a</u>' preferably in subdirectory C:\INTERM
(where <u>a</u>: letter A-E)
2.2) Quit 1-2-3 and select option 'Translate' in Lotus (/ Q Y T)
2.3) What do you want to translate from: Select the installed Lotus version
2.4) What do you want to translate to: Select DIF
2.5) Source file: Type 'C:\INTERM\LOT2GIL<u>a</u>'
(where <u>a</u> as above)
2.6) Target file: Accept the same name
2.7) Process with translation
2.8) Leave Translate and Lotus

3) This DIF file can be read by GILES

3.3.23 How to Aggregate Mapping Units for Outprint Through Lotus 1-2-3

This is particularly recommended if a large number of mapping units occur or have to be aggregated for retrieval or further processing in GILES. For a small number, say less than 20, it is faster to aggregate them through GILES.

1) Copy the mapping unit codes from GILES into LOTUS

1.1) Main Menu: Select 'Database'
1.2) Select the project area
1.3) Select 'Mapping unit codes'
1.4) Select map
1.5) Select option 'See and transfer the data in Lotus file C:\INTERM\GIL2LOTa.PRN'
(where a: letter A-E)
1.6) Without saving, exit GILES
('N', 'Return to Main Menu', 'Exit to system')

2) Convert this print file into a Lotus worksheet file

2.1) Enter Lotus 1-2-3
2.2) Change directory to C:\INTERM (/ F D)
2.3) Import the 'GIL2LOTa' print file as text (/ F I T ; where a as above)

3) Treat this file as any Lotus worksheet file,
but **do not change column A** and
be aware that only **numeric values in column B** will be read in GILES

4) Translate this file into a DIF file

4.1) Quit 1-2-3 and choose option 'Translate' in Lotus (/ Q Y T)
4.2) What do you want to translate from: Select the installed Lotus version
4.3) What do you want to translate to: Select DIF
4.4) Source file: Type 'C:\INTERM\LOT2GILa'
(where a as above)
4.5) Target file: Accept the same name
4.6) Process with translation
4.7) Leave Translate and Lotus

5) Select the map through GILES

5.1) Type 'GILES' at the C: prompt
5.2) Main Menu: Select 'Base map (complete/aggregating/selective/parametric)'
5.3) Select project area
5.4) Select 'Whole study area'
5.5) Accept 'C:<— default'
5.6) Accept the default subdirectory
5.7) Select map
5.8) Select 'Selective/aggregating map'
5.9) Enter the total number of new mapping units (highest value in column B; see step 4.5)
5.10) Select 'Import from Lotus file LOT2GILa'
(where a as defined in step 1.5)
5.11) Continue with the selection of the requested map as described in the other 'How to ...' Sections

3.3.24 <u>How to Transfer Area Size Tables / Raw Data (DBMS) / Crosstabulation into Lotus</u>

1) During selection of overlaid/calculated map (e.g.see 'How to calculate the area sizes' or 'How to overlay selected areas'), choose the transfer into a Lotus file:

1.1) Select 'yes' and choose one of the five 'GIL2LOTa.PRN' files (where a letter: A-H)

2) Convert this print file into a Lotus worksheet file

2.1) Enter Lotus 1-2-3
2.2) Change directory to C:\INTERM (/ F D)
2.3) Import the 'GIL2LOTa' print file as numbers (/ F I N) , where a as above

3) In case of crosstabulation (selected areas):
Row 1 is the total area,
row 2-84 are the overlaid windows/selected areas;
column 1 is number of the selected area,
columns 2-83 are the mapping units of the 'main map'.

Eventually you have to fill blank parts of this matrix have to be filled with zeros.
Rows with 0 can be deleted.

If any row has a length of more than 240, continuation to the right is in file GIL2LOTZ.PRN, then in GIL2LOTY.PRN, then in GIL2LOTX.PRN !

If column 1 has a number greater than 1000, this row is the right extension of the row above (row 1000+n is the right extension of row n).

3.3.25 How to Transfer a Area Size Tables / Raw Data (DBMS) / Crosstabulation into dBase

1) During selection of overlaid/calculated map (e.g.see 'How to calculate the area sizes' or 'How to overlay selected areas'), choose the transfer into a Lotus file:

   1.1) Select 'yes' and choose one of the five 'GIL2LOTa.PRN' files (where a letter: A-H)

A) If Lotus is available:

2) Convert this print file into a Lotus worksheet file

   2.1) Enter Lotus 1-2-3
   2.2) Change directory to C:\INTERM (/ F D)
   2.3) Import the 'GIL2LOTa' print file as numbers (/ F I N) , where a as in step 1

3) In case of crosstabulation (selected areas), see remarks of step 3 of Section 3.3.24 (p.136).

4) Insert a heading row

   4.1) Insert a row above the data as row 1 (/ W I R)
   4.2) Label each cell of this row where data occur in the same column with a name beginning with a letter (e.g.COL1, COL2)
   4.3) Save this sheet under a new name (/ F S)

5) Translate the spreadsheet file into dBase format

   5.1) Quit 1-2-3 and select option 'Translate' in Lotus (/ Q Y T)
   5.2) What do you want to translate from: Select the installed Lotus version
   5.3) What do you want to translate to: Select dBase
   5.4) Source file: Enter the name as chosen in step 4.3
   5.5) Destination file: Accept the same name
   5.6) Select 'Worksheet'
   5.7) Process with translation
   5.8) Leave Translate and Lotus

6) Enter dBase and retrieve the file

B) If Lotus is not available and dBase version III+ is used:

2) Create an empty dBase file

2.1) Enter dBase III+
2.2) Create a dBase file either from Assist or from dot prompt ('CREATE...')
2.3) Define the structure by giving field names, selecting 'numeric' as the type, a sufficient width (e.g. 10), decimals (if necessary) for as many columns as there are in the source (GILES) file

3) Translate the print file into dBase

3.1) Enter from dot prompt:
APPEND FROM C:\INTERM\GIL2LOTa.PRN TYPE DELIMITED
(where a number as chosen in step 1.1)

3.3.26 How to Retrieve a DTM (3D Display) and : How to Transfer Maps Into Lotus 1-2-3

For further processing in spreadsheets (e.g.Lotus 1-2-3) or for transfer into graphic packages for 3D display (e.g. 'Perspective' or Boeing Graph), it is possible to convert GILES' maps into ASCII or DIF formats:

1) Convert the map into print files (ASCII format)

1.1) Main Menu: Select 'Base map (complete/aggregating/selective/parametric)' or any other option for map retrieval
1.2) Select the project area
1.3) Select the sheet (or 'Whole study area')
1.4) Accept 'C: <— default'
1.5) Accept the default subdirectory
1.6) Select the map (e.g.'Altitude')
1.7) Select 'Complete map'
1.8) Select 'As (1) but with storage...'
1.9) Select 'print file for 3D display'

After retrieval of the map:
1.10) Press Space to return to Main Menu

2) Import the print files into Lotus spreadsheet files

2.1) Enter Lotus 1-2-3
2.2) Change directory to C:\INTERM (/ F D)
2.3) Import the 'DG0CMPbc' print file as numbers (/ F I N)
2.4) If there are more than one run:
Locate the cursor at the right side of the displayed Lotus sheet (column 'AC', 'BE' or 'CG') and repeat step 2.3 with the next run

2.5) Save this sheet under 'C:\INTERM\DG0CMP' and exit Lotus

3) Load the worksheet files into 'Boeing Graph' or 'Perspective'

3.1) Load '3D'
3.2) Load the file C:\INTERM\DG0CMP
(e.g. in Boeing Graph:
F3: Data Manager
F2: File Manager
F1: File Load)
3.3) Manipulate the 3D display the way you like

3.3.27 How to Transfer LGP Charts into Lotus 1-2-3

To demonstrate the pattern of the growing period at a certain location, it is possible to transfer the growing period on decadal basis of all observed years into Lotus 1-2-3 and further to graphic packages.

1) Define the location of the LGP assessment (preferably of one grid cell only)

Overlay the 29-112-transparent on the map and note the GILES coordinates: sheet, run, x, y

2) Assess the LGP

2.1) Main Menu: Select 'Length of growing period'
2.2) Select project area
2.3) Select sheet of the required location
2.4) Select run of the location
2.5) Give the S, N, W, E coordinates of the location
2.6) Select 'Whole study area'
2.7) Accept 'C:<— default'
2.8) Accept the default subdirectory
2.9) Select ' 75 %'
2.10) Select 'Average crop'
2.11) Select 'Pure function of the climate'
2.12) Select 'Maps/data on screen only'
2.13) Select 'No'
2.14) Select 'No'
2.15) Select 'Yes: screen and transfer in Lotus file GIL2LOTA.PRN'

After retrieval of the map:
2.163) Press Space and <Enter> to return to Main Menu

3) Import the print file into Lotus spreadsheet file

3.1) Enter Lotus 1-2-3
3.2) Change directory to C:\INTERM (/ F D)
3.3) Import the 'GIL2LOTA' print file as numbers (/ F I N)

3.4) Manipulate and process the data:

The number in the spreadsheet stands for the relative soil moisture saturation, as explained in Section 3.2.1.11 (p.80)
columns 1-36 stand for 36 decades of the year,
column 37 for the mean length of the 1.rainy season,
column 38 for the mean length of the main season,
column 39 for the decade number of the end of the main rainy season,
the rows for the consecutive years,
the row at the bottom of one LGP block:
number of soil mapping unit/precipitation
mapping unit/altitude mapping unit/coded LGP number

3.5) Save this spreadsheet under 'C:\INTERM\DG0CMP'

4) Load the worksheet file into 'Boeing Graph' or 'Perspective'

4.1) Load '3D'
4.2) Load the file 'C:\INTERM\DG0CMP'
(e.g. in Boeing Graph:
F3: Data Manager
F2: File Manager
F1: File Load)
4.3) Manipulate the 3D display the way you like

3.3.28 How to Import Precipitation Data From Lotus

1) Enter precipitation data into Lotus 1-2-3

Following criteria for the structure of the Lotus spreadsheet have to be considered:

a) Data must be either on monthly or decadal basis.
b) The first column must contain the recorded year in numbers of 1900-1999
c) The second and consecutive columns (columns 2-13 for monthly, 2-37 for decadal data) shall contain the precipitation data in mm as values, not as labels.
Decimals are allowed.
d) Blank cells are read as 0. Missing data are therefore interpreted as 0-rainfall.
e) Blank columns or any labels (e.g. 'x' for missing data) are not allowed.
f) Blank rows or rows with text are accepted. They will be ignored by GILES.

2) Create a Lotus file with one station

2.1) Delete the rows above and below the data rows **of one selected station** (/ W D R)
2.2) Save this file under 'C:\INTERM\LOT2GILa'
(where a: letter A-Z)

3) Translate this file into DIF file

3.1) Quit 1-2-3 and select option 'Translate' in Lotus (/ Q Y T)
3.2) What do you want to translate from: Select the installed Lotus version
3.3) What do you want to translate to: Select DIF
3.4) Source file: Type 'C:\INTERM\LOT2GILa'
(where a as above)
3.5) Target file: Accept the same name
3.6) Process with translation
3.7) Leave Translate and Lotus

4) Import the individual station files into GILES ('aPREC.DAT')

4.1) Enter GILES by typing 'GILES' at the C prompt
4.2) Main Menu: Select 'Database'
4.3) Select project area
4.4) Select 'Precipitation data'
4.5) Select 'Import precip.data of a station from Lotus file LOT2GILa.DIF'
4.6) Select 'No'; or:
4.6a) Enter the number of stations (precipitation units)
4.6b) Data by month or decade: Enter 1 or 2
4.7) Give the number of the DIF file you like to import (see step 3.5)
4.8) Give the number (not the mapping unit code !)
of the precipitation mapping unit these data are for
4.9) Another station: Answer 'Y',
if more DIF files are prepared

5) Repeat step 2-4 for each mapping unit

6) Combine all stations into one GILES file ('aPREC.TWY)

This processing can only be performed if no data are missing!

6.1) Main Menu: Select 'Database'
6.2) Select project area
6.3) Select 'Precipitation data'
6.4) Select 'Transfer complete precipitation data set in final TWY file'
6.5) Data by month or decade: Enter 1 or 2

3.3.29 <u>How to Stop Program Execution</u>

There are different means to stop, to correct the selection procedure or to stop the map processing or retrieval:

1) If a wrong decision was made at the previous or one of the previous menus:

Press the **F2** function key to return to the previous menu (or menus) and choose the right selection.

2) If the whole selection was wrong or the F2 does not work:

Press the **F10** function key (or F10 and <Enter>) to prompt you back to the Main Menu and start again with the selection.

3) If the retrieval of the map (scrolling at the screen) shall be stopped with continuation afterwards:

Press the space bar to stop as well as to continue.

4) If processing or map retrieval shall be stopped:

Press the **F10** function key to prompt you back to the Main Menu.

3.3.30 How to Speed Up Map Retrieval

Harddisk access is always a limiting factor in retrieving large data amounts. Virtual disks can speed up the retrieval process considerably.

1) Transfer the map(s) from the harddisk to the virtual disk

1.1) Main Menu: Select 'File Operation'
1.2) Select project area
1.3) Accept 'C: <— default'
1.4) Accept the default subdirectory
1.5) Select the map
1.6) Press any key
1.7) Select 'Yes'
1.8) Select 'Copy'
1.9) Select 'D:'
1.10) Accept the default subdirectory

2) Perform the requested task retrieving data from the virtual drive

2.1) Start with the selection of the required map as described in the other 'How to ... ' Sections
2.2) In menu 'Where are the maps ?': Select the virtual drive (D:)
2.3) Continue with the selection of the required task

3.3.31 <u>How to Dump the Screen</u>

Screen dumping is a fast and easy way to save and print hardcopies of high resolution images on EGA/VGA screens. Most of the text maps in this manual are produced by screen dump utility 'Inset' (by MicroPro). As best experience was made with this utility and images can easily be imported into wordprocessor (Wordstar 2000), it will be explained here.

1) Load 'Inset' as memory resident program

1.1) At C: prompt, change default directory to 'Inset', e.g. CD:\WS2000\GRAPHICS
1.2) Type 'Inset' and press <Enter>
1.3) After 'Inset' menu appears, press <Enter>.

2) Prepare and display the map on screen

2.1) At C: prompt, type 'GILES'
2.2) Retrieve the requested map as high resolution image

3) Dump the screen

3.1) At the final display of the map, press RightShift together with PrintScreen
3.2) Move the selection with the arrow keys to 'Save'
3.3) Type the name of the file to save
3.4) Press <Enter>
3.5) Leave 'Inset' by <Escape>
3.6) Press Space to return to Main Menu of GILES
3.7) Select 'out (Exit to DOS)'

4) Edit and print through 'Inset'

4.1) At C: prompt, press RightShift together with PrintScreen
4.2) Move the selection with the arrow keys to 'View'
4.3) Type the name of the file with the image (step 3.3)
4.4) Press <Enter>
4.5) Edit the image, as required
4.6) Define the window with commands: 'Modify', 'Clip',
Move the left and top frame with the arrow key to the correct distance from the most extreme point of the study area (see App.10; p.257) or test new configuration and press press <Enter>
Do the same with the right and bottom frame
4.7) Define the size with the options: 'Modify', 'Expand', 'Inches' and enter width and aspect ratio, then <Esc>
4.8) 'Save'
4.9) Print the image with commands: 'Print', 'Go'

3.3.32 How to add a Mapping Unit

During map entry it can happen that a mapping unit which was not predefined is found at the map. This unit has to be entered to the definition of the mapping units (mapping unit code file).

1) Add the unit to the mapping unit code file
   1.1) Main Menu: Select 'Database'
   1.2) Select project area
   1.3) Select 'Mapping unit codes'
   1.4) Select map
   1.5) Select 'Change the size (dimension) of the data set'
   1.6) For each mapping unit to be added, increase the total number of units by one
   1.7) Enter the new units with their mapping unit code (label) and with their corresponding ASCII symbol
   1.8) After input of all new unit(s), give "N"
   1.9) After display, save ("Y", then "YY") and return to Main Menu

2) Rearrange the mapping unit code file during or after map entry
   (Unit 'OUT' has to be the last one)

   2.1) Main Menu: Select 'Database'
   2.2) Select project area
   2.3) Select 'Mapping unit codes'
   2.4) Select map
   2.5) Select 'See the data'
   2.6) Check which unit is the 'OUT' unit (number a) and which is the last one (number b)
   2.7) Select 'Mapping unit codes'
   2.8) Select map
   2.9) Select 'Enter/change part of data'
   2.10) Enter the number of the previous unit of 'OUT' (number a) and give code and ASCII-Symbol of the last unit (number b)
   2.11) Enter the number of the last unit (number b) and give code 'OUT' and ASCII-symbol '46'.
   2.12) After input, give "N"
   2.13) After display, save ("Y", then "YY") and return to Main Menu

3) Rearrange the map files to the new mapping unit codes definition
   –> Right after step 2 ! <–

3.1) Main Menu: Select 'Systematic Change of Base Map'
3.2) Select project area
3.3) Select 'Whole study area'
3.4) Accept 'C: <— default'
3.5) Accept the default subdirectory
3.6) Select the map
3.7) Select 'Replace/aggregate old units with new units'
3.8) Enter number a as 'Old unit NUMBER'
3.9) Enter number b as 'New unit NUMBER' and press <Enter>
3.10) Enter number b as 'Old unit NUMBER'
3.11) Enter number a as 'New unit NUMBER' and press <Enter>
3.12) Enter "000"
3.13) Select 'No'

3.3.33 How to dump a screen image within GILES

1) Dump the screen

- 1.1) Retrieve the requested map as high resolution image
- 1.2) After final display, press F9 function key
- 1.3) Give the number (1-9) of the stored image

2) Retrieve the screen dump

- 2.1) Main Menu: Select 'Overlay/reprint of previously configured maps'
- 2.2) Select 'Screen dump'
- 2.3) Choose the number of the saved image (step 1.3)

G I L E S

PART C:

For System Analysts

Chapter 4) Data Structure (References)

Appendices

4 DATA STRUCTURE (References)

4.1 INTRODUCTION

This chapter is addressed only to the **system analyst** who is setting up GILES with all data entry and processing facilities.

It is possible to run GILES following the menus on the screen or the Users Manual in the previous Chapter: No knowledge of the structure of GILES, of the data files or of the programs is required !

Even though, this chapter serves three functions:

a) To prevent that GILES becomes a 'black box', not knowing what is going on with the maps overlays and evaluation assessments

b) To give system analysts the chance to modify the maps or the data in the most efficient way

c) To help in case of trouble shooting

This chapter is only for the system analysts which have an appropriate knowledge about computer processing, data structuring, DOS and high-level languages !

This chapter shall only work as a reference !

The software package consists of
a) 21 programs partly to be overlaid during program execution,
b) 22 types of data files serving specific processing needs

Perhaps the most important technical topic within the field of GIS concerns the appropriate data structures for storing and manipulating very large quantities of spatially-referenced data (Coppock/Anderson 1987).

Even though this should not be the concern of the user, it is part of the problem of setting up a new database, e.g. of a new study area. Therefore, the 'system analyst' installing or modifying the GILES system should be aware of the structure of all data files. This is explained in detail in Section 4.2.

General Retrieval Procedure for Land Evaluation

```
                                                        Computer
                                                          File
                                                        --------

                         ┌─────────────────────────── MAP
                         │
                         │
                         │ <──Mapping unit code     MUC
                         V
          ┌──────── Mapping Unit
          │              │
          V              │
     'Base map'          │
                         │ <── Translation Table
                         V
          ┌────── Land Characteristic
          │              │
          V              │
 'Parametric base map'   │
                         │ <── Land Quality Model
                         V
                   Land Quality
                         │
                         │
                         │ <── Land Evaluation Model
                         V
              Land Suitability Assessment
```

In the particular case of processing soil maps and soil data, one additional step is required as soil mapping units can consist of more than one soil type:

```
                                                          Computer
                                                            File
                                                          --------
                    ---------------------------------------  MAP
                   |
                   |  <-- 'Mapping unit code'
                   |          file of soil map             MUC
                   V
           Soil Mapping Unit
                   |
                   |  <-- Soil mapping unit
                   |           composition                 MCP
                   V
              Soil Type
                   |
                   |  <-- Soil type charac-
                   |          terization                   TCH
                   V
      Land (Soil) Characteristics
                   |
                   |  <-- Land Quality Models
                   |        in soil suitability
                   |      assessment:          'sosuit'
                   V
          Land (Soil) Quality
                   |
                   |  <-- Rating system of land
                   |        quality models
                   |        in soil suitability
                   |      assessment:          'sosuit'
                   V
   Land (Soil) Suitability Assessment
```

The 'Mapping unit codes' files handle the decoding of computer internal map files into understandable mapping codes (equals to 'indicator'; see Section 3.2.3; p.98)

Translation tables handle the decoding of computer internal files into a specific information retrieval through an information matrix.

4.2 DATA FILES (REFERENCES)

4.2.1 Description of Data Files

Each file has a file name of not more than eight characters, a period and a file name extension (file type) of three characters. All file names and extension names are defined as follows:

Table 4.1

Data Files

Data	File Name[1]		Sub-directory	Explanation Sect.	p.
Digitized maps	DGbmn	.MAP	\aDG\	4.2.2	155
Area sizes	**ARS**bm	.DAT	\aDG\	4.2.3	157
Mapping unit codes	ab	**.MUC**	\aDG\	4.2.4	158
Soil mapping unit composition	aSOIL	**.MCP**	\LANDEV\	4.2.5	160
Soil type names	aSOIL	**.STN**	\LANDEV\	4.2.6	162
Soil type characterization	aSOIL	**.TCH**	\LANDEV\	4.2.7	163
Altitude correlation	aALT	**.COR**	\LANDEV\	4.2.8	165
Administrative unit characterization	aADM	**.ACH**	\LANDEV\	4.2.9	167
Precipitation raw data	a**PREC**	**.DAT**	\LANDEV\	4.2.10	168
Raingauge relations	a**REL**	.DAT	\LANDEV\	4.2.11	169
Gamma distribution of precipication data	a**GAM**	.DAT	\LANDEV\	4.2.12	170
Expected precipitation values at given reliability level	aPREC	**.RLV**	\LANDEV\	4.2.13	171
Precipitation figures of (up to 20) years	aPREC	**.TWY**	\LANDEV\	4.2.14	172
Land characteristic names	**LCHAR**	.NAM	\LANDEV\	4.2.15	174
Land characteristic class names	**LCHATN**	.NAM	\LANDEV\	4.2.16	176
Structural characteristic class names	a**ATN**	.NAM	\LANDEV\	4.2.17	177
LUT/crop names	**LUT**	.NAM	\LANDEV\	4.2.18	178
Study area names	**STAREA**	.NAM	\LANDEV\	4.2.19	180
Crop requirements	**CREQ**o	.DAT	\LANDEV\	4.2.20	182
Help menus	**HELP**	.TXT	\LANDEV\	4.2.21	183
Configured map files	**DG**p**CMP**mn	.MAP	\INTERM\	4.2.2	156
Explanation files	**DG**p**CMP**	.NAM	\INTERM\	4.2.2	171

[1] The short reference name is printed in bold.

where: a short form of study area name (abbreviation, 3 or 4 letters; e.g. BORK, BICH, HOS)
- b short form of map theme (abbreviation, 3 or 4 letters; e.g.SOIL, ALT, PREC) see Glossary: Predefined maps
- m map sheet number (1-9, followed by A-Z)
- n run number of the map sheet (1-4)
- o 1 or 2
- p number 1-9

All files, except of the first three and of the last two types, belong to the 'general data set' and are therefore in the GILES subdirectory \LANDEV\.

Files of the first three types are located in the area specific subdirectory (e.g. \ETHDG\), if stored on harddisk. If floppy disks are used (e.g. for backup), **one complete map** (e.g.altitude map of Ethiopia) **should be stored on one disk together with the mapping unit code file** and the area size files (e.g. all DGALTmn.MAP files with ETHALT.MUC and ARSALTm.DAT).

Files of the last two types are created only for temporary use.

4.2.2 Digitized Map File ('MAP file')

Function:

All entered base maps are stored in digitized form in map files with extension MAP. The principle of map digitizing based on a grid cell system is explained in Section 2.2.4 (p.26). These files are the basic information carrier of inventoried data any map outputs are derived from.

These files will be created or modified through option 'Entry of base map' of the Main Menu (see 'How to enter a map', p.126).

Nomenclature:

The syntax of these map files is:

DGbmn.MAP

where: b theme of map (e.g.SOIL, ALT, PREC, VEG, ADM, AEZ)
see Glossary: Predefined maps
m map sheet number (1-9, followed by A-Z)
n run number of map sheet (1-4)

e.g. **DGSOIL43.MAP** digitized soil map of the 3.run of map sheet 4

The area name is not incorporated in the file name. Thus, care has to be taken, that the map files are always stored on the **subdirectory of the right area** (e.g. C:\ETHDG\) !

Structure:

Each digitized map is split into four runs consisting of:
111 rows in N-S-direction and 28 columns in W-E-direction.

Each run is constituted by one random-access digitized map file, i.e. 4 map files make up one map sheet. Each run is input and read as a random access file with:
column number of the grid cell (X, starting with 1 at the W margin, up to 28 at the E margin), as the field number,
row number of the grid cell (Y, starting with 1 at the S margin, ending with 111 at the N margin), as the record number.

The pixel is stored with its number of the occurring mapping unit which serves as 'pointer'.

Therefore, each digitized map file has 111 records, and takes 6272 bytes of computer memory. An average study area consisting of 5-10 map sheets (some 60000-120000 pixels) takes some 150-250 kB (for file sizes see App.6; p.208).

Example:

The pixel (6.25 ha) of the soil map of Borkena, sheet 4, run 1, column (x coordinate) 12, row (y coordinate) 89 is stored in file DGSOIL41 under record 89, field number 12. It has value 29, which stands for the mapping unit C2-3, expressed by the symbol "4" on computer outprint maps.

****

Special form of MAP files:

'Configured' Map File ('CMP file')

Function:

Each map retrieved, compiled or modified through GILES can be stored as a 'new map' in a 'composite' map file in C:, subdirectory \INTERM\. They can be retrieved for further processing or reprint through options 'Overlay/reprint of previously configured map(s)' or - in case of suitability assessment - through 'Land suitability' of the Main Menu.

These 'configured' map files are stored, if one of the options 'as (..) but with storage on C:\INTERM\ ' in the output selection menu is chosen and the storage number p (see below) is defined (range 1-9). With storage number 10, a similar configured map is stored which is reserved for retrieval in ASCII.

They are always created together with the documentary file 'DGpCMP.NAM' explaining the 'configured' map file.

Nomenclature:

The syntax of these map files is:

DGpCMPmn.MAP
together with **DGpCMP.NAM**

where: m map sheet number (1-9, followed by A-Z)
n run number of map sheet (1-4)
p storage number (1-9): 1 climatic suitability
2 soil suitability
3 land suitability

e.g. **DG1CMP43.MAP** climatic suitability map of the 3.run
with **DG1CMP.NAM** of map sheet 4

Structure:
The structure is the same as explained as above, but saving and retrieving differ slightly: Each pixel consists of two letters; all pixels of one row form one string which is added to array DCBA$(1..111).

4.2.3 Area Size File ('ARS file')

Function:

For each base map the area sizes of all mapping units are compiled and stored in the area sizes files. The area sizes for the entire study area, for each individual map sheet or for each map run can be retrieved through option 'Area Sizes'.

The area size files are created through menu 'Did you run the area sizes before ?' (option 'no') when retrieving the area sizes (see 'How to calculate the area sizes'; Section 3.3.13; p.120).

Nomenclature:

The syntax of these area sizes files is:

ARSbm.DAT

where: b theme of map (e.g.SOIL, ALT, PREC, VEG, ADM, AEZ)
see Glossary: Predefined maps
m map sheet number (1-9, then A-Z)

e.g.ARSSOIL4.DAT area sizes of the digitized soil map of sheet 4

The area name is not incorporated in the file name. Thus, care has to be taken, that the map files are always stored on the **subdirectory of the right area** (e.g. C:\ETHDG\) !

Structure:

Running through a map (run) will count the number of pixels occurring in the particular run for each individual mapping unit. The number of the mapping unit serves hereby as the record number in these random access files, the run number of the map sheet as the field number.

Example:

The outprint of the area sizes of the administration units of Borkena is shown in Table 3.3 (p.61). It can be seen that the Peasant Association 0117 covers some 2268 ha, equals 0.9 % of the total study area.

4.2.4 Mapping Unit Code File ('MUC file')

Function:

The mapping unit code file with extension MUC contains all codes (mapping symbols) of a particular thematic map of a project area including the symbols represented in map outprints (fonts). These mapping unit codes are given by the authors of the map. It is the **only data set which has to be entered before the map input ('digitizing') starts** because each mapping unit has to be input with its given symbol (mapping unit code).

First definition and later modifications are made through option 'Database' in the Main Menu, then 'Mapping unit codes'(see Section 3.3.18(2); p.126). Alternatively, the codes can be input into Lotus and then imported into GILES.

In case of changing the mapping unit, attention has to be given that **all** concerned mapping units will be labeled with the new codes afterwards ! (See 'How to add a mapping unit', Section 3.3.32; p.147).

Through changing the second code, it is possible to modify the outprint code for the individual mapping unit(s) (see 'How to change fonts'; Section 3.3.11, p.118, and App.9, p.255 for recommended fonts).

Nomenclature:

For each project area and for each thematic input map, a separate list of mapping unit codes are given by its author(s). This is entered into:

ab.MUC

where: a name of study area (e.g. BORK, BICH, HOS)
see Glossary: Predefined maps
b theme of map (e.g.SOIL, ALT, PREC, VEG, ADM, AEZ)

e.g. **HOSADM.MUC** codes of the mapping units of the administration map of Hosaina

The area name is not incorporated in the file name. Thus, care has to be taken, that the map files are always stored on the **subdirectory of the right area** (e.g. C:\ETHDG\) !

Structure:

The soil mapping unit code file is a two-dimensional array with the number of rows equals to the total number of mapping units and with two columns. Thus, each line stands for one mapping unit. Column 1 gives the name of the mapping unit (e.g. A1-2), column 2 gives the number of the symbol on the map outprint (in ASCII code).
(In the programs ('digittab','datach') the mapping unit code file is converted to the array ACOD$(a,b) and MUC$(a,b)) respectively).
Together with the digitized map files (see Section 4.2.2; p.171) and the area size files (see Section 4.2.3; p.173) they are the only data files to be stored under the subdirectory of the area name !

Example:

In the soil map of the Borkena study area, 57 different mapping units were identified by the soil inventory,e.g.A1-1 (flat alluvial soil, printed as "a") or L (Lithosols, printed as "O").

No.	Mapping Unit Code	ASCII code for printout	Printout on matrix printer
1	M1	64	@
2	A1-1	97	a
3	A1-2	98	b
4	A1-3	99	c
5	A1-4	100	d
.			
.			
55	B6	126	^
56	L	48	0
57	W	42	*
(58	OUT	46	.)

A good map should have as many selfexplicatory codes as possible. This request has to be fulfilled by the authors. At soil maps e.g. there are various standard systems of coding the soil associations; mapping unit codes of the administrative maps can be a combination of the number of the district plus the number of the Peasant Association, e.g. 0115: 15.PA in Woreda 01.

4.2.5 Soil Mapping Unit Composition File ('MCP file')

Function:

The soil mapping unit composition file with extension MCP gives the information about the various soil types forming a soil mapping unit. In homogeneous areas at large inventory scales, a mapped soil unit (recommendable with an appr. minimum size of not less than 50 ha at the scale of 1:50,000) will consist of one soil type. In heterogeneous areas and in smaller mapping scales, several soil types will form a mapping unit: soil associations. In the present GILES version, up to 4 different soil types will form a mapping unit.

These files are created or modified through option 'Database' of the Main Menu, then option 'Soil Mapping Unit Composition'. Alternatively, the composition table can be input into Lotus and then imported into GILES.

In case of a change, care has to be taken that the soil type characterization file might have to be adjusted.

Nomenclature:

For each study area, a separate soil mapping unit composition is given by the soil survey. It is filed under the name:

aSOIL.MCP

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. **BORKSOIL.MCP** information about the composition of all soil mapping units of Borkena

Structure:

The soil mapping unit composition file is a two-dimensional integer array with each row standing for one soil mapping unit (a). Therefore, this array has as many rows as soil mapping units occur (MAXUNS). The column indicates the importance of the soil type in the soil mapping units.

Table 4.2

Structure of Soil Mapping Unit Composition

Column	1	2	3	4	5	6	7	8
Dominance	>90 %	75 %	50 %	50 %	25 %	25 %	25 %	25 %

If a figure exists in the first column, it indicates the dominant soil (> 90 % coverage of the unit). Figures in the following columns give the soil type coverage in the association.

(This data array is handled in the programs under the name of SMUCP%(a,b) with a not greater than MAXUNS, b not greater than STPMU).

Example:

In the Borkena study area, the soil mapping unit composition looks like:

Soil Types

Soil Mapping Unit	Area Coverage							
	>90%	70%	50%	50%	25%	25%	25%	25%
1	5	0	0	0	0	0	0	0
2	0	17	0	0	1	0	0	0
3	0	17	0	0	4	0	0	0
.								
56	64	0	0	0	0	0	0	0

(The numbers 5,17,1,4,64 are soil types).

4.2.6 Soil Type Name File ('STN file')

Function:

Different soil types are occurring in each area. Due to the scale of the inventory it is mostly not possible to map the soil units, but only soil complexes (soil associations, soil complexes, or 'soil mapping units'). The list with the names of all occurring soil types (in some studies called 'land units') is given in this soil type name file with extension STN.

Input and modifications is made through option 'Database' of the Main Menu, then option 'Soil Type Names'. Alternatively, the names can be input into Lotus and then imported into GILES.

The soil type names are not essential for land evaluation assessments.

Nomenclature:

The name of these soil type name files is:

aSOIL.STN

where: a name of the study area (e.g.BORK, BICH, HOS)

e.g. **BORKSOIL.STN** list of the soil type names of Borkena

Structure:

The soil type name file is a one-dimensional string array with the number of soil types as its size.

(Depending on the purpose of the retrieval of these files, they are handled in the programs either as STN$(a) array or as MUC$(a) array with a not greater than AMST and STN respectively).

Example:

In Borkena, there are 64 soil types, beginning with no.1 as an eutric Gleysol (Ge1) and ending with no.64 as Lithosol (I).

No.	Soil Type
1	Ge1
2	Ge2
3	Gc1
.	
64	I (in B6/L)

4.2.7 Soil Type Characterization File ('TCH file')

Function:

The soil type characterization file with extension TCH gives all essential information about the 50 soil specific land characteristics for each soil type occurring in the study area. This list of land characteristics is determined by the necessity for land evaluation. All values in this file are coded following the legend of the land characteristics (LCHATN file, see Section 4.2.16; p.176). The specific parameters for these land characteristics for the considered soil type are taken out of this file after the soil type is called through the soil mapping unit composition file (see Section 4.2.5 above).

Entry or modifications can be made through option 'Database' of the Main Menu, then through option 'Soil type characterization'. Alternatively, the table can be input into Lotus and then imported into GILES.

It is recommended to print first the land characteristics (LCHATN file) to see the classes and their ranges.

Nomenclature:

For each study area, the specific land characteristics for each soil type are given by the soil inventory. The name of this file is:

aSOIL.TCH

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. **BORKSOIL.TCH** information about all land characteristics of all soil types in Borkena

Structure:

The soil type characterization file is a two-dimensional integer array with the soil types as the rows and the land characteristics as the columns. Therefore, it has as many rows as soil types and as many as 50 rows.

(In the programs, the soil type characterization file is converted into the STCH%(a,b) array with a not greater than AMST, b not greater than 50).

Example:

There are 64 soil types in Borkena study area, giving a soil type characterization file of 64 rows and 50 columns. Each figure stands for the specific land characteristic class of the referring soil type, e.g. soil type no.20 (Lo2, in line 20) has in land characteristic no.4 (mineral fragments of the top-soil, in column 4) a value of 2, which stands for a mineral fragments content of 0-15%).

Soil Type	Drai-nage	Texture top	Texture sub	Min.fragm. top	Min.fragm. sub	Soil depth	Tops. depth	Pond.	Flash flood.	...
1	3	16	16	1	1	6	2	9	1	...
2	3	9	9	1	1	6	3	1	2	...
3	3	16	16	1	1	6	3	9	1	...
.										
.										
20	3	17	17	2	1	5	3	1	1	...
.										
.										
63	7	19	19	4	9	2	1	1	1	...
64	7	19	19	4	9	2	1	1	1	...

4.2.8 Altitude Correlation File ('COR file')

Function:

Temperature and potential evapotranspiration correlate to a high degree with the altitude a.s.l. The values to calculate the annual and monthly temperature and potential evapotranspiration out of the altitude are given in this altitude correlation file with extension COR. Thus, it presents climatic land characteristics. For both the temperature and the potential evapotranspiration the intercept as well as the slope of the regression can be read out of this data file.

If the PET-altitude correlation varies in the study area, it is possible to define a second PET-altitude correlation being effective in selected, predefined precipitation mapping units.

The formula

$$y = a - b * x$$

where: a intercept (C or mm)
b slope (C/100 m or mm/100 m), positive
x altitude (in 100 m)

enables the calculation of the mean annual and monthly temperatures (C) or of the annual and monthly potential evapotranspiration (mm/year).

Entries or changes can be made through option 'Database' of the Main Menu, then option 'ALtitude correlation'. Monthly PET figures can be entered with:

a) intercept and slope of the regression of every month, or:
b) intercept and slope of the annual PET regression and the monthly percentages of the annual amount.

Nomenclature:

The values for the definition of the regression equation are calculated out of the temperature, potential evapotranspiration, and altitude figures of the meteorological stations. The data files are stored under the name:

aALT.COR

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. **BORKALT.COR** correlation figures for the estimate of annual and monthly temperature and PET values

Structure:

The altitude correlation file is a two-dimensional array with two columns: one for the intercept of the regression line, the other one for its slope, and with 26 or 39 rows (if two PET-altitude regressions occur): Row 1 stands for the annual temperature, row 2-13 for the monthly temperature figures, row 14 for the annual potential evapotranspiration, row 15-26 for the monthly potential evapotranspiration figures, eventually rows 27-39 for the monthly potential evapotranspiration figures of the second regression.

(In the application programs, this file in assigned to the array ALT(a,b) with a not greater than 39, b either 1 or 2).

Example:

In the Borkena study area, the intercept (a) for the temperature of July is 33.8 C, the regarding slope is 0.71 C/100 m. Therefore, the July temperature at 2000 m is

y = 33.8 - 0.71 * 20 = 19.6 C.

Temperature	annual	30.5	0.60
"	January	26.7	0.50
"	February	28.1	0.52

4.2.9 Administrative Unit Characterization File ('ACH file')

Function:

The administrative unit characterization file with extension ACH gives any information about the 50 structural characteristics for each administrative unit (e.g. PA) occurring in the study area. All values in this file are coded following the legend of the structural characteristics (aATN.NAM file, see Section 4.2.17; p.177). The specific parameters for these structural characteristics for the administrative unit are taken out of this file.

Entry or modifications can be made through option 'Database' of the Main Menu, then option 'Administrative unit characterization'. Alternatively, the table can be input into Lotus and then imported into GILES.

It is recommended to print first the structural characteristic classes (aATN file) to see the classes and their ranges.

Nomenclature:

The syntax of these files is:

aADM.ACH

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. BICHADM.ACH information about all structural characteristics of all administrative units in Bichena

Structure:

The administrative unit characterization file is a two-dimensional integer array with the administrative units as the rows and the structural characteristics as the columns. Therefore, it has as many rows as administrative units (e.g. PA) and 50 columns.

Handling and structure of this file is similar to the 'soil type characterization file (TCH), see Section 4.2.7 (p.163).

Example:

There are 162 Peasant Associations in the Hosaina study area, giving an administrative unit characterization file of 162 rows. Each value stands for the specific structural characteristic class of the referring PA.

The form of this matrix is the same as of the soil type characterization file, see Section 4.2.7 (p.163).

4.2.10 Precipitation Raw Data File ('PREC.DAT file')

Function:

The raw monthly or decadal rainfall data are entered into this file and give the possibility for further processing (calculation of mean, standard deviation etc., interpolation of data, generation of rainfall data) or for direct input (if the data set is sufficient) for length of growing period calculations or for climatic suitability assessments.

Data entry mode can be accessed through option 'Database' in Main Menu, then option 'Precipitation data', then option 'Input precipitation data'. As an alternative, precipitation data can be entered into Lotus 1-2-3 spreadsheets and then incorporated through above mentioned options with option 'Input of one station from Lotus file' into the 'Precipitation raw data' file (see 'How to import precipitation data', Section 3.3.28; p.142).

Nomenclature:

The syntax of this file is:

aPREC.DAT

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. **BICHPREC.DAT** monthly precipitation figures of all precipitation mapping units of the Bichena area

Structure:

In this sequential file the rainfall (in 1/10 mm) is stored for each station unit for each month/decade for each recorded year. Missing data are coded as -990. A figure at the begin of the file indicates whether monthly or decadal data are recorded.

Example:

The precipitation data set in this file looks like any datasheet of precipitation data recorded at Meteorological Agencies with the years as the rows and the months/decades as the columns, e.g.:

	Jan	Feb	Mar	Apr	May	...
1961	53.4	32.4	79.5	79.4	40.5	...
1962	12.6	0	91.0	53.4	23.5	...
1964	34.6	12.4	27.9	x	x	...
.						
1980	41.9	23.9	34.9	12.6	65.8	...

4.2.11 Raingauge Relation File ('REL file')

Function:

If the available rainfall data set is not sufficient (i.e. many missing data), it is necessary for the calculation of long-term mean values to refer to nearby situated raingauges with a similar rainfall pattern and to compare with the data available there.

This is done through option 'Database' of the Main Menu, then option 'Precipitation data', then option 'fill missing data (interpolation model)'.

For this interpolation model it is necessary to know about the reference relations between the raingauge stations. These references are stored in the 'Raingauge relations' file. They have to be entered before processing of the interpolation. Rules defining the references between raingauges have to be followed strictly (see App.7.7; p.237).

Nomenclature:

The syntax of this file is:

aREL.DAT

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. BICHREL.DAT reference relations of all raingauge stations in Bichena area

Structure:

In this sequential file the relations are stored for each station unit as a two-dimensional array with the rows (1.dimension) standing for precipitation units and 7 columns standing for:

1 Station number
2-4 Reference station number (1-3 reference stations accepted)
5-7 Weighting of these 1-3 reference stations

Example:

Station	Reference station			Weighting		
	I	II	III	of I	of II	of III
1	4	3	0	1	1	0
2	3	6	1	2	1	1
3	0	0	0	0	0	0
4	2	3	8	3	1	1
.						

4.2.12 Gamma Distribution of Precipitation File ('GAM file')

Function:

To execute the gamma distribution for processing of a poor rainfall data base, mean (without the months of no-rainfall), standard deviation (without the months without rainfall) and the probability-of-no-rain have to be known. They are stored in the 'gamma distribution of precipitation file'. Based on these figures, gamma distribution is applied to create any number of precipitation values. These data have to be entered before processing starts.

The access is through option 'Database' of the Main Menu, then option 'Precipitation data', then option 'calculate long term averages' or 'generate randomly distributed rainfall figures'.

(The results of the interpolation model (see Section 4.2.11, above) can be stored in a different gamma distribution file, called 'aRES.DAT').

Nomenclature:

The syntax of this file is:

aGAM.DAT

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. BICHGAM.DAT characterization values of all precipitation mapping units of Bichena

Structure:

The sequential access file stores:

monthly mean without the months without rainfall,
monthly standard deviation without the months without rainfall, and
probability of no rainfall

for each month/decade for each precipitation mapping unit in mm.

Example:

Columns 10-12 of the processed precipitation data of one station in Table 3.13 (p.90) show how the gamma distribution output data.

4.2.13 Expected Precipitation Values at Given Reliability ('RLV file')

Function:

The precipitation map supports the information about the mean and the precipitation to be expected at 6 reliability levels (90%, 80%, 75%, 66%, 50%=median). These data are stored in the 'Expected precipitation values at given reliability file' with extension RLV (see Section 4.2.11, above, and App.8.22; p.253).

They can be retrieved for any location by option 'Site-specific information' in the Main Menu.

Nomenclature:

The syntax of these files is:

aPREC.RLV

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. **BICHPREC.RLV** annual and monthly mean and annual and monthly precipitation to be expected at 4 reliability levels of all precipitation mapping units of the Bichena area

Structure:

The random access file with 7 records for the different reliability levels is stored under record number:

(mapping unit - 1) * 13 + month + 1, or:
(mapping unit - 1) * 13 + decade + 1

Example:

The example of site-specific information retrieval in Table 3.4 (p.63) gives the lines with the annual and monthly precipitation to be expected at various reliability levels as the output of this file.

4.2.14 Precipitation Figures of (20) Years File ('TWY file')

Function:

The calculation of the growing period to be expected has to calculate first the growing periods of a number of years (e.g. 20 years) and then to incorporate the reliability level. Therefore, the monthly/decadal precipitation figures of the considered period (i.e. 20 years) have to be taken out of this 'precipitation figures of (20) years file' with extension TWY. This is **essential** in the application programs for the assessment of the growing period.

Monthly or decadal precipitation figures of all mapping units of the study areas are either:

a) collected by Meteorological Services on monthly or decadal basis, input and then converted from 'precipitation raw data file' (...PREC.DAT) to this 'precipitation figures of (20) years file' (.TWY) by option'Database' in the Main Menu, then option 'Precipitation data' and finally option 'Transfer into TWY file'; or:

b) if the original data base is not available or not very reliable, monthly precipitation figures will be simulated ('**generated**') out of the 'gamma distribution file' (...GAM.DAT) through option 'Database' in the Main Menu, then option 'Precipitation data', then option 'Produce randomly distributed rainfall figures'. The generated monthly or decadal precipitation figures of (20) years will be stored under this 'precipitation figures of (20) years' file.

Nomenclature:

These precipitation figures are stored under file name:

aPREC.TWY

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. **BICHPREC.TWY** original or simulated monthly precipitation figures of (up to 20) years of all precipitation mapping units of the Bichena area

Structure:

This file is random access file with 26 different fields containing the rainfall values of (20) years and additionally expected and simulated mean(0) (not used), standard deviation(0) (not used) and probability-of-no-rain (not used) of a particular month/decade of a particular mapping unit. The record number of the file gives the information about month/decade and mapping unit (station) by the formula:

(mapping unit - 1) * 12 + no.of month + 1, for monthly data; or:
(mapping unit - 1) * 36 + no.of decade + 1, for decadal data

The first record is reserved for two control variables:
Generated (1) or not (0) in field 1,
monthly (12) or decadal (36) data in field 2.

All values are stored in integer figures in their ten times value.

Example:

The data look like any other precipitation data (e.g. in file 'precipitation raw data', ...PREC.DAT), but without any data gaps ('x').

4.2.15 Land/Structural Characteristic Name File ('LCHAR file')

Function:

139 characteristics concerning the 'land' (physical properties) or the 'structure' (infrastructure or administration) can be entered and retrieved from GILES.

The first 89 land characteristics are measurable or estimatable 'physical' attributes of the land to describe the land qualities and thus the ability of the potential of the land for certain land uses. They serve as the main input for land suitability assessments and are retrieved through soil (mapping) units, altitude or precipitation (mapping) units.

Up to 50 characteristics describe the population, infrastructure, administration and food situation, based on administrative units (e.g. PA) and therefore referring to administrative maps.

The names of these land/structural characteristics are stored in this 'land/structural characteristic name file'.

Modifications can be made through option 'Database' of the Main Menu, then option 'Land/Structural characteristics names'.

Nomenclature:

The name of this one file is:

LCHAR.NAM

and is accessible for any project area in the same way.

Structure:

This file is a random access file converted into a one-dimensional string array with 139 lines; each line stands for the name of one land/structural characteristic.

Example:

The first 26 land characteristics refer to physical soil properties, no. 27-50 to chemical soil properties, no.51-89 to climatic land characteristics, no.90-139 to structural characteristics. Not all of them are finally defined.

<u>Table 4.3</u>

Names of Land/Structural Characteristics

1 Drainage
2 Texture (tops.)
3 Texture (subs.)
4 Mineral fragment (tops)
5 Mineral fragment (subs)
6 Depth
7 Topsoil depth
8 Ponding
9 Flash flooding
10 Flooding
11 Surface stoniness
12 Surface rockiness
13 Erosion/gully/badland
14 Necessity for gully erosion measures
15 Mean slope
16 Mean maximum slope
17 Topography
18 Microrelief
19 Slope shape
20 Slope length
21 Groundwater level
22 Permeability
23 Consistence
24 Structure (tops.)
25 Surface sealing
26 Bulk density
27 Organic matter
28 N_t (tops.)
29 N_t (subs.)
30 P_{avail} (tops.)
31 Ca_{exc}
32 Mg_{exc} (tops.)
33 Mg_{exc} (subs.)
34 K_{exc} (tops.)
35 K_{exc} (subs.)
36 pH (tops.)
37 pH (subs.)
38 CEC (tops.)
39 BS (tops.)
40 BS (subs.)
41 Na_{exc} (tops.)
42 Na_{exc} (subs.)
43 EC (tops.)
44 EC (subs.)
45 Soil type
46 Erodibility (kc)

49 (not defined yet)
50 (not defined yet)

51 Annual temperature
52-63 Monthly temperature
64 Annual PET
65-76 Monthly PET
77 Annual precipitation
78-89 Monthly precipitation
90 Woreda (District)
91 Awraja (Province)
92 Region
93 Population
94 Present population density
95 Population density in 10 y
96 Population density in 25 y
97 PA members
98 TLU
99 TLU density
100 Cows
101 Oxen
102 Cattle (total)
103 Cattle density
104 Sheep
105 Sheep density
106 Goats
107 Goats density
108 Equines
109 Equines density
110 Access
111 Education
112 Medical situation
113 Population support capacity
114 Population support capacity in 10 y
115 Population support capacity in 25 y
116 AGH (Arable + grazing land/househ)
117 Surplus producing Woredas
118 Ongoing Farming Research
119 Livestock Carrying Capacity
120 Grazing Pressure
121 (not defined yet)
.
139 (not defined yet)

4.2.16 Land Characteristic Class Name File ('LCHATN file')

Function:

Each of the 50 soil land characteristics (see Section 4.2.15, above) is grouped into discrete classes with individual class ranges and class names. They are filed under this 'land characteristic class name' file.

The names can be retrieved or changed through option 'Database' in the Main Menu, then 'Land characteristic classes names'.

Attention: Soil characteristics being used for land evaluation assessments should not be redefined!

Nomenclature:

The name of this one file is:

LCHATN.NAM

and is accessible for any project area in the same way.

Structure:

This file is a random access file with 50 (=total number of land characteristics) as the total number of records. Thus, the number of the considered land characteristic is the taken record number, the class within this land characteristic is the field number.

At the retrieval, the names of the called land characteristic are converted into a one-dimensional string array with 30 lines. Each line stands for the name of one land characteristic class.

The handling and structure of this file is similar to that of aATN.NAM file (see Section 4.2.17) which handles structural characteristics but area-specifically.

Example:

The land characteristic class names of the first land characteristic: drainage, are as follows:

1 very poorly drained
2 poorly drained
3 imperfectly drained
4 moderately well drained
5 well drained
6 somewhat excessively drained
7 excessively drained

4.2.17 Structural Characteristic Class Name File ('ATN file')

Function:

Up to 50 structural characteristics can be set to define the characteristics of the administrative units (see Section 4.2.16 above). The class names within these structural characteristics are filed under this 'Structural characteristics classes file', **individually for each area**.

The names can be retrieved or changed through option 'Database' in the Main Menu, then option 'Land/Structural characteristic class names'.

Nomenclature:

The syntax of these files is:

aATN.NAM

where: a name of study area (e.g. BORK, BICH, HOS)

e.g. **HOSATN.NAM** structural class names of Hosaina study area

Structure:

This file is a random access file with 50 (=total number of structural characteristics) as the total number of records. Thus, the number of the considered structural characteristic is the taken record number, the class within this structural characteristic is the field number.

At the retrieval, the names of the called structural characteristic are converted into a one-dimensional string array with 30 lines. Each line stands for the name of one structural characteristic class.

The handling and structure of this file is similar to that of the LCHATN.NAM file (see Section 4.2.16) which handles physical characteristics.

Example:

The structural characteristic class name of the third structural characteristic: population density, in Hosaina area reads as:

1 < 25 cap/km2
2 20 - 50 cap/km2
3 50 - 75 cap/km2.
.

4.2.18 LUT/Crop Name File ('LUT file')

Function:

Several crops were selected by either being representative or dominant for the (sub)tropical highlands or as having a high potential for the future development in this environment.

This list is given in the 'LUT/crop name' file.

In a next stage, these crops can be combined to crop mixtures and later to farming systems ('land utilization types'). Thus, in the first instance, this file - as well as the respective suitability assessments - will handle the names of crops (e.g. wheat, sorghum, coffee), species and generally defined major kinds of land use, in the second instance the names of crop mixs (e.g.barley-ensete-horsebean zone).

A more accurate, but more time consuming method for the assessment of crop mix suitabilities is to overlay the suitability assessments of the various components (crops) by 'overlay previously configured maps'.

Modifications can be made through option 'Database' of the Main Menu, then by option 'LUT/crop names' (see 'How to add a crop', Section 3.3.12; p.119).

In case of a change care has to be taken that the referring crop requirements have to be changed as well.

Nomenclature:

The name of this one file is:

LUT.NAM

and is accessible for any project area in the same way.

Structure:

This file is a random access file converted into a one-dimensional string array; each line stands for one crop name.

Example:

In the present version, this list is:

Table 4.4

List of Considered Crops

1	Sorghum	26	Cabbage
2	Maize	27	Pineapple
3	Rice (paddy)	28	Sisal
4	Rice (upland)	29	Niger seed
5	Wheat	30	Sesame
6	Barley	31	Sunflower
7	Teff	32	Safflower
8	Oats	33	Flax (linseed)
9	Field Peas (pis.arv.)	34	Tobacco
10	Haricot Beans (phas.v.)	35	Cassava
11	Horse Beans (vic.f.)	36	Cotton
12	Chickpeas (cic.ar.)	37	Groundnut
13	Lentils	38	Pearl millet
14	Vetch	39	Finger millet
15	Soybeans	40	Grape
16	Coffee	41	Ensete
17	Tea	42	Cow Pea
18	Banana	43	Maize:Short LGP var.
19	Citrus	44	Testcrop A
20	Sugarcane	45	Testcrop B
21	Pepper	46	
22	Shallot	47	(Cattle)
23	Tomato	48	(Sheeps/goats)
24	White potato	49	(Fuelwood Forest)
25	Sweet potato	50	(Conservation Forest)**Function**:

4.2.19 Study Area Name File ('STAREA file')

Names and stored characteristics of the considered areas (project areas, regions) where data are gathered from, entered and retrievable (in the particular subdirectories), are listed in this file. In particular:

1) Study area name
2) Working abbreviation (3 or 4 letters)
3) Scale of map input (in thousands)
4) Total number of soil types per study area (not essential)
5) Names (list) of additional maps, beyond the predefined set which is: soil, altitude, precipitation, land use/land cover, administration, agroecological zones, planning zones
6) Working abbreviations of these additional maps (3 or 4 letters)
7) Names of all map sheets of the project area
8) Working abbreviation of these map sheets (1 number or 1 letter: 1-9, then followed by A-Z)
9) Relative position of these map sheets to the previous sheet, where:

1 one to the right	6 one down and one to the left
2 two to the right	7 one down and two to the left
3 three to the right	8 one down and three to the left
4 four to the right	9 one down and four to the left
5 one down	

10) N,S,W,E coordinates of these map sheets

Modifications, in particular the entry of new areas, map sheets or additional maps, can be made through option 'Database' of the Main Menu, then option 'Study areas' (see 'How to add a new area', Section 3.3.15; p.122).

Nomenclature:

The name of this one file is:

STAREA.NAM

and is accessible for any project area in the same way.

Structure:

This file is a random access file where parameters 1-4 are stored in one (area-specific) record and the names and abbreviations of the map sheets (parameter 7 and 8) and, if existing, of the additional maps (parameter 5 and 6).

The number of study areas and the allover maximum number of sheets per study area is saved under record 1.

Example:

Stored data of Borkena study area are:

Study area name : Borkena
Study area abbreviation: BORK
Scale of inventory and data entry: 1:50000

Maps: Soil
Altitude
Precipitation
Land use/cover
Administration
Agroecological Zones
Planning Zones
Linear Features (additional map)

Mapsheets:
1: Degaga
no.=working abbreviation: 3
Relation: 2 (two to the right)
N: 11.00
S: 10.75
W: 39.50
E: 39.7545
2: Harbu
no.=working abbreviation: 4
Relation: 1 (one to the right)
N: 11.00
S: 10.75
W: 39.7545
E: 40.0091
3: Rabel
no.=working abbreviation: 9
Relation: 6 (one down and one to the left)
N: 10.75
S: 10.50
W: 39.50
E: 39.7545
4: Kemise
no.=working abbreviation: A
Relation: 1 (one to the right)
N: 10.75
S: 10.50
W: 39.7545
E: 40.0091

4.2.20 Crop requirement File ('CREQ file')

Function:

The crop requirements describe the various biological characteristics and thus different requirements of crops. They correlate to the land qualities and are expressed with the same (qualitative or quantitative) classes as the land qualities. They are called by the suitability assessment programs whenever they are required for the matching procedure.

The crop requirements are entered - or can be retrieved - through option 'Database' in the Main Menu, then option 'Crop requirements' (see 'How to change the crop requirements', Section 3.3.12 (3); p.119).

Nomenclature:

There are two crop requirement files:

CREQ1.DAT and
CREQ2.DAT

Structure:

The number of the crop functions as the record number, the considered quality or characteristic is the field number. CREQ1 handles crop requirements 1-20, CREQ2 21-40.

(The required crop requirements will be checked at the beginning of each application program and then converted into single variable, such as FLDSENS).

Example:

Example of the crop requirements of wheat is shown in Table 3.11 (p.87) and of all considered crops for drainage tolerance in Table 3.12 (p.88).

4.2.21 Help Menu File ('TXT file')

Function:

This is a GILES internal file to present context-sensitive help menus individually for each menu of GILES.

At the Main Menu, help menus are individual for each line (option) to present information about each general facility of GILES.

In the present version, 102 help menus are installed.

They are called by pressing F1 function key at the top left side of the keyboard whenever a menu is displayed.

Modifications can be made through option 'Database' of the Main Menu, then option 'Help menus'.

Nomenclature:

The name of this one help file is:

HELP.TXT

Structure:

Help information is stored in 10 lines in a random access file (each line forms a field). The record number is given as the menu number shown at the top of the help screen.

Example:

Examples can easily be retrieved by pressing F1.

Appendix 1

SET UP AND INSTALLATION

This appendix describes how to install GILES in your computer:

1) Getting started
2) Configuration
3) Hard disk installation
4) Transfer of GILES from one system to another
5) Backup

*****

App.1.1) GETTING STARTED

GILES software system consists of:

a) 6 disks containing all programs and data files:
   GILES-1
   GILES-2
   GILES-3
   GILES-4
   GILES-5
   GILES-6 (general data)

   (Listing of all files is given in App.6; p.208)

b) 4 disks with sample for tutorial and demonstration:
   GILES-SAMPLE-1 (general area data)
   GILES-SAMPLE-2
   GILES-SAMPLE-3
   GILES-SAMPLE-4

c) Manual of GILES

The system is not copy protected.

All disks should be backed up on separate disks before the first installation. This can be done by the DOS command DISKCOPY:

1) If you have two floppy disk drives:
   Type DISKCOPY A: B: , then press <Enter>
   If you have one floppy disk drive:
   Type DISKCOPY A: A: , then press <Enter>
2) Insert disk GILES-1 in drive A

3) Insert a blank, formatted, double-sided disk in drive B
   (if not existing, in drive A) and press <Enter>
4) Follow the instruction on the screen
5) Repeat procedure 2 and 3 for disks GILES-2,GILES-3, GILES-4, GILES-5, GILES-6

The Epson printer (or compatible) should be set up to print in ESC/P mode (see your printer manual).

***

App.1.2) CONFIGURATION

Every time the computer boots, it checks for the configuration file (CONFIG.SYS). To have GILES on the computer, this file should allocate <u>20 as the number of concurrently open files</u> and approximately <u>30 disk buffers</u>.

Additionally, it is recommended to allocate memory (at least 250 kB) to a <u>virtual disk (D:)</u> drive, using extended memory (if installed).

Therefore, the configuration file must contain:
FILES = 20 (or greater), and
BUFFERS = 30 (or greater).
A virtual disk drive D (or E) should be installed.

These lines can be inserted or modified in the CONFIG.SYS file through the DOS editor 'edlin' or through a wordprocessor.

***

App.1.3) HARDDISK INSTALLATION

GILES will be installed (for the first time) on a hard-disk-system by following procedure. Only if you get new equipment, you may need to repeat this procedure. Some 4 MB should be free on the harddisk before installation of GILES.

1) Make sure the C prompt is on screen
   (if not, type C:)
2) Insert disk GILES-1 in drive A
3) Type A:INSTALL FROM A <Enter>
4) Keep disk GILES-1 in drive A
5) Follow the instruction: Type \LANDEV\GILESIN FROM A
6) Follow the instructions on the screen and change disks GILES-2, GILES-3, GILES-4, GILES-5,GILES-6,
   (GILES-SAMPLE-1, GILES-SAMPLE-2, GILES-SAMPLE-3, GILES-SAMPLE-4)

By this installation, four subdirectories will be created:

C:\LANDEV\ to store programs and general data files of GILES-1, GILES-2, GILES-3, GILES-4,GILES-5,GILES-6
C:\INTERM\ to store intermediate map files
C:\WORKD\ as an auxiliary directory
C:\BORKDG\ to store map files of GILES-SAMPLE-a

and all files will be copied to C:\LANDEV\ or C:\BORKDG\.

Additionally, it copies the file BRUN40.EXE essential for program execution of QuickBasic compiler programs to the root directory C. If it is already in a directory (e.g.DOS subdirectory) with installed path, it can be taken out.

For each project area stored on disks, you have to:

1) Make sure the C prompt is on screen
   (if not, type C:)
2) Type MKDIR \aDG <Enter>, e.g. MKDIR \ETHDG
3) Insert the first disk with data/maps of the additional project area into drive A

4) Insert the disk with 'General area data' of the project area into drive A

5) Enter 'GILES' and use the 'File operation' option of the Main Menu to copy all files of the 'General data' from A:\LANDEV\ to C:\LANDEV\

OR:

5) Type: COPY A:\LANDEV*.* C:\LANDEV*.*

6) Enter 'GILES' and use the 'File operation' option of the
Main Menu to copy all files from A:\aDG\ to C:\aDG\
OR:
6) Type COPY A:\aDG*.* \aDG*.* <Enter>

7) Repeat procedure 6 with each disk of the considered area

where a name of study area (abbreviation, not more than 4 letters, e.g. BORK)

***

App.1.4) TRANSFER OF GILES FROM ONE SYSTEM TO ANOTHER

If you want to copy the entire GILES system from the harddisk to floppy disks or to copy it (possibly in an upgraded version) into a hard-disk system where GILES is already installed, you can use two additional commands of GILES:

aa) To copy **GILES out** from the system:

1) Make sure the C prompt is on screen
(if not, type C:)
2) Insert disk GILES-1 in drive A or B
3) Type: \LANDEV\GILESOUT TO a <Enter>
4) Follow the instructions on the screen and insert disks GILES-2, GILES-3, GILES-4, GILES-5 and GILES-6

where a is the drive with the target disk (A or B)

Additionally **for each study area**, you have to copy the data (general area data, map files, area sizes files and mapping unit codes) to disks. Start with the sample area BORK, i.e. a is BORK in following procedure:

5) Insert a blank, formatted, double-sided disk in drive A
6) Create a subdirectory: MKDIR A:\LANDEV

7) Enter 'GILES' and use the 'File operation' option of the Main Menu to copy all files of the 'General data' from C:\LANDEV\ to A:\LANDEV\
OR:
7) Type: COPY C:\aDG\a*.* A:\aDG*.*

8) Insert a blank, formatted, double-sided disk in drive A
9) Create a subdirectory: MKDIR A:\aDG

10-12) Enter 'GILES' and use the 'File operation' option of the Main Menu to copy all files of a map from C:\aDG\ to A:\aD\

OR:

10) Type: COPY \aDG\DGb??.MAP A:\aDG*.* <Enter>
11) Type: COPY \aDG\ab.MUC A:\aDG*.* <Enter>
12) Type: COPY \aDG\ARSb?.DAT A:\aDG*.* <Enter>

13) Repeat procedure 8-12 with each map of the considered project area

where a name of study area (abbreviation, not more than 4 letters, e.g. BORK)
b theme of map (abbreviation, not more than 4 letters, e.g. SOIL, ALT)
see Glossary: Predefined map

If more project areas have to be copied out, replace a with the abbreviation name of the additional project area and go back to step 5.

---

bb) To copy (an updated version of) **GILES** into a harddisk system where GILES is already installed in:

1) Make sure the C prompt is on screen (if not, type C:)
2) Insert (new) disk GILES-1 in drive A or B
3) Type: \LANDEV\GILESIN FROM a <Enter>
4) Follow the instructions on the screen and change disks GILES-2, GILES-3, GILES-4, GILES-5, GILES-6

where a is the drive with the source disk

For **each additional project area** stored on disks, you have to:

1) Make sure the C prompt is on screen (if not, type C:)
2) If no subdirectory for the considered project area is installed yet, type: MKDIR \aDG <Enter>

3) Insert the disk with 'General area data' of the project area into drive A
4) Enter 'GILES' and use the 'File operation' option of the Main Menu to copy all files of the 'General data' from A:\LANDEV\ to C:\LANDEV\

5) Insert the first disk with data/maps of the additional project area into drive A

6) Enter 'GILES' and use the 'File operation' option of the Main Menu to copy all map files of a disk from A:\aDG\ to C:\aDG\

OR:

7) Type COPY A:\aDG*.* C:\aDG*.* <Enter>

8) Repeat procedure 5 - 7 with each disk of the area

where a name of study area (abbreviation, not more than 4 letters, e.g. BORK)

If more project areas have to be copied, replace a with the abbreviation name of the additional project area and go back to step 2.

*****

App.1.5) BACKUP

Making backup copies of data stored on disks is an essential data processing practice with any computer. **Backup copies should be made frequently and consistently.**

At the stage of data entry, following back up copy can be recommended:

- daily back up copies alternatively to one of two "daily backup sets"
- every one or two weeks back up copies to a "weekly backup set"

Backup copies have to be made of 'general data set' (non-spatial data) as well as of recently entered/modified map data. Both of them can be made through the 'File operation' option of the Main Menu.

Two back up copies of finalized study areas should be stored on floppy disks. Recommended is a subdirectory for the study area (e.g. A:\ETHDG\... or A:\BORKDG\...) and the label of the disk should carry the study area name. Diskettes should be kept in a dry, clean place and be rewritten regularly (i.e. every two years).

Appendix 2

TUTORIAL

A Quick Introduction:

This chapter will show you how to retrieve information, lets say a map, without knowing anything of GILES.

First thing is to install GILES in your system (micro computer with hard disk). Thus, go first through App.1 if GILES is not installed yet. For an experienced DOS user, it will take only a few minutes to install GILES (which is nothing else but adjusting the configuration file, creating three or four sub-directories and copying all GILES files into the harddisk).

Then, start GILES by typing 'GILES' and press <Enter>. It will prompt you to the opening screen and after pressing any key, as proposed on the screen, to the MAIN MENU. This menu shows you all the facilities of GILES.

GILES menus typically show a number of options in different lines with a 'Command Bar' at the bottom, the 'Status Bar' at the top and the menu number in the upper right corner. All the options you can do within one menu are shown in the Command Bar.

At color screens, one line (one option) will always appear in 'reverse video', highlighted, with an arrow on the left. This is the option which will be chosen when <Enter> is pressed. You can move up and down by pressing the up or the down button on the keypad on the right handside of the keyboard.

Try to move up and down. If you are at the bottom and continue to go down, it will jump automatically to the top.

Once you press <Enter>, the next menu will appear. If you made a wrong decision, pressing the function key F1 at the left top of your keyboard will bring you back to the previous menu (at least in most of the cases). Once you think you are completely wrong, press function key F10 and come back all the way to the Main Menu.

From the Main Menu, you can get out of GILES by going down to the bottom line called 'out (Exit to System)' and then pressing <Enter>.

Try it - and come back again by entering 'GILES' and <Enter> !

If the example area of Borkena/Ethiopia is installed in your system, as proposed for your installation (see App.1), try a first map retrieval:

How to display a base thematic map, i.e. altitude map ?

Step	Selected Line	Selected Option
1	1	Base map
2	e.g. 1	(Selected area) [2]
3	1	Whole study area
4	3	C: <-- Default [1]
5	1	\....\ [1]
6	e.g.3	Altitude
7	1	Complete map
8	1	Map/data on screen only
9	2	High resolution image
10	1	No
11	2	Right column
12		<Enter>

[1] Assuming that all data and programs are stored on harddisk
[2] E.g. Borkena, Ethiopia

In a very similar way, Section 3.3 ('How to ...') will help you to get familiar with the most important options of GILES.

Section 3.3 (p.105-149)

is therefore to be understood as

Tutorial, part II.

Appendix 3

ERROR MESSAGES / TROUBLE SHOOTING

Error Message	Occurrence	Error Cause	Trouble Shooting
Button released ! Sorry, do it again	Map digitizing	Stylus released; or: active area of digitizing tablet left or to close to its margin	Press <Enter> and enter this unit again, starting at the same starting point
Bad test: Unplug and plug the transformer again	Digitizing tablet initialization	Digitizing tablet does not react on signals of computer; or: no handshake	> See under error > message: > 'No interface' If problem remains, digitizing tablet has to be checked (IC and wiring)
Calculated unit does fit to mapping unit codes	Area size calculation	Occurring mapping is greater than total number of mapping units in MUC file [4]	Check which unit(s) were forgotten (by running the area sizes with the old MUC file) and assign them (with their number) to the correct new mapping unit
Climatic suitability not in this drive/path	Land evaluation procedure	Climatic suitability files (DG1CMPxx.MAP) not in the mentioned drive/path	Try another drive and path; or: press F10, exit and look in other drives for missing files; or: create climatic suitability

Data file .. for this studyarea not input yet	Selection of options	Requested data are not entered yet; or: datafile is in another drive or another subdirectory	Press F10, select option 'Database' in Main Menu, proceed with other menues and enter the data
Double assignment at ...	Map digitizing	Listed grid cell assigned previously to another unit	If current (new) assignment is ok, press 'N', if previous assignment is correct, press 'P', if neither current nor previous assignment is correct, press 'C', if current assign ment is correct for the indicated and all following cells,press 'ALLN', if previous assignment is correct for the indicated and all following cells,press 'ALLP', if only one particular unit shall be replaced with the new unit, but all others remain unchanged, press 'SP'
Load paper into printer, turn printer on-line and press any key	Print of maps	Printer is out of paper; or: not on-line;or: not connected; or: not on	Load paper into printer, turn printer on-line again and press <Enter>
Lotus file not prepared yet	Selection of options	File 'LOT2GILx' for selection of mapping unit codes not declared; or: not converted into DIF file; or: not stored in C:\INTERM	Press F10, enter Lotus 1-2-3 and create requested file (See 'How to aggregate mapping units' Section 3.3.23); or: look in other directories for file 'LOT2GILx'

Mapping unit codes (file.) not entered yet	Selection of options	Mapping unit codes of this map not entered yet	Press F10, select option 'Database' in Main Menu, then 'Mapping unit codes', proceed with other menues and enter the mapping unit codes
No interface: Unplug and plug transformer again	Digitizing tablet initialization	Communication not established	Unplug the cable digitizing tablet-transformer from the transformer, plug it in again and try it again by pressing <Enter>; repeat this procedure 5-10 times;or: check, if the transformer has power;or: check, if the cable tablet-computer is in serial adapter board for serial interface 1; or: open the computer and check if the serial adapter board (for serial interface 1) is properly installed; if possible,check interface by plugging another serial device(e.g.serial printer,modem,Brooklyn bridge); or: unplug the cable from serial adapter board open the digitizing tablet and check the pin layout 2/
Not at starsting point	Map digitizing	Entered mapping unit is not 'closed' ('dead end')	If you want to continue at the last location (by stylus or keypad), press 'C', if you want to start allover again with this unit, press 'A'

Previously entered: codes	Map digitizing	Mapping unit code and starting coordinates are different than entered before digitizing	If most recent data are correct, press 'Y' and start again with this unit; if recent data are not correct, check them, enter 'N', code and coordinates again
Printer is not on	Selection of options	Printer is not on;or: not connected; or: not on-line; or: out of paper	Turn printer on; or: turn it on-line; or: load printer with paper; or: check cable and connections If no printer can be connected, press F2 or F10 and repeat selection procedure, but without print request
Soil suitability not in this drive/ path	Land evaluation procedure	Soil suitability files (DG2CMPxx.MAP) not in the mentioned drive/ path	Try another drive and path; or: press F10, exit and look in other drives for missing files; or: create soil suitability
Sorry, this map is not finally input yet	Selection of options	Map is not entered yet (MAP files are not created)	Press F10, prepare the maps and enter them (see 'How to enter a map', Section 3.3.18)
Sorry, too fast	Map digitizing	Stylus moved too fast (communication buffer overflow)	Press <Enter> and enter this unit again, starting at the same starting point
Subdirectory not found	Selection of options	Subdirectory is not created (thus, no maps are accessible), eventhough study area listing shows it [1]	> See under error > message: > 'This study > area is not > installed yet'

Suitability of different input level than loaded	Land evaluation procedure	The climatic and soil suitability are of a different input level than defined just right now	Either: accept it by pressing "YY" Or: press "N", exit, try it again; or: load/create climatic and soil suitabilities of the requested input level
Suitability of different LUT than loaded	Land evaluation procedure	The climatic and soil suitability are of a different crop/LUT than defined just right now	Either: accept it by pressing "YY" Or: press "N", exit, try it again; or: load/create climatic and soil suitabilities of the requested crop/LUT
Suitability of 2 diff. input levels were loaded	Land evaluation procedure	The climatic suitability (DG1..) and the soil suitability (DG2..) are of different input levels	Either: accept it by pressing "YY" Or: press "N", exit and load/create climatic and soil suitabilities of the same (requested) input level
Suitability of 2 diff. LUTs were loaded	Land evaluation procedure	The climatic suitability (DG1..) and the soil suitability (DG2..) are of different crops/LUTs	Either: accept it by pressing "YY" Or: press "N", exit and load/create climatic and soil suitabilities of the same (requested) crop/LUTs
Tablet area left ! Sorry, do it again	Map digitizing	Active area of digitizing tablet left or too close to its margin; or: stylus released	Press <Enter> and enter this unit again, starting at the same starting point
There is no communication: Check the cable from tablet to transformer	Digitizing tablet initialization	Digitizing tablet not functioning	Check power supply of digitizing tablet (transformer); or: check if transformer is connected to main source; or: check output voltage with voltmeter (± 12 V); or: check if transformer

			warmsup,then ok);or: check cable from transformer to tablet with all connections; or: unplug power cables and plug them in and try it through the menues again; or: check cable from tablet to computer; or: check if serial plug is in serial adapter; unplug it, plug it in and try it again Try all other recommendations: If it does not work, open the digitizing tablet and check the input voltage (right where the power cable comes in): ± 12 V
This study area is not installed yet	Selection of options	Subdirectory is not created (thus, no maps are accessible), even though study area listing shows it [1]; or: study area is not entered yet	Press F10 and check, if the requested area is listed; if yes, create a new subdirectory at the data drive by: MKDIR C:\aDG and copy resp. enter all available map files and MUC files into this subdirectory, any other data files into subdirectory INTERM; if no, press F10, select option 'Database' in Main Menu, 'Study area names' and enter the data (See Section 3.3.15; p.117)
This subdirectory is not allowed	Selection of options	Wrong subdirectory declared; or: backslashes forgotten at begin and end of subdirectory	Press <Enter> and give correct subdirectory with backslashes at front and end (e.g.\ETHDG\)
Too tricky shape ! Split it into two and start	Map digitizing	Too many 'stalactites' (more than 10 times crossing of the boundary	Press <Enter>, enter a starting point, enter half of this unit (with half of

again		of this unit in one row)	the 'stalactite' area), then enter the rest of this unit
Unit too big! Split it into two and start again	Map digitizing	Entered unit is too large (more than 5700 coordinates in 1 mm-grid system; boundary longer than appr. 1000 5 mm grid cells)	Press <Enter>, enter half of this unit, starting at the same starting point, then enter the rest of this unit
1 line not correct ! Do line .. again	Map digitizing	Not correct data processing of line .. (malfunction of communication buffer flow)	Note this line and press <Enter> to continue, after successful processing of this unit, enter the part of this unit which falls in line .. (± 2 lines) again
7	Program execution	Out of memory	3
9	Program execution	Subscript out of range	3
24	Program execution	Device timeout	3
25	Program execution	Device fault	3
27	Print of maps	Out of paper	Load paper into printer, turn printer on-line again and press <Enter> 3
53	Program execution	File not found	3
57	Program execution	Device I/O error	3
61	Program execution	Disk full	Break program execution by CTRL-break, free some space at the default drive or: change disk or drive and start again

69	Map digitizing	Communication-buffer overflow	Press <Enter>, 'save' the entered map and continue with the 'old' map
71	Program execution	Disk not ready	Close disk drive door; or: change floppy disk, or: check cable(s) from disk drive to controller board; or: change disk drive
75	Program execution	Path/file access error	3
76	Program execution	Path not found	3

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[1] This can happen, if a 'starea.nam' file is modified (e.g.a new area is added) and then copied to another computer, without creating the corresponding subdirectory/ies.

[2] For pin layout of dititizing tablet cable, see App.4 (p.202).

[3] These errors are very unlikely, but can occur in some situations. It is recommended to note all messages shown at the screen and to press <Enter> to continue or to start again. The displayed error messages should be reported to the systemanalyst.

[4] This can occur after assignment of mapping units to form new base map and redefinition of 'mapping unit codes' if units were forgotten.

Appendix 4

SYSTEM REQUIREMENTS

GILES requires the following hardware and software:

App.4.1) MINIMUM HARDWARE CONFIGURATION :

Personal Computer 'PC-compatible' or 'PS/2-compatible'
Memory of 384 KB
DOS operating system (version 2.10 or higher)
Harddisk and one floppy disk drive (HD with at least 4 MB free space)
Dot matrix printer at ESC/P (Epson) standard code [5 9]

Estimated costs for this minimum configuration:
1500 US$

App.4.2) OPTIMUM HARDWARE CONFIGURATION :

Personal Computer 'AT-compatible' or 'PS/2-80-compatible' [1]
Memory of 1-2 MB [2]
DOS or OS/2 operating system (DOS version 3.10 or higher)
Virtual disk driver (VDISK, Above Board or similar) [3]
Harddisk with at least 30 MB and access faster than 20 ms and one floppy disk drive
(HD with at least 5 MB free space)
EGA or VGA facilities (multiscan monitor and EGA/VGA adapter)
Serial interface [7]
Dot matrix printer Epson FX or LQ or compatible [5 9]
or: Color ink printer
Plotter at HP-GL standard code (ISO A3 size or greater) [6]
Digitizing tablet at Summasketch or Houston Instrument standard code [4 7]
Back up system for uninterruptible, continuous, regulated power supply (UPS)

Estimated costs for this optimum configuration:
4000 US$

Large size digitizing and plotting facilities at ISO A1 or A0 (ANSI D or E) will increase the costs by approximately 4000 US$ (or more). [4 6]

App.4.3) SOFTWARE RECOMMENDATIONS

Not essential for GILES execution, but recommended for additional processing or presentations:

Inset (EGA-Print for 24 dot matrix printer), Grab or any other screen dump utility:
for hardcopy outprints of screen displays
Lotus 1-2-3, Quattro or any other spreadsheet/database software
reading ASCII file ('print files') and writing DIF files:
for data processing of GILES data
Perspective, Boeing Graph or any other graphic package, reading DIF or ASCII files:
for DTM, 3D displays
QuickBasic Compiler : for modifying source code

App.4.4) HARDWARE MAINTENANCE

For maintaining and checking of the PC it is recommended: [8]

daily:	
- to check the harddisk logically	'CHKDSK' DOS
weekly:	
- to aggregate fragmented files of the harddisk (cluster)	'OPTIMIZE' Disk-Optimizer
- to check harddisk and its files physically	'DT c:/m' Norton
- to clean all floppy disk drives	Disk drive cleaning kit
monthly:	
- to check the entire system	Diagnostic disk, or: Advanced diagnostic disk

[1] Recommended: More than 20 MHz speed
[2] Recommended: More memory (e.g. 2 MB) for installation of extended virtual disk to increase the speed
[3] Recommended: Intel Above-Board
[4] Recommended: Summasketch MM1200 series or preferably: Houston Instrument 8000 series
[5] Recommended: Epson FX,EX,LX,RX,MX,LQ printers
[6] Recommended: HP 7475A plotter for ISO A3 (ANSI B) size,
HP 758x plotter for ISA A1 (ANSI D) size,
Roland plotter
[7] Pin layout for digitizing tablet:

		Pin at 25-pin D-shell communication plug (e.g.IBM-PC)	Pin at 9-pin D-shell communication plug (e.g.IBM-AT)
Summasketch:			
	RCPU	2	3
	TCPU	3	2
	GND	8	1
Houston Instrument:			
		2	2
		3	3
		7	5
		4	8
			1+4+6+9 Connected with each other

[8] For maintenance and storage of data, see App.1.5 (p.189).
[9] For direct GILES outprint, the printer has to recognize following print commands:

ESC-P	Pitch 10	Print style: Pica size
ESC-M	Pitch 12	Print style: Elite size
ESC-W	Pitch 200 %	Print style: Enlarged
15 (ESC-SI)	Pitch 60 %	Print style: Condensed
ESC-3	Line spacing n/216" (LX/EX/FX series)	
ESC-3	Line spacing n/180" (LQ series)	
ESC-@	Printer initialization	
ESC-x	Set/cancel letter-quality	

Only ASCII codes are printed (characters 127-159 are not used) !

For printers with different print commands, it is recommended to make use of commercial screen dump utilities.

Appendix 5

COMPUTERIZED PROCESSING

To have GILES - as any other computerized processing - functioning, basically 4 components are required:

1) Hardware
2) Software
3) Trained personnel (experienced users)
4) Institutional context (awareness of decision makers about facilities)

***

App.5.1) HARDWARE:

'Every part of the computer, you can touch, is hardware'.

The enormous advances made in electronic technology now enable the integrated circuitry for any specified applications to be miniaturized and reliably manufactured on a mass scale. These small, low cost integrated circuits have become popularly known as 'chips'.

The main chip, the heart of a computer is the processor or Central Processing Unit (**CPU**). This processor consists of a single silicon chip, which is a black plastic chip of some 30 x 30 mm with integrated silicon circuits right in the center of the computer. There are a number of different processors in the various computers, at the present the most common ones are the 8088, 80286 in the IBM-PC/AT, 80386 or 68030. 'The processor is nothing magical - it is just a bunch of electronic circuits. It is definitely not a "brain" '(PCW 1984).

This CPU stores all program instructions, stores the necessary data, and brings these two sets of information together to execute a program.

Beside the processor, the most important hardware part of a computer is its **memory**, because all programs and data have to be stored. There are two types of memory: Read Only Memory (ROM) and the badly-named Random Access Memory (**RAM**). ROM is so-called because the processor can 'read' (get things out of) its contents, but is unable to 'write to' (put things in) it.

It is possible to write to the RAM as well as to read from it. This means that the processor can use it to store both the program it is running and data (information). The second important difference is that RAM needs a constant power supply to retain its contents: as soon as the power is off, you lose your program and data.

(The storage capacity of a computer is described by the size of its memory, which is the 'number of characters' which can be stored. Each character makes one byte, 1024 (characters or) bytes make one kilobyte (or 1 k). 512 k of an IBM-PC/AT for example mean, that in its memory (ROM) 512 * 1024 = 524,288 characters can be stored, the expanded version of the IBM-PC/AT contains 640 k which is the potential storage of 655,360 characters).

The most common media for permanent storage are floppy disk drive and harddisks. **Floppy disks** are circular pieces of thin plastic coated with a magnetic recording surface similar to that of tapes and with a diameter of 5 1/4 inch (13 cm) or 3 1/2 inch (9 cm). The disk drive, to write on and to read from these disks, comprise a high-speed motor to rotate the disk and a read/write head. The disk is divided into concentric rings ('tracks') which are in turn divided into small blocks by spoke-like divisions ('sectors') and which define the storage capacity of the disks (360 KB, 720 KB, 1.2 MB, 1.44 MB). The advantage of floppy disks is the easy transfer of data from one computer to another.

Less transferable, but more efficient is to store data on **harddisks**. Their capacity starts around 10 MB and rises to 40, 70 or more MB. Besides offering a much greater capacity, harddisks are more reliable and considerably faster.

Most of the Personal Computers have the CPU, ROM and RAM on the 'mother board' at the bottom of the machine, while a number of **boards** fitting into slots at the mother board enable the communication flow between the mother board and the various **devices**: These input and output devices are essential because computers need some way of communicating with the outside world.

The most common input device is the **keyboard** where data and commands can be entered like on a typewriter.

The **monitor** (or visual display unit, screen, cathode ray tube) is the standard output device to display messages or to show entered or processed maps, tables, text. MDA (monochrome display adapter), CGA (colored graphics adapter), EGA (enhanced graphics adapter), VGA (video graphics adapter) and PGC (professional graphics adapter) stand for various graphic facilities (adapter in the computer and screen) with different resolution (up to 800 x 600 pixels on screen and more) and different number of colors (up to 16 and more).

There are a large number of peripherals to produce hardcopies of the output on paper:

Dot matrix printers print symbols (letters or graphic symbols) through a system of number of needles (e.g. nine needles above each other moving along the line: 9 pin printer, e.g. Epson FX printers; similarly 24 pin printer, e.g.Epson LQ printer) in black or with colors. **Daisy wheel printers** use a daisy wheel like a daisy wheel typewriter. **Laser jet printers** for better quality printing and **ink jet printers** with high-quality colored prints are becoming more popular.

Plotters draw pen(s) on a flat surface and thus allow much better quality of maps or graphics output.

An input device is the **digitizing tablet** which consists of a board with an embedded wire grid in the tablets top and a stylus. The stylus is used to follow the lines on the map laid on the board. The x-y-coordinates of the lines are recorded at some interval which can be selected either manually, depressing a button to store the current x-y-values of the cursor, or automatically as it is done by GILES.

Video digitizers (to read graphics or maps through a video camera system) and scanners (to read graphics, maps, text) are not fully operational and therefore not recommendable for GILES for the time being, but with some more development they might perform another input possibility in the future.

UPS (Uninterruptible Power Supply) can provide continuous, regulated, noise-free ac power to the computer system. In case of power failure, power break down or power spikes they guarantee a safe power supply.

The hardware requirements of GILES are listed in App.4 (p.200).

App.5.2) SOFTWARE:

A general-purpose device needs some way of knowing what to do. We do this by giving the computer a set of logical instructions called a program. The general term for computer programs is **'software'**. It is the combination of hardware and software which provides the computer resource.

Any kind of programs must be written in a form the computer can recognize and act on - this achieved in a code known as a computer language. There are literally hundreds of different languages around: Basic, Forth, Pascal, Logo, C, Fortran, Cobol to name but a few. These are known as **high-level languages** because they are symbolic, operating at a level easily understood by people but not directly understood by the processor, thus they approach the sophistication of a human language.

There are also low-level languages, assembly language, and machine code: Machine code (or machine language) is called a low level language because it operates at a level close to that 'understood' by the processor. Between high-level languages and machine code is a low level language known as assembly language or, coloquially assembler. This is a mnemonic code using symbols which the processor can quickly convert into machine code.

A program written in a high-level language must be converted into binary code before the processor can carry out its instructions. There are two types of program to do this translation:

The first of these is a compiler which translates our whole program permanently into machine code. When we compile a program, the original high-level language version is called the source code while the compiled copy is called the object code. Compiled programs are fast to run but hard to edit. If we want to change a compiled program, we either have to edit it in machine code (extremely difficult) or we have to go back to a copy of the source code. For this reason there is a second translation program: an interpreter. An interpreter waits until we actually run (use) the program, then translates one line at a time into machine code - leaving the program in its original high-level language. This makes it slower to run than a compiled program, but easier to edit.

The most popular high-level language is **Basic**. Basic is an acronym of Beginners All-Purpose Symbolic Instruction Code. Although originally intended as a simple introductory language, Basic is now a powerful and widely used language in its own right.

'The advent of powerful minicomputers and microprocessors has led to a resurgence in the use of Basic, as it is more suited than Fortran to use on these smaller machines. For this reason Basic language capability and its level of compatibility have also been extended. Added to the fact that BASIC already performed better than Fortran in the areas of character string and matrix handling and input/output, it would appear to be a most suitable language for those parts of any data base system which must be developed by the user. However, this should be weighted carefully against the availability of programming expertise in developing countries. ... Nevertheless, the increasing use of mini-computer and microprocessors will develop Basic expertise.'

Previously faced problems with Basic, such as low processing speed and unstructured programming style, is now overcome by Basic compiler, particular of the second generation which allow high speed and structured programming. GILES is written in this language (Microsoft's QuickBasic 4.0).

As a link between the hardware configuration and the software written in any computer language, an **operating system** is essential to run the access of the programs to CPU, RAM, ROM and disk storage media. At Personal Computers, mainly DOS is used, others are CP/M, XENIX, UNIX, OS/2. The present version of GILES is developed under DOS 3.20 environment, but it will function under OS/2 (in protected mode) as well.

For general purposes (i.e. by far more than 90 % of computer applications), there is no need to design programs as there is a large collection of **commercial software** available. Thousands of programs cover most of the application needs which are, to mention only a few:

Word processing: Wordstar, Word, Multimate, Wordperfect
Desktop publishing: Ventura Publisher, Pagemaker
Spreadsheets (calculation and organisation of tables): Lotus, Quattro, Multiplan, Supercalc, Excel
Database (storage and retrieval of data): dBase, FoxBase, R:Base
Integrated packages: Symphony, Framework, Open Access, Works
Statistics: Microstat, SPSS, SAS, Statgraphics
Graphics: Boeing Graph, Halo, Concorde, Harward Presentation, Perspective
CAD (computer aided design): AutoCad, VersaCad
Utilities: Norton; Brooklyn-Bridge, Smalltalk; Sidekick
GIS: GILES, ARC/INFO, ERDAS, Terra-Pak, MAP, Cries, GIMMS

(All mentioned names are trademarks).

Particular attention shall be given by GILES users to screen dump utilities. They allow high-quality hard copy printouts of screen displays on printer: Inset, EGA-Print, Grab.

Most of them are menu-driven, easy to understand and to learn and support many help-menus and translation facilities.

Software GILES consists of 6 DS/DD or 2 DS/HD diskettes (see App. 1 and 6; p.184/208; without tutorial, source code).

App.5.3) TRAINED PERSONNEL: USERS EXPERIENCE

App.5.4) AWARENESS OF DECISION MAKERS

These important aspects of the use and application of computer processing are explained in Section 2.1 (p.17).

Appendix 6

GILES FILES

1) Software package GILES on disk 1-5 (if HD, one disk)
2) 'General data set' on disk 6
3) Source codes on disks 7-10 (if HD, one disk)
4) Samples for tutorial lessons on disk SAMPLE1-SAMPLE4
   (if HD, two disks)

App.6.1) SOFTWARE PACKAGE GILES

			Explanation page		Explanation page
Content of GILES-1:					
GILES.BAT		GILESCMPL.BAT		DIGITTAB.EXE	242
GILESIN.BAT		SELE1.EXE	239	DATACH.EXE	243
GILESOUT.BAT		SELE3.EXE	242	DATASTA.EXE	243
GILESBAS.BAT					
Content of GILES-2:					
GRIDINF.EXE	244	GRIDSUP.EXE	245	GRIDCOMP.EXE	245
GRIDMAP.EXE	244				
Content of GILES-3:					
SELEDOS.EXE	242	CREQ.EXE	243	EROS.EXE	246
SELECONT.EXE	242	ARSIZE.EXE	243	EROREC.EXE	247
Content of GILES-4:					
LGP.EXE	247	CLSUIT.EXE	249	LANDEV.EXE	249
Content of GILES-5:					
DIGITHLP.EXE	242	ADJUST.EXE	251	SCRDMP02.PCT	
SOSUIT.EXE	249	GAMMA.EXE	252	SCRDMP03.PCT	
PINPUT.EXE	249	SCRDMP01.PCT		SCRDMP04.PCT	

2) 'GENERAL DATA' ON DISK GILES-6

Content of GILES-D:

BRUN40.EXE	183	HELP.TXT	183	BORKATN.NAM	177
				BORKSOIL.MCP	160
CREQ1.DAT	182	DUMLIN.MUC		BORKSOIL.STN	162
CREQ2.DAT	182			BORKSOIL.TCH	163
LCHAR.NAM	174	SCRDMP05.PCT		BORKALT.COR	165
LCHATN.NAM	176	SCRDMP06.PCT		BORKPREC.DAT	168
LUT.NAM	178			BORKPREC.RLV	171
STAREA.NAM	180			BORKPREC.TWY	172
				BORKREL.DAT	169
				BORKGAM.DAT	170
				BORKADM.ACH	167

3) SOURCE CODES ON DISK 7-10

Content of GILES-7:

SELE1.BAS	CREQ.BAS	COMMONIN.BAS	254
SELE1SB.BAS	ARSIZE.BAS	DECISIN.BAS	252
SELE3.BAS	DIGITTAB.BAS	MENPLIN1.BAS	
SELEDOS.BAS	DIGTTBSB.BAS	MENPLIN2.BAS	
SELECONT.BAS	DIGITHLP.BAS		

Content of GILES-8:

GRIDINF.BAS	GRIDSUP.BAS	LGP.BAS
GRIDIFSB.BAS	GRIDSPSB.BAS	LGPSB.BAS
GRIDMAP.BAS	GRIDCOMP.BAS	
GRIDMPSB.BAS	GRIDCPSB.BAS	

Content of GILES-9:

EROS.BAS	ERORECSB.BAS	DATACHSB.BAS
EROSSB.BAS	DATACH.BAS	DATASTA.BAS
EROREC.BAS		

Content of GILES-10:

CLSUIT.BAS	GAMMA.BAS	GRIDCOMP.MAK
CLSUITSB.BAS	SIZEMOD.BAS	EROS.MAK
SOSUIT.BAS	SELE1.MAK	EROREC.MAK
SOSUITSB.BAS	DIGITTAB.MAK	LGP.MAK
LANDEV.BAS	DATACH.MAK	CLSUIT.MAK
LANDEVSB.BAS	GRIDINF.MAK	SOSUIT.MAK
PINPUT.BAS	GRIDMAP.MAK	LANDEV.MAK
ADJUST.BAS	GRIDSUP.MAK	

App.6.4) Samples for tutorial lesson on disk SAMPLE1-SAMPLE4

—

Note about file size:

	Extension	
Map file of one sheet:		
in GILES (with extension MAP)	MAP	25 kB
as print file (transfer to Lotus)	PRN	appr. 40 kB
as spreadsheet file (in Lotus)	WK1	appr.136 kB
as DIF file (transfer to Perspective)	DIF	appr.103 kB
as 3D file (in Perspective)	3DL	(appr.480 kB)

Appendix 7

LAND EVALUATION MODELS

In this appendix, all models for the land evaluation procedures are explained in brief. Details are given in FAO 1987 b, which forms part 1 of this manual.

*****

App.7.1) EROSION HAZARD (module 'eros')

This model calculates the erosion hazard caused by sheet erosion by means of a model, developed by Hurni (1985). This model is an adoption from the Universal Soil Loss Equation by Wischmeier and Smith (1978):

$$A = R * K * L * S * C * P$$

where: A = total soil loss (t/ha/year)
R = rainfall erosivity factor
K = soil erodibility factor
L = slope length factor
S = slope gradient factor
C = land cover factor
P = management factor

The model takes rainfall erosivity, slope length and slope gradient as physical environmental conditions into consideration. For the soil erodibility factors, the values established for the FAO soil degradation assessment methodology (FAO 1979) were applied. Constant values for the land cover and the management factors (C,P) are applied as default, but can be modified through menu.

R = 0.55 * annual precipitation (mm)

K =

Af	0.1	E	0.1	K	0.15	Pl	0.15	U	0.1
Ag	0.15	F	0.1	La	0.2	Po	0.2	V	0.2
Ah	0.1	Gc	0.1	Lc	0.15	Pp	0.2	Wd	0.2
Ap	0.15	Gd	0.15	Lf	0.1	Q	0.1	We	0.2
Bc	0.15	Ge	0.15	Lg	0.15	Rc	0.1	Wh	0.15
Bd	0.15	Gh	0.1	Lk	0.15	Rd	0.15	Wm	0.15
Be	0.15	Gm	0.1	Lo	0.15	Re	0.15	Ws	0.2
Bf	0.1	Gp	0.15	Lp	0.2	Rx	0.2	Wx	0.2
Bg	0.15	Gx	0.2	Lv	0.2	Sg	0.2	X	0.2
Bh	0.1	H	0.1	M	0.15	Sm	0.15	Y	0.2
Bk	0.15	I	0.1	N	0.1	So	0.2	Zg	0.15
Bv	0.2	Jc	0.1	O	0.1	Th	0.1	Zm	0.1
Bx	0.2	Jd	0.15	Pf	0.2	Tm	0.1	Zo	0.15
C	0.1	Je	0.15	Pg	0.2	To	0.15	Zt	0.2
D	0.2	Jt	0.2	Ph	0.15	Tv	0.15		

High surface stoniness can increases this factor by 0.05

The K factor (kc, erodibility) has to be entered for each individual soi type in the soil type characterization table (column 46), where kc 0.05 = 1, kc 0.10 = 2, kc 0.15 = 3 ... kc 0.30 = 6).

```
L = 0.3  for slope length 'n.a.' (e.g.< 2% gradient) (code 9)
    1.2  for   "      "         <  50 m              (code 1)
    2.5  for   "      "      50 - 200 m              (code 2)
    3.8  for   "      "         > 200 m              (code 3)
```

L can be entered for each individual soil type in the soil type characterization table (column 20), where < 50 m = 1, 50-200m = 2, > 200m = 3, n.a. = 9). If the value is omitted, the intermediate value of 2 will be assumed.

```
S = 0.1  for slope gradient (mean max.)   < 2 %      (code 1 or 2)
    0.2  for   "         "       "   "   2 -  4 %    (code 3)
    0.35 for   "         "       "   "   4 -  6 %    (code 4)
    0.6  for   "         "       "   "   6 -  8 %    (code 5)
    1.0  for   "         "       "   "   8 -  13 %   (code 6)
    2.0  for   "         "       "   "  13 -  25 %   (code 7)
    3.2  for   "         "       "   "  25 -  40 %   (code 8)
    4.2  for   "         "       "   "  40 -  55 %   (code 9)
    5.5  for   "         "       "   "  55 - 100 %   (code 10)
   10.0  for   "         "       "   "     > 100 %   (code 11)
```

S has to be entered for each individual soil type in the soil type characterization table (column 16), where < 1% = 1... > 100% = 11).

The C land cover factor corresponds to the 'erosion resistance' characteristic of the crop requirements.

Perennial 0.01 - 0.05
Large grain 0.1
Small grain, pulses 0.15

The C and V factors are combined and set to 0.8 by default. It can be modified in the menu 'Which kind of management is to be applied ?' to a value between 0.1 (extremely intensive conservation measures) through 0.5 (high stone cover) to 1.0 (ploughing up and down).

Additional option is given to apply slope leveling through construction of bunds and/or terraces. The effect is to reduce higher slope gradients. Each individual slope class can be changed (see above for slope codes).

The calculated soil losses are grouped into four classes:

Table A7.1

Sheet Erosion Hazard Classes

Class	Sheet erosion hazard	Soil loss (t/ha/year)
I	low	< 10
II	medium	10 - 30
III	severe	30 - 75
IV	very severe	> 75

Additional consideration can be taken of the existing (present) erosion status as observed in the field. This allows the mapping and assessment of the erosion integrating the potential hazard with the actual status.

A second version is assessing the slip and gully erosion:

It takes into consideration the existing gully erosion, soil type and slope class, which are combined on a limiting factor basis as explained below.

	Gully erosion hazard
Solodic Planosols	moderate
Vertisol, vertic Cambisol	slight
all others	nil
slope 13 - 55 %	at least slight
slope > 55 %	at least moderate
slight present gully erosion	at least slight
moderate	at least moderate
severe	severe
badland	severe

As this type of erosion is also strongly influenced by distance from an actively eroding front, classes are downgraded if the area assessed is adjacent to an area of badland or an area with severe gully erosion. If there is severe gully attack or badland observed in the surrounding (at 1:50000 scale: adjacent pixel = 250 m distance; at 1:250000 scale: same pixel = 625 m radius), this area is considered as having severe gully erosion attack (e.g. from moderate to severe gully erosion hazard).

This model is called by option 'Erosion hazard' in the Main Menu.

*****

App.7.2) CONSERVATION BASED LAND USE RECOMMENDATIONS (module 'erorec')

This model gives the possibility to define broad land use recommendations for appropriate land use under the soil conservation point of view.

It gives the answer for the questions: What is best major kind of land use if the land degradation has to be stopped?, and: What kind of soil conservation measures should be undertaken to stop soil degradation?

The definition of recommendations are based on sheet erosion loss, soil depth, erosion status (badland), (mean max.) slope, flooding, vertic properties, and gully occurrence. The quantitative sheet erosion loss is calculated by means of a model, developed by Hurni (1985) and explained in App.7.1.

Table A7.2

Conservation Based Land Use Recommendations

Unit		Frequent Flooding	Bad-land	Soil Depth (cm)	Mean max. Slope (%)	Montm. Clay	Annual Soil Loss (t/ha/yr)	Gully
1	A	No	No	> 25	< 6	No	< 30	No
2	Ag	No	No	> 25	< 6	No	< 30	Yes
3	As	No	No	> 25	6- 8	No	< 30	No
4	Asg	No	No	> 25	6- 8	No	< 30	Yes
5	Ab	No	No	> 25	8-25	No	< 30	No
	.	No	No	> 25	< 8	No	30-75	No
6	Abg	No	No	> 25	8-25	No	< 30	Yes
	.	No	No	> 25	< 8	No	30-75	Yes
7	At	No	No	> 25	< 25	No	> 75	No
	.	No	No	> 25	8-25	No	30-75	No
8	Atg	No	No	> 25	< 25	No	> 75	Yes
	.	No	No	> 25	8-25	No	30-75	Yes
9	Ad	No	No	> 25	< 25	Yes	any	No
10	Adg	No	No	> 25	< 25	Yes	any	Yes
11	FP	No	No	> 50	25-55	any	any	any
12	Gw	Yes	No	any	any	any	any	any
13	X	No	Yes	any	any	any	any	any
	.	No	No	n.a.[1]	n.a.	any	any	any
	.	No	No	< 50	> 55	any	any	any
14	A	No	No	> 50	> 55	any	any	any
15	Gr	No	No	< 50	25-55	any	any	any
	.	No	No	< 25	< 25	any	any	any

[1] Waterbody

This module is called by option 'Conservation based land use recommendation' in the Main Menu.

App.7.3) LENGTH OF GROWING PERIOD (module 'LGP')

The assessment of the length of the growing period is based on a decadal soil moisture balance model.

Even though precipitation (monthly or decadal) and potential evapotranspiration are the main input parameters, it can not be seen as a straight comparison of P and PET (or 1/2 PET) only. In areas with a wide range of moisture holding capacities of different soil types, as in the Ethiopian highlands, it is not realistic to assume an average moisture holding capacity. Opposite extreme of holding capacities can result in very different growing periods (in the rainy season in shallow soils, after the rainy season in Vertisols).

The length of growing period assessment is done in four steps:

Step 1 calculates the moisture holding capacity of the soil
Step 2 " " actual (decadal) soil moisture of the soil
Step 3 compares the (decadal) soil moisture with the moisture requirement(s)
Step 4 compiles the assessments for the number of years, data are available for (e.g. 20 years)

The entire assessment can be calculated

1) with consideration of **site-specific** soil moisture holding capacities for a **specific crop** (for land suitability assessments), or:
2) with consideration of **site-specific** soil moisture holding capacities for an **average crop**, or:
3) for an **'average' soil** (with 100 mm moisture holding capacity) for a **specific crop**, or:
4) for an **'average' soil** (with 100 mm moisture holding capacity) for an **average crop** (as climatic 'reference growing period')

*****

Step 1:

If the moisture holding capacity is not measured, the available moisture holding capacity:

AWHC = f (texture, bulk density, fragments of top soil, fragments of sub soil, topsoil depth, soil depth, organic matter content)

is calculated based on following **general formula**:

$$AWHC' = MHC_{t/bd} * (D - FRAGM)$$

where: $MHC_{t/bd}$ available moisture holding capacity, as function of texture and bulk density

D depth

FRAGM content of mineral fragments

Consideration of topsoil and subsoil as well as of the organic matter contribution results in the **complete formula**:

$$AWHC = MHC_{t/bd} * (D_t - FRAGM_t) / 10000 + MHC_{t/bd} * (D_s - FRAGM_s) / 10000 + MOD_{om} * D_t$$

where: AWHC available water holding capacity (mm)

$MHC_{t/bd}$ available moisture holding capacity, as function of texture and bulk density (see Table A7.4, p.220) (mm/m)

D_t topsoil depth (20/8/18/30 cm) (if not recorded, default: 20 cm)

D_s depth (5/20/37/75/125/175 cm)

$FRAGM_t$ content of mineral fragments in topsoil (0/7/27/50 %) (if not recorded, default: 0 %)

$FRAGM_s$ content of mineral fragments in subsoil (0/7/27/50 %) (if not recorded, default: 0 %)

MOD_{om} moisture contribution of organic matter (see Table A7.5, p.220) (mm)

No higher moisture holding capacity figures than 200 mm are accepted, no lower figures than 50 mm.

If the moisture holding capacity of the soil is measured, this value is read from the soil type characterization table (column 47; file 'aSOIL.TCH').

The topsoil moisture holding capacity is defined as 20 mm.

For the non-site-specific LGP calculation (without consideration of occurring soils), this first step is suppressed and an average moisture holding capacity of 100 mm is assumed.

Step 2:

For each decade the moisture input and moisture output is calculated, thus contributing or reducing moisture from the soil, giving the <u>actual (decadal) moisture content</u> for the next decade:

$$S_{10} = S_0 + MOD_{prec} * P_{10} + GW - MOD_{pet} * PET_{10}$$

where: S_{10} moisture content at end of the decade (mm)
S_0 moisture content at the beginning of the decade (mm)
MOD_{prec} conversion actual to effective rainfall, as function of actual soil moisture and rainfall (see Table A7.6, p.221)
P_{10} actual decadal rainfall (mm) (measured, generated or interpolated)
GW groundwater contribution (mm) (see Table A7.7, p.221)
MOD_{pet} conversion PET into effective evapotranspiration, as function of PE, actual top soil moisture and crop (see Table A7.8, p.222)
PET_{10} decadal potential evapotranspiration (mm) out of altitude - PET regression

Example of the soil moisture balance dynamic with the entire data for two years is shown in Table 3.10 (p.84).

Step 3:

The soil moisture (S10, in mm) is set in relation to the soil moisture holding capacity, giving the relative soil moisture saturation (in %), which will be compared with the ability of the crop roots to extract moisture of the soil (water requirements):

Table A7.3

Relative Soil Moisture Saturation of available water holding capacity				results in:
Cereal[1]	Pulses[2]	Pulses[3]	Potato[4]	
> 99%	> 99%	> 99%	> 99%	---> WET
> 30%	> 36%	> 23%	> 50%	---> HUMID
15-30%	18-36%	12-23%	25-50%	---> MOIST
< 15%	< 18%	< 12%	< 25%	---> DRY

1 Sorghum, wheat, barley, teff; sesame; 'reference LGP'
2 Haricot beans, horsebeans
3 Chickpeas, lentils, vetch
4 and pepper, shallot

At the beginning of the rainy season (until the top soil is saturated with moisture by at least 75 %), the relative top soil moisture is considered.

Step 4:

The calculation of the decadal moisture support condition is done for a number of years (if precipitation data were generated: 20 years; if actual data were used: 5-20 years). For each year the longest growing period (i.e. without any dry decade) is considered as the main growing period ('Kremt'), the second longest before the main rainy season is the 'second' growing period ('Belg').

If the separate 'Belg' is less than 30 days, the part of the main rainy season before the 1.of July is considered as 'Belg' season.

For perennial crops all humid and moist decades are added.

The output shows for the requested reliability (75,66 or 50 %):

1) What is the expected main growing period (calculated out of mean and standard deviation, and put into classes of < 60 / 90 / 120 / 150 / 180 / 210 / 240 / >240 days) ?

2) In how many years does the first, small rainy season have < 60/ at least 60 / at least 90 days ?

3) When is the end of the main rainy season ?

Result 1 and 3 enable the calculation of the onset for a given reliability level.

Example of an outprint in Table 3.9 (p.78) shows the growing periods of 20 years.

*****

Table A7.4

Available Moisture Holding Capacity (pF 4.2-1.8)
as Function of Texture and Bulk Density
(mm moisture / m soil)
(for assessment of available moisture holding capacity)

Texture	Bulk density (g/cc) <1.0	1.0-1.6	>1.6	Texture	Bulk density (g/cc) <1.0	1.0-1.6	>1.6
S (coarse)	60	60	60	sC	190	150	120
S	100	90	90	siC	200	160	120
S (fine)	160	120	120	C	200	150	110
lS (coarse)	110	90	80	C(montm)	200	150	110
lS	130	100	90	n.a.	0	0	0
lS (fine)	150	110	100	variabel	220	170	140
sL	220	170	140	L+cL	190	150	120
scL	220	160	120	L+siL+sicL+cL	210	170	140
L	220	170	140	sL+scL	220	160	130
siL	240	190	160	cL+C	190	150	110
Si	280	250	230	scL+L+siL+cL	210	170	140
sicL	210	170	120	cL	190	150	120
cL	190	150	120	cL+C(montm)	190	150	110

If bulk density is not recorded, default: 1.0-1.6 g/cc
If texture is not recorded, default: lS
As bulk density figures are highly unreliable in the present study, AWHC will always be calculated using the medium bulk density value.

Table A7.5

Moisture Contribution due to Organic Matter
(for assessment of available moisture holding capacity)
(mm moisture / m soil)

Organic matter content	%	Texture: S	lS Si	sL L siL	scL, sicL, cL and all combined classes	sC siC cL+C	C cL+C
very low	< 1	0	0	0	0	0	0
low	1-3	20	10	0	0	0	0
medium	3-5	40	30	20	10	0	0
high	> 5	100	80	80	60	30	30

If organic matter is not recorded, default: < 1%

Table A7.6

Conversion Actual to Effective Rainfall
as Function of Soil Permeability, Actual Soil Moisture
and Topography

Relative actual soil moisture saturation	vertic gleyic	others
< 25 %	.7	.8
25-49 %	.7	.8
50-74 %	.7	.8
75-99 %	.7	.8
100 %	.7	.8

If precipitation is greater than 100 mm/decade (high rainfall intensity with high runoff):
decrease of rainfall by 10 % (*.9)
If precipitation is less than 15 mm/decade (low rainfall with high evaporation):
decrease of rainfall by 10 % (*.9)

Table A7.7

Groundwater Contribution
(mm / decade)

GW level (perennial)	Decadal rainfall (mm)	GW contrib.
> 150 cm	any	0
< 150 cm	> 20	10
< 150 cm	10 - 20	5
< 150 cm	< 10	2.5

Table A7.8

Conversion PET to Effective Evapotranspiration
as Function of PE, Top Soil Moisture and Crop

Relative actual soil moisture saturation	Conversion
< 25 %	0.6
25- 49 %	0.8
50-100 %	1

This factor is multiplied with the crop specific transpiration intensity figure (kc): e.g.

Rice	1.1
Oats; sugarcane; tobacco	0.9
Horsebean, fieldpea, haricotbean, cowpea; citrus; sweet potato; cotton	0.85
Sorghum, maize, wheat, barley, teff, millet; niger seed, sunflower, soybean; potato, cassava, groundnut; shallot, tomato	0.8
Chickpea, lentil, vetch; sesame, flax; pepper, cabbage; ensete, banana	0.75 [1]
Coffee, tea, grape	0.7
Safflower	0.65
Pineapple; sisal	0.6

to give the conversion factor MODpet for:

$$\text{actual ET} = MOD_{pet} * PET$$

This module is called by option 'Length of growing period' in the Main Menu.

[1] This value is used for 'reference LGP'

App.7.4) CLIMATIC SUITABILITY ASSESSMENT (module 'clsuit')

This module matches three climatic parameters ('land qualities') with the corresponding climatic requirements of a specific crop:

a) **Length of the growing period**: The growing period is assessed as explained in App.7.3 (above). The duration of the main growing period (with minimum and maximum to be expected at a given reliability level) is matched with the length of the growing period requirement (growth cycle) of the crop (crop requirements: 'minimum length of growing period', 'maximum length of growing period'). As at temperatures of < 20 C the growth cycles of many crop increase considerably, the required growing periods are increased at altitudes of > 1800 m by a number of days per each 100 m altitude increase (crop requirements: regression of minimum LGP', 'regression of maximum LGP').

The crop requirements of length of growing periods are given at different suitability levels: If the optimum growth cycle does not match the assessed growing period of the main growing period both at the minimum and the maximum side, checking is done for the next suitability level growth cycle etc. The result is the suitability assessment of the moisture (growing period) for the particular crop.

Similar to the LGP module, the suitability can be made purely climatic or the site-specific soil parameters (moisture holding capacity) can be taken into consideration to assess the site-specific moisture suitability.

If the option of land improvement: irrigation is chosen, no constraints due to moisture are considered at all in areas with slope of < 4 %. Steeper areas are assessed as not suitable (suboption 'excluding rainfall') or with their precipitation pattern (suboption 'including rainfall').

*****

b) **Temperature**: Based on an altitude-temperature regression, the temperature of the location is calculated out of the altitude. The annual mean temperature is matched with both the minimum temperature and the maximum temperature of the tolerance of the crop at different suitability levels (crop requirements: 'minimum temperature', 'maximum temperature'). The suitability class of which the minimum temperature is below the actual temperature and maximum temperature is above the actual temperature gives the temperature suitability.

*****

c) **Frost hazard**: Frost is assessed as a function of altitude and topographic situation (see Table A7.9; the topographic situation is read of the soil type characterization table, column 17). The frost hazard is compared with the ability of the crop to stand frost (crop requirement: 'frost sensitivity'; see Table A7.10).

Residual moisture crops are downgraded by one suitability class (except if there is no frost hazard), as they are planted after the main rainy season during the coldest part of the year.

Table A7.9

Frost Hazard

Altitude	Upper slope Middle slope or any other	Valley bottom	Lower slope Extensive plain
< 1600 m	nil	nil	nil
1600-2000 m	nil	medium	nil
2000-2400 m	nil	severe	medium
2400-2800 m	medium	very severe	severe
2800-3200 m	medium	very severe	very severe
3200-3600 m	severe	extreme	extreme
> 3600 m	extreme	extreme	extreme

Table A7.10

Frost Constraint

Frost sensitivity of crop	Frost hazard nil	medium	severe	very severe	extreme
tolerant	s1	s1	s1	s2	s4
moderate tolerant	s1	s1	s1	s3	n
moderate sensitive	s1	s1	s3	n	n
sensitive	s1	s3	s4	n	n

*****

d) **Combination**:

The lowest of these three individual suitabilities gives the 'climatic suitability'.

The individual suitability ratings for length of growing period, moisture and frost hazard can be printed on request. Example of an outprint is given in Table 3.5 (p.66).

This program is called by option 'Climatic suitability' in the Main Menu.

App.7.5) SOIL SUITABILITY ASSESSMENT (module 'sosuit')

This module matches 5 soil parameters ('land qualities') with the corresponding soil requirements of a specific crop:

a) **Oxygen availability**: Drainage characteristic of the soil is matched with the drainage sensitivity (see Table A7.11; below) of the crop, resulting in an oxygen availability suitability.

If a crop is highly capable to extract residual moisture and thus planted on heavy soils after the rainy season (e.g. chickpea, lentil, vetch) and following soil parameters are given:

- montmorillonitic clay
- > 100 cm rooting depth
- < 8 % slope gradient

oxygen availability (after the rainy season) for this crop is considered as s1.

Rice (or any other crop with '0' as drainage sensitivity class) is always assessed as s1.

Under the land improvement of '**minor** drainage measures' it is assumed that:
imperfect drainage ---> moderately good [1], or
poor drainage ---> imperfect [1], or
very poor drainage ---> poor [1].

Under the land improvement of '**major** drainage measures' it is assumed that:
drainage worse than or equal to moderately good
---> good, if texture is finer than sand
drainage worse than or equal to imperfect
---> moderately good, if sandy texture

---

[1] If soil is vertic (montmorillonitic clay)

Table A7.11

Drainage Suitability

Drainage sensitivity of crop	very poor	poor	imper- fect	moderat. good	good	somewh. excess.	excess.
tolerant	n	s2	s1	s1	s1	s1	s1
moderately tolerant	n	s4	s2	s1	s1	s1	s1
moderately sensitive	n	n	s3	s1	s1	s1	s1
sensitive	n	n	s4	s2	s1	s1	s1

*****

b) **Nutrient availability**: For N and P and K the resources of the soil are calculated. Under high input level with fertilizer input, the nutrient retention (CEC) is calculated instead of the nutrient availability (see p.229).

The N content of the soil is matched against the N requirement of the crop (see Table A7.12; below), the same for P (see Table A7.13; below).

—

Table A7.12

N Suitability

N requirement of crop	Low input level N_t				Medium input level N_t			
	low	medium	high	v.high	low	medium	high	v.high
very low	s2	s1	s1	s1	s1	s1	s1	s1
low	s2	s1	s1	s1	s2	s1	s1	s1
medium	s3	s2	s1	s1	s2	s1	s1	s1
high	s3	s3	s2	s1	s3	s2	s1	s1
very high	s3	s3	s2	s1	s3	s3	s2	s1

*****

bb) P:

Table A7.13

P Suitability

P requirement of crop	Low input level P_{avail} low	medium	high	v.high	Medium input level P_{avail} low	medium	high	v.high
very low	s2	s1	s1	s1	s1	s1	s1	s1
low	s2	s1	s1	s1	s2	s1	s1	s1
medium	s3	s2	s1	s1	s2	s1	s1	s1
high	s3	s3	s2	s1	s3	s2	s1	s1
very high	s3	s3	s2	s1	s3	s3	s2	s1

*****

The lower suitability of the N and P is taken as the nutrient availability assessment.

At low input level, if subsoil or topsoil pH shows a pH value of < 5.2 or > 8.0, the suitability will be decreased by one.

At medium input level, if the topsoil has a pH of < 4.5, the suitability will be decreased by two; if the topsoil has a pH of 4.5-5.2 or higher than 8.0 or the CEC of subsoil is very low or the bulk density is low, the suitability will be decreased by one class.

*****

bc) **Retention** (in case of high input):

The CEC of the topsoil (Table A7.14; below; column 38 of soil type characterization table), organic matter content (Table A7.14; below), the topsoil and subsoil pH (Table A7.15; below) are matched with the fertilizer response (crop requirement) to come up with the nutrient retention assessment.

Table A7.14

Fertilizer Response Suitability I

Fertilizer response of crop	CEC of soil				Organic Matter			
	Very low	Low	Medium	High	Very low	Low	Medium	High
Very low	s1	s1	s1	s1	s1	s1	s1	s1
Low	s2	s1	s1	s1	s1	s1	s1	s1
Medium	s2	s2	s1	s1	s1	s1	s1	s1
High	s3	s2	s1	s1	s1	s1	s1	s1
Very high	s3	s3	s2	s1	s1	s1	s1	s1

Table A7.15

Fertilizer Response Suitability II

Fertilizer response of crop	pH of topsoil/subsoil						
	<4.5	4.5-5.2	5.3-5.9	6.0-6.6	6.7-7.3	7.4-7.9	>8.0
Very low	s1	s1	s1	s1	s1	s1	s1
Low	s2	s1	s1	s1	s1	s2	s2
Medium	s2	s1	s1	s1	s1	s2	s3
High	s3	s1	s1	s1	s1	s2	s3
Very high	s3	s1	s1	s1	s1	s2	s3

If the bulk density is low, the assessment can not be better than s2.

The lowest of these individual suitabilities is taken as the fertilizer response assessment.

*****

c) **Rooting conditions**: Depth of the soil (limited by solum or groundwater) is matched with the rooting depth of the crop at different suitability levels (crop requirement: Rooting requirement).

If constraints due to mineral fragments in topsoil and/or subsoil, consistence and bulk density exist, the suitability will be downgraded:

If the mineral fragment content in topsoil and/or subsoil, and/or a clayey texture combined with a high bulk density, and/or a very hard/sticky consistence occurs, the suitability will be downgraded by one class.

If the mineral fragment content is above 75 %, the soil is not suitable.

*****

e) **Flood hazard**: Both the flash flooding situation is matched (see Table A7.16) with the sensitivity of the crop for flash flooding (crop requirement: 'flash flooding requirement') as well as the ponding situation (see Table A7.17) with the sensitivity of the considered crop for ponding (crop requirement: 'ponding/ flooding sensitivity'). The higher constraint of these two assessments is considered as the flood hazard suitability.

In montmorillonitic clay soils with a depth of more than 100 cm, slope of > 13 % gradient, flood hazard constraints are not considered for crops growing on residual moisture.

Under the land improvement: 'flood protection' it is assumed that there are no flood hazard problems. With the assumption of 'minor drainage measures', exceptional flash flooding can be controlled and ponding problems do not occur, unless there is very severe ponding. With the assumption of 'major drainage problems', even these are eliminated.

Table A7.16

Flash Flooding Constraints

Sensitivity of crop	Flash flooding none	except.	common
low	s1	s1	s3
medium	s1	s2	s4
high	s1	s3	n

Table A7.17

Ponding Constraints

Sensitivity of crop	Ponding none-slight	moderate	severe	very severe	permanent
low	s1	s1	s2	s4	n
medium	s1	s1	s3	n	n
high	s1	s2	s4	n	n
very high	s1	s3	n	n	n

*****

f) **Sodicity / salinity hazard**: Topsoil sodicity, subsoil sodicity and salinity are matched (see Table A7.17 and A7.18; below) with the sensitivity of the crop for sodicity and salinity respective (crop requirement: 'sodicity sensitivity', 'salinity sensitivity'). The lowest suitability of these is the sodicity/salinity suitability assessment.

Table A7.18

Sodicity Suitability

Sensitivity of crop	Topsoil Sodicity				Subsoil Sodicity			
	low <6%	medium 6-15%	high 15-30%	v.high >30%	low <6%	medium 6-15%	high 15-30%	v.high >30%
low	s1	s1	s2	s4	s1	s1	s1	s2
medium	s1	s1	s3	n	s1	s1	s2	s3
high	s1	s2	s4	n	s1	s2	s3	s4

Table A7.19

Salinity Suitability

Sensitivity of crop	Salinity nil <2	slight 2-4	moderate 4-8	strong 8-12	very strong 12-16	extremely strong >16 mmhos
tolerant	s1	s1	s2	s4	s1	s1
medium	s1	s1	s3	n	s1	s1
mod.sensitive	s1	s2	s4	n	s1	s2
sensitive						

*****

In case of soil associations, assessment is made for each of the occurring soil types.

The individual soil suitability ratings can be printed. Example of an outprint is given in Table 3.6 (p.70).

The module is called by option 'Soil suitability' in the Main Menu.

*****

App.7.6) LAND SUITABILITY ASSESSMENT (module 'landev')

In this module the climatic and soil suitabilities are combined by considering the higher constraint of these two assessments (see Paras. 3 and 4 of this appendix; Liebigs 'Law of minimum').

Additionally, for the land suitability assessment following two parameters are taken into consideration:

a) **Erosion hazard**: The quantitative sheet erosion hazard is calculated based on USLE/Wischmeier formula, modified by Hurni (1985), with consideration of the present, observed erosion status, as explained in Para. 1 of this appendix: See Table A7.23!

With **minor soil conservation measures** (always under high input level) it is assumed, that:
mean maximum slope of 6-25 % are leveled to 4-6 % (with slope length of < 50 m),
moderate gully occurrence is decreased to slight, or
slight gully occurrence is decreased to nil.

With **major soil conservation measures**, it is assumed, that

at slopes < 25 % , and
slopes 25-40 % with depth of > 50 cm, and
slopes > 40 % with depth of > 100 cm

erosion hazard can be stopped (except at badlands).

The quantitative soil loss is calculated, following the formula of App.7.1 (see p.211), but with consideration of crop specific erosion characteristics (crop requirement 'erosion resistance', C) and a management factor (V = 0.8 at low and intermediate input level, 0.7 at high input level).

Table A7.20

Erosion Hazard Suitability

Soil loss	Gully erosion status none-slight	moderate	severe	badland
< 10	s1	s2	s3	s3
10-30	s2	s3	s4	s4
30-75	s3	s4	n	n
> 75	s4	n	n	n

For annual crops without major conservation measures at slopes of 25-55 % erosion hazard suitability can not be better than s4, at slopes of > 55 % it is always n.

*****

b) **Workability**: The constraints due to slope, surface stoniness, surface rockiness, consistence, topsoil structure (only if consistence is not loose/nonsticky), vertic properties and 'hard' clay are matched (see Table A7.21; below) with the working requirement of the crop (crop requirement: 'workability requirement').

Under intermediate and high input and on special request at low input level, it is assumed that stone clearance is made:

gravely or stony —> non stony
very stony —> stony

—

Table A7.21

Workability Constraints

Land Characteristic	Input level: low & intermediate			Input level: high		
	Crop requirement			Crop requirement		
	low	medium	high	low	medium	high
Slope						
< 4 %	s1	s1	s1	s1	s1	s1
4- 6 %	s1	s1	s1	s1	s1	s2
6- 8 %	s1	s1	s1	s1	s2	s3
8-13 %	s1	s1	s1	s2	s3	s3
13-25 %	s1	s1	s2	s3	s4	s4
25-40 %	s1	s2	s3	s4	n	n
40-55 %	s2	s3	s4	n	n	n
55-100 %	s3	s4	n	n	n	n
> 100 %	s3	s4	n	n	n	n
Surface stoniness						
non stony	s1	s1	s1	s1	s1	s1
non st,grav	s1	s1	s1	s1	s2	s2
stony	s1	s1	s2	s1	s2	s2
very stony	s1	s2	s2	s2	s3	s3
exc.stony-1	s2	s3	s3	s4	s4	s4
exc.stony-2	s3	s4	n	n	n	n
Surface rockiness						
< 0.1 %	s1	s1	s1	s1	s1	s1
0.1- 2 %	s1	s1	s1	s1	s2	s2
2 -10 %	s1	s2	s2	s2	s3	s4
10 -25 %	s2	s2	s3	s4	n	n
25 -50 %	s2	s3	s3	n	n	n
50 -90 %	s3	s4	s4	n	n	n
> 90 %	s4	n	n	n	n	n
Consistence:						
loose/non-st	s1	s1	s1	s1	s1	s1
hard/non-st	s1	s1	s1	s1	s1	s1
hard/sticky	s1	s2	s2	s1	s1	s2
v.hard/stick	s2	s3	s3	s2	s2	s3

*****

Combination: Downgrading of the climatic + soil suitability is made based on the erosion and the workability assessment whichever suitability is lower. Thus, the lower suitability of the following two tables stands for the final suitability:

Table A7.22

Land Evaluation Rating Due to Erosion

Erosion assessment	Climatic + soil suitability s1	s2	s3	s4	n
s1	S1	S2	S3	S4	N
s2	S2	S2	S3	S4	N
s3	S3	S3	S3	S4	N
s4	S4	S4	S4	S4	N
n	N	N	N	N	N

Table A7.23

Land Evaluation Rating Due to Workability

Workability assessment	Climatic + soil suitability s1	s2	s3	s4	n
s1	S1	S2	S3	S4	N
s2	S1	S2	S3	S4	N
s3	S2	S2	S3	S4	N
s4	S3	S3	S3	S4	N
n	N	N	N	N	N

The individual suitability ratings for erosion hazard and workability and their downgrading of the land suitability can be printed out on request. Example of an outprint is given in Table 3.7 (p.74).

This module is called by option 'Land suitability' in the Main Menu.

*****

App.7.7) PRECIPITATION STATION REFERENCE (module 'adjust')

If the precipitation data base is poor, reference of poor rainfall stations to rainfall stations with a better data base gives the chance to calculate characteristic values (mean, standard deviation etc.).

For the interpolation, it is necessary to give the relation between the stations. For this, data entry is going through all stations to give one to three reference stations with their weighting (importance, expressed in integer figures, e.g.station with weighting 3 will be weighted three times as high as station with weighting 1).

When defining the reference stations and their weighting, attention has to be given, that:

- there is a clear hierarchy of reference relations
- station(s) without missing data are at the bottom
- poorest station(s) are at the top
- no counter, circular or upwards references occur
- not more than 3 reference steps from the top to the bottom station(s)

Basically, at each missing value it checks the mean, standard deviation and probability-of-no-rain with and without the months without rainfall of the reference stations at the missing month. Then, it calculates the below mentioned values out of the available input figures and out of the reference to the other stations.

The outprint will show:

uncorrected monthly mean,
uncorrected monthly standard deviation,
number of monthly recorded years,
uncorrected monthly mean without months without rainfall,
uncorrected monthly standard deviation without months without rainfall,
number of monthly recorded years without months without rainfall,
corrected monthly mean,
corrected monthly standard deviation,
corrected monthly mean without months without rainfall,
corrected monthly standard deviation without months without rainfall,
monthly probability of no rainfall,
corrected coefficient of variance,
corrected coefficient of variance without months without rainfall.

An example is shown in Table 3.14 (p.91).
This module is called by option 'Database' in the Main Menu, then option 'Precipitation data' and by 'fill missing data'.

App.7.8) GENERATION OF PRECIPITATION DATA (module 'gamma')

This procedure generates rainfall figures out of the monthly mean (without the months without rainfall), standard deviation (without the months without rainfall) and the probability-no-rain, which can be calculated by module 'adjust' (App.7.7).

To calculate long term average rainfall data at different reliability levels, a large number of years have to be generated (e.g. 200).

For generation of monthly rainfall data for further processing, e.g. in length of growing period assessments, a number of 20 is the minimum. A greater number of years will improve the quality of the simulation models, but increases considerably the processing time.

If the input data (mean(0), standard deviation(0), probability-of-no-rain) are not in the system, entry mode is given to enter these three values for each month for each station or mapping unit.

Display of all generated figures is given at the screen.

Example of an outprint is given in Table 3.13 (p.90).

This module is called by option 'Database' in the Main Menu, then option 'Precipitation data' and 'Calculate long term averages at different reliability levels' and 'produce randomly distributed rainfall figures' respectively (for further processing).

Table A7.24

Maximum Obtainable Yield (Q)
in the Highlands of Ethiopia

Crop	Input level			
	Low	Interm.	High	High-mech.
Banana	160	220	320	400
Barley	14	18	24	30
Cabbage	200	260	360	450
Cassava	80	280	480	600
Chickpea	6	8	11	14
Citrus	140	180	240	300
Coffee	6	11	20	25
Cotton (seed)	5	10	18	22
Field pea	12	14	16	20
Flax (linseed)	7	10	14	18
Grape	50	90	160	200
Groundnut	7	13	24	30
Haricot Bean	12	14	16	20
Horse Bean	15	17	20	25
Lentil	15	17	20	25
Maize	20	30	48	60
Millet	7	14	28	35
Nigerseed	6	8	10	12
Oats	14	18	24	30
Pepper (chilli)	25	38	64	80
Pineapple	200	300	480	600
Potato (Irish)	120	180	280	350
Rice (upland rice)	15	18	24	30
Safflower	7	12	20	25
Sesame	5	8	14	18
Shallot (onion)	150	220	320	400
Sisal	140	280	560	700
Sorghum	14	21	32	40
Soybean	11	13	16	20
Sugarcane	400	600	1200	1500
Sunflower	8	14	24	30
Sweet potato	100	150	240	300
Tea	12	18	28	35
Teff	11	14	18	22
Tobacco	7	12	20	25
Tomato	300	400	520	650
Vetch	8	10	12	15
Wheat	17	23	32	40

Yields are in Q (100 kg); Source: FAO 1987 c

Appendix 8

STRUCTURE OF PROGRAMS

The retrieval procedure of all models is explained in Section 3.2 (p.105) for the user, their functions in detail in App.7 (p.211) for evaluation experts.

In the following, the computer-internal program structure of the computer programs and modules and their processing are presented in a rather detailed way to give system analysts an overview of the programs. Therefore, this appendix is addressed **only to computer programmers** familiar with Basic computer language and in particular with QuickBasic, version 4, of Microsoft. The source codes (structured Basic) can be requested from FAO-Headquarter-AGL division.

App.8.1) SELE1

The main function of this program is the selection of the chained program (through variable SEP) and the definition of the essential control variables passed over (through 'common' command).

Table A8.1

Definition of SEP

SEP	Program	Explanation page	SEP	Program	Explanation page
1	creq	243	10	clsuit	249
2	arsize	243	11	sosuit	249
3	gridinf	244	12	-	
4	gridmap	244	13	landev	243
5	gridsup	245	14	datach	242
6	gridcomp	245	15	digittab	251
7	eros	246	16	seledos	241
8	erorec	247	17	selecont	241
9	lgp	247	18	digithlp	242

The program is called by entering 'GILES' at the DOS prompt C: or by pressing function key F10 within GILES.

The start handles inclusion of file 'decisin' and checking of installed graphic facilities.

If chaining of various functions is selected (through 'selecont'), the variable CONTNO is > 0 and variables defining function, crop, input level, outprint, storage etc. are read from file 'C:\LANDEV\CONTFILE.DAT'.

Alternatively to the selection of sheet/run/x/y coordinations, option is given to selection of one location (pixel) by giving its coordinates in the latitude/longitude system or in the UTM system.

Conversion rules:

a) from UTM to latitude/longitude:

$$Lat = N_{UTM} * \frac{360}{2 * 6334 * 3.14159 * LongCor}$$

$$Long = (E_{UTM} - 500) * \frac{360}{2 * 6378 * \cos(Lat) * 3.14159} + LongRef$$

b) from latitude/longitude to UTM:

$$N_{UTM} = Lat * 2 * 6334 * \cos(Long-LongRef) * \frac{3.14159}{360}$$

$$E_{UTM} = (Long-LongRef) * 2 * 6378 * \cos(Lat) * \frac{3.14159}{360} + 500$$

where:
- N_{UTM} = North coordinates in UTM system (distance to equator in km)
- E_{UTM} = Longitudinal coordinates in UTM system (distance to central meridian - 500 in km)
- Lat = Latitude North in degrees, with decimals
- Long = Longitude East in degrees, with decimals
- LongRef = 27, when longitude between $23^{o}30'$ and $30^{o}30'$
  33, when longitude between $29^{o}30'$ and $36^{o}30'$
  39, when longitude between $35^{o}30'$ and $42^{o}30'$
  45, when longitude between $41^{o}30'$ and $48^{o}30'$
- LongCor = Abs(cos(Long-LongRef))
  Correction factor which can be applied if Long is already calculated in approximation

For base map retrieval ('gridmap', 'gridsup', 'gridinf'), the variables THEM$ (for opening the particular files), SM and THEMPRINT$ (for printing the title) will be defined to express the map theme:

Table A8.2

SM Values of Base Maps

	THEM$	SM	
Predefined maps:	SOIL	1	
	(SOIL	2	, reserved for soil types)
	ALT	3	
	PREC	4	
	VEG	5	
	ADM	6	
	AEZ	7	
	PLZ	8	
Additional maps:		9-17	

It is possible to read selected mapping units from a DIF file: The first 18 read values characterize the DIF file. Consequently LOT$ (for the mapping unit) and LOTPREV$ (for the new aggregated mapping unit) are read until 'EOD' is reached.

Any crop specific treatment (with AVSP=2) requires the name of the crop (LUT$) and the input level (LTLT= number of crop, combined with input level).

App.8.2) SELE3

This is the continuation module for selection of the parameters.

In particular, the form of output will be defined: PRY stands for outprint of map (PRY=1 on FX/LX/EX 9-pin matrix printer, 2 on LQ 24-pin matrix printer; PRY=100 on plotter; with the scale of SC * 1000), PRLEG (0 or 1) for the outprint of the legend, STOR (0 or 1) for storing the maps on disk (with the number STORNUM, 1-9), GIL2LOT (0 or 1) for storing the output tables on Lotus compatible file (with number TRANSFER=1-5).

At the end of this program chaining will be done into the individual executing modules.

App.8.3) SELEDOS

This program handles the DOS facilities of GILES, such as copying, typing, deleting files or showing directories (see Section 3.2.1.17; p.96) through 'shell' and exit to GILES.

The program is called by option 'File operation' in the Main Menu (SEP=16).

App.8.4) SELECONT

Through this program it is possible to chain various GILES procedures and write chain parameters into a queue in file 'C:\LANDEV\CONTFILE.DAT (see Section 3.2.1.15; p.95).

The program is called by SEP = 17 (option 'Chaining of various selections' in the Main Menu.

For each requested procedure, the variables SEP (program), LTLT (crop and input level), LIMPR (land improvement), PRY (print of map), PRLEG (print of legend), STOR (storage), STORNUM (storage number), number of stored map 1 and 2 for map overlay (STMAP1, STMAP2), total number of units of overlaid map (MAXNO), source files for copying (THEM$, PATHFL2$) are defined and stored under the number of the process in file 'CONTFILE.DAT'.

The program is called by option 'Chaining of various procedures' in the Main Menu (SEP=17).

App.8.5) DIGITTAB

This module manages the digitized entry of maps either through digitizing tablet or numeric keypad or combination of both, including the possibility of correcting the map input (see Section 3.2.1 n, p.87).

The 5 mm move will change the variable C (column) and/or R (row) by $\pm$ 1. The x-y-coordinates of all (max.600) points will be assigned to UN%(1..600,1) for x and to UN%(1..600,2) for y. Thus, in this stage it is a vectorial system.

Next part runs the conversion from the vector reading into a grid cell system (raster system) by checking the on and off mode of the mapping unit for each row, following the scan line approach. There is a warning message if a particular pixel was assigned already beforehand.

The program is called by option 'Entry of base map' in the Main Menu (SEP=15). It has the submodule 'DIGTBSB'.

App.8.6) DIGITHLP

This map entry utility program gives the possibility to check or to change entered digitized maps.

Two maps, with pixels row-wise assigned to D1%(1..28) and D2%(1..28), can be compared with each other and, if they differ (i.e. one map shows outside, the other one inside the study area), a print of 'Reduction necessary' or 'Enlargement necessary' with the particular location will appear and eventually the corrected (if ONLYTOSM=2) array (MAP%(1..28,1..111)) will be stored in part 5.

Another part handles the replacement and checks, if a pixel is covered by one of the units to be changed (OLDUN%(..)) and, if yes, the new unit NEWUN%(..) is assigned and continued with the next pixel.

The program is called by option 'Systematic change of base map' in the Main Menu (SEP=18).

App.8.7) CREQ

This database module is for entering, correcting and retrieving crop requirements essential for crop suitability assessments.

The crop requirements will be read from random access files "CREQ1.DAT" (for crop requirements 1-20) and "CREQ2.DAT" (21-40) into array CRQ%(1..40). Writing of the newly defined crop requirements to these two data files is organized.

The program is called by option 'Database' in the Main Menu (SEP=14), then option 'Crop requirements'.

App.8.8) DATACH

Except the maps (map files; see Paras. 4 and 5 of this appendix), all data in GILES can be entered or modified through this module (1400 lines, 83 k).

The program is called by SEP = 14 (option 'Database' in the Main Menu.

A newly assigned variable SEP (defined in menu 14.1) selects the file to be modified (e.g. SEP=2: MUC file, SEP=6: COR file) and thus the access to the referring block. Variable ACT gives the action number (1: declare a new data set - 2: change data - 3: change dimension - 4: display - 5: print - 6: import from Lotus file). Each of the blocks has 4 subsections (controlled by ACT) for the various modifications.

For manipulation of study area definitions, crop requirements and precipitation data, this program serves as a transfer (to 'datasta', 'creq', 'pinput').

The program is called by option 'Database' in the Main Menu (SEP=14). It has the submodule 'DATACHSB'.

App.8.9) DATASTA

This submodule runs the definition of all map sheets.

The program is called by option 'Database' in the Main Menu (SEP=14), then 'Study areas'.

App.8.10) ARSIZE

This program calculates the area sizes of all units of the base maps for the total area or per sheet or run.

Area size files can be created by loading the run(s) into the array MAP%(1..28,1..111) and then increasing the ACOD$(...,3) array by one for each pixel per occurring mapping unit.

The program is called by option 'Area sizes' in the Main Menu (SEP=2).

App.8.11) GRIDINF

All available information retrievable from the base maps are displayed or printed for a particular location through this program.

The main program contains several blocks, each with error trap routine (in case the requested map, mapping unit code or translation table is not input yet, in order to bypass this block), call of the data file, print of the parameter and print of the result.

The program is called by option 'Site specific information' in the Main Menu (SEP=3). It has the submodule 'GRIDIFSB'.

App.8.12) GRIDMAP

It gives all computer retrieve facilities of the entered base maps: Display, print, plot or computer storing of the entire area, of one sheet, one run or a window of all units or of specified units only.

All print subroutines are defined in one part, in particular those for printing the symbols on screen, paper or file and for printing the title of the map, the coordinates and the legend.

The main program is split into 5 submodules:

Submodule 1 runs the retrieval of 'complete' base maps (SM<100 (exc.2) and ALSP=2). Processing from the top line of the map towards the bottom line: from N to S (YYY counter; default 111-1) and, within, from left to right: from W to E (XXX counter; default 1-28 or, with smaller scales at matrix printer, 1-56), it displays all units with their mapping unit codes as defined in program 'datach' (see Section 3.2.1 m, p.86). Special attention is made if the unit is not assigned (DDS=0) or assigned with "OUT" (".", then DDS=0).

Submodule 2 handles the output of 'selective' and/or 'aggregating' base maps (SM<100 (exc.2) and ALSP=3). Proceeding in the same way as above, it checks, if the pixel is in the definition of any newly defined mapping unit (content of array CHE%(1..400,1..70). It it does, the code of the new mapping unit (CUNOMUSP) will be displayed. If not, it will show a blank area.

Submodule 3 shows the soil types interpreted out of the soil map (SM=2 and ALSP=3, with soil mapping units) when asked for specific soil types ('selective' version). In principal, the same procedures are performed as in submodule 2, but interpretation is made through the soil mapping unit composition table giving the soil types per soil mapping unit.

Submodule 4 retrieves 'parametric' maps in the 'complete' version (SM>100 and ALSP=2). Processing as in the other modules from N to S and from W to E, it shows the required parameter (characteristic, e.g. drainage: very poor) for each pixel. This is read out of the translation table(s) (e.g. land characteristic which is read out of soil mapping unit composition which is read out of soil mapping unit; or: structural characteristic which is read out of the administrative unit). At queries to be answered out of the altitude, calculations are made based on the found unit (altitude) and the latitude-correlation file (e.g. temperature of January); similar with the precipitation data.

Submodule 5 acts in a similar way, but there the 'parametric' map (SM>100 and ALSP=3) is shown in the 'selective/aggregating' version. The unit of the translation table(s) is checked, if request was made for it (content of array CHE%(1..400,1..70); see above) and, if yes, groups it into the 'new' mapping unit (CUNOMUSP). If not, a blank area will be shown.

At the end of each run, check is made, if plotting, high resolution display or file saving is requested. At the former two options the array MAPPL%(1..110,1..111) will be given after each map sheet to the include file 'maplotin' (for plotting) or part 9 (for high resolution display).

For saving a composite file, all rows of cells ("$" + SYMB$(..)) were assigned to DCBA$(..) for column 1-28 or to HGFE$(..) for column 29-56 and will be written to file 'DGaCMPmn.MAP' in C:\INTERM\ with 'DGaCMP.NAM' in part 7 after each run. If writing to an ASCII ('print') file is requested (STORNUM=10), the strings of the pixels values will be written, with "/" instead of "$" to import them as text into Lotus, to file 'DG0CMPxx.PRN'.

The subroutine for plotting of maps is explained in App.8.25 (p.255).

The program is called by option 'Base maps' in the Main Menu (SEP=4). It has the submodule 'GRIDMPSB'.

App.8.13) GRIDSUP

This module displays all areas which fulfill all required parameters as defined.

The array SM(1..10,1..30) of 'sele1' contains the mapping units giving the numbers of the overlaid maps (first variable, SMCNT loop) and the accepted, requested mapping units within the overlay map (second variable, CHECNT loop). For each pixel, checking is done if the found mapping units of all overlaid maps can be found in the array SM. E.g. if 5 maps are overlaid, it checks if mapping unit of map 1 is in column SM(1,...), if yes, it checks if mapping unit of map 2 can be found in column SM(2,...), if yes, it looks in the same way for map 3,4 and 5. Only if all answers are positive, it is true that this location fulfills all requirements and a black ("#") is printed ('yes').

The program is called by option 'Overlay of base maps' in the Main Menu (SEP=5). It has the submodule 'GRIDSPSB'.

App.8.14) GRIDCOMP

This program performs only processing of previously created ('configured', 'composite') maps, stored under map file 'DGaCMPmn.MAP (with 'DGaCMP.NAM') in C:\INTERM\ (where a number 1-9, m sheet number, n run number). It can overlay, window, combine and plot them in almost any way.

The program is called by SEP = 6 (option 'Overlay/reprint of previously configured map(s)' in the Main Menu.

In case of overlaying selected window/areas, it checks for each location (grid cell, running from N to S and from W to E), first the selected area (variable SELSEL; for window: SELSEL=1) and then the occurring mapping unit (variable SYMBSYMB) and increases the variable in array CNT(SYMBSYMB,SELSEL+1) by 1. If less than 8 selected areas and less than 11 main mapping units were defined, storage is possible through SYMBTM$ array. This file can be retrieved later (e.g. for a second overlay).

If various suitability maps are overlaid (ONLYSUIT=1), the suitability assessments for all suitability maps (number of suitability maps: 1,3,5,7,9; their total number: NUMMAP), coded by values of 1 (S1) - 5 (N) per soil type, then by values of 1 (all S1) - 15 (all N) per soil association, are retrieved, decoded (through LEVSEP%(..)) and then assigned to LEVFSL (50 % of the unit) and LEVFSR (50 % of the unit). For each of these two half units, the lowest of the assessments of the suitability maps is the final one; the combination of the two units is coded (though LEVAGGR%(..)) and then assigned to LEV%.

In case of 'simple' retrieving of a previously configured map (NUMMAP=1), it differentiates if the retrieved map is a suitability map (THEMEVAL=2; without "$") or any other thematic map (THEMEVAL=1; with "$" in the 'DGxCMPxx.MAP' file).

The program is called by option 'Overlay/reprint of previously configured maps' in the Main Menu (SEP=6). It has the submodule 'GRIDCPSB'.

App.8.15) EROS

This program runs the quantitative assessment of annual sheet erosion (t soil loss/ha/yr) and the hazard by gully erosion.

In the main program, checking is made first for the entire selected area, which soil and precipitation mapping unit combinations occur. These will be identified by a '1' in COMB$(..,..,1). The combinations are processed through the second part where access is given to part 6: Erosion estimate model. The calculated erosion value will replace the '1' in COMB$(..,..,1).

After this checking, the program runs again through the entire area to allocate the calculated value to each pixel (COMB$(..,..,1) assigned to SYMB$), prints SYMB$ on screen, paper and/or on 'DGaCMPxx.MAP' files (with 'DGaCMP.NAM') and adds the area size of this unit (through SYMB$(THTH)). In case of assessing the neighborhood of gullies (for slip and gully erosion assessment, SHORSG=2), it checks for each pixel the surrounding 8 pixels in the arrays DSU%, DAU%, DSD%, DAD% for their erosion status (subroutine in part 7, modifier SGEH).

In part 6 the quantitative sheet erosion hazard is defined (see App.7.1; p.210). The annual precipitation per precipitation mapping unit and the erosivity class per soil type are required for the sheet erosion loss and have to be entered manually into the program.

Next part runs the handling of the slip and gully erosion hazard, considering the soil types (entered manually), erosion status and slope and expressed through SGEH (1-4).

The program is called by option 'Erosion hazard' in the Main Menu (SEP=7). It has the submodule 'EROSSB'.

App.8.16) EROREC

Interpretation of erosion hazard and erosion related parameters (e.g. slope) allow the definition of potential major kinds of land uses and need for conservation measures through this program.

The main program is equal to the main program in 'eros' (see App.8.13): Checking for all soil and precipitation mapping unit combinations, then their processing in part 6, then allocation of the calculated value to each pixel and print.

The model for the conservation measure recommendations is defined (see App.7.2; p.215 and 'eros' description above). First part, for the calculation of sheet erosion loss, is equal to 'eros'; second part checks for threshold values of soil depth, erosion status and slope and gives the REC value. At the end, they are aggregated (with new REC values).

Next part runs the handling of the slip and gully erosion hazard, considering the soil types (entered manually), erosion status and slope and expressed through SGEH (1-4).

The program is called by option 'Conservation based land use recommendation' in the Main Menu (SEP=8). It has the submodule 'ERORECSB'.

App.8.17) LGP

The length of growing period calculation is based on a decadal soil moisture balance model (see App.7.3; p.215) and executed.

The main program checks first the entire map for occurring combinations of precipitation, altitude and soil mapping units and writes a '1' in string COMB$(1.. no.of soil mapping units, 1..no.of precipitation mapping units) for the combination. If COMB$ is too large for the memory of the computer, COMBALT will be '1' and the file 'COMBALT' in drive D with the total number of soil mapping units as the total number of records will be used.

Second, it calculates the LGP assessment in part 8 for all occurring combinations of these 3 overlays the LGP assessment in part 8, last, it runs again through the entire map and prints the calculated values on screen, printer and/or on 'DGaCMPmn.MAP' file with 'DGaCMP.NAM' in C:\INTERM\.

The LPG model is explained in App.7.3 (p.241). For an occurring precipitation - altitude - soil combination the available water holding capacity/capacities is/are calculated (if CLSL$="CLI"). Then, it reads monthly precipitation figures of 20 years (if they were generated, GENPREC=1, on a defined random basis) and interpolates these or it uses the actual decadal precipitation figures (MMMAX=36 from file RANDFIL$='xPREC.TWY) as well as the monthly PET figures (out of the correlation with the altitude) to form decadal precipitation and PET figures.

Two loop complexes are following: The year loop (YY=1-20) and, within, the decadal loop (DECDEC=1-36). In the latter, the model with all quantitative moisture input and output is processed, resulting in a string (LGP$) showing the LGP of one year. Outside the latter, but still within the year loop the definition of the main and of the second rainy season is done. After processing 20 years, the mean, the minimum (mean - a * standard deviation), maximum (mean + a * standarddeviation, a=f(reliability level)) is calculated.

In the next part the LGP units (with "$" for each pixel in DCBA$
resp. HGFE$) are stored in file(s) 'DGaCMPmn.MAP' with 'DGaCMP.NAM' in C:\INTERM\ (where a = STORNUM, number of 1-9).

The program is called by option 'Length of growing period' in the Main Menu (SEP=9). It has the submodule 'LGPSB'.

App.8.18) CLSUIT

Based on the LGP assessment, but with consideration of altitude/ temperature hazard and frost hazard, the climatic suitability of a crop is calculated.

The main program in part 7 is equivalent to the main program of 'lgp' (see App.8.17, above).

The first block of the 'climatic suitability model' in part 8 (explained in App. 7.3; p.216) is identical to the LGP model of part 8 of 'lgp' (see App.8.17, above). But it only uses the mean and standard deviation of the longest rainy season (KREMPTMEAN, KREMPTSDEV) and matches these with the crop requirement (LGPCONS).

The calculated temperature (TEMP) and the assessed frost hazard (out of ALTIT regression) are matched with their corresponding crop requirements (TMAXSa, TMINSa, FRSENS).

The program is called by option 'Climatic suitability' in the Main Menu (SEP=10). It has the sub-module 'CLSUITSB'.

App.8.19) SOSUIT

Seven land qualities are compared with the requirements of the crop to assess the suitability of the soil for the crop through this program.

The main program checks first the entire map for all occurring soil types. Second, it calculates the soil suitability for all occurring units, with access to part 7, and assigns the added value of the suitability of the two half (1-25) to LEV, then converted into ASCII code (LEV$) which replaces the '1' in COMB$(..).

At last, it runs again through the entire map and prints the calculated values for each pixel on screen, paper and/or on file (1-25 code, without "$").

Next part calculates the soil suitability assessment as explained in App.7.5 (p.226). Attention is paid to eventual land improvements (LIMPR) which can change land characteristic values. The land qualities are treated in various blocks.

The program is called by option 'Soil suitability' in the Main Menu (SEP=11). It has the submodule 'SOSUITSB'.

App.8.20) LANDEV

The combination of climatic and soil suitability ('ecological suitability') with consideration of erosion hazard and workability constraints give the 'land suitability' for a given crop ', executed through this program).

Subroutines open and read base map files and composite map files ('DG1CMP<u>mn</u>.MAP' and 'DG1CMP.NAM' with climatic suitability, 'DG2CMP<u>mn</u>' and 'DG2CMP.NAM' with soil suitability).

The main program checks the entire map for all occurring soil and precipitation units and assigns a '01' for each found combination into COMB$(). Second, it runs the access to part 9 for all occurring units, replacing '01' with LEV$. At last, it runs again through the entire map, selects of the climatic suitability (DD1) and of the soil suitability (DD2, converted from 1-25 code into 11-55 code) whichever is lower and gives this 'ecological suitability' to LEV1 (50% of the unit) respectively LEV2 (other 50% of the unit). The downgrading due to erosion and workability constraints (COMB$() gives LEVEROS and LEVWORK) is then expressed through FINLEVEROS% and FINLEVWORK%. The land suitabilities LEV1 and LEV2 are converted back to 1-25-code for storing and to 1-15-code for printing.

At last, it runs again through the entire map and prints the calculated values for each pixel on screen, paper and/or on file.

The evaluation parts calculates the erosion hazard (similar to part 6 of program 'eros', but with consideration of land improvements) and workability assessments (see App.7,6, p.233) and returns the ultimate downgrading out of these two assessments for the two soil types with their ASCII codes through variable LEV$.

The program is called by option 'Land suitability' in the Main Menu (SEP=13). It has the sub-module 'LANDEVSB'.

App.8.21) PINPUT

'pinput' runs the precipitation data entry and correction and the access to further processing of precipitation data in the programs 'adjust' and 'gamma' (see App.8.22 and 8.23; below).

Begin contains selection of options with either reading or declaration of the number of stations (AMSTAT), of the first and the last year of observation period (FIRSTY, LASTY) and if monthly or decadal data are recorded (MMMAx: 12 or 36).

It reads and saves the data files under the name 'aPREC.DAT' (where a abbreviation of project area, e.g. 'HOSPREC.DAT') with the preceeding variables of AMSTAT, FIRSTY, LASTY (see above).

If all data are available and therefore no generation (through 'adjust' and 'gamma') is necessary, it is possible to convert the PREC%(..,..,..) data of file 'aPREC.DAT' straight into a 'aPREC.TWY' file, which is necessary for the LGP and climatic suitability assessment. Record no. 1 in the random access file 'aPREC.TWY' contains an indicator, if data are generated (GENPREC=1: yes - 0: no), and one for observation frequency (MMMAX=12: monthly - 36: decadal).

The program is called by option 'Database' in the Main Menu (SEP=14), then option 'Precipitation data'.

App.8.22) ADJUST

The 'adjust' procedure is particularly designed for a very weak precipitation data base. Monthly precipitation data gaps are set in relation to data of reference station(s) at the same year to calculate the (modified) monthly mean, standard deviation and probability-of-no-rain, which enable the generation of precipitation data through module 'gamma' (see App.8.23; below).

After reading the original precipitation data from file 'aPREC.DAT' (where a abbreviation of project area), the program checks if the file 'aREL.DAT' with the reference relations of the rainfall stations already exists. If not, they have to be entered into RELA%(...,2..7), with storing. Rules of the reference relations (see App.7.7; p.242) have to be carefully followed !

The main program runs through all 12 months, checking for all stations, if reference station is given and, if yes, merges into subroutines of 1. and 2. level.

The file with the calculated can be be stored under the name 'aRES.DAT'.

The program is called by option 'Database' in the Main Menu (SEP=14), then option 'Precipitation data', then option 'fill missing data (interpolation model)'

App.8.23) GAMMA

Mean, standard deviation and probability-of-no-rain (as calculated e.g. in module 'adjust', see above) allow the generation of monthly precipitation data of any number of years in this program.

Mean (without the months without rainfall), standard deviation (without the months without rainfall) and probability-of-no-rain are read out of file "aGAM.DAT" (a abbreviation of project area). If there are not input yet or not complete, they have to be entered.

The main program calculates alpha, beta, and n, part 6 gamma and c, part 7 the lower and upper boundary and controls the access to the Simpson formula which is calculated in part 8.

The generated monthly rainfall figures are stored in random access file 'aPREC.TWY' (in part 12), the average data of a long term generation under various reliability level in the file 'aPREC.RLV' (in part 13).

The program is called by option 'Database' in the Main Menu (SEP=14), then option 'Precipitation data', then option 'calculate long term averages' or 'generate randomly distributed rainfall figures'

Three 'include files' can be called by the main modules:

App.8.24) DECISIN

This submodule (100 lines, 6 k) displays the menus on screen and activates and reacts on all potential command keys.

Menus are called by their menu record number.

When entering this submodule, arrow-up, arrow-down and <Enter> keys are reactivated. Key trapping takes place as defined for function keys:

F1 to access the on-line help menus which are stored in the 'help.txt' and be called by the menu help number, within this submodule,
F2 to go back to the previous menu (leaving this subroutine, with PREVMENU flag on),
F10 to go back to the start (leaving this submodule by loading GILES again),

arrow-up key to decrease the line number (CCSS) by 1,
arrow-down key to increase the line number (CCSS) by 1.

App.8.25) MAPLOTIN

This submodule activates the plotter driver and controls all commands for the plotter to draw the requested map.

At the beginning, a plotter coordinate system is set to define the scale of the plotted map; optionally the frame can be drawn with tick marks and coordinates outside the frame lines.

a) To draw boundary lines:

Starting from the northwestern corner, the system checks for mapping units (YYYPPP loop from N to S, and XXXPPP loop from W to E). When it finds an untreated unit, it will start to follow its boundary and to draw this line on the plotter (executed in a subroutine). After the unit is closed, the program assigns each pixel with a 'covered' value (+ 2000).

In a subroutine eight internal modules with 24 submodules run the checkng of the continuation of the boundary:

After each move (of one pixel length) XCUR and YCUR might be newly assigned and give the coordinates of the new pixel considered. Variable NEXTDRAW gives the location of the plotter pen in relation to the considered pixel and runs therefore the access to the next module.

Table A8.3

NEXTDRAW Value

1	right of the pixel, moving down
2	left of the pixel, moving down
3	below the pixel, moving to the left
4	above the pixel, moving to the left
5	left of the pixel, moving up
6	right of the pixel, moving up
7	above the pixel, moving to the right
8	below the pixel, moving to the right

Table A8.4

Plotter Movement Conditions

	Coming from:	Bordering the pixel:	Which is different than the one:	Continuation to:	NEXT-DRAW:
1	up	to the left	to the right	down	1
				left	3
				right	7
2	up	to the right	to the left	down	2
				left	4
				right	8
3	right	above	below	down	1
				left	3
				up	5
4	right	below	above	down	2
				left	4
				up	6
5	down	to the right	to the left	right	3
				up	5
				left	7
6	down	to the left	to the right	left	4
				up	6
				right	8
7	left	below	above	down	1
				up	5
				right	7
8	left	above	below	down	2
				up	6
				right	8

Mapping unit boundaries at the margin of the sheet are not drawn.

If a label is to be given to this unit, the module checks for the center and draws the mapping unit code. Additionally, at the end of each map any code (to be entered manually) can be drawn on any place of the sheet.

b) To color units:

In case of filling the units with color, the program reads (from SW to NE) the mapping unit (=color) and colors all units of no.1 with color 1, then all units of no.2 with color 2 etc. This reduces the number of changing the color pens to a minimum.

App.8.26) COMMONIN:

This submodule consists of three lines with control variables of GILES which are global and therefore have to be passed over through 'common' when chaining from one program to another.

The include file will be included during compilation into **all programs** by call through lines 150, 160 and 170.

Following variables control the processing and retrieval procedures in programs explained in Paras. 2-21 of this appendix. They are defined in 'sele1' and 'sele3'.

Appendix 10

RECOMMENDED ASCII CODES

Following ASCII codes are used for definition of symbols both for outprint ('fonts') and for computer storage.

0-31 Control commands for printer: not recommended

ASCII	Symbol		ASCII	Symbol		ASCII	Symbol	
32		Not recom![1]	64	@		96	`	
33	!		65	A		97	a	
34	"		66	B		98	b	
35	#		67	C		99	c	
36	$		68	D		100	d	Not recom![1]
37	%		69	E		101	e	
38	&		70	F	Not recom![1]	102	f	
39	'		71	G		103	g	Not recom![1]
40	(		72	H		104	h	
41	)	Not recom![1]	73	I		105	i	
42	*		74	J		106	j	
43	+		75	K		107	k	
44	,	Not recom![1]	76	L		108	l	Not recom![1]
45	-		77	M		109	m	
46	.	for 'OUT'	78	N		110	n	
47	/		79	O	Not recom![1]	111	o	
48	0		80	P		112	p	Not recom![1]
49	1		81	Q		113	q	
50	2		82	R		114	r	
51	3		83	S		115	s	
52	4		84	T		116	t	
53	5		85	U		117	u	
54	6		86	V		118	v	
55	7		87	W		119	w	
56	8		88	X		120	x	
57	9		89	Y		121	y	
58	:		90	Z		122	z	
59	;	Not recom![1]	91	[		123	{	
60	<		92	\		124			
61	=		93	]	Not recom![1]	125	}	Not recom![1]
62	>	Not recom![1]	94	^		126	~	
63	?		95	_	Not recom![1]			

127 - 159 Interpretation depends on printer and print setup:
not recommended

[1] Difficult to differentiate

List of ASCII symbols which can improve the display:

168	¿	198	╞	228	Σ
169	⌐	199	╟	229	σ
170	¬	200	╚	230	µ
171	½	201	╔	231	τ
172	¼	202	╩	232	Φ
173	¡	203	╦	233	Θ
174	«	204	╠	234	Ω
175	»	205	═	235	δ
176		206	╬	236	∞
177	░	207	╧	237	φ
178	▓	208	╨	238	ε
179	│	209	╤	239	∩
180	┤	210	╥	240	≡
181	╡	211	╙	241	±
182	╢	212	╘	242	≥
183	╖	213	╒	243	≤
184	╕	214	╓	244	⌠
185	╣	215	╫	245	⌡
186	║	216	╪	246	÷
187	╗	217	┘	247	≈
188	╝	218	┌	248	°
189	╜	219	█	249	∙
190	╛	220	▄	250	·
191	┐	221	▌	251	√
192	└	222	▐	252	η
193	┴	223	▀	253	²
194	┬	224	α	254	■
195	├	225	β	255	
196	─	226	Γ		
197	┼	227	π		

The interpretation of these symbols can depend on printer and printer setup. Therefore, they are usually not used by GILES.

Indeed, for users familiar with the setup of printers, the 'World Trade characters' ('IBMcodes'):

```
 32   light  (blank)
 58     ^
176     |
177     |
178     v
219   dark   (black)
```

can be used to present a very nice, gradual shading **if they can be printed** by the printer (e.g.Epson FX series).

Appendix 11

MAPS ENTERED INTO GILES

In FAO-project 'Assistance to Land Use Planning' (ETH/82/010 and ETH/87/006) following base maps were entered in GILES and can be retrieved, modified, overlaid or interpreted (July 1989):

Area	Size (ha)	Scale of Entry	Map
Ethiopia	127,823,016	1:865,000 [10]	Soil Altitude [1] Precipitation [3] Woredas (District) Soil Management Units LGP [4] New Administrative Regions Awrajas
Menagesha (Shewa)	886,155	1:106,000 [9]	Soil [7] Altitude [2] Precipitation Land use/land cover Service Cooperatives Agroecological zones Planning zones Linear Features Fuelwood Project
Haykoch & Butajira (Shewa)	1,177,336	1:106,000 [9]	Soil [7] Altitude [2] Precipitation Land use/land cover Service Cooperatives Agroecological zones Planning zones Linear Features

Yerer & Kereju (Shewa)	1,182,308	1:106,000 [9]	Soil [7] Altitude [2] Precipitation Land use/land cover Service Cooperatives Agroecological zones Planning zones Linear Features
Borkena (N-Shewa/ S-Wello)	305,250	1: 50,000 [8]	Soil [5] Altitude [2] Precipitation Land use/land cover Peasant Associations Planning zones Linear Features
Bichena (Gojam)	365,513	1: 50,000 [8]	Soil [6] Altitude [2] Precipitation Land use/land cover Peasant Associations Agroecological zones Planning zones
Hosaina (S-Shewa)	229,606	1: 50,000 [8]	Soil [6] Altitude [2] Precipitation Land use/land cover Peasant Associations Agroecological zones Planning zones

1 With contour intervals of 500 m
2 With contour intervals of 200 m
3 Only with differentiation of > 700 and < 700 mm p.a.
4 Length of growing period at 80 % reliability level
5 Soil associations of 1-3 soil types
6 Soil associations of 1-2 soil types
7 Soil associations of 1-4 soil types

The input raster size of 5 x 5 mm (0.25 cm^2) is equal to:

	Area on ground	Input scale
8	250 * 250 m = 6.25 ha	at 1 : 50,000
9	530 * 530 m = 28.09 ha	at 1 : 106,000
10	4325 * 4325 m = 1870.56 ha	at 1 : 865,000

Map Index:

For each entered area, the names of all sheets, their relative location ('map index') and the latitude/longitude coordinates of their frames are given. Coordinates can be converted into UTM system using the formula of p.241.

ETHIOPIA :

1 Eritrea
2 W-Gonder
3 Tana
4 Assab
5 Ilubabor
6 Shewa
7 Dire Derwa
8 E-Ogaden
9 Omo
A Sidamo
B Ogaden
C SE-Ogaden

	1		
2	3	4	
5	6	7	8
9	A	B	C

MENAGESHA :

1 Muga
2 Inchini
3 Sululta
4 Sendafa
5 Belo
6 Akaki
7 Wedecha

1		
2	3	4
5	6	7

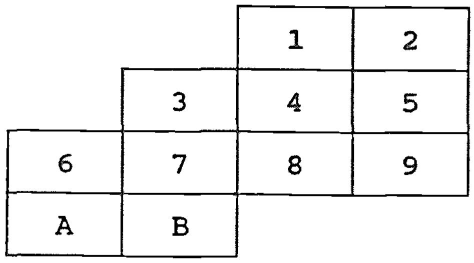
HAYKOCH & BUTAJIRA :

1 Chifra
2 Guye
3 Butajira
4 Meki
5 Dalocha
6 Ziway
7 Kulito
8 Negel

1	2
3	4
5	6
7	8

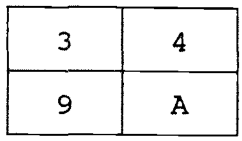
YERER &
KERJU :

1 Ankober
2 Hafele
3 Konisa
4 Kesem
5 Melka Werer
6 Debre Zeyt
7 Nazareth
8 Metehara
9 Awash
10 Ararto
11 Wonj



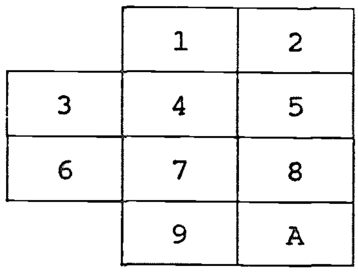
BORKENA :

3 Degaga
4 Harbu
9 Rabel
A Kemise



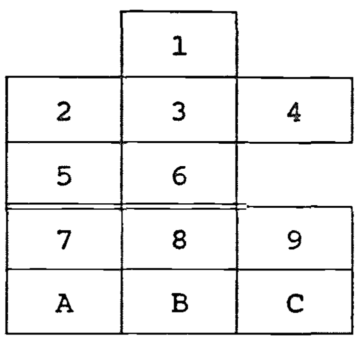
BICHENA :

1 Gunde Weyn
2 Tenta
3 Rob Gebeya
4 Debu Work
5 Gedeb
6 Amber
7 Bichena
8 Borebor
9 Dejen
A Dule



HOSAINA :

1 Jembero
2 Geja
3 Dalocha
4 Tora
5 Hosaina
6 Wilbareg
7 Gimbicho
8 Angacha
9 Kulito
A Areka
B Shone
C Ropi



Recommendations for outprint of complete maps (high resolution screen display) as text maps (not larger than DIN A 4) through 'Inset':

		Distance Extreme part of area - Frame				Height	Ratio
		N	S	W	E		
Menagesha	1:1 Mio.	10	10	10	10	5.4	110
	1:1 Mio.	55	10	10	55	6.6	110
	small	30	10	10	10	3.3	115
	small	63	9	15	18	3.5	115
Haykoch & Butajira	1:1 Mio.	10	10	10	110	7.3	110
	small	10	10	10	10	3.6	108
Yerer & Kereyu	1:1 Mio.	10	10	10	10	7.3	110

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