A METHOD OF REDUCING THE NUMBER OF PARAMETERS USED IN ENVIRONMENTAL RESEARCH

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The modelling of ecological changes taking place in geographical environment, the Enviromental Impact Assessment, the qualification of the resources and properties of physical or economical environment requires the processing of a big amount of data. I believe, that these research projects can considerably support the decisions concerning the intensifying of economy, the halting of the environment's fallback or the improval of its conditions. At the same time it is clear that these decisions can not wait for the results of dragging research, so it is essential to produce fast available and exact results.

Recently we find several mathematical-statistical solutions, mainly in the field of integrated environment qualification and EIA, and more methods are supported by computers. These methods, often requiring a lot of work, have significantly modernized the method of the environment evaluation and examination of the impacts, increased its objectivity but in their method of examination and the essence of their logic they are based on the previously elaborated qualitative, verbal principles, i.e. they convert these into the language ot mathematics. It must be noted that examinations neither made with the mathematical methods used until now, nor made with the traditional statical cartographical procedures, do not reflect the structure of the environment in its complexity. We still lack those generally applicable methods that serve to show the processes and the complex interrelationships of environment, and to measure their extent.

The groups of methods developed and suggested by us takes its origin in the idea of environment as a system, and put the stress on the analyses of the environment's internal structure.

The investigation set a triple goal:

- to find the minimal system of parameters with the help of which the system to be modelled can be described with a big probability
- to find those key parameters, the change of wich we must observe (monitoring system), i.e. which are wort examining more detailed — this can reduce and speed up the examination considerably
- to find those parameters, with the help of which we may try to direct the system

The basic idea of the method consists of determining the correlation connections between the parameters, and to select those *key parameters*[1], with the help of which the system as a whole can be properly described.

Knowing the sturcture of the connections between the system factors depending of each other, we may determine certain parameters with the help of other parameters. In extreme cases a parameter may be relatively independent of the others, but in the case this will be a key parameter.

The key parameters do not necessarily mean those parameters, that are primary in forming the type of a landscape. Depending of the aim and character of the studies, the key parameters and the relations may slightly change[2]. Attention must be payed to the fact that in environmental research the reduction of used parameters is not allowed, because this may lead to the loss of important factors (e.g. by feasibility studies, or environmental qualification a parameter value excluding production may have a major importance).

The study was made on the example of the Szendrői-basin in the Bódva Valley (North-Hungarian Mountains), on a chosen area of 55 square kilometres. The sample data were gathered or calculated on the basis of a square grid with 1 cm squares put on an 1:25 000 scale map. The used parameters and the way they were calculated is shown in Table I.

Table I.
Parameters

1. Average altitude	12. Soil type
2. Relative relief	13. Mechanical soil composition
3. Drainage density	14. The estimated value of soil erosion
4. Average slope	15. Soil forming rock
5. Maximum slope	16. Soil pH
6. Slope direction	17. Litology
7. Absolute surface *	18. Vegetation type
8. Temporarily water covered surface %	19. Estimated biomass production
9. Potential solar radiation E IV–X.**	2O. Soil water depth
10. Heat total ***	21. River water yield
11. Moisture E III–IX.	22. Soil water, layer water yield

* The percental growth of the real surface compared to the projection
** Percental variation of the average sunshine term as a function of slope and exposure
*** Orographically corrigated

[1] By key parameter we mean the elements of that minimal set of parameters, which describe the other parameters with a good approximation.

[2] We may assume, that the change here is a continous one, i. e. in similar studies and areas, that are closed to each other, the relations and the key parameters may be regarded indentifical.

In a square of 250x250 m (with 6,25 ha area) the average value of 22 parameters was determined, which were supplied with 5 „identifier" per square. Thus the sample density was about 500 sample/km^2, and reached the desirable amount put down in the literature on the subject. During the calculations the data were used directly, and were not put into categories. The qualitative parameters were assigned to formal numerical values. A more complete composition of the sample data, or the selection of parameters (e.g. about climatic and hydrological data). The method, in the frames of the criteria function, or when comparing the function, takes into consideration those factors, which may specially hinder or exclude the usage of the method.

The method

As the first phase of the qualification, we suggest two methods[3] for the study of the physical environment's structure, and we give another procedure to develop or increase the efficiency of those two methods. The logical process and the used apparatus during the two methods to be described here after are the same, the difference is in their starting point. The first method is very precise, but very difficult to handle, and needs computer support from the very beginning. The second method at the same time has weaker criteria as starting point, is easier to operate, is still effective and fast.

The 1[st] *method* has two steps. First we must examine for each parameter, which other parameters they *essentially* depend of: i.e. let p_i the i-th parameter, based on the previously said we assume, that

$$p_i = f(p_1, \ldots, p_{i-1}, p_{i+1}, \ldots, p_n)$$

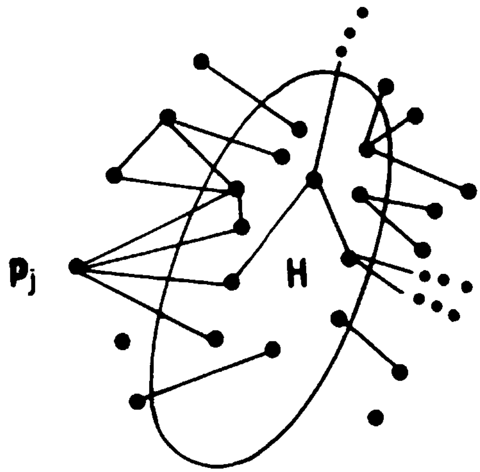
In practice there may occur certain p_j parameters, which p_i do not essentially depends of. More exactly, when the p_j parameters remain unchanged, the value of p_i does not change substantially. Neglecting these p_j parameters, we may say of the rest that p_i is a function of them (determined of them with a good approximation). Thus we can select to any parameter those parameters, which determine it with a good approximation. Let's represent the acquired results in a graph.

Let the parameters be the vertice of the graph, and the p_i vertex (parameter) is connected with the p_j with an edge, if p_i is essentially depending of p_j. Let's find the following H set of vertice in the graph thus constructed.

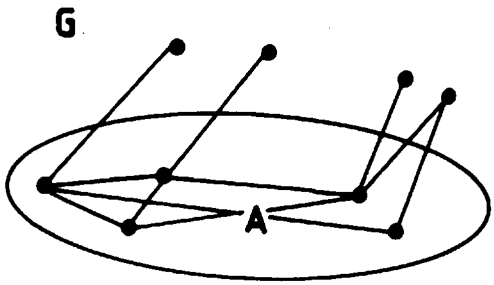
First assumption: Let $|H|$ ($|E|$ is the cardinality of the set E) minimal. That is, there should be as few as possible parameters in this group.

Second assumption: Let H be so, that to arbitrary p_j parameter either $p_j \in H$, or the parameters essentially determining p_j are in the set H.

[3]The programs were run on the József Attila University's R 55 computer.



In a mathematical way and language the determination of the set H is the following:



I. definition: *Minimal matching vertex system* is the vertex set A with minimal cardinality, which has following property: to arbitrary *e* edge there exists an $a \in A$, so that *a* is one of the endpoints of the edge *e*.

It is obvious, that for any p_j parameter is a vertex in the set A, or all parameters essentially determining p_j are in the set A. Refessing to earlier statements we note, that our goal is to find the set A in the graph described above.

II.definition: The set |B| is a maximal independent set of vertice (in some references maximal point set of inner stability), if |B| is maximal, and there are no two vertice in B, which have an edge between them.

We need this B — as it is seen from the followingstatement — because of practical reasons, namely to be able to determine set A, i.e. the minimal matching vertex system.

Statement: Taking the maximalset of independent vertice in a graph, the points outside this set form a minimal matching vertex set.

Proof: i) This set A' (the points in the graphoutside set B) is a matching point system. Indeed, to arbitrary *e* edge there exist a point $a \in$ A', that is an endpoint of *e*, as there are no edges inside the point set B.

ii) If there were a point set, which were smaller (with a smaller cardinality) then A', then B — i.e. the maximal independent point set — could be increased, and that would lead to contradiction.

Thus we have proved the statement. So the work is to find the maximal independent point set in agiven graph (2nd step). To find the maximal independent vertex set in a given graph we used an about 150 steps long Pascal programme based on the algorithm of A. Bednarek and O. Taulbee (1966) — see Appendix.

In the *2nd method* the construction of the graph is based on the examination of the parameter pairs. In this way the description and construction of the graphs is simpler, and does not require computer work. (We may still expect from this method, that the number of key parameters should be small.)

The basic idea in the method is to determine the graph based on the strength and weight of the relation between the individual parameter pairs. Let's put down an α (preferably bigger than 50 %) connexion factor, relating with the percental strength (which may be changed as desired) of the connexion. If we set the connexion factor between p_i and p_j, the occurence of p_i in A indicates that the value of p_j can be determined with a probalility of at least 0.50.

In the case of parameters we must examine $\binom{k}{2} = \frac{k^2 - k}{2}$ connexions before drawing the edges. Also here the vertice are parameters, and they are connected with an edge if the relation between them proves to be enough strong. The method continous with the algorithm described in the previous method, that is we look for the minimal matching point set.

The drawing of this graph is much simpler, and we need the computer only to find the maximal independent point set. With the help of this we can determine the minimal matching point system, which determines a key parameter set though more weakly, but still acceptably treatable for us.

Third method. If we want to reduce the cardinality of the key parameter set even more, the following is a possible method. Let's consider the set obtained with the first or the second method (depending of the accuracy), and let's take the set called A in the first and second chapter. Repeating the procedure used in point 1. on the graph of set A we obtain a substantially more restricted point set C, having the following properties:

i) $A \in C$
ii) all essential key parameters of A are in C
iii) all essential key parameters of the essential key parameters of A (except a) are in C.

The main advantage of this supplementary method is that the cardinality of C is very little, but because of the large reduction of parameters it must always be examined, that how exactly is the system described with this.

Results

Based on the experiences until now, we suggest the second method for practical application, but if time and computer capacity make it possible, it is adviseable to use the first more exact and correct method. Based on the second method we calculated the minimal matching point systems of a graph (the key parameters) constructed of the stronger correlation connexious between the ecological parameters. As a result we obtained 21 sets with 13 elements (key parameters). The cardinality of these were reduced individually again based on the third method.

The „key parameter groups" thus found and containing only 6–7 elements can be included in four groups shown in Table 2. Of this can be seen, that the description of the whole system as a function can be done with several key parameter groups. Some of these groups emphasize the relief, some the soil factors.

Table 2.
Key parametergroups

1. group
- Absolute altitude
- drainage density
- slope direction
- moisture supply
- soil type
- soil forming rock
- rivers average water yield

2. group
- Absolute altitude
- relative relief
- slope direction
- potential solar radiation
- soil type
- soil forming rock

3. group
- Absolute altitude
- slope direction
- moisture supply
- soil type
- litology
- vegetation type

4. group
- Absolute altitude
- drainage density
- moisture supply
- soil type
- soil forming rock

Summary

The advantage and significance of the method, and the new in it is as I see it, that it has been succesfully proved that knowing the connection system it is enough intensively to study the key parameters. Using this, we may even undertake formulate short-term environmental prognoses. The environment analysis can be based on the comparison between the functions generated by the parameters and described by the criteria. Of this follows, that the qualifications with a different viewpoint can be made similarly, the changing of the method is not necessary.

Another great advantages of the methods are that they can be developed to several directions, they are open, and can be used not only for ecological parameters, but for the parameters of social and economical factors of environment as well.

References

BEDNNAREK A. — TAULBEE, O. (1966): On maximal chains Rev. Romm. de Mat. Vol. 11. 1. pp. 23–25.
CHORLEY, R. J. — KENNEDY, B. A. (1971): Physical Geography. A system Approach, London, p. 272.
MEZŐSI, G. (1984): The construction of environmental models based on structural studies. XXV.IGU Congress, Paris, 1984, Abstracts I. pp. 127–130.
RICHLING, A. (1984): Geocomplexes as the basic fields of practically oriented assessment of natural conditions IALE Proceedings 1984, Roskilde, III. pp. 17–26.

APPENDIX

```
PROGRAM MAXI (INPUT,OUTPUT);
    CONST SZPONTSZ=22;

    TYPE GR=@SZHOZ;
        SZHOZ=RECORD MIK:INTEGER;
            TOV :GR
        END;
        GRAFT=@SZOGP;
        SZOGP=RECORD PONT:INTEGER;
            MUTAT:GRAFT;
            ELEK: GR
        END;
        MSTH=@XK;
        XK=RECORD GO:MSTH;
            HAL:SET OF 1..SZPONTSZ
        END;

VAR EM,Y:SET OF 1..SZPONTSZ;
    I,J, COUNT, KPEGY,FOKROSZ,KAA:INTEGER;
    IDEI,KUPAFO,ELKA,ELKAFO,IKAFO:MSTH;

    GRAF, GRAFFEJ:GRAFT;
    KISSEG:GR;SEG:GRAFT;
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```
PROCEDURE GRAFKREAL (PONTSZ:INTEGER);
    VAR SZP,DB:INTEGER;
        HOZZA:GR;
    BEGIN NEW (GRAF);
        GRAFFEJ: = GRAF;
        SEG: = GRAF;
        FOR I: = 1 TO PONTSZ DO
            BEGIN READ (SZP);
                GRAF@,PONT: = SZP;
                NEW (GRAF@, ELEK);
                HOZZA: = GRAF@,ELEK;
                READ (DB);
                FOR J: = 1 TO DB DO
                    BEGIN READ (SZP);
                        HOZZA@, MIK: = SZP;
                        NEW (HOZZA@, TOV);
                        HOZZA: = HOZZA@,TOV;
                    END;
                READLN;
                HOZZA@,TOV: = NIL;
                NEW(GRAF@,MUTAT);
            END;
        GRAF@,MUTAT: = NIL;
        GRAF@,ELEK: = NIL;
    END;

PROCEDURE IPSZILON(VAR KA:INTEGER);
    VAR VONZA:GR;
    BEGIN Y: = (...);
        IF KA<>1 THEN BEGIN
            FOR I: = 1 TO KA DO
            Y: = Y + (.I.);
            GRAF: = GRAFFEJ;
            WHILE (GRAF@,PONT<>KA) DO GRAF: = GRAF@,MUTAT;
            VONZA: = GRAF@,ELEK;
            WHILE (VONZA@,MIK<KA) DO BEGIN
                IF (VONZA@, MIK IN Y)THEN BEGIN
                    Y: = Y = (.VONZA@,MIK,)                END;
                VONZA@,TOV;
            END;
        END;
    END;

PROCEDURE IIII(VAR IFO:MSTH);
    VAR IK,FIRST:MSTH;
    BEGIN IK: = IFO;
        ELKA: = ELKAFO;
        KPEGY: = KAA + 1;
        IPSZILON(KPEGY);
        REPEAT EM: = ELKA@,HAL;
            IF IK<>NIL THEN BEGIN IK@,HAL: = EM*Y,
                FIRST: = IK END
            ELSE BEGIN
```

```
            NEW(FIRST@,GO);
            IK:=FIRST@,GO;
            FIRST:=FIRST@,GO;
            IK@,HAL:=EM*Y;
            IK@,GO:=NIL;
         END;

         IF ELKA@,GO=NILTHEN IK@,GO:=NIL
         ELSE IK:=IK@,GO;
         ELKA:=ELKA@,GO
      UNTIL (ELKA=NIL);
   END;

PROCEDURE ELEL (VVAR ELFO,UFO:MSTH);
   VAR IKA,ELK,ELKAPU,FIR:MSTH;
      MEGVAN:BOOLEAN;
   BEGIN ELK:=ELFO;
      MEGVAN:=FALSE;
      KPEGY:=KAA+1;
      IPSZILON(KPEGY);
      ELKAPU:=UFO;
      REPEAT EM:=ELK@,HAL;
         IF ((EM<=Y) AND (EM<>Y)) THEN
            BEGIN IF ELKAPU<>NIL THEN
               BEGIN ELKAPU@,HAL:=EM+(.KPEGY.);
                  FIR:=ELKAPU END
               ELSE
                  BEGIN NEW(FIR@,GO);
                     ELKAPU:=FIR@,GO;
                     FIR:=FIR@,GO;
                     ELKAPU@,HAL:=EM+(.KPEGY.);
                     ELKAPU@,GO:=NIL;
                  END;
            IF ELK@,GO=NIL THEN ELKAPU@,GO:=NIL
            ELSE ELKAPU:=ELKAPU@,GO;
         END
         ELSE BEGIN IF ELKAPU<>NIL THEN
            BEGIN ELKAPU@, HAL:=EM;
               FIR:=ELKAPU
            END
            ELSE BEGIN NEW(FIR@,GO); ELKAPU:=FIR@,GO;
               FIR:=FIR@,GO;
               ELKAPU@,HAL:=EM;
               ELKAPU@.GO:=NIL;
            END;
            IF ELK@,GO=NIL THEN ELKAPU@,GO:=NIL
            ELSE ELKAPU:=ELKAPU@,GO;
            IKA:=IKAFO;
            WHILE (IKA<>NIL) AND (MEGVAN<>TRUE) DO
               BEGIN IF IKA@,HAL=EM*Y THEN
                  BEGIN IF ELKAPU<>NIL THEN
                     BEGIN NEW (FIR@,GO), ELKAPU:=FIR@,GO,
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                        ELKAPU@,HAL:=(EM*Y)+(KPEGY.);
                        MEGVAN:=TRUE;FIR:=ELKAPU END
                    ELSE
                      BEGIN
                        NEW(FIR@,GO), ELKAPU:FIR@,GO;
                        FIR:=FIR@,GO;
                        ELKAPU@,HAL:=(EM*Y)+(K.PEGY.);
                        ELKAPU@,GO:=NIL; MEGVAN:=TRUE;
                      END;
                    IF ELK@,GO=NIL THEN ELKAPU@,GO:=NIL
                    ELSE ELKAPU:=ELKAPU@,GO
                END
              ELSE IKA:=IKA@,GO
          END
      END;
      ELK:=ELK@,GO; MEGVAN:=FALSE
    UNTIL (ELK=NIL);
  END;

PROCEDURE MAXAM(VAR LISTAFO:MSTH);
  VAR KONK,LIS,ELSO:MSTH;
    HELEM:SET OF 1 ..SZPONTSZ;
  BEGIN KONK:=LISTAFO;
    LIS:=KONK@,GO;
    IF LIS<>NIL THEN
      BEGIN ELSO:=NIL;
        HELEM:=KONK@,HAL;
        WHILE KONK<>NIL DO
          BEGIN IF LIS=ELSO THEN BEGIN IF LIS<>NIL THEN
                LIS:=ELSO@,GO; END;
            IF LIS<>NIL THEN
                BEGIN IF HELEM<=LIS@,HAL THEN
                    BEGIN KONK@,HAL:=(. .);
                        KONK:=KONK@,GO;
                        ELSO:=KONK;
                        LIS:=LISTAFO;
                        IF KONK<>NIL THEN
                            HELEM:=KONK@,HAL;
                    END
                    ELSE LIS:=LIS@,GO;
                END
                ELSE BEGIN KONK:=KONK@,GO;
                    ELSO:=KONK;
                    IF KONK<>NIL THEN
                        HELEM:=KONK@,HAL;
                    LIS:=LISTAFO;
                END
          END
      END;
  END;
```

```
PROCEDURE KIIRO(VAR HAMON:MSTH);
    VAR KROSZ:INTEGER;URES: B BOLEAN;KAMON:MSTH;
    BEGIN KROSZ:=O; URES:=FALSE; KAMON:=HAMON;
        WHILE (KAMON<>NIL) DO
            BEGIN IF KAMON@,HAL=(. .) THEN
                BEGIN KAMON:=KAMON@,GO,
                        URES:=TRUE;
                END
                ELSE
                    FOR I.=1 TOSZPONTSZ DO
                        IF (I IN KAMON@,HAL) THEN
                            BEGIN WRITE (I:3);
                                KROSZ:=KROSZ+1;
                            END;
                WRITELN;
                IF URES<>TRUE THEN KAMON:=KAMON@,GO;
                URES:=FALSE;
                IF FOKROSZ<=KROSZ THEN FOKROSZ:=KROSZ;
                KROSZ:=O;
            END;
    END;


BEGIN WRITELN(' A GRAF-LISTA KOVETKEZIK:');
    WRITE( ' A NYIL UTÁN EGY ADOTT SZOGPONTHOZ TARTOZO');
    WRITE(' SZOGPONTOK VANNAK FELSOROLVA,');
    WRITELN(' VAGYIS AMELYEKBE AZ ADOTTBÓL MEGY EL');
    GRAFKREAL(SZPONTSZ);
    WHILE SEG@,MUTAT<>NIL DO
        BEGIN WRITE (SEG@,PONT:3,'- →'),KISSEG:=SEG@,ELEK;
            WHILE (KISSEG@,TOV<>NIL) DO
                BEGIN WRITE (KISSEG@,MIK:2,' ');
                    KISSEG:=KISSEG@,TOV;
                END;
            WRITE(' ');
            WRITELN;
            SEG:=SEG@,MUTAT;
        END;
    WRITELN;
    FOKROSZ:=O;
    KAA:=1;
    NEW(IKAFO); IKAFO@,GO:=NIL;
    NEW (KUPAFO),KUPAFO@,GO=NIL;
    Y:=(.1);
    NEW (ELKA);
    ELKAFO:=ELKA;
    ELKA@,HAL:=(.1);
    ELKA@,GO:=NIL;
    WRITELN(' A MAXIMALIS BELSO STABILITASU PONTHALMAZOK:');
    FOR COUNT:=1 TO (SZPONTSZ-1) DO
```

```
        BEGIN IIII(IKAFO);
            MAXAM(IKAFO);
            ELEL(ELKAFO, KUPAFO);
            MAXAM(KUPAFO);
            KAA:=KAA+1;
            ELKAFO:=KUPAFO;
            NEW(KUPAFO); KUPAFO@,GO:=NIL;
            NEW(IKAFO); IKAFO@,GO:=NIL;
        END;
    KIIRO(ELKAFO);
    WRITE(' A GRAF BELSO STABILITASSZAMA:',FOKROSZ:4);
    WRITELN;
END.
```