1986 National Environmental Engineering Conference
Melbourne 17-19 March 1986

Systematic Classification of Environmental Criteria (SCOEC)

R.A. PATTERSON
Postgraduate student. Resource Engineering Department University of New England
M.J. BRENNAN
Agricultural Economist. Resource and Environmental Services, Armidale

SUMMARY SCOEC is a software project for the manipulation and analysis of environmental characteristics, such as soil types and topographic slope classes, used in deriving and implementing policies for the protection of the environment. The SCOEC programme developed for personal computers has the capacity to store data from grid cell input for a matrix 60 x 120 or 120 x 240 for each of 100 variables for 30 categories. The system is designed for the smaller office or consultancy while the simplicity of operation requires little technical skill for accurate manipulation. Output from the system produces mono or multiple criteria maps of a square grid format, allowing direct relationship with available maps. The benefits of the system are the time efficient manipulation of environmental and socio-economic criteria, the ability to undertake sensitivity analysis without affecting the physical conditions and the choice of data input techniques.

1 INTRODUCTION

The New South Wales Environment Planning and Assessment Act (1979) requires Local Government Councils to undertake Local Environmental Studies (LES) as a prerequisite for the documentation to a Draft Local Environmental Plan (DLEP). Under the provisions of a gazetted plan the Council is then able to enforce and coordinate the favourable development and conservation of the physical and environmental resources of the Shire/Municipality. The preparation of a Local Environmental Plan is undertaken either by the staff of the Council or contracted to Environmental Consultants. In either case the planner is involved in a lengthy exercise in the collection, collation and synthesis of numerous environmental, socio-economic and physical constraints. The manipulation of this complex data base is often beyond available computational resources and not utilized in accordance with the costs of collection.

Techniques currently available to the Councils and the smaller Consultant planning firms rely heavily upon manual production of a series of maps and scales varying from 1:1 000 000 to 1:10 000 depending upon the local conditions. Urban areas require more intense mapping where specific requirements for planning have to be met. Individual maps currently produced for a local environmental study (LES) may include those detailed in Table 1 below. Each map may have up to 20 variables, for example the geology map may relate the position of tectonic, intrusive, extrusive and sedimentary phenomena of various periods.

Parametric mapping techniques are labour intensive and crude while the overlay method for selecting interactions of criteria from the grids produced on the maps above is restricted to visual acuity and personal sensitivity to implied configurations of variables. The need to objectively evaluate these constraints has increased since land use options for non-agricultural uses have become major pressures on the planning bodies. Sensitivity analysis under the normal economic constraints of planning are beyond the realm of manual sorting techniques. The landscape approach, subdivision based on observable patterns relevant to landscape allocation, neglects the social and economic issues involved. The Patter may be added in the gridded parametric approach and their effects upon planning examined. However, this further complicates the manual techniques.

In Australia and overseas the systematic correlation and selection of multiple criteria groupings has been managed by data banks of mainframe status. The Pristine Environment Planning Language and Simulator (PREPLAN) (Kessell *et al.*, 1982) simulates development within the Kosciusko National Park such that inferences can

TABLE 1

MAP TITLES CURRENTLY REQUIRED FOR AN ENVIRONMENTAL STUDY

Cadastral Base Map	Environmental Protection
Topographic Map	Agricultural Capability
Slope Components	Land Capability
Geology and Mineral Resources	Soils
Surface Waters and Groundwater	Road Classification
Flooding and Inundation	Bushfire Hazard
Land Onwership Patterns	Present Land Use
Urban Capability	Recreational Zones

with 'PerfectCalc' thereby integrating with SCOEC. These features give the package the user friendliness aimed for at the commencement of the project.

An approximate value of the SCOEC package, computer, RGB monitor, dot matrix printer, word processor, speller, thesaurus, filer, spreadsheet is in the vicinity of $7,000.

3.2 Sample Survey

The data chosen for the study related to the environmental and sociological variables for a shire of 3000 km^2 and in particular to an area suitable for urban expansion. The latter area was known to have constraints relating to poor septic tank effluent disposal. It was the manipulation of variables relative to this area that provided the best example of land use variation. Initially variables for soil type, landscape features such as slope, erosion potential, aspect, and vegetation together with land ownership patterns were assigned to a grid of size 100 x 100 metres, thus each hectare of the survey area was covered by the manipulation.

3.3 Grid arrangement

Data output is produced using a programmable dot matrix printer. The limitations of the computer printout dictated that a single grid was 60 units wide by 120 units long or in compressed mode –120 units wide by 240 long. By the use of an overlay technique for a particular constraint, up to 100 variables could be entered for each grid cell or grid point. The choice between the latter is determined at the commencement of each separate study. Each mapping unit (60 x 60) produced a square printout, a feature which then allowed manual reproduction of the final selected option back to a master map without conversion difficulties.

3.4 Variable manipulation

The selection of the categories to be manipulated and the variables within each were seleted at the beginning of the programme, producing a print out of the interaction as shown in Figure 1 below. The input of data can be by individual grid cell or block assembled configuration depending upon the complexity of the pattern. In cases of small subdivisions, individual entry of grid cell information was simpler. Only a specific selection of the variables for each map (category) is required.

4 RESULTS

The overall results of this initial step in developing a personal computer programme to land use planning has shown some of the restrictions to their use. However, the benefits of sensitivity analysis and the ability to swiftly interact many variables greatly exceeds the few short comings. The choice of gridded pattern can be freely chosen at the commencement of the exercise and is only limited by the availability of suitable data and the scale of the planning exercise. While it would be possible to grid a 3000 km^2 area at less than one kilometre squares, the cost of gathering the data would exclude the use of the programme as an inexpensive tool except where such an intense manipulation was necessary. At the urban planning level, the choice of grid cell can be more or less intense as required. Manipulating data for septic tank effluent disposal strategy at the 1:10 000 scale using a grid of 100 metres proved a rapid method of determining constraints.

The choice of parameters was restricted only by the ability of the user to be able to define the variables at the grid cell location. There is a need, however, to restrict the choice to those variables which have the greatest influence. For example, the choice of soil types by Great Soil Groups inferred variations in soil texture, water holding capacity, erosion stability, dispersion index. The use of the single term for soil type was sufficient to determine the total soil constraints for a known area. The selection of quality versus quantity with respect to categories and variables needed to be decided at the start. The programme was able to accept further categories at any stage.

The sensitivity analysis was restricted only by time at computer. Initially there was a tendency to attempt prediction of obscure variables to observe the options available. During the study it was possible to determine a specific set of criteria to be manipulated together with additional sensitive variables. The use for effluent disposal became straight forward with the alteration of housing density and water consumption as the two variables most affecting site suitability.

The choice of map scales was dependent upon individual requirements, not affecting the ability of the programme to handle the data, only dictating the number of disks used to cover a particular area (in those instances where only 5.25" floppy disks are used). The ability to produce a square grid output from the computer allowed the use of

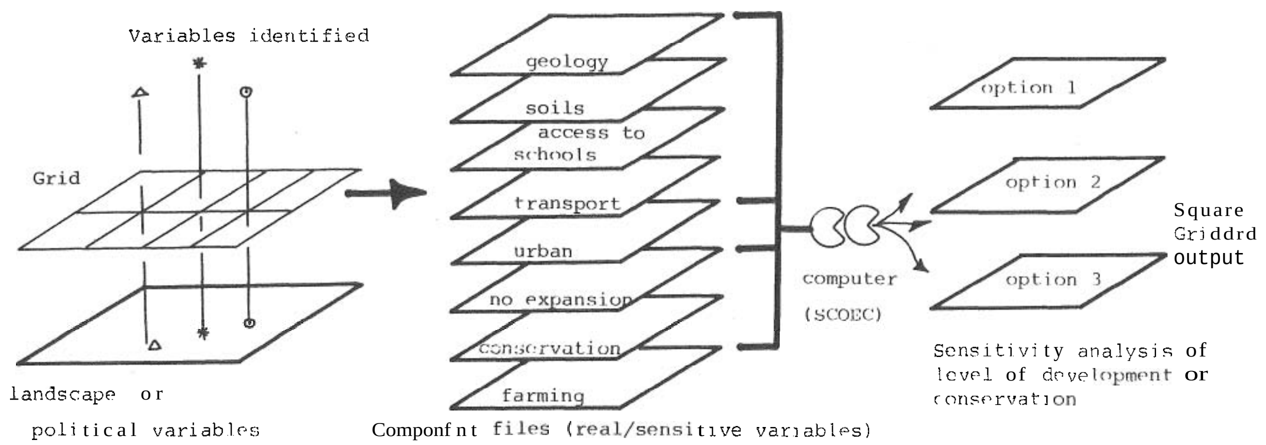

Figure 1 Diagram of manipulation of categories and variables

be drawn about specific management options. The Fortran IV programme precludes its use on personal computers. The Soil Data Card (Morse et a., 1982) has initiated a data base for New South Wales Soil survey data. This relates simply to the criteria used to evaluate the soils and landscape for land capability mapping. In the United States, the Areal Non-point Source Watershed Environment Response Simulation (ANSWERS mode) of the U.S. Environmental Protection Agency and the Resource Information and Analysis (RIA) of the U.S. Army Corps of Engineers both use grid cell data analysis for natural resource and land use data management. Similarly these models are beyond the capabilities of computers having less than 640 kilobytes of RAM (Random Access Memory).

2 PROJECT AIMS AND OBJECTIVES

The project aimed at the scientific manipulation of data to provide options of the most suitable and sustainable use of land. Thus at the environmental and land use level multi-disciplinary analysis would need to be performed at a high level of sophistication without the need to employ such a team. The system had to be compatible with the range of personal computers currently available at the local and regional level such that objective evaluation of up to 30 biophysical and economic constraints could be undertaken. While these criteria specifically related to land use planning options, other management uses were not excluded.

Four objectives to be met by SCOEC included speed of manipulation of variably selected data, flexibility to sensitivity analysis performed on the data base available, low capital requirement for both computer hardware and software and ability to utilise land use data already available.

The speed with which the data could be entered and manipulated was seen to be related directly to the scale of mapping, the availability of published documents and maps and the access to current aerial photographs. The grid density related to the end use and the economic constraints of identification. In this project two scales were examined. 1:100 000 scale was used for the environmental study of a whole shire (300 km) and 1:10 000 for a survey into septic tank effluent disposal constraints for a small portion of the Shire. The inference of similarity in the landscape between the two scales was not realistic and separate mapping exercises were undertaken.

The flexibility envisaged at the commencement of the project was expected to provide a series of land use options not identified at the manually integrated level, particularly for complex patterns involving more than four component maps. The sensitivity analysis available by manipulation of possible variations in physical or environmental constraints would allow the examination of hypothetical management options. It was this sensitivity analysis that provided the impetus for programme development, in particular for predicting the areas suitable for potential urban development based on septic tank effluent disposal.

It was expected that the speed of providing options of land use and management would be reduced from several man weeks to man days for a Shire in the Northern Tablelands of New South Wales. The reduction in labour for projects of urban development would be of a similar order, with an unprecedented return for projection of courses of action. Further the ability of the system to manipulate a series of political options, weighting environmental and political criteria could be derived without detriment to either the environment or socio-economic factors. Thus the economic savings in labour and the streamlining of political decision making could reduce planning costs by half.

The economic benefit is in the improved utilization of skilled labour in the data collection and manipulation phases. The benefits are, however, miniscule to the long term benefits of employing land resources in soundly based uses.

3 METHODOLOGY

3.1 Computer selection

Three prime target areas for the project were seen as the choice of a suitable computer, the selection of environmental criteria suitable for a sensitivity analysis, and the arrangement of the grid cells to suit computer print-out configurations.

The system chosen was based on Microsoft Disk Operating System (MSDOS) Version 2.0, a system readily transported between computers and adaptable to UNIX. Because of a unique system of mass storage (data base management) and the integration of various data bases by a modularised series of software, SCOEC is presently restricted to Microsoft Advanced enscripted BASIC or CBASIC. While the execution time of these languages may be slower in some operations than ML, Fortran, Pascal or Cobol, the versatility of the resulting data base information more than compensates for this factor. The present project is operating with the minimum of hardware in an effort to make the system acceptable to basic computer systems.

The computer used in this instance was a Ferranti Advanced 86 (Challenger), an IBM compatible utilising a Central Processing unit (CPU) 16-bit 8086 running at a clock speed of 4.77 MHz. 256K bytes of Random Access Memory (RAM) were available with additional expansion to 640K, 16K video RAM and 8K diagnostic and BIOS. Capability of graphics was for 640 x 200 bit mapped display.

The Ferranti Advance 86 was selected because of its excellent technical specifications and robust design. For monitor presentation of data output the unit comes complete with RGB output, graphics and 16 colour pallet.

Operating under SCOEC, this computer is faster than all other computers used in comparative testing; part of the reason for this performance is accredited to its true 16 bit structure. Unlike other IBM compatible computers, the Advance 86 has output for TV and cassette, two features important in the more advanced usage of the SCOEC system. Storage capacity is provided by the twin slimline 360K disc drives (included) or 10 megabyte hard disc (optional). Whilst this storage capacity is beyond most requirements, additional capacity can be obtained for large application uses by interfacing with the standard RS-232-C serial communications port. Three expansion slots, two true 16-bit and a facility for the 8087 mathematical chip give this unit an expansion potential comparable with any other PC.

In addition to the advantages of the computer system, the Australian distributors include in the sale price some of the best software for general office usage. The 'Perfect' software is integrated small scale maps of A4 size, provided the ratio of input to output grids was standard.

Further refinements are required to the system to allow variations of data input such that a combination of bulked data with keyboard entered data are compatible. The extension of the categories into areas related to growing season, pasture species, vegetation associations or agricultural uses is undergoing investigation. The basis of the programme is, however, flexibility and user friendly input. In this was the number of users and uses will be maximised.

5 CONCLUSION

The SCOEC programme has been designed to allow small Councils and consultancy firms the opportunity to systematically classify environmental and socio-economic criteria as a tool for maximising land use resources.

In its present form SCOEC allows the manipulation of up to 100 variables in each of 30 categories for a gridded input of matrix 60 x 120 or multiples of this. Refinement of the programme is expected to result in innovative input procedures without destroying the user friendly operation.

6 REFERENCES

ANONYMOUS (1979). M. S.W. Environmental Planning and Assessment Act, No. 203 Covt. Printer, Sydney.

BEASLEY, D.B. and HUGGINS, L.F. (undated). (Areal Nonpoint Source Watershed Environment Response Simulation): User's Manual. U.S. Environ. Protection Agency, Chicago.

KESSELL, S.R., GOOD. R.B. and POTTER, M.W. (1982). Computer Modelling in Natural Area Management. Aust. Nat. Parks Wildlife Sew., Canberra.

MORSE, R.J., ATKINSON, G. and CRAZE, B. (1982). Soil Data Card Handbook. Technical Handbook No.4. N.S.W. Soil Conservation Service, Sydney.

US ARMY CORPS OF ENGINEERS (1978). Resource Information and Analysis Using Grid Cell Data Banks: User's Manual. U.S. Army Corps of Engineers, Calif.