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INTERACTIVE COMPARATIVE DISPLAY SYSTEM

Paul E.V. van Walsum

ACKNOWLEDGEMENTS

The bulk of the work that resulted in the Interactive Comparative Display System was done at the International Institute of Applied Systems Analysis (IIASA) in Laxenburg, Austria. In the period 1983-1985 I spent a good two years at IIASA as a member of the Regional Water Policies Project.

The very first version of the system was developed by K.Fedra, with me in a minor collaborative role. Through this collaboration I became familiar with a way of thinking and computer programming that was quite new to me. I got to know enough to pick up the thread and further develop the system -- especially the programme structuring that was needed for implementing the doubling of the colour graphics was nearly all my own work. In this respect I should mention the programming assistance I received from E.Heinrich, who did a lot of sweating on the layout of the graphics and also had some good ideas about the programme structure. On the road I also received some helpful comments from my IIASA colleagues S.A.Orlovski and S.Kaden.

Finally I should mention the valuable comments of ICW's J.Drent -- during the finalisation stage of programme development he served as a touch-stone with regard to the relevance of certain features from the USER's point of view. And -- speaking in Fedra's terms -- the user is the guy who it's all about.

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1. INTRODUCTION

The display system described herein evolved in the course of research focussed on developing a decision-aid tool for water management in regions with conflicting interests. This tool consists of a system of computer models that is coupled to a linear optimization algorithm. Large numbers of data are generated by running the models. One set of such results is in this text referred to as a "scenario". A strong need was felt for having a tool that facilitates the interpretation of the scenarios. An interactive software system that makes use of colour graphics was thought to be the most suitable for this purpose.

The developed system makes possible the comparative analysis of data using colourings of subregions on a map, or using coloured pie and bar charts. By utilizing twin maps and pie or bar charts, the system mobilizes the excellent human capability of visually comparing two objects, in this case images on a screen.

Though the display system was originally developed for the specific purpose of analysing watermanagement scenarios, it can also be used for analysing other types of numerical data that relate to a schematized map or any surface that is divided into subunits, e.g. a soil profile with a number of compartments for the layers. And for instance the bar chart feature can be used for displaying time diagrams, even though this was not the original intention of including it. But of course each system has its limitations, and no pretence is made of having developed a general-purpose system.

In the next section an outline of the system is given. This outline is written in a relatively abstract manner; the reader may therefore prefer to proceed first to Section 3, which contains an example of an interactive session. After having gone through this session the reader may then be interested in reading more about the underlying concepts in Section 2. Section 4 gives a description of the various input files that are required for implementing the system -- this section is meant for the person who is intending to implement the system in a computer environment where there already is a running implementation of it. Section 5 is meant for the reader who intends to implement the system for the first time on his hardware/software system.

2. OUTLINE OF THE SYSTEM

The hardware set-up consists of a monochrome computer terminal with a colour monitor attached to the auxiliary port (see Fig. 1).

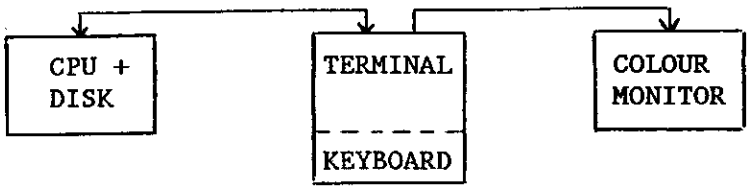


Fig. 1 Hardware set-up of the system.

The terminal is used for handling the dialogue between the user and the system and also for the display of data in their numerical form supplemented by a monochrome bar chart. The colour monitor is purely for presenting data by graphical means. This monitor is optional because the system can also be run without it; but in that case the user has to make do with the relatively primitive graphics on the terminal screen.

The system requires the data to be stored in a structured way on disk. Per "scenario" this structure has to be repeated in an exactly identical manner. A series of numbered data files is used for this purpose.

After initialization of the system (by giving a simple RUN command), the user is presented on the terminal with the MODE CONTROL MENU as shown below in Fig. 2 .

Fig. 2 MODE CONTROL MENU.

All the dialogue between the user and the system takes place through the use of menus from which the user must select an item by typing a code number. Once the user has become acquainted with the basic ideas of the system, no manuals or whatever are needed for using it : all the specific information that the user needs is presented to him on the terminal screen. Furthermore, the system has been safe-guarded against erroneous inputs by the user; so instead of crashing, the system simply repeats the prompt-line (".....type:") if the user makes a keyboard entry that is not on the menu. Also, the user always gets informed of "where he is" in the system by means of (abbreviated) texts along the top of the terminal; so the user can never get lost.

The main option switch is the one for SINGLE/DOUBLE MODE. In SINGLE MODE, data from only one scenario are displayed at a time. In this mode the system is used for displaying two different aspects of the same scenario. In DOUBLE MODE the system is used for displaying the same aspect of two different scenarios. A schematized flowchart of the system is given in Fig. 3.

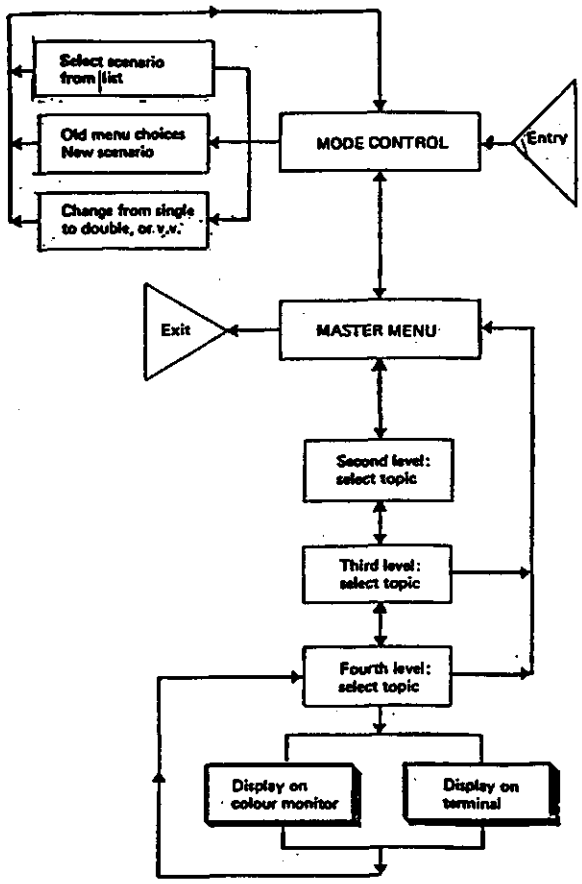
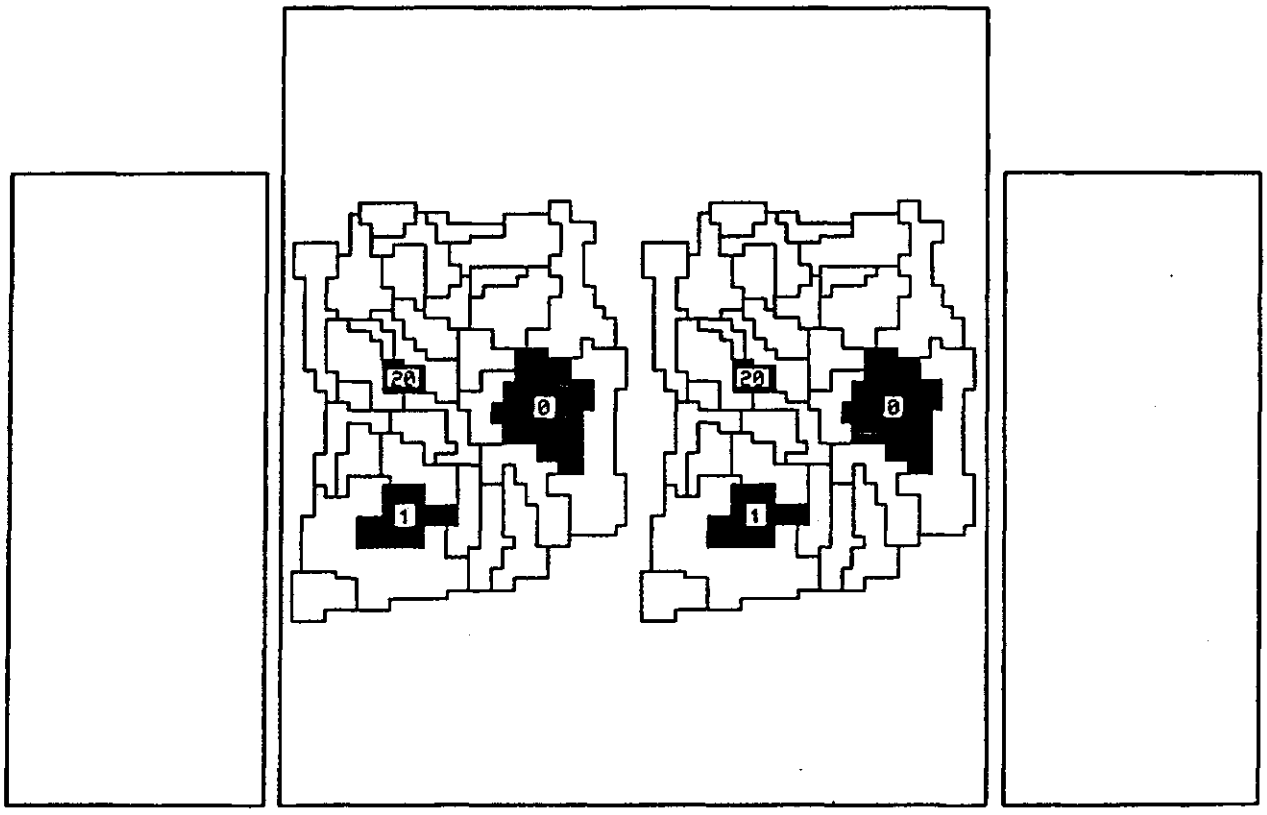


Fig. 3 Schematized flowchart of interactive comparative display system

Selection of a scenario is done at the mode control level by paging through a list of one-line characterisations that are contained in the first record of each of the files. The characterisations consist of a sequence of numbers that in the original implementation of the system represent values of certain "indicators of well-being" of a region; additional information can be present in the form of a code number indicating certain other characteristics (like option parameter values of the models that generate the data).

After a scenario has been chosen, two identical maps are projected on the colour monitor (see Fig. 4). The values of the indicators that characterise the chosen scenario are displayed along the bottom of the colour monitor. The system also allows for the display of indicator values in certain subregions on the maps. In the original implementation the numbers displayed in the dark-blue coloured areas indicate the extent of damage done to the natural vegetation by groundwater pumping in the region. The spaces to the left and right sides of the maps are available for pie and/or bar charts. (There is space for one chart on each side.)



Scenario			
1	Weather year	1975	---
	Agric. income	191	mill.fl/y
	Total labour	3342	man year
	P. w. supply	10	mill.m3/y
	Quality of PW	37	mg N /l
	Quality of FW	30	mg N /l
	Phosph. norm	1	---
	SW supply cap	2	m3 /sec

Fig. 4 Colour monitor after selection of a scenario.

After the user has finished interacting on the mode control level, the MASTER MENU is accessed (see Fig. 5).

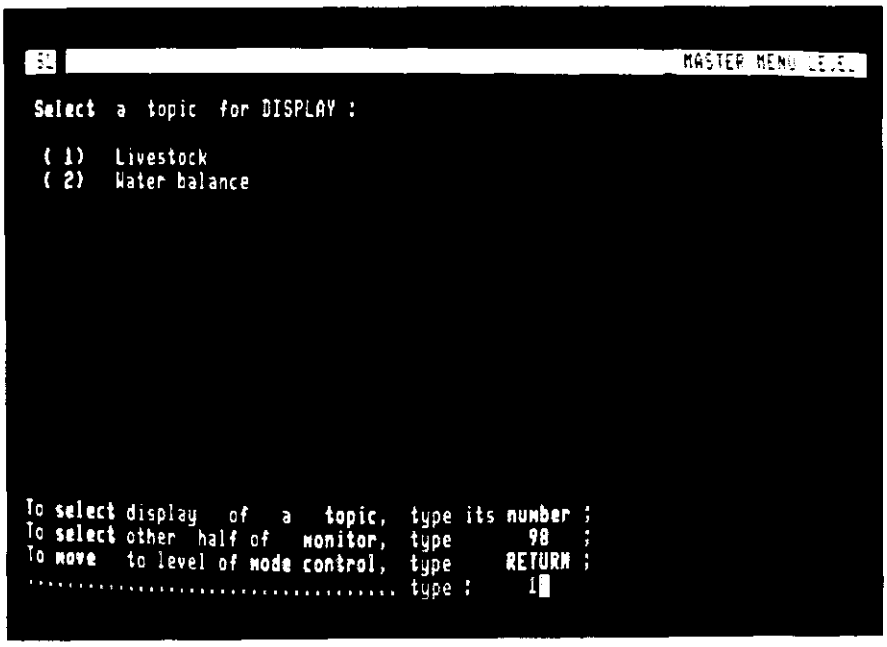


Fig. 5 MASTER MENU.

The MASTER MENU serves as a "home" location in the system : it can always be accessed by typing "97". The master menu level is the "top" level of a hierarchy that characterizes the structuring of a data-set contained in one (numbered) file on disk. A single data-element from such a hierarchically structured data-set can be pinpointed by a combination of branch choices at all the levels of the hierarchy, indicated by (m1,m2,..,mC), where for instance m2 is the number of the branch that was chosen at the second level and where C is the total number of levels in the hierarchy. The "menus" are in effect sets of names that are attached to the branches that proceed downwards from a certain node; it is by giving names to these branches that the user is able to find his way around the data-set and not get lost in the jungle of data. (In the computer memory these data are stored in a multi-dimensional array.)

The hierarchies that the system can be implemented with have been limited to a certain subset of all possible hierarchies; the imposed limitations have advantages in terms of efficiency of programme coding, compactness of hierarchy representation in an input file, and user-friendliness. The main limitations are that a hierarchy has to have

- a maximum of four levels of branching and a minimum of three levels;
- identical branching at all bottom-level branching nodes in the form of the N numbers of the subregions on the map, followed by the number N+1 that represents "whole region" (see Fig. 6).
- identical third-level branchings of a certain first-level branch (see the repetition of "income,labour" in Fig. 6.)

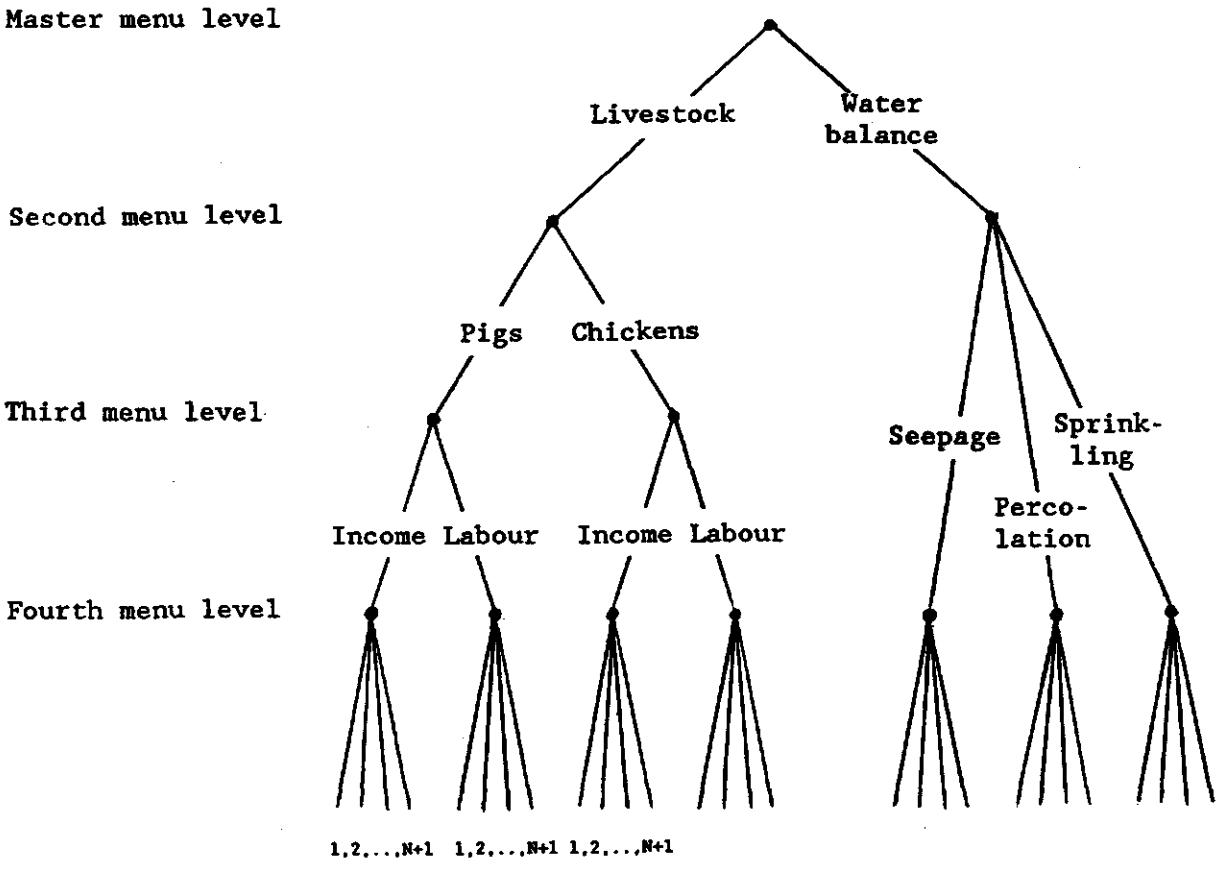


Fig. 6 Example of a menu hierarchy. Fat dots correspond to menus. N is the number of subregions on the map.

The latter characteristic does not apply if there are three levels down from a certain first-level branch : the programme treats such a case as a four-level branch with the third-level branching as missing completely (see the "water balance" branch in Fig. 6).

Proceding down the hierarchy by successively making menu choices is fairly straightforward. At the second and third level (if present) the user can either pick a single topic or else "all of the topics" with the intention of showing them in a pie or a bar chart. If the user each time chooses a single topic all the way down to the third level, the system assumes that the user wants the particular menu element (which is characterised by the triple (m1,m2,m3)) to be shown

on the map -- so instead of letting the user also make a fourth-level choice and then presenting to him the single numerical data-element that corresponds to the quadruple (m1,m2,m3,m4), the system presents in the form of colourings on the map the set of data-elements that correspond to the quadruples ((m1,m2,m3,1), (m1,m2,m3,2), ... (m1,m2,m3,N)) where N is the number of subregions on the map. (The (N+1)-th fourth-level branch shown in Fig. 6 is the data-element that is obtained by aggregating the subregional values either by totalling or averaging, depending on the unit of the data.)

If the user chooses "pie chart" or "bar chart" at either the second or third level of the hierarchy, he is presented with the fourth-level menu consisting of the numbers of the subregions: it is not possible to show charts for all of the subregions at the same time, so he has to choose one of them.

Put in more abstract terms, the end result of going through the process of making menu choices is a vector of data that is selected from the four-dimensional data-structure whose data-elements are addressable by a quadruple of index values (m1,m2,m3,m4). Either the second, third or fourth index is made into a "vector", the others are given a single integer value. If the second or third index is made into a vector, the data are shown in a pie or bar chart; if the fourth index is made into a vector, the data are shown on the map. However, the system only allows the user to make the second or third index into a vector if this has sense with a view to the units of the data: it only has sense to show a vector of data that all are in the same unit. In the example hierarchy given in Fig. 6, for instance, the system does not allow the user to show "income" and "labour" of "pigs" in a pie or bar chart; but the showing of "income" for both "pigs" and "chickens" is allowed because both incomes are in the same monetary unit.

Prior to the plotting of data on the colour monitor, the user is asked by the system whether he wants the data in so-called absolute values or in relative values. The relative values are obtained by dividing the absolute ones by the area of a subregion. However, for some types of data this question is irrelevant because they are by virtue of their nature already in a "relative form", e.g. a water balance term in "mm"; in such a case the system skips asking the question and immediately presents the data after the menu hierarchy has been passed through.

If the user is in SINGLE MODE, he may want to modify the side of the colour monitor that he is working on. This modification can take place by typing "98" at any level from the master menu downwards. When the system is in DOUBLE MODE, the user does not have to bother about sides : whenever a topic is selected, the data of the two selected scenarios are shown on respectively the left and right sides of the monitor without any further intervention of the user being required.

A convenient short-cut feature is provided at the mode control level in the form of "old menu-choices new scenario". The user can for instance have proceded in SINGLE MODE down the hierarchy and have made

his menu choices for scenario number 1. If he now wants to see the same data but for a different scenario, he only needs to go back to the mode control level, go through the scenario selection procedure, and consequently choose the mentioned short-cut option; the system then takes care of the rest.

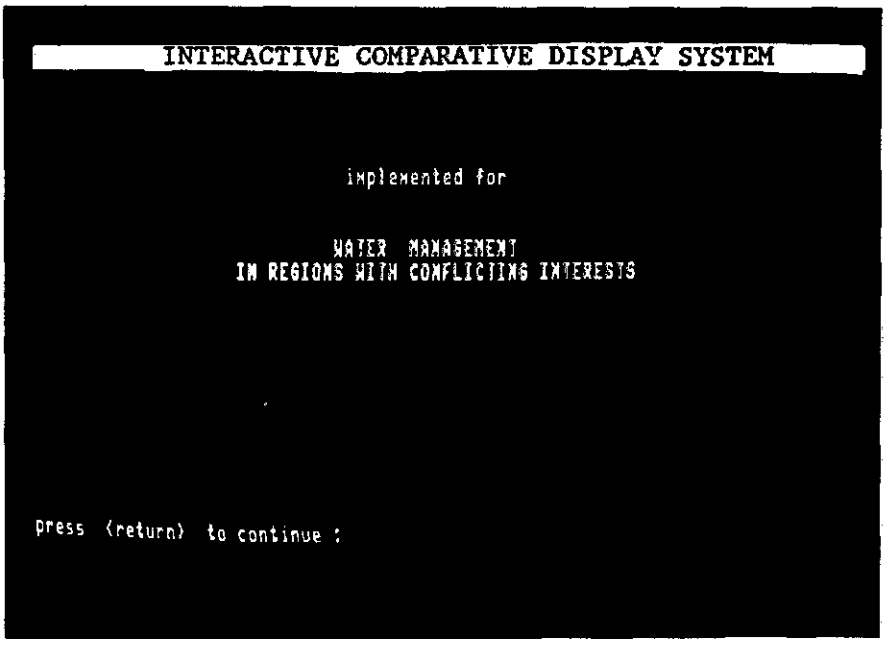
In the subsequent section an example of an interactive session is given. In this session the reader will not be shown all corners of the system -- for this kind of exercise the reader can better settle for real and play around with the system himself.

3. INTERACTIVE SESSION

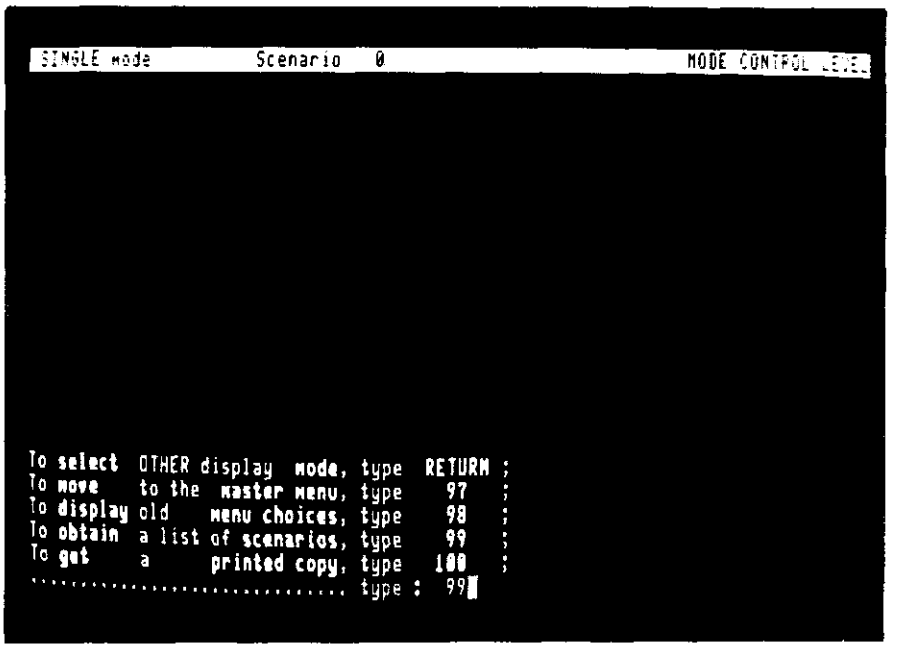
The system is initiated by the command

RUN ICDS

followed by pressing the Return key (which does not cause a letter or a number to appear on the screen). The system responds with the "titel page" :



After the user has pressed the Return key, he gets presented with the first menu from which he must choose an item :



The bar along the top of the screen contains information about the setting of option switches and the "whereabouts" of the user in the system. In the screen given above the information in the bar indicates that the user is at the "MODE CONTROL LEVEL", that the system is in "SINGLE MODE", showing "Scenario 0". The MODE CONTROL LEVEL is the control level at which the user can modify the SINGLE/DOUBLE MODE switch and perform some other special operations. In SINGLE MODE data from only one scenario are displayed at a time. What the system does in DOUBLE MODE will be explained and demonstrated further on in this session.

Before the user can proceed to MASTER MENU LEVEL by typing "97", which one can see as making a step to the next lower level in the system, the scenario selection procedure must be gone through : "Scenario 0" means that no selection of a data-set has yet taken place. The user continues to this procedure by typing "99" (see the number in the bottom right-hand corner of the screen given above); the scenarios that are available on the disk storage system are now listed on the screen (in this case there are only two of them) :

Each scenario has a one-line characterisation; the explanation of the abrreviations used in the heading of the table can be obtained by typing "99" (see the number in the bottom right-hand corner of the screen given above) :

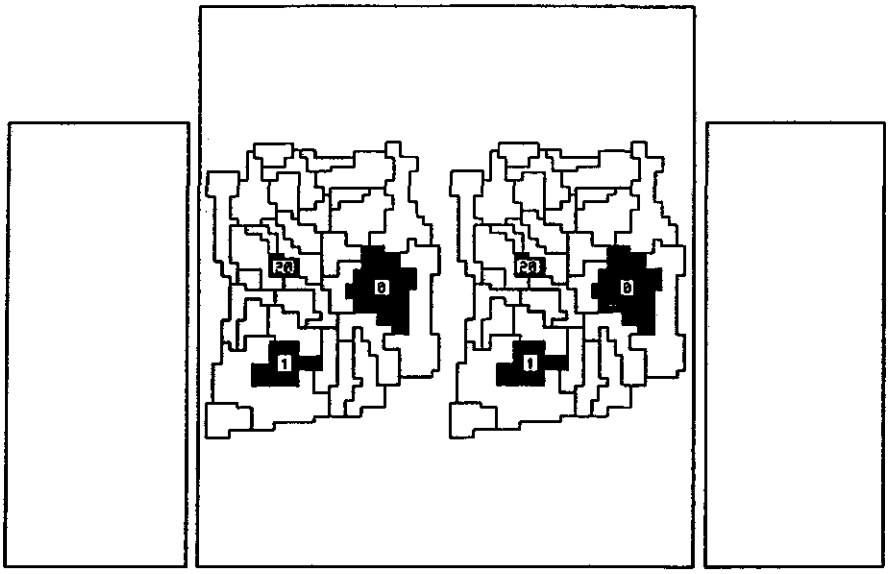
```
                                                              LIST OF SCENARIOS

      YEAR  INC  LAB QPWS  CPM  CFM PHOS  QSW   W1   W2   W3   options
       -   mill. man mill. mg/  mg/   -   m3/   %    %    %
           fl year   m3    l    l        sec                    QSXZUE
*******************************************************************************
YEAR    - meteorological year that the scenario generating system was run with
INC     - total yearly income from agriculture in the region
LAB     - total labour requirement in the region
QPWS    - total yearly extraction of groundwater for public water supply
CPM     - highest value of Nitrogen concentrations in phreatic aquifer cells
CFM     - highest value of Nitrogen concentrations in first   aquifer cells
PHOS    - phosphate norm,according to Ministry of Agriculture planned measures
QSW     - total capacity for supply of surface water to the region
W1-3    - lowering of the GW level at the end of summer, in  nature  areas 1-3
QSXZUE  - code for  option parameters of the  scenario generating system
          ) Q = 0 for FIXED p.w.s extractions        ) Q = 1 for OPTIMAL ones
          ) S = 0 for FIXED sprinkling capacities    ) S = 1 for OPTIMAL ones
          ) X = 0 for FIXED landuse technologies     ) X = 1 for OPTIMAL ones
          ) Z = 0 for FIXED non-landuse techs        ) Z = 1 for OPTIMAL ones
          ) U = 0 for ALLOWED winter slurry appl.    ) U = 1 for PROHIBITION
          ) E = 0 for NO limitation on slurry export ) E = 1 for export (emax
press (return) to continue :
```

After hitting the Return key the system returns to the list :

```
                                                              LIST OF SCENARIOS

      YEAR  INC  LAB QPWS  CPM  CFM PHOS  QSW   W1   W2   W3   options
       -   mill. man mill. mg/  mg/   -   m3/   %    %    %
           fl year   m3    l    l        sec                    QSXZUE

 ( 1)  1975  191 3342   10   37   30    1    2   20    1    0    011100
 ( 2)  1975  165 2858   10   37   29    4    2   26    1    0    011111
 -------------------------------------------------------------------------------




To select   a scenario,   type its number ;
To continue with listing, type     RETURN ;
To obtain   explanations, type       99   ;
..................... type :      1
```

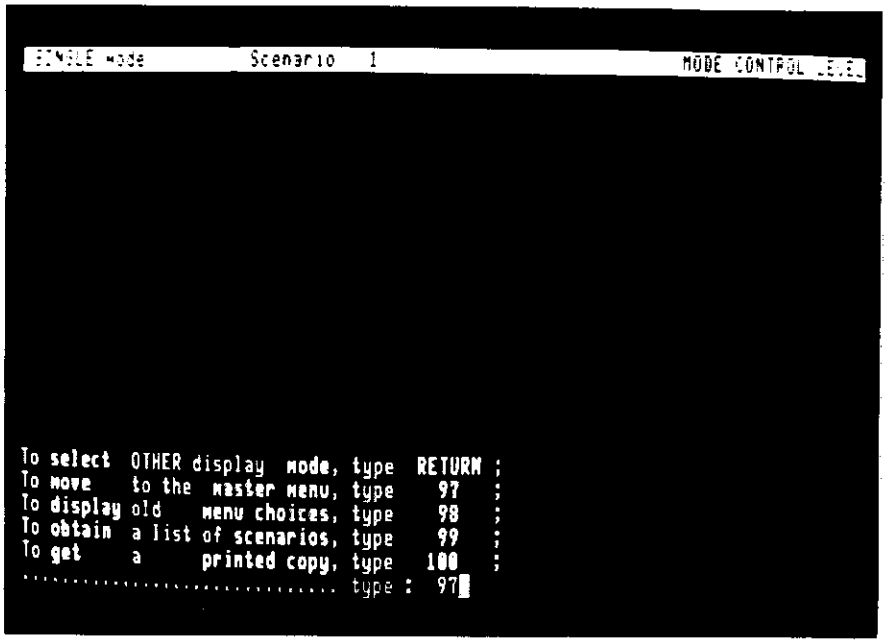
As can be seen from the number "1" in the bottom right-hand corner, the first scenario is selected in this case; the system now does two things :

- On the colour monitor two identical maps are projected (see the figure below). The nature areas get coloured dark blue and the parameters indicating the "loss of nature performance" (see the values under the headings "W1 W2 W3" in the table of scenarios that are available on disk) are plotted in their centre. Note that the nature areas on BOTH maps are filled in an identical manner because the system is in SINGLE MODE, meaning that the maps are used for showing two different aspects of the SAME scenario. The other indicator values that characterise a scenario are plotted along the bottom of the monitor -- the box is centred along the bottom of the screen because only one scenario gets shown at a time in SINGLE MODE.

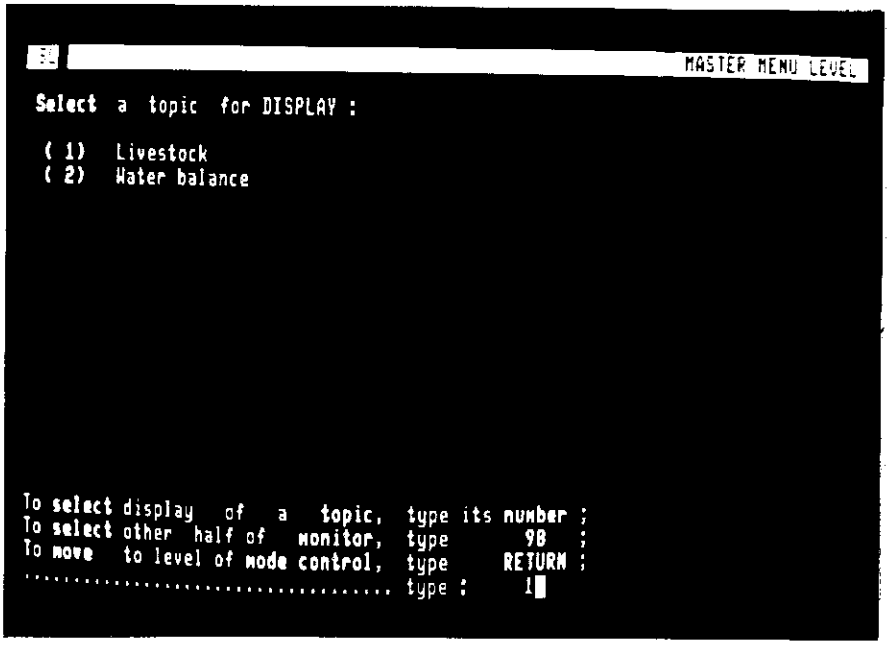


Scenario			
1	Weather year	1975	---
	Agric. income	191	mill.fl/y
	Total labour	3342	man year
	P. w. supply	18	mill.m3/y
	Quality of PW	37	mg N /l
	Quality of FW	30	mg N /l
	Phosph. norm	1	---
	SW supply cap	2	m3 /sec

- On the terminal screen the system presents the MODE CONTROL MENU. The only difference with the MODE CONTROL MENU that was given before is that in the bar along the top the information "Scenario 0" has been replaced by "Scenario 1" :

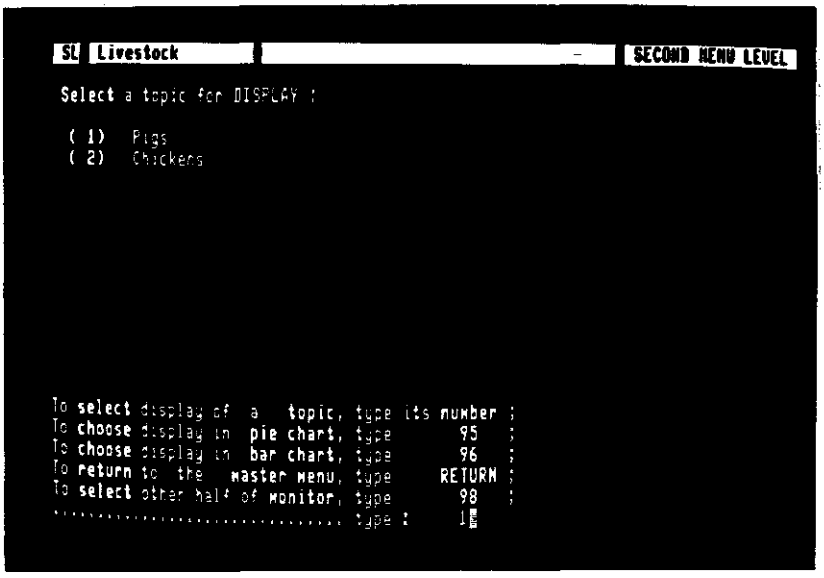


By typing "97" the MASTER MENU LEVEL is now accessed :



The MASTER MENU LEVEL serves as a sort of "home" location -- it can be accessed from almost any point in the system (which is especially useful if the user may have become confused). The letters "SL" in the bar along the top indicate that the system is in SINGLE MODE and that the user is working on the LEFT-hand side of the colour monitor; the latter means that when it comes to the plotting of data on the monitor, this will be on the left-hand side, i.e. on the left-hand map or in the left-hand vertical box. The user can modify the side of the monitor by typing "98" (see menu above); but since nothing has been plotted yet on the left-hand side, this option is not relevant at this point of the session.

Now a choice of one of the topics must be made; in this example session the user selects topic number 1, as is evidenced by the number in the bottom right-hand corner of the menu given above. The system responds by showing the SECOND MENU LEVEL of the choice that the user made at the MASTER MENU LEVEL (the latter is equivalent to "FIRST MENU LEVEL"):

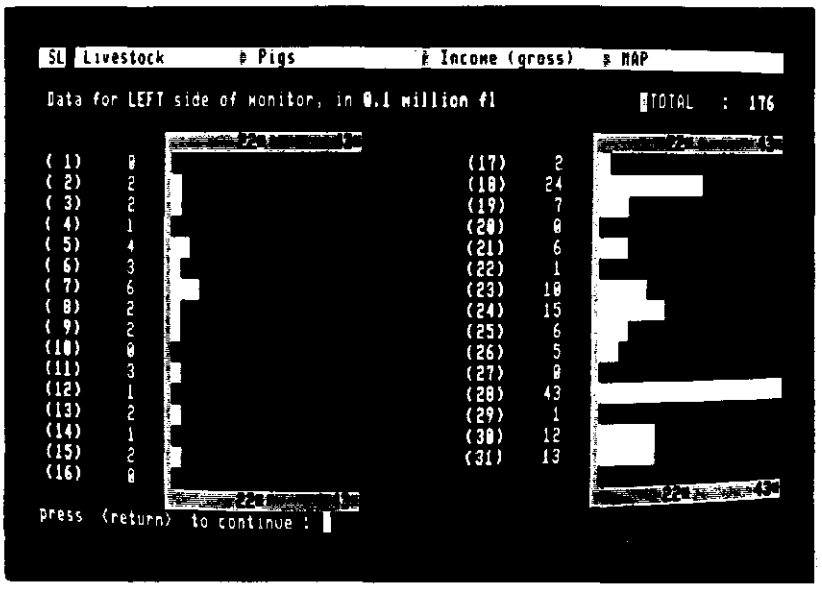


The choice of "Livestock" is indicated in the bar along the top of the screen. The user again chooses the first topic and the system then presents the THIRD MENU LEVEL :

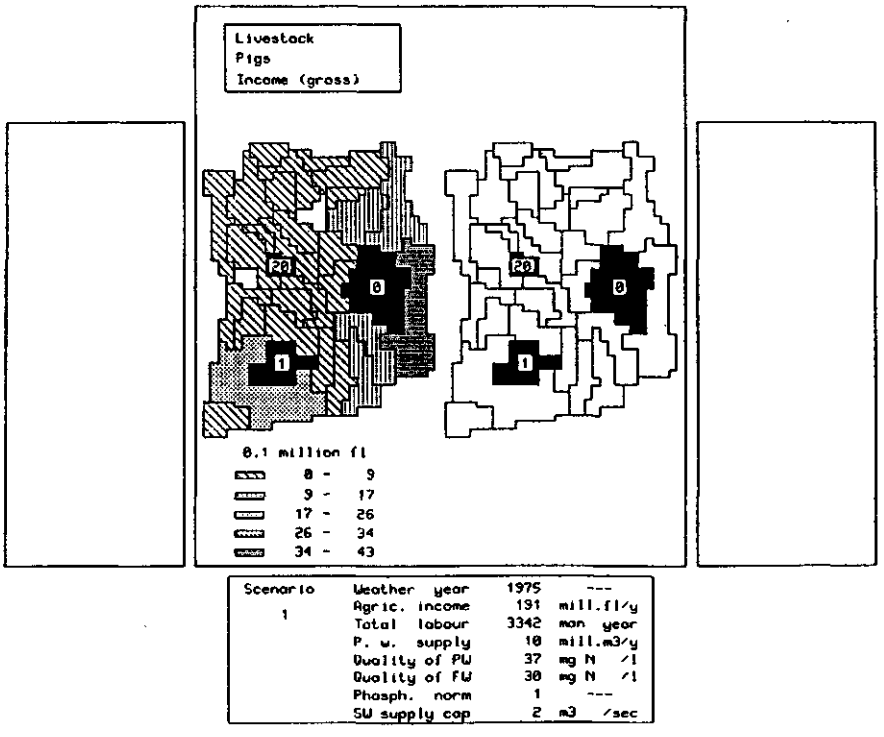
At this level "Income" is chosen in the example. Prior to the displaying of data on the terminal screen and on the monitor, the user has to choose between two alternatives for the unit of the data:

Here the user chooses "absolute values" by simply pressing the Return key (which does not cause a number or letter to appear on the screen; so the space after the ":" remains blank). Two things now happen :

- On the terminal the relevant data get presented in the form of a monochrome bar chart. In the top right-hand corner (just below the system information bar) the aggregated data-element is shown, in this case the total of all the subregional values:



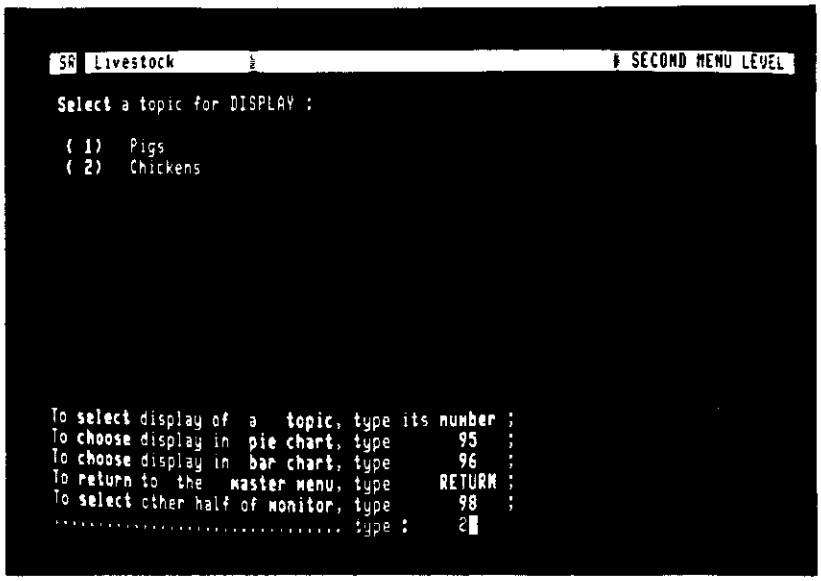
- On the colour monitor the same data get presented in the form of colourings of the subregions, according to the scale that is given below the map. For the purpose of being able to reproduce the image on the monitor in black-and-white, the colourings have here been replaced by a set of shadings :

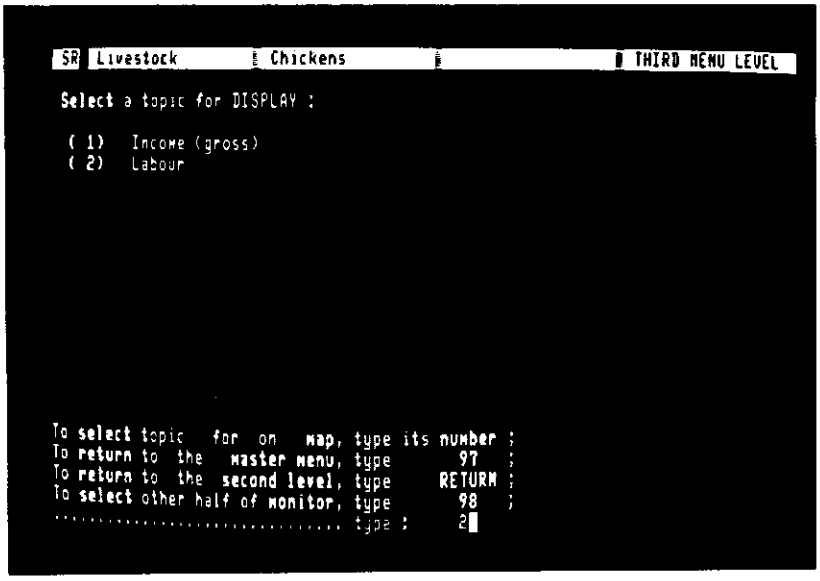


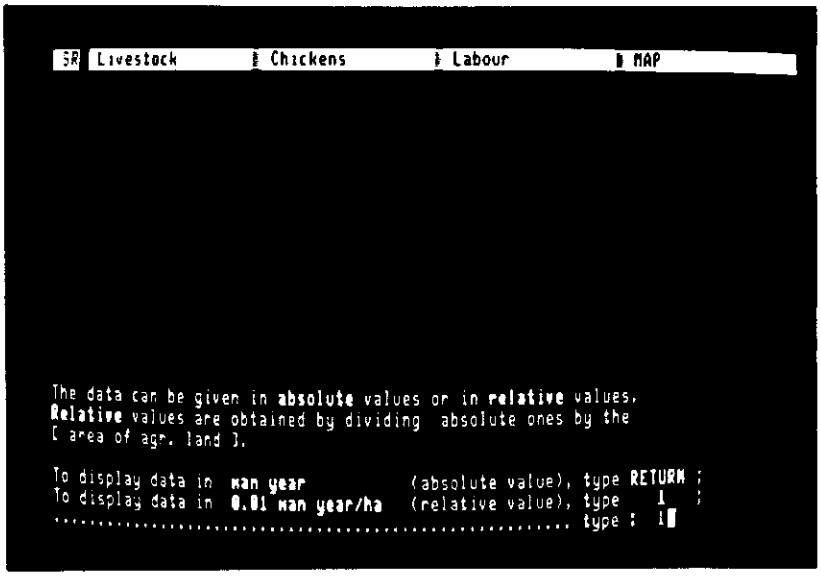
After having hit the Return key (see the last line of the terminal screen given above), the system returns to the last menu that was shown before the choosing of the unit and the plotting of the data :

In this example session, the user now first changes to the right-hand side of the monitor by typing "98" (see number in bottom right-hand corner of screen given above). The system responds by showing the same menu again, with the difference that "SL" has been replaced by "SR", indicating that the user is now working in SINGLE MODE, on the RIGHT-hand side of the monitor:

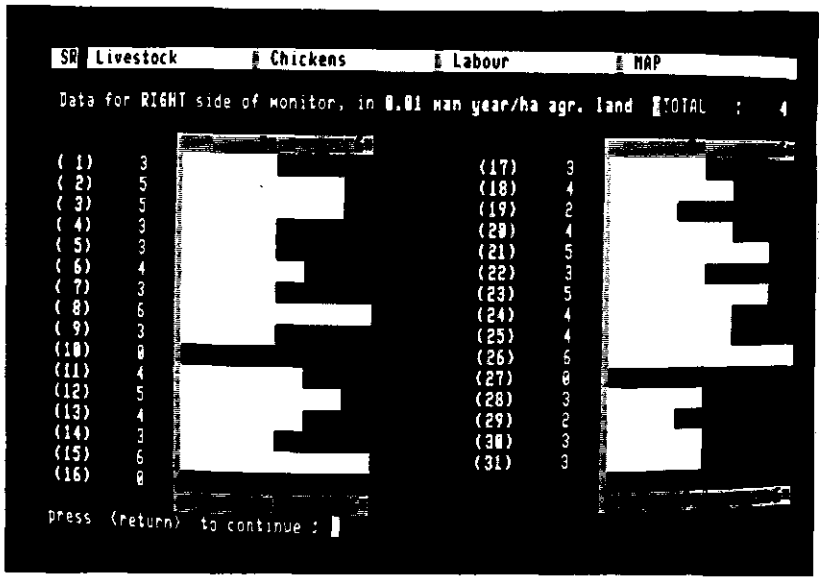
After going a menu level up by hitting the Return key (see blank space after ":" in the menu given above) the following choices are made for plotting on the right-hand map :

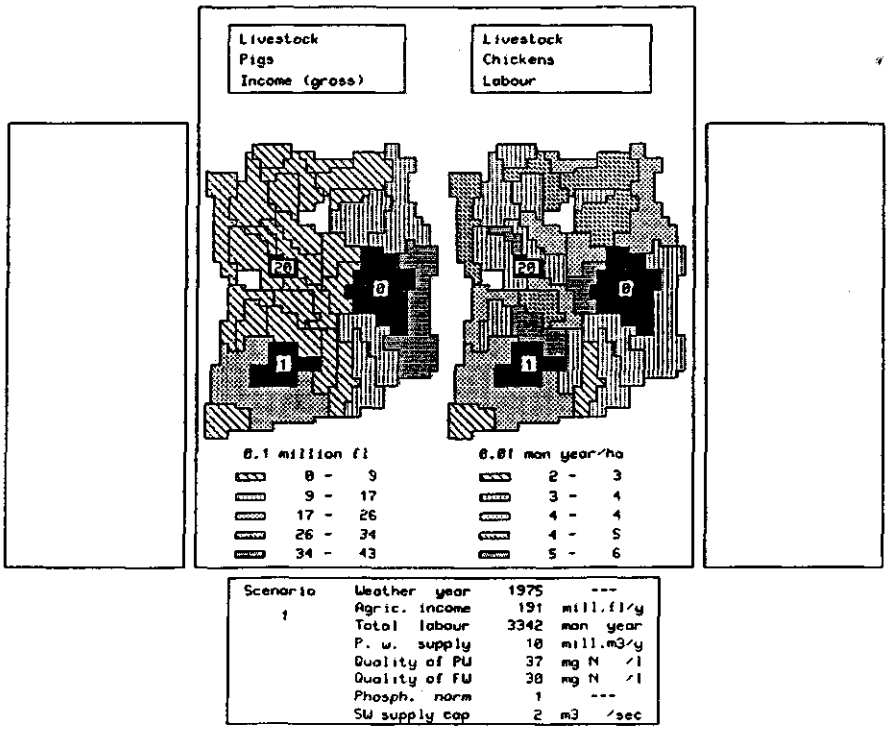

SR Livestock
SECOND MENU LEVEL
Select a topic for DISPLAY :
(1) Pigs
(2) Chickens
To select display of a topic, type its number ;
To choose display in pie chart, type 95 ;
To choose display in bar chart, type 96 ;
To return to the master menu, type RETURN ;
To select other half of monitor, type 98 ;
..... type : 2


SR Livestock
Chickens
THIRD MENU LEVEL
Select a topic for DISPLAY :
(1) Income (gross)
(2) Labour
To select topic for on map, type its number ;
To return to the master menu, type 97 ;
To return to the second level, type RETURN ;
To select other half of monitor, type 98 ;
..... type : 2


SR Livestock
Chickens
Labour
MAP
The data can be given in absolute values or in relative values.
Relative values are obtained by dividing absolute ones by the
[area of agr. land].
To display data in man year (absolute value), type RETURN ;
To display data in 0.01 man year/ha (relative value), type 1 ;
..... type : 1

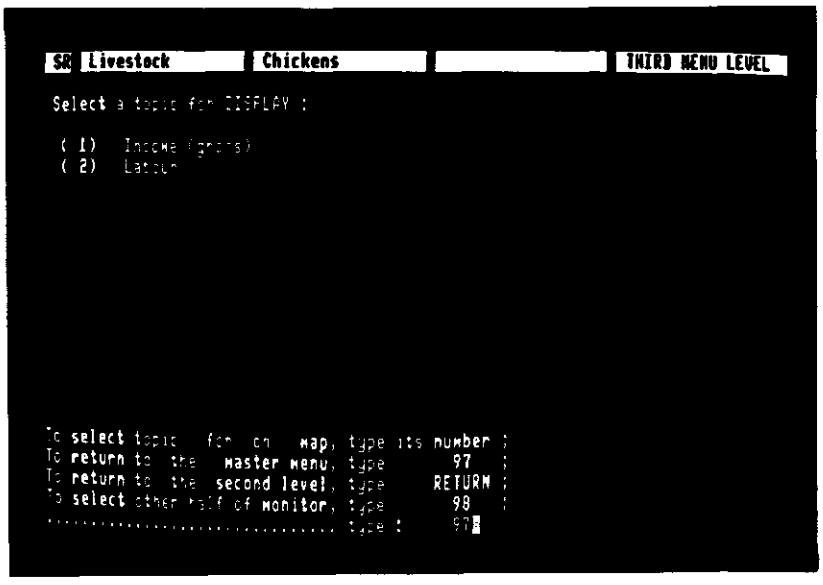
Instead of choosing "absolute values" like before, the user has now chosen "relative values" by typing "1" before hitting the Return key. Again the system responds by giving the data in the form of a bar chart form on the terminal screen and in the form of colourings (here shadings) on the map:



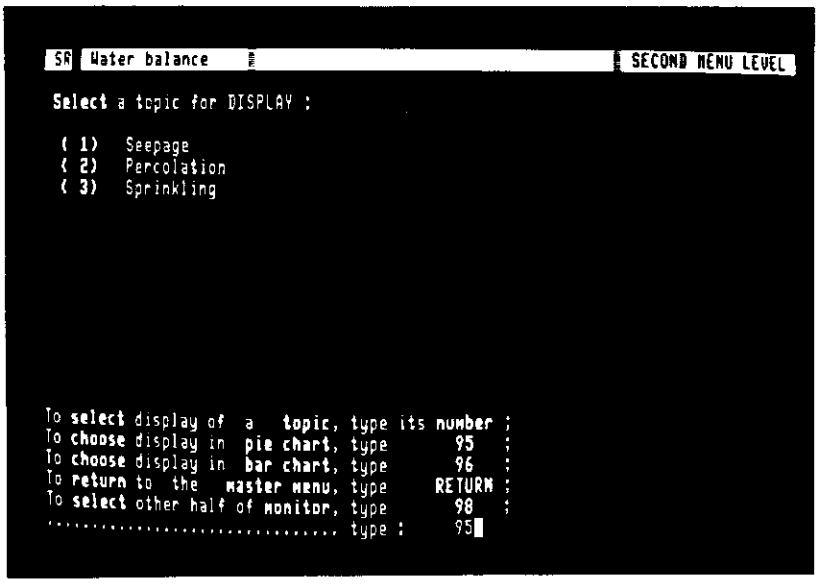


The meaning of "TOTAL" (top right-hand corner below information bar in the screen given above) requires some explanation here : Since the user has chosen "relative values", the aggregated data-element given after "TOTAL" is not simply the arithmetic sum of the subregional values, because this would go against the nature of data that are per-unit-of-area. Here the aggregated data-element is taken as the sum of the data in their ABSOLUTE form, divided by the TOTAL AREA of the region.

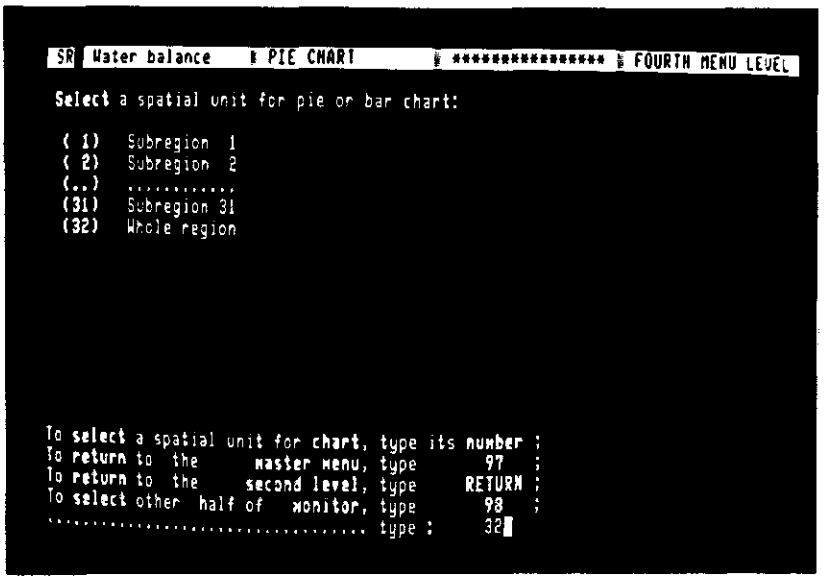
The spaces in the vertical boxes to the left and right sides of the maps can be used for displaying "pie charts" and/or "bar charts". Such charts can be selected by the user by typing "95" for "pie chart" or "96" for bar chart at either the second or third level of the system -- by typing "95" or "96" the user indicates that he does not want to choose a single topic from the list, but that he wants to show "all of the topics" in either a pie or a bar chart. However, the system only allows him to do this if the resulting selection of data are all in the same unit, because it does not have make sense to show a mumbo-jumbo of data in the same chart. In the following, the user first passes to the master menu, and then chooses "Water balance", followed by the choosing of "pie chart".



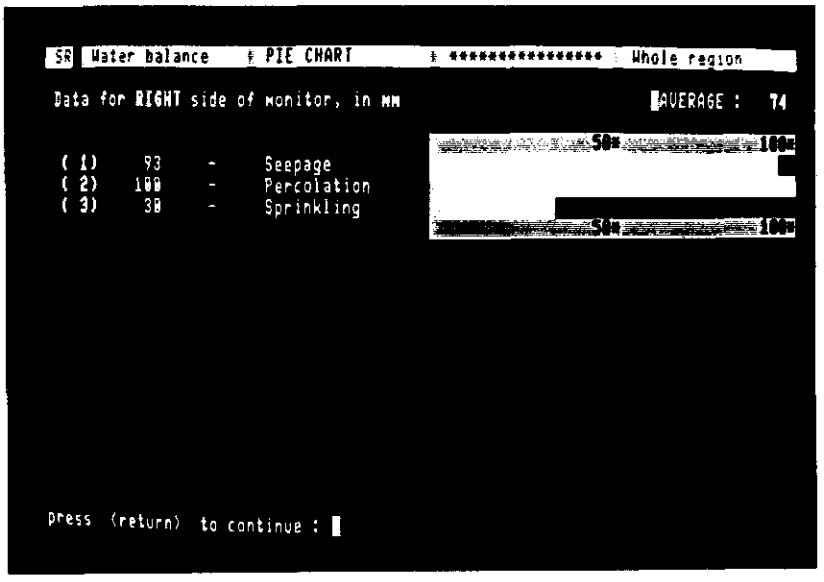

SR
MASTER MENU LEVEL
Select a topic for DISPLAY :
(1) Livestock
(2) Water balance
To select display of a topic, type its number ;
To select other half of monitor, type 98 ;
To move to level of mode control, type RETURN ;
..... type : 2

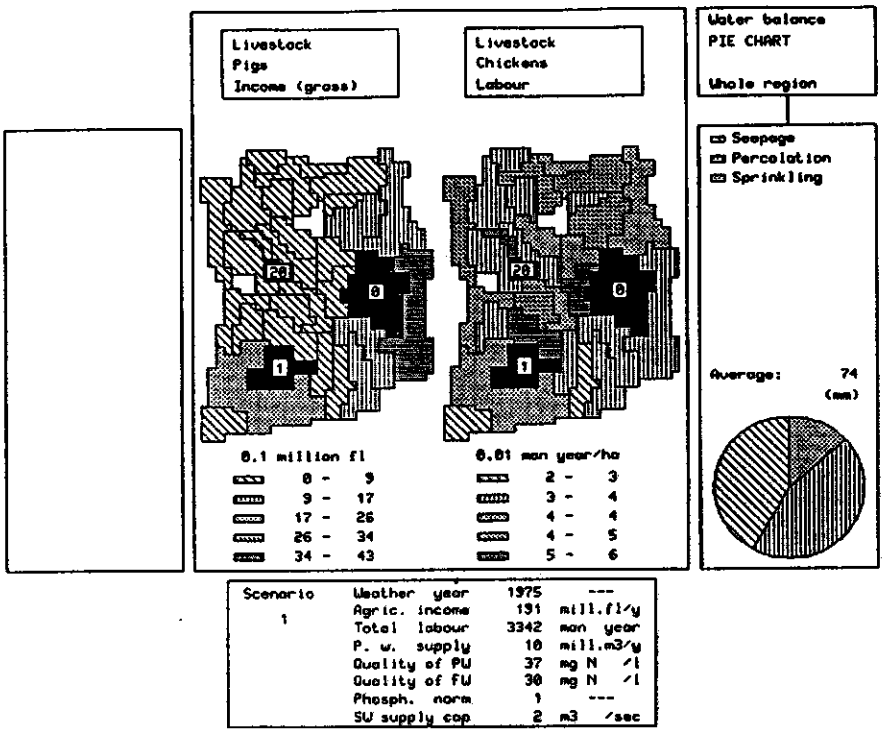

SR Water balance
SECOND MENU LEVEL
Select a topic for DISPLAY :
(1) Seepage
(2) Percolation
(3) Sprinkling
To select display of a topic, type its number ;
To choose display in pie chart, type 95 ;
To choose display in bar chart, type 96 ;
To return to the master menu, type RETURN ;
To select other half of monitor, type 98 ;
..... type : 95

Because there is no third-level branching of the "Water balance" branch, the third level is skipped. Since it is not possible to show pie charts for all the subregions at the same time, the user has to choose one (or "Whole region") from the fourth-level menu :

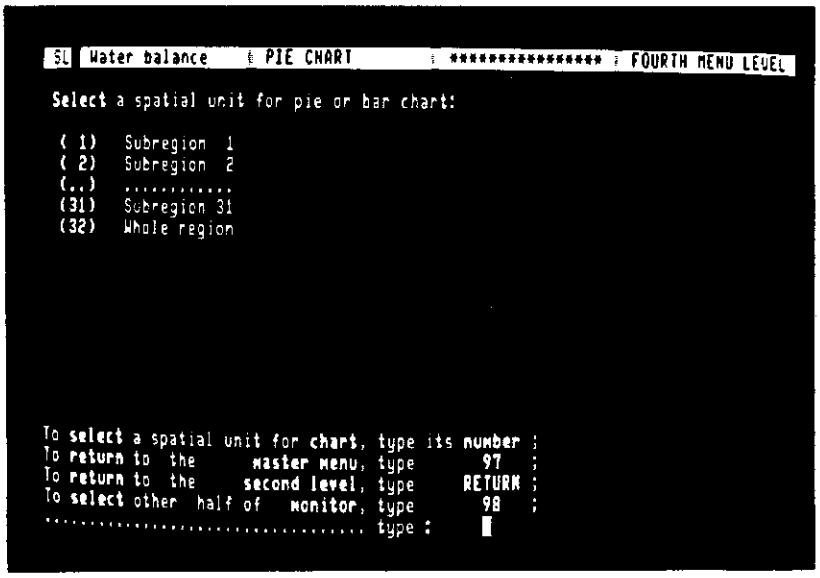


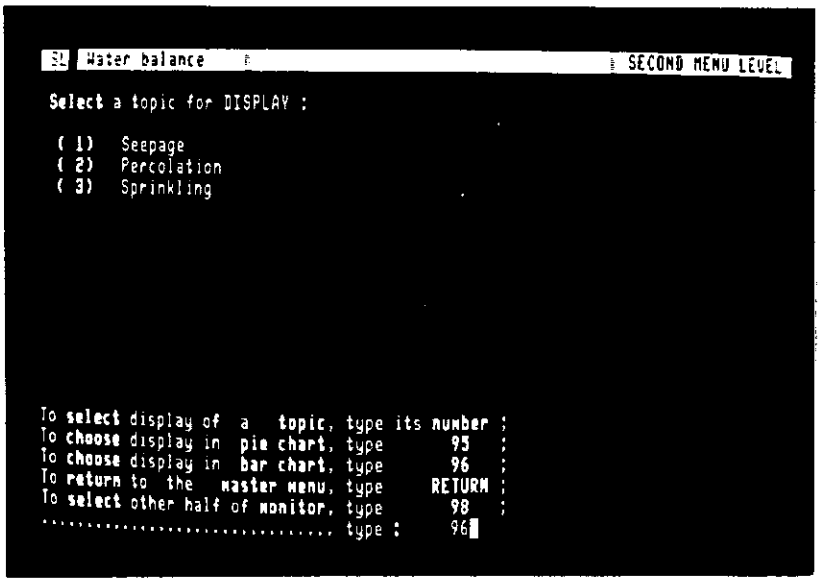
The water balance data are already in the form of "relative data" -- a "mm" is a measure for "volume per unit area". So here the user does NOT first get asked to choose the unit:

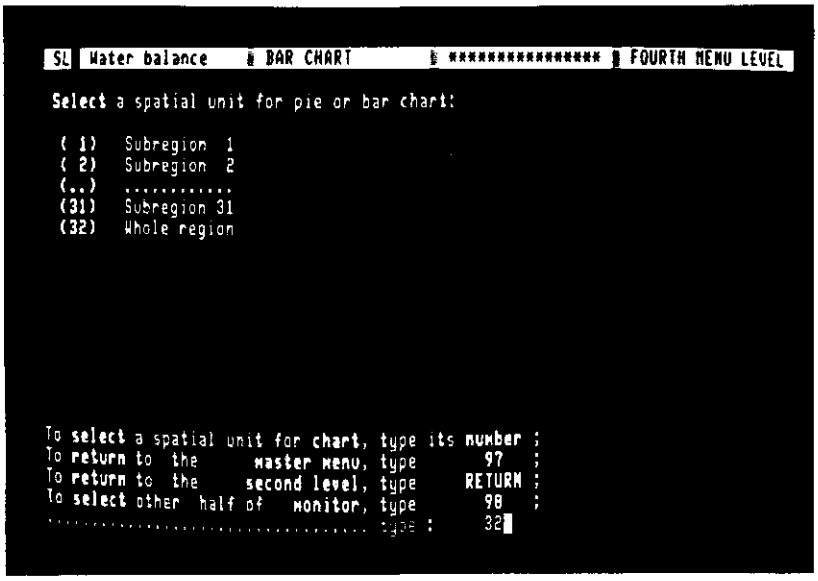




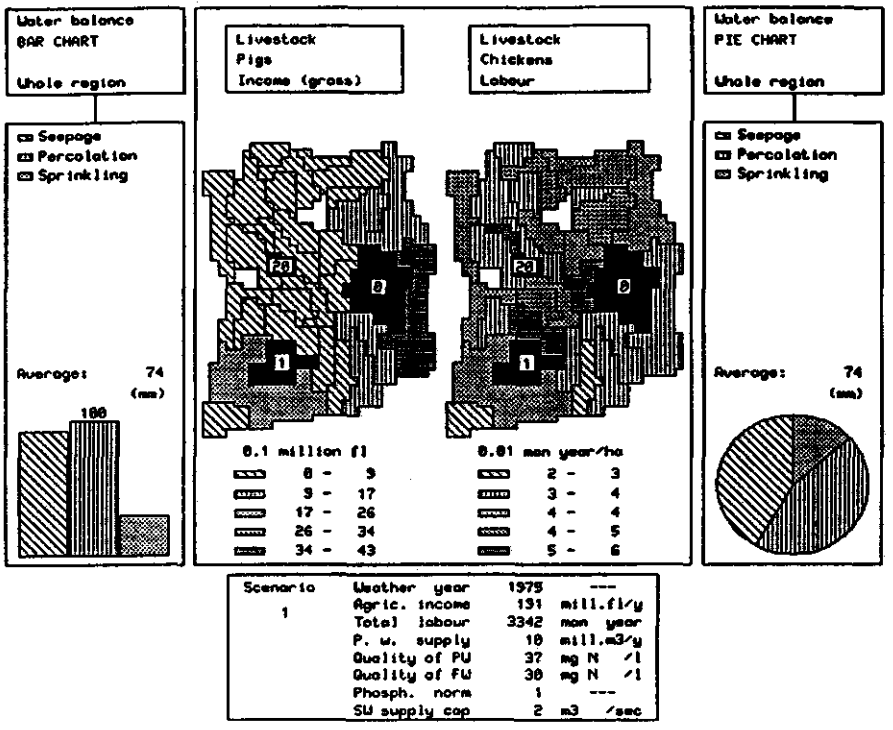
After switching to the other side of the monitor, the user here proceeds to make a bar chart (after having first gone to the second level):

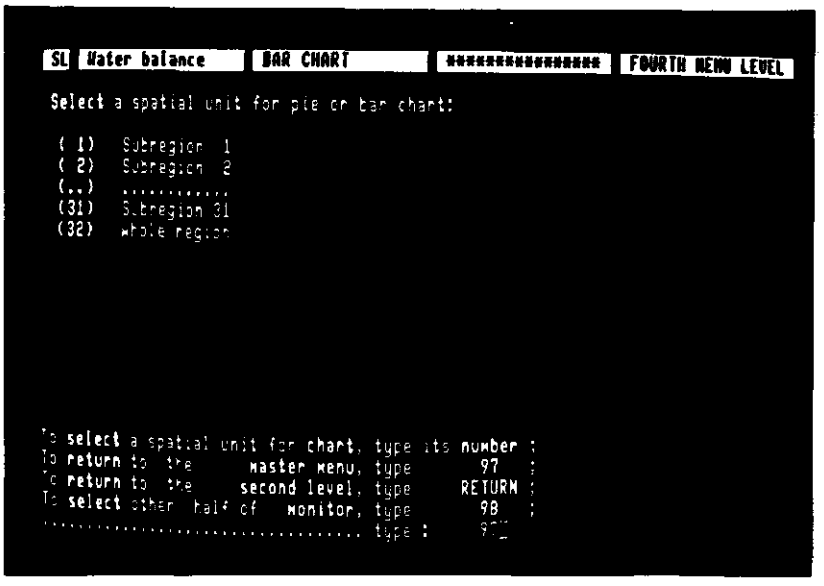

SL Water balance : PIE CHART : ********** : FOURTH MENU LEVEL
Select a spatial unit for pie or bar chart:
(1) Subregion 1
(2) Subregion 2
(..) .....
(31) Subregion 31
(32) Whole region
To select a spatial unit for chart, type its number ;
To return to the master menu, type 97 ;
To return to the second level, type RETURN ;
To select other half of monitor, type 98 ;
..... type :


SL Water balance : SECOND MENU LEVEL
Select a topic for DISPLAY :
(1) Seepage
(2) Percolation
(3) Sprinkling
To select display of a topic, type its number ;
To choose display in pie chart, type 95 ;
To choose display in bar chart, type 96 ;
To return to the master menu, type RETURN ;
To select other half of monitor, type 98 ;
..... type : 96

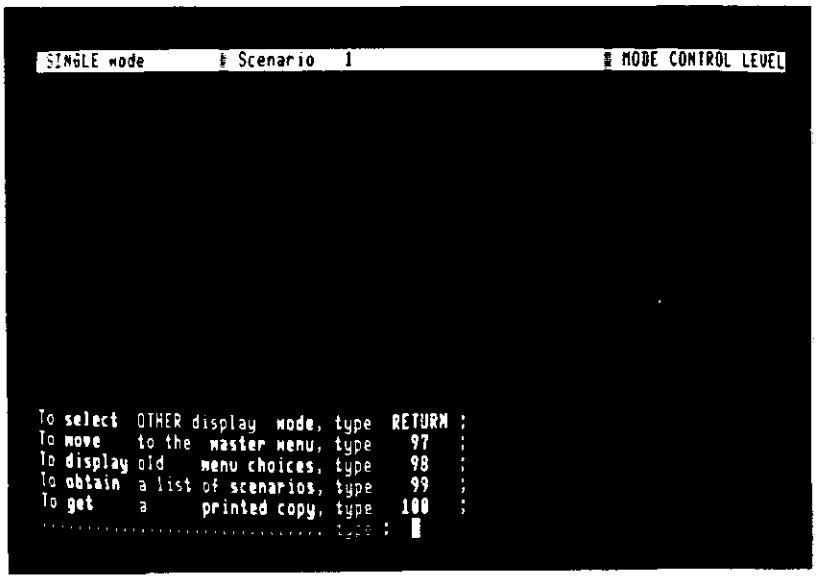

SL Water balance ▮ BAR CHART ▮ ********** ▮ FOURTH MENU LEVEL
Select a spatial unit for pie or bar chart:
(1) Subregion 1
(2) Subregion 2
(..) .....
(31) Subregion 31
(32) Whole region
To select a spatial unit for chart, type its number ;
To return to the master menu, type 97 ;
To return to the second level, type RETURN ;
To select other half of monitor, type 98 ;
..... type : 32


SL Water balance ▮ BAR CHART ▮ ********** ▮ Whole region
Data for LEFT side of monitor, in MM
AVERAGE : 74
(1) 93 - Seepage
(2) 100 - Percolation
(3) 30 - Sprinkling
press (return) to continue :

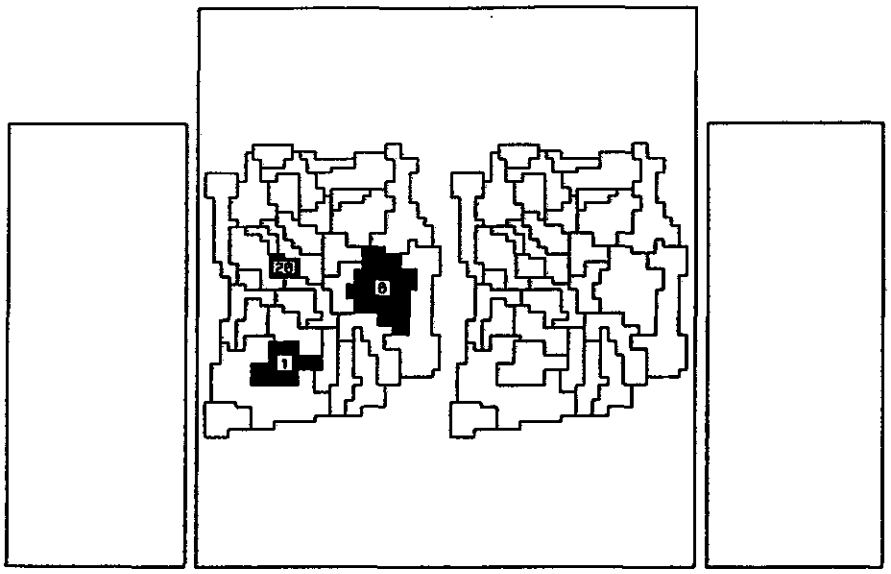

Water balance
BAR CHART
Whole region
Seepage
Percolation
Sprinkling
Average: 74
(mm)
100
Livestock
Pigs
Income (gross)
Livestock
Chickens
Labour
0.1 million fl
0 - 9
9 - 17
17 - 26
26 - 34
34 - 43
0.01 man year/ha
2 - 3
3 - 4
4 - 4
4 - 5
5 - 6
Water balance
PIE CHART
Whole region
Seepage
Percolation
Sprinkling
Average: 74
(mm)
Scenario
1
Weather year 1975 ---
Agric. income 131 mill.fl/y
Total labour 3342 man year
P. w. supply 10 mill.m3/y
Quality of PU 37 mg N /l
Quality of FW 30 mg N /l
Phosph. norm 1 ---
SW supply cap 2 m3 /sec


SL Water balance
BAR CHART
FOURTH MENU LEVEL
Select a spatial unit for pie or bar chart:
(1) Subregion 1
(2) Subregion 2
(..) .....
(31) Subregion 31
(32) whole region
To select a spatial unit for chart, type its number ;
To return to the master menu, type 97 ;
To return to the second level, type RETURN ;
To select other half of monitor, type 98 ;
..... type :

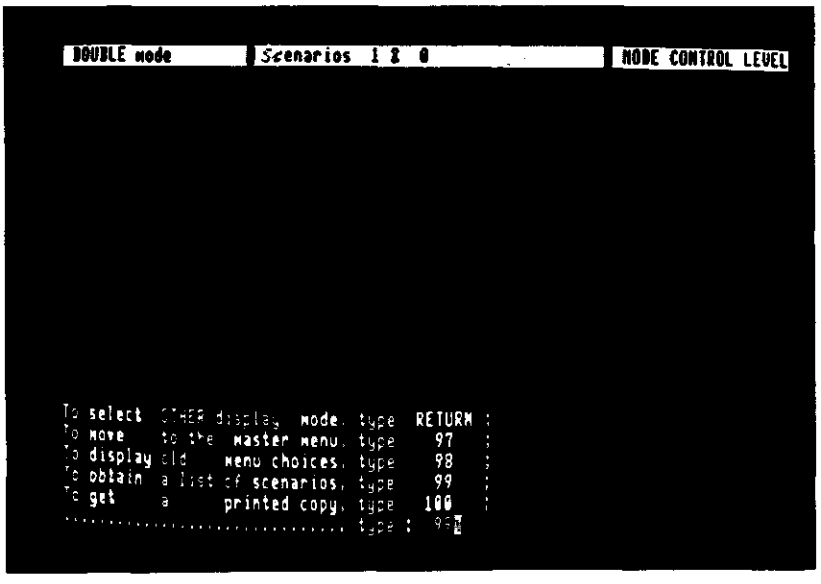
In the final part of this session, an example is given of the DOUBLE MODE option that the system has. In this mode, the system is used for displaying the same aspects of two different scenarios. After passing to MODE CONTROL LEVEL the user hits the Return key to obtain DOUBLE MODE:



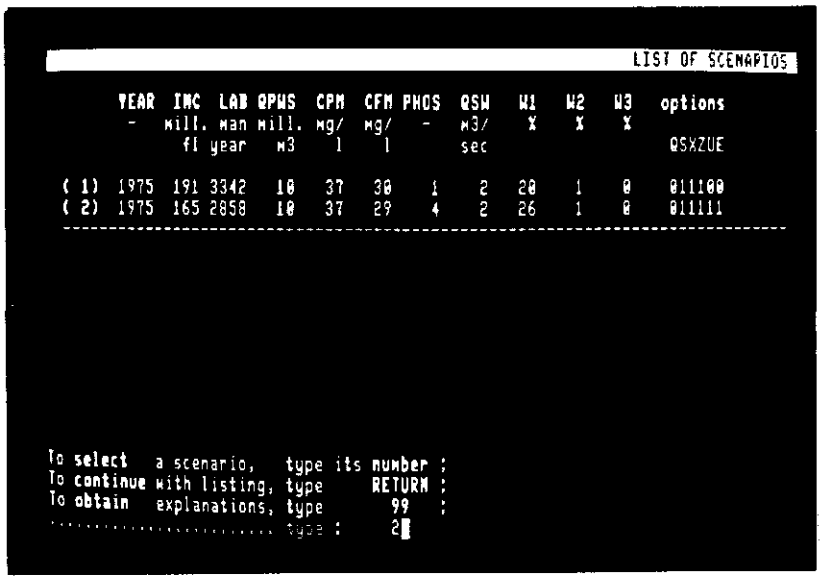
On the colour monitor the "indicator values" of "Scenario 1" are now only projected on the left-hand side. Only the nature areas of the left-hand map are filled with dark blue and the box along the bottom is not centred but placed to the left. Nothing is plotted on the right-hand side yet (apart from the basic graphics), because the user must first select a scenario from the list : "Scenarios 1 and 0" indicates that no choice has yet been made for the right-hand scenario.

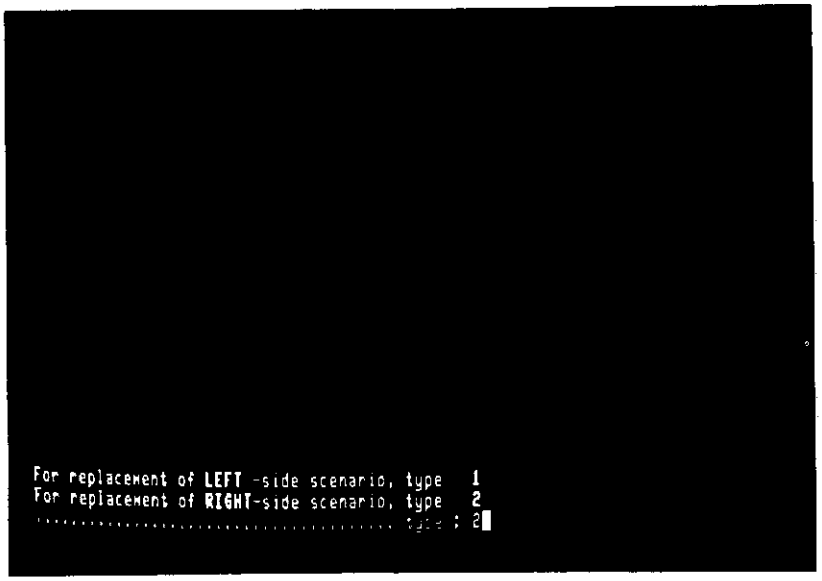


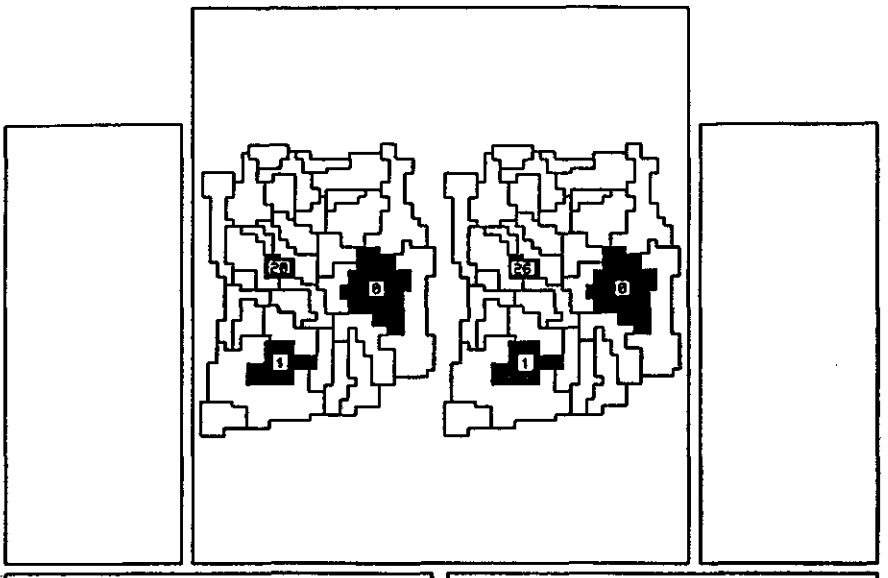
Scenario			
1	Weather year	1975	---
	Agric. income	191	mill.fl/y
	Total labour	3342	man year
	P. w. supply	18	mill.m3/y
	Quality of FU	37	mg N /l
	Quality of FU	30	mg N /l
	Phosph. norm	1	---
	SW supply cap	2	m3 /sec



So before the user can proceed, he must choose a second scenario from the list :

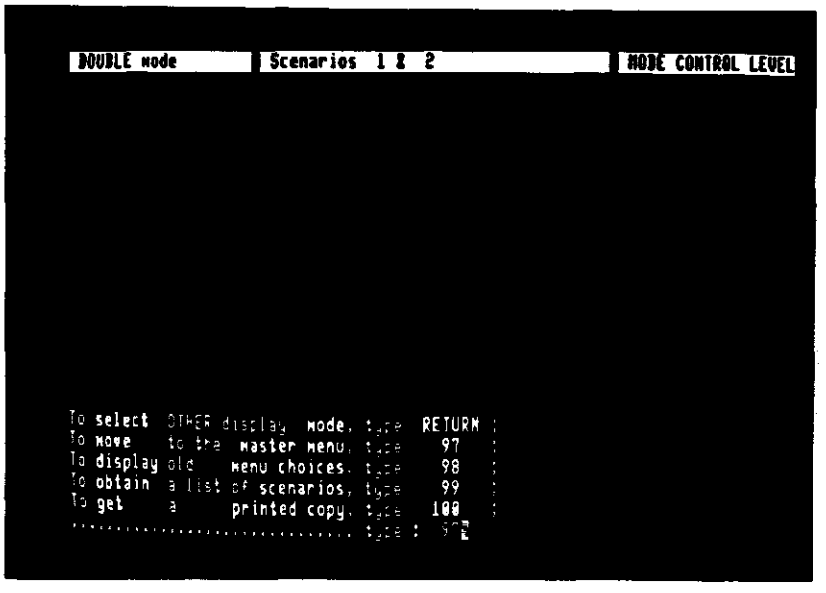




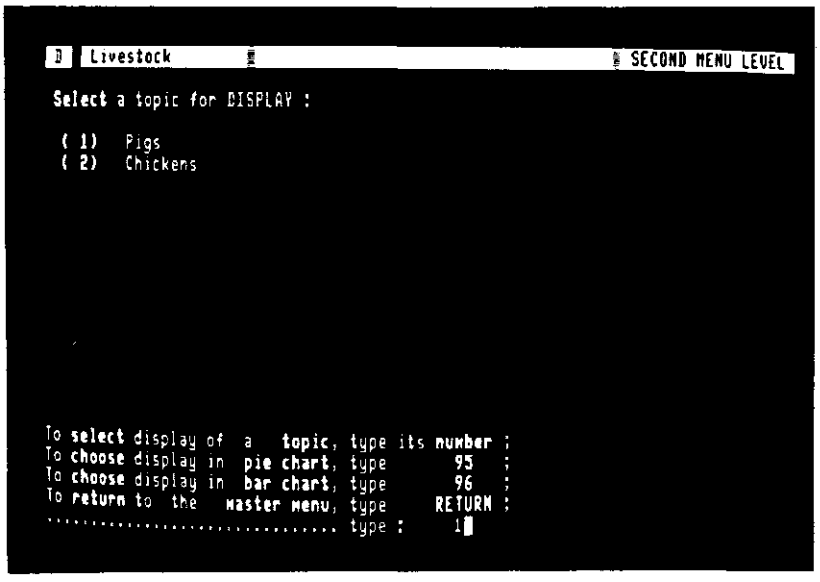


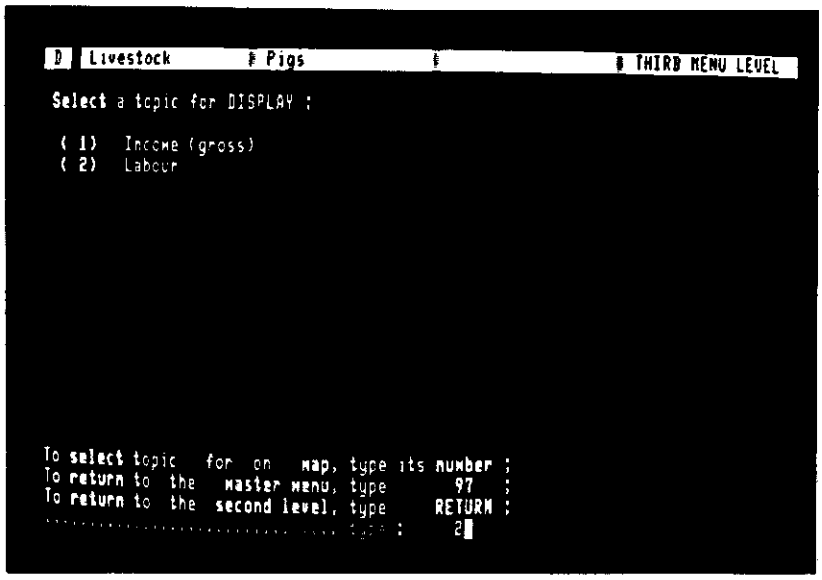
Scenario			
1	Weather year	1975	---
	Agric. income	191	mill.fl/y
	Total labour	3342	man year
	P. w. supply	10	mill.m3/y
	Quality of PU	37	mg N /l
	Quality of FU	30	mg N /l
	Phosph. norm	1	---
	SU supply cap	2	m3 /sec

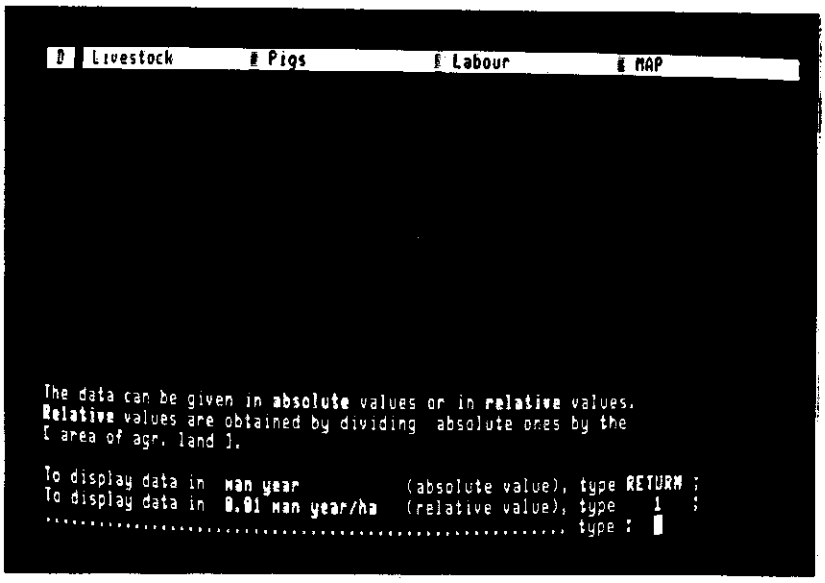
Scenario			
2	Weather year	1975	---
	Agric. income	165	mill.fl/y
	Total labour	2858	man year
	P. w. supply	10	mill.m3/y
	Quality of PU	37	mg N /l
	Quality of FU	29	mg N /l
	Phosph. norm	4	---
	SU supply cap	2	m3 /sec

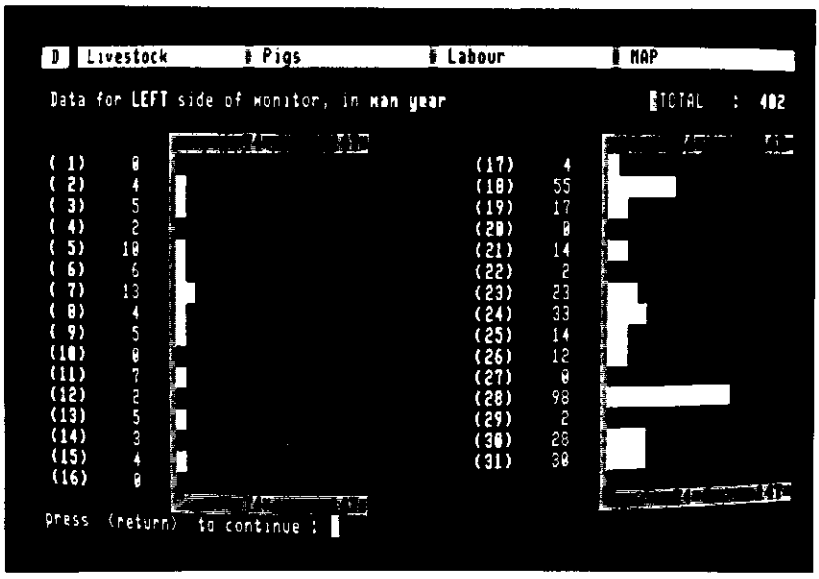


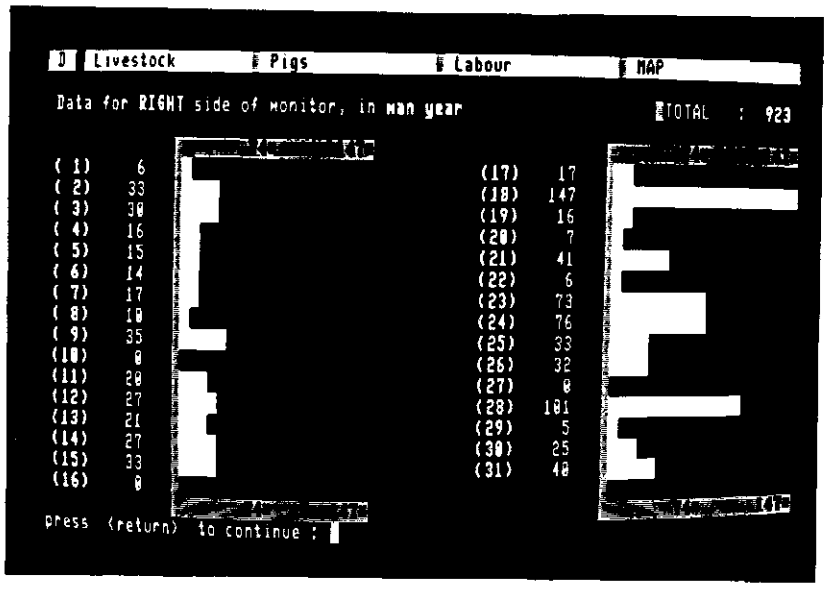
Now that a second scenario has been selected, the user proceeds down the menu system as in the example given for SINGLE MODE. The difference being that the user does not have to bother about sides (the "D" in the information bar is not followed by "L" or "R"). When he has made a choice for the map, the system plots the relevant data on BOTH sides of the monitor, without any further intervention of the user being required; the same applies to the data that are shown in the vertical boxes :

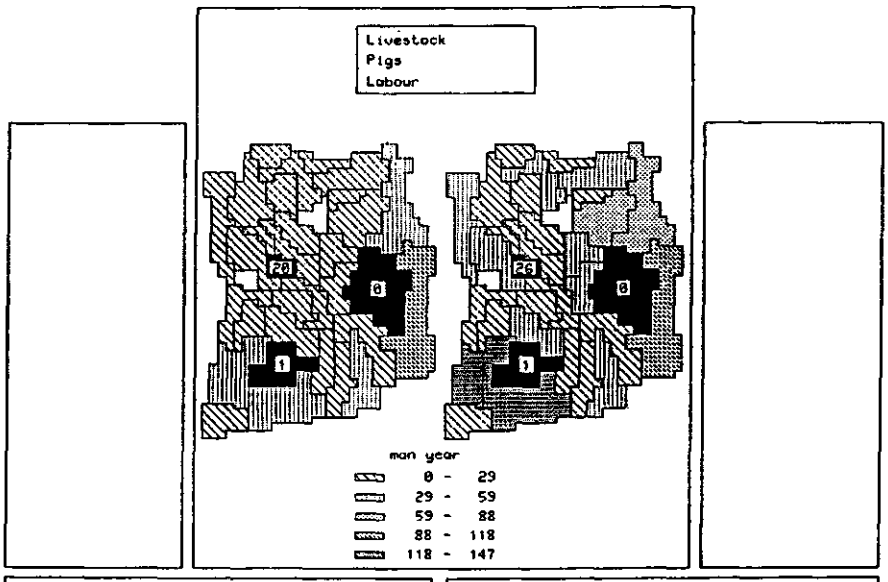



D Livestock # Pigs # # THIRD MENU LEVEL
Select a topic for DISPLAY :
(1) Income (gross)
(2) Labour
To select topic for on map, type its number ;
To return to the master menu, type 97 ;
To return to the second level, type RETURN ;
type : 2


D Livestock # Pigs # Labour # MAP
The data can be given in absolute values or in relative values.
Relative values are obtained by dividing absolute ones by the
[area of agr. land].
To display data in man year (absolute value), type RETURN ;
To display data in 0.01 man year/ha (relative value), type 1 ;
type :

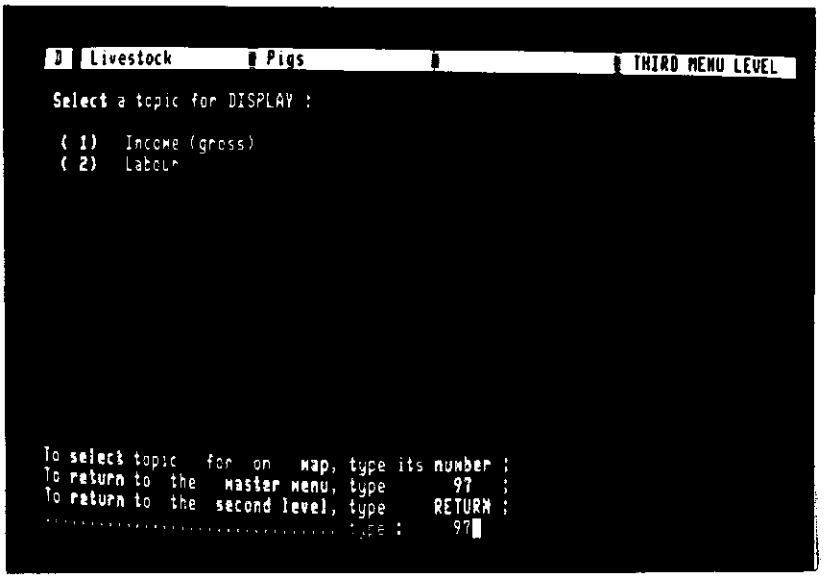

D Livestock # Pigs # Labour # MAP
Data for LEFT side of monitor, in man year
TOTAL : 402
(1) 0
(2) 4
(3) 5
(4) 2
(5) 10
(6) 6
(7) 13
(8) 4
(9) 5
(10) 0
(11) 7
(12) 2
(13) 5
(14) 3
(15) 4
(16) 0
(17) 4
(18) 55
(19) 17
(20) 0
(21) 14
(22) 2
(23) 23
(24) 33
(25) 14
(26) 12
(27) 0
(28) 98
(29) 2
(30) 28
(31) 30
press (return) to continue :





Scenario				
1	Weather year	1975	---	
	Agric. income	191	mill.fl/y	
	Total labour	3342	man year	
	P. w. supply	10	mill.m3/y	
	Quality of PW	37	mg N	/l
	Quality of FW	30	mg N	/l
	Phosph. norm	1	---	
	SW supply cap	2	m3	/sec

Scenario				
2	Weather year	1975	---	
	Agric. income	165	mill.fl/y	
	Total labour	2858	man year	
	P. w. supply	10	mill.m3/y	
	Quality of PW	37	mg N	/l
	Quality of FW	29	mg N	/l
	Phosph. norm	4	---	
	SW supply cap	2	m3	/sec

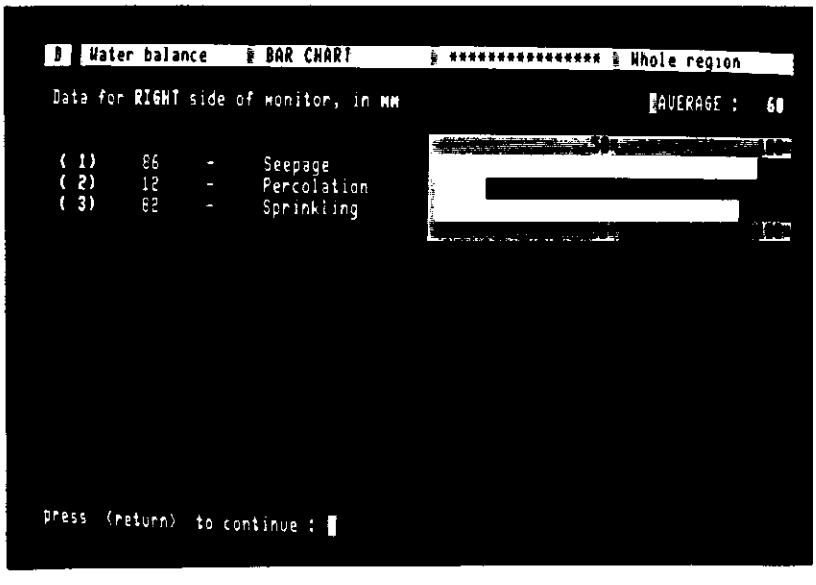

D Livestock Pigs THIRD MENU LEVEL
Select a topic for DISPLAY :
(1) Income (gross)
(2) Labour
To select topic for on map, type its number ;
To return to the master menu, type 97 ;
To return to the second level, type RETURN ;
type : 97

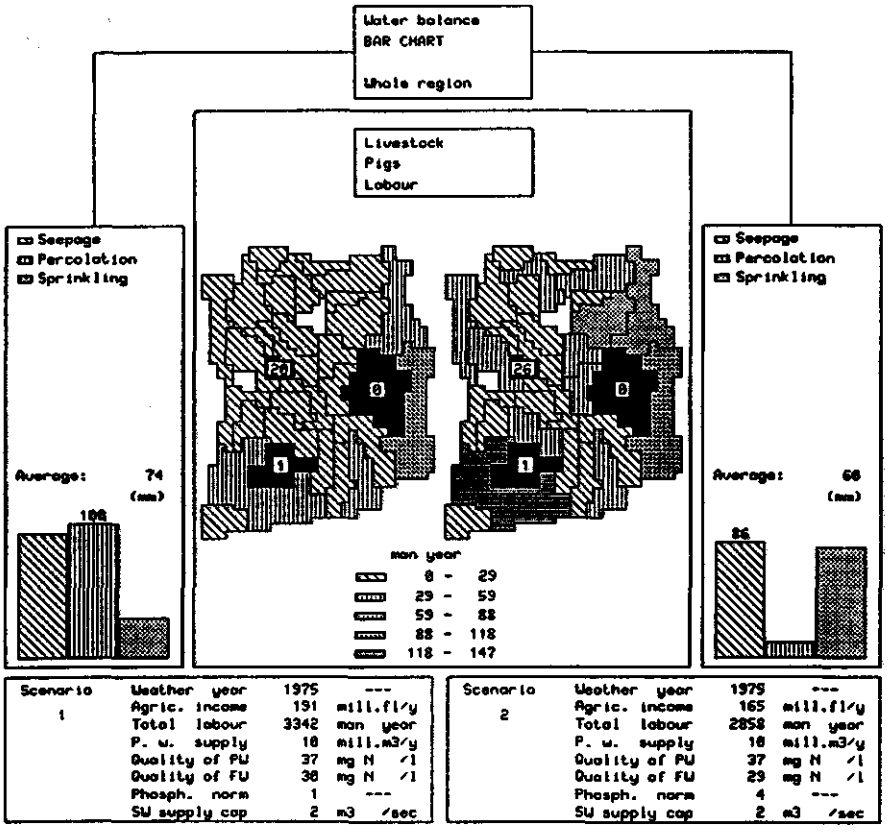

D MASTER MENU LEVEL
Select a topic for DISPLAY :
(1) Livestock
(2) Water balance
To select display of a topic, type its number ;
To move to level of mode control, type RETURN ;
type : 2


D Water balance SECOND MENU LEVEL
Select a topic for DISPLAY :
(1) Seepage
(2) Percolation
(3) Sprinkling
To select display of a topic, type its number ;
To choose display in pie chart, type 95 ;
To choose display in bar chart, type 96 ;
To return to the master menu, type RETURN ;
type : 96


D Water balance BAR CHART ********** FOURTH MENU LEVEL
Select a spatial unit for pie or bar chart:
(1) Subregion 1
(2) Subregion 2
(..) .....
(31) Subregion 31
(32) Whole region
To select a spatial unit for chart, type its number ;
To return to the master menu, type 97 ;
To return to the second level, type RETURN ;
..... type : 32


D Water balance BAR CHART ********** Whole region
Data for LEFT side of monitor, in MM
AVERAGE : 74
(1) 93 - Seepage
(2) 100 - Percolation
(3) 30 - Sprinkling
Press (return) to continue :


D Water balance BAR CHART ********** Whole region
Data for RIGHT side of monitor, in MM
AVERAGE : 60
(1) 86 - Seepage
(2) 12 - Percolation
(3) 82 - Sprinkling
Press (return) to continue :



Scenario				
1	Weather year	1975	---	
	Agric. income	191	mill.fl/y	
	Total labour	3342	man year	
	P. w. supply	18	mill.m3/y	
	Quality of PW	37	mg N	/l
	Quality of FW	38	mg N	/l
	Phosph. norm	1	---	
	SW supply cap	2	m3	/sec

Scenario				
2	Weather year	1975	---	
	Agric. income	165	mill.fl/y	
	Total labour	2858	man year	
	P. w. supply	18	mill.m3/y	
	Quality of PW	37	mg N	/l
	Quality of FW	29	mg N	/l
	Phosph. norm	4	---	
	SW supply cap	2	m3	/sec

4. INPUT FILES

4.1 Introductory text of interactive system

The two-line introductory test that appears on the terminal screen after "implemented for:" should be contained in the two-line file "intro.txt". The records should be filled up with trailing blanks up and till the 80-th position.

File "intro.txt" :

```
                              WATER  MANAGEMENT
                        IN REGIONS WITH CONFLICTING INTERESTS
```

4.2 Indicator texts for display on colour monitor

The first record of the file "indic.txt" should contain the number NI of indicators that the user wants to have displayed along the bottom of the colour monitor. The maximum number that the programme can handle is 8; the number should be in "i2" format. The description of an indicator should be in "a13" format; then should come 8 blanks followed by the unit of the indicator in "a9" format.

File "indic.txt" :

```
 8
Weather  year              ---
Agric. income          mill.fl/y
Total  labour          man  year
P. w.  supply          mill.m3/y
Quality of PW          mg N   /l
Quality of FW          mg N   /l
Phosph.  norm              ---
SW supply cap          m3   /sec
```

4.3 Texts for scenario selection procedure

For the purpose of allowing the user to select a scenario from the list of available ones, there should be an input file containing texts that explain the one-line characterisations of the scenarios. The first three lines should contain the heading of the table that gets shown to the user; the first line of which should contain the short names of the indicators in the following format :

```
"8x,NT(a4,1x),3x,'options', ... "
```

where NT is the total number of indicators, being the sum of NI (that is read from the file "indic.txt") and the maximum number of special areas NN that occur in the scenario data-files data.xx on disk (see

Section 4.5). The dots indicate the filling up with trailing blanks up and till the 80-th position. The second and third record should contain the units of the indicators and a sequence of code letters for the code number that is contained after the indicator values in the second record of a scenario data file on disk. All three records should be filled up with trailing blanks up and till the 80-th position. The 4-th till the 20-th record (max.) can contain help-texts for explaining the short names of the indicators and the code letters at the end of the 3-rd record. All the records should be filled up with trailing blanks up and till the 80-th position.

File "scelst.txt" :

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
        YEAR  INC  LAB QPWS  CPM  CFM PHOS  QSW   W1   W2   W3   options
         -   mill. man mill. mg/  mg/   -   m3/   %    %    %
              fl  year  m3    l    l        sec                   QSXZUE
YEAR    - meteorological year that the scenario generating system was run with
INC     - total yearly income from agriculture in the region
LAB     - total labour requirement in the region
QPWS    - total yearly extraction of groundwater for public water supply
CPM     - highest value of Nitrogen concentrations  in  phreatic aquifer cells
CFM     - highest value of Nitrogen concentrations  in  first    aquifer cells
PHOS    - phosphate norm,according to Ministry of Agriculture planned measures
QSW     - total capacity for supply of surface water to the region
W1-3    - lowering of the GW level at the end of summer, in  nature  areas 1-3
QSXZUE  - code for  option parameters of the  scenario generating system
          > Q = 0 for FIXED p.w.s extractions       > Q = 1 for OPTIMAL ones
          > S = 0 for FIXED sprinkling capacities   > S = 1 for OPTIMAL ones
          > X = 0 for FIXED landuse technologies    > X = 1 for OPTIMAL ones
          > Z = 0 for FIXED non-landuse techs       > Z = 1 for OPTIMAL ones
          > U = 0 for ALLOWED winter slurry appl.   > U = 1 for PROHIBITION
          > E = 0 for NO limitation on slurry export > E = 1 for export <emax
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

4.4 Menu hierarchy

The file "menuf.txt" should contain the full menu-texts; the file "menua.txt" the abbreviated ones. In a file with menu-texts, the integer numbers (that should be in "i3" format) indicate the number of elements that a certain menu-level contains. The text that directly follows such a number is a form of comment -- this text does not get read by the programme. The format of the full menu-texts should be "a70" (meaning that trailing blanks should be included up and till the 70-th character position); the format of the abbreviated menu texts should be "a16" (including trailing blanks). The example given below corresponds to the menu-hierarchy given in Fig. 6 (Section 2).

File "menuf.txt" :

```
  2  Master menu
Livestock technologies
Water balance
  2  1. Livestock
Pigs
Chicks
  2  third-level elements
Income (gross)
Labour
  3  2. Water balance terms
Seepage
Percolation
Sprinkling
  0  third-level elements
 31  subregions
```

File "menua.txt" :

```
  2  Master menu
Livestock
Water balance
  2  1. Livestock
Pigs
Chicks
  2  third-level elements
Income (gross)
Labour
  3  2. Water balance
Seepage
Percolation
Sprinkling
  0  third-level elements
 31  subregions
```

The maximum number of menu-elements that the programme can handle at the master menu level is 12. At the second and third menu-level the maximum is 32. However, if there are more than 12 the programme assumes that they are numbered according to some logical sequence (like "time = January 1", "time = January 2", etc till "time = January 31") so that it is not necessary for them all to appear on the screen for the user to be able to make his choice: the system gives the first two and the last two menu-elements, with '....' in between. The maximum number of subregions that the programme can handle is also 32.

4.5 Scenario data

Files with scenario data should be in a numbered sequence "data.01, data.02, data.03 etc ". The programme does not have to be told how

many files there are : it finds that out itself during runtime. The data files have to have fixed-length records of 80 characters, because they have to be suitable for "direct-access" read operations. The correct fixed length can be ensured by writing the data to a file that gets opened in the data-generating programme by means of (for VAX/VMS systems)

```
 OPEN(UNIT=10,FILE='DATA.01',STATUS='NEW',
$ RECORD SIZE=80,CARRIAGECONTROL='LIST',BLOCKSIZE=80,
$ FORM='FORMATTED',RECORDTYPE='FIXED')
```

The first record of a file with scenario data should indicate the subregions that have been designated as "special" (e.g. as a nature area) and that should not be coloured according to a certain scale, but should always remain dark blue and have a "indicator" number plotted in it. The first number in the record should be the total number of subregions that are nature areas, followed by the index numbers of the subregions themselves. These data should be in "i5" format; the programme can handle a maximum of 5 special areas.

The second record should contain the values of the "indicators" that characterise a scenario. First should come the NI values corresponding to the texts in the input file "indic.txt"; then should come the NN values for plotting in the subregions on the maps; these latter values should not be higher than 99 .

All the data corresponding to the menu hierarchy should be in "16i5" format . The way that the data should be contained in the file is simply according to a strict left-to-right order along the bottom of the menu-hierarchy as drawn in Fig. 6 of Section 2. Since all the data have to be in "i5" format, the implementator of the system should judiciously choose the units, in order to make the best use of the available "span" 0 - 99999 . An example of a data file (corresponding to the menu-hierarchy given in Fig. 6) is given below.

File "data:xx" :

```
    3   10   16   27
 1975  165 2858   10   37   29    4    2   26    1    0   011111
    0    6    8    4   16   10   20    6    7    0   11    4    7    5    6    0
    6   88   26    0   22    4   37   53   22   19    0  155    4   44   48
    0    1    1    0    2    1    2    1    1    0    1    0    1    1    1    0
    1    9    3    0    2    0    4    6    2    2    0   17    0    5    5
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0
    0    2    2    1    4    3    6    2    2    0    3    1    2    1    2    0
    2   24    7    0    6    1   10   15    6    5    0   43    1   12   13
    0    4    5    2   10    6   13    4    5    0    7    2    5    3    4    0
    4   55   17    0   14    2   23   33   14   12    0   98    2   28   30
    0    1    1    0    2    1    2    1    1    0    1    0    1    1    1    0
    1    9    3    0    2    0    4    6    2    2    0   16    0    5    5
    0    6    8    4   16   10   20    6    7    0   11    4    7    5    6    0
    6   88   26    0   22    4   37   53   22   19    0  155    4   44   48
```

4.6 Areas of land for computing "relative data"

The implementator can supply a file "areas.dat" with the areas of the subregions, or of certain parts of the subregions (e.g. the parts that are in use by agriculture). These areas are then used for computing so-called relative data from the the absolute ones : the relative data are obtained by dividing the absolute data through the areas (and multiplying by a factor -- see Section 4.7) This feature is, however, optional; by simply not having a file "areas.dat" available, the programme knows that the mentioned feature is not desired.

The first record of the file should contain a 4-character abbreviation of the type of areas in the file; e.g. "agr." for agricultural areas, "tot." for total areas. Then should come the areas (which are assumed to be in "ha") in f7.0 format.

File "areas.dat" (optional) :

```
~~~~~~~
agr.
   232.
   905.
   574.
   449.
   521.
etc.
etc.
~~~~~~~
```

4.7 Units of data

Per group of N data along the bottom of the hierarchy, where N is the number of subregions (see Fig. 6 in Section 2) there should be a record for the unit. This unit should be in "a19" format, followed by a vertical slash and then an integer parameter with the value "0" or "1" : the value "0" indicates that that when the programme performs operations of aggregating the data, it should "totalize"; the value "1" indicates it should "average". In the example given below the unit "mm" is followed by "1" because it has no sense to add the mm's of all the subregions : all the "mm"'s pertain to different areas, so it has no sense to simply totalize them; on the other hand the averaging (can) have sense. The file given below is for the example used throughout this documentation.

File "unit.txt"

```
~~~~~~~~~~~~~~~~~~~~~
0.1 million fl      |0
man year            |0
0.1 million fl      |0
man year            |0
mm                  |1
```

```
mm                    |1
mm                    |1
----------------------
```

If the implementator wants to makes use of the option of computing "relative data" from "absolute data", there should be a file "unitha.txt" containing the units of the "relative data" that are obtained from the "absolute data" by dividing through the area of a subregion. The format of the unit should be "a16". In the 17-th position of a record there should be a vertical slash followed by an integer in "i1" format. This latter integer serves as a power of ten in the conversion operation from absolute to relative data. The conversion gets done with :

[relative value] = 10**power * [abolute value]/[area of a subregion]

By including this feature in the programme it is possible for the implementator to ensure that data can still be handled in a meaningful way as rounded numbers in the graphical routines of the programme : there is loss of information if all the data are converted to small numerical values. The power input value should be chosen in such a manner that the converted data remain in the interval 0-99999.

File "unitha.txt" :

```
----------------------
fl/ha                 |5
0.01 man year/ha      |2
fl/ha                 |5
0.01 man year/ha      |2
mm                    |0
mm                    |0
mm                    |0
----------------------
```

4.8 Input data for map of subregions

The coordinates that define the map should be in such a form that the x-coordinates are in the interval 0.00-260.00 and the y-coordinates in the interval 130.00-500.00. The first record of the file with the data that specify the map should contain the number of subregions in the format "i5". Then come the x-coordinates of the so-called internal points of the subregions. These internal points only play a role for those subregions that have been designated as "special": the coordinates determine the postioning of the indicator value in the subregion. The format of data should be 10f5.0; the x-coorinates should be followed by the corresponding y-coordinates; the y-coordinates should start on a new record.

The data defining the boundary of a subregion should be preceded by a record containing the number of the subregion followed by the number of points that define the boundary. The format should be "2i5". The number of points defining a boundary should not exceed 50; boundaries

of subregions should not overlap and preferably the boundaries of neighbouring subregions should coincide exactly, since this gives the neatest graphics. For each subregion the x-coordinates should be given in 10f8.2 format; the y-coordinates should start on a new record.

File "map.dat"

```
------------------------------------------------------------------------------
   31
  86.  68.  20.  50.  95.  86. 110.  55.  32.  78.
  97.  81.  32.  50.  77.  79. 135.  32.  14. 108.
 167. 149. 158. 208. 140. 135. 186. 230. 152. 152.
 167.
 469. 449. 430. 451. 442. 397. 330. 377. 379. 327.
 313. 298. 307. 293. 284. 213. 253. 230. 167. 469.
 460. 423. 402. 475. 370. 320. 304. 361. 239. 275.
 259.
    1    9
   52.36   95.69   95.69   86.67   86.67   60.49   60.49   52.36   52.36
  479.38  479.38  461.32  461.32  452.29  452.29  461.32  461.32  479.38
    2   21
   60.49   86.67   86.67   95.69   95.69  104.72  104.72  112.85  112.85  121.88
  121.88  130.90  130.90  121.88  121.88  103.82  103.82   78.54   78.54   60.49
   60.49
  452.29  452.29  461.32  461.32  472.15  472.15  462.22  462.22  445.07  445.07
  427.01  427.01  410.76  410.76  400.83  400.83  444.17  444.17  435.14  435.14
  452.29

and so on
```

5. COMMENTS ON SOFTWARE

The programme is written in FORTRAN 77. The source code (excluding the library of graphics primitives) consists of ~3000 lines including those for comments and layout spacing. Implementation is on a DEC MicroVAX under VMS with a CIT-220+ terminal; the colour monitor is a TEKTRONIX 4111. The source code is contained in four files :

- common.for : declarations of variables and common blocks;
- ansi.dat : ansi character control sequences as definitions of symbols;
- port.dat : control sequences for turning "on" and "off" of the auxiliary port of the terminal;
- part0.for : main programme;
- part1.for : non-graphical subroutines;
- part2.for : graphical subroutines, excluding TEKTRONIX TCS-library;
- tcslib.for : TEKTRONIX TCS-library of graphics primitives.

5.1 Use of non-standard FORTRAN

The use of non-standard FORTRAN has been avoided as much as possible. However, because it is such a handy feature when constructing a modular programme, the "include" statement has been used for inserting at compile time the files "common.for","ansi.dat" and "port.dat" (which are explained below). If the system is to be run with a compiler that does not have the "include" feature, the use of it can be replaced by inserting the mentioned files with the help of the editor before any compiling is done.

5.2 I/O control

The programme makes use of VT100-compatible control characters; a number of "character constants" are defined in the file "ansi.dat"

File "ansi.dat"

```
        character*2 ESC
        character*4 RESET,BOLD,BLINK,REVERS

        parameter ( ESC    = char(27)//'['   )
        parameter ( RESET  = char(27)//'[0m' )
        parameter ( BOLD   = char(27)//'[1m' )
        parameter ( BLINK  = char(27)//'[5m' )
        parameter ( REVERS = char(27)//'[7m' )
```

By defining these constants it is possible to use neat and self-explaining symbols in the programme, so as to avoid the littering of the code with escape sequences. By turning the auxiliary port "on" and "off" the programme alternately sends data to the terminal screen or to the colour monitor. The sequences of control characters that are required for doing this are terminal-specific. The one for the CIT-220+ are contained in the file "port.dat":

```
DATA CLEAR_PORT/'  [5z'/,PORT_ON/'  1'/,PORT_OFF/'  2'/
CLEAR_PORT(2:2) - CHAR(27)
PORT_ON(2:2)    - CHAR(27)
PORT_OFF(2:2)   - CHAR(27)
```

FORTRAN compilers are notoriously diverse with respect to their I/O control. For running with another compiler the implementator will probably have to make changes in the OPEN-statements and possibly in the statements for output to the terminal.

In VAX/VMS FORTRAN 77 the default unit number for the terminal as input device is 5, for the terminal as output device it is 6. If this is different for the compiler with which the system is to be implemented, the values of "iin" and "iout" as specified in statements at the beginning of the main programme, will have to modified. In the programme, ample use is made of control characters for the output to the terminal. In VAX/VMS FORTRAN the default maximum amount of characters that can be outputted per "line" to the terminal is 132; if this default setting is left as it is, the programme crashes due to "record overflow"; therefore it gets reset to 200 by the statement "OPEN(UNIT=6,RECL=200,STATUS='NEW')". On other compilers this may not work and something else may have to be thought of.

In the statements for output to the terminal, the first position is either a blank or a '+'. The programme expects the blank to achieve that it causes the cursor to jump to a new line. The only thing that the programme expects the '+' to achieve is that there does not occur a jump to the next line of the terminal for the output that directly follows it. In the programme it is always preceded by a cursor-control command that puts the cursor in the first character position - so the '+' should simply leave it there instead of going to the next line; for cursor positioning within a line use is made of intermediate variables for buffering the whole contents of a line before sending it to the terminal.

5.3 Subroutines

The subroutines contained in the file partl.for are :

- cmove : positions cursor on terminal screen;
- data : reads data from the relevant scenario file(s), displays raw data in the form of monochrome bar chart on the terminal, does the preparatory work for the plotting subroutines;
- readi : reads the "indicator" values from the second record of a scenario file;
- readm : reads the menu-texts, units of data, areas of subregions;
- sclear : cleans part of the terminal screen;
- select : allows the user to select a scenario from the files available on disk;
- typert : interrupts output to the terminal in a graceful manner.

The file part2.for contains the graphical subroutines, excluding the TEKTRONIX TCS library :

- plota : initiates the making of a hardcopy of the image on the colour monitor;

- plotb : draws a bar chart (gets called by plotc);
- plotc : draws the scale below the map, colours the subregions on the map (except the "special" areas), draws the colour descriptors of the charts, calls the specific chart subroutines (plotb or plotp);
- plotf : draws a rectangle filled with a colour;
- ploth : plots the heading-texts (plus lines) above maps and charts;
- plotn : colours the "special" subregions; plots indicator values in their centre;
- plotp : draws a pie-chart (gets called by plotc);
- plotr : draws a rectangle;
- plots : initializes the colour monitor, reads coordinates of map of subregions;
- plott : does the output of texts to the colour monitor (gets called by diverse subroutines).

5.4 TEKTRONIX library of graphics primitives

The TEKTRONIX TCS library contains a number of subroutines for graphics primitives. In the source code of subroutines contained in the file part2.for, the names of TEKTRONIX subroutines are written with spaces between each of the characters -- this makes these subroutines easily recognisable. If the system is to be implemented with another graphics libray, it is usually easier to redefine the names of the TEKTRONIX subroutines than to insert other names throughout the coding. This may still take some doing, however, because different graphical systems "work" differently in certain respects -- but with a bit of imagination it is often possible to construct an equivalent subroutine using one or more subroutines from the library that is available.

The TEKTRONIX TCS subroutines that get used are :

- hdcopy : initiates the making of a hardcopy by the copier attached to the colour monitor;
- linclr(n) : sets the colour of lines that are drawn; n is a number of a colour in the colour lookup table (that has to be set by some means, e.g. by running a special programme before running the system);
- movea(x,y) : moves the cursor to position with coordinates (x,y), where x and y are reals;
- drawa(x,y) : draws a line from the current cursor position to (x,y);
- home : moves the cursor to its home position, on the TEKTRONIX this is the top-lefthand corner;
- anmode : sets the TEKTRONIX to alphanumerical mode; it also flushes the buffer containing graphical instructions - for this latter purpose anmode is used most; resetting to graphical mode is not required for the TEKTRONIX;
- panclr(n) : sets the colour for the colouring of closed polygons ("panels") that are subsequently drawn;
- vbgpnl(x,y,i): initiates the drawing of a "panel", with the first corner of the polygon at the point (x,y); i=1 means "draw border", i=0 means "do not draw border" The call

of vbgpnl should be followed by a number of "movea(x,y)" calls that define the rest of the polygon (ending in the starting point);

- endpnl : indicates that the drawing of a panel has been terminated;
- erase : cleans the colour monitor;
- tminit(i) : initalizes the TEKTRONIX;
- initt(i) : sets the BAUD rate of the TEKTRONIX;
- twindo(x1,y1, x2,y2) : defines the screen window within which the graphics should be drawn on the monitor;
- dwindo(x1,y1, x2,y2) : defines the coordinate system that the programme uses for addressing points within the screen window;
- chrclr(n) : sets the colour of the characters that are sent to the monitor in alphanumerical mode;
- chrsiz(n) : sets the size of the characters that are outputted to the colour moniotr (n=2 for all of the calls in the programme).

5.5 Definition of colours

The numbers of the colours to be used for the scale on the map and for the charts should be contained in the file "colour.dat". These numbers pertain to the colour look-up table of the colour monitor. This table is "entered" into the machine by running the programme "pat", which reads colours from the file "pat4111.hex"

File "colour.dat"

```
  71
  74
  -7
  -6
 -12
  80
  62
 130
 118
  91
 140
 152
```