

PRINCIPLES OF MODEL INDEPENDENT DESIGN OF ENVIRONMENT MONITORING SYSTEMS

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ABSTRACT:

The integrated evaluation of environment must be based on an evaluating model which defines the data to be collected and used for evaluation as well as algorithms of evaluation. When designing environment monitoring we must have this model but there are also other basic principles that are independent from specialities of this model and are equally important for designing. These includes the following issues: which system of data collecting spots is to be used, should it be systematical or not; which statistical and other considerations are there to design the data collecting grid; what should be the frequency of data collection; what is the relationship between scopes of evaluating models; what are elements and subsystems of environment monitoring system; what is an expedient model for data base of environment monitoring. The paper tries to review these issues of monitoring system design which hopefully can be applied in regional as well as in global monitoring.

KEY WORDS: Global monitoring, GIS, Terminology.

1. INTRODUCTION

In recent years the researches at the Department of Environment Protection of University and Wood Technology in Sopron, Hungary were focused on monitoring and evaluation of environment. A part of this research dealt with the formal issues of monitoring and evaluation which are independent from evaluating model that is the algorithm used and data to be collected for the evaluation. Therefore our aim was to give a base for unified access and understanding of issues of monitoring. This could help the design of a possible Hungarian national system under the supervisor activity of Ministry Environment Protection and Regional Development Policy but the principles can be applied to the global monitoring as well.

2. DATA COLLECTING SYSTEM

Above all we have to take it into consideration that the data collecting system should be operated under a supervisor organisation with the function of system organisation, data administration and system administration. This unit may have the role of only an organiser but may be involved itself in data collection through its regional centers. Anyway there will be also other institutes specialised and experienced in some field measure techincs or aerial photography who join in the data collection. So the data collecting system consists of a so called "own" as well as of "foreign" subsystems. From other point of view this system consists of the organisation units of participating institutes, the list of data and their measuring system, and the data transmitting system as shown on Fig.1.

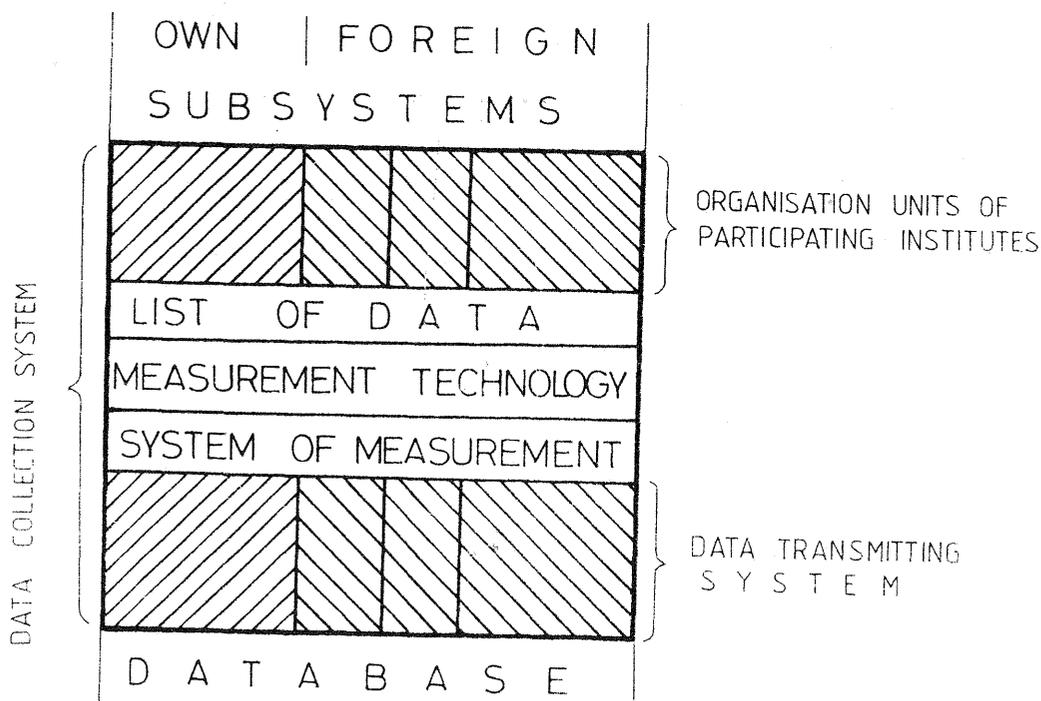


Fig.1 Subsystems of data collection system

3. SYSTEM OF MEASUREMENTS

The system of measurements can be described concisely by the following formula:

System of measurements = system of measuring points in space and time = grid of measuring points (in space) + schedule of measurements.

This system can be described by model in which the value scores of environment yield as a function of environmental variables measured at a given point and time:

$$V_{A,t} = f(M(u_{i,t}^1), M(u_{j,t}^2), \dots, M(u_{p,t}^n)) \quad (a)$$

and

$$V_{A,t} = f(R(u_{i,t}^1), R(u_{j,t}^2), \dots, R(u_{p,t}^n)) \quad (b)$$

or

$$V_{A,t} = M(V_{i,t}(u_{i,t}^1, u_{i,t}^2, \dots, u_{i,t}^n)) \quad (c)$$

and

$$V_{A,t} = R(V_{i,t}(u_{i,t}^1, u_{i,t}^2, \dots, u_{i,t}^n)) \quad (d)$$

where

$V_{A,t}$ is the value scores of environment over A evaluation area and in t-th evaluation period;

u^k is the k-th environmental variable

i is a point in the 1st measuring grid

j is a point in the 2nd measuring grid

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p is a point the nth measuring grid

t means the t-th evaluation period

M is the average according to i, that is the average of data measured in the 1st grid

R row of data measured in the 1st grid

$V_{i,t}$ means the value scores of environment in i-th point of the measuring grid and in t-th evaluation period.

Models a) and b) are formal models of the so called area evaluation while c) and d) are that of so called point evaluation. Area evaluation models are used when we want to take the environment variables into account with their quantity, average or row over the whole evaluation area. In point evaluation we use the value scores of measuring points of the grid.

In complex environment evaluation we use a common philosophy at the choice of variables to be monitored. For example our evaluation model is based on three groups of variables which are to describe 1) the operation of ecological system, 2) scenic impression, 3) presence of pollutants. If we use a systematic grid, a given measuring point can be within a forest, a cultivated land, a lake or an inhabited place. By the design of monitoring we must apply the above three groups of variables for these different "environment types" so their implementation will produce somewhat different variables to be monitored in the some group for forest or for lake. But having applied the common philosophy by the design the values of different environment types remain comparable.

We must add two notes concerning the "value scores" of environment. 1) Many times not the value scores itself but the changes in it are of importance. 2) It is only theoretical simplification that we say "scores". There will be evaluation models which cannot assign scores to the state of environment but give less accurate characterisation of it or produce a map to describe it. In such cases in above models a)-d) the role of f function will be weak but these models can still formally describe the evaluation and monitoring.

In case of area evaluation the A area of evaluation is the area of one environment type. Each valuable may have its own independent grid as shown in model a) and b). Though this solution may have its advances we try to apply one unified grid for which purpose the UTM grid seems most expedient. The measuring points should be in the middle of UTM squares. Such a grid can be used for simple one stage sampling, two stage sampling and stratified sampling. The measurement according to the nature of the variable requires a smaller or larger plot around the measuring point. Practically this plot may be a land use unit, e.g. a forest stand, an agricultural parcel or a district in a city. These units are to be sampled again so our sampling tends to be a two staged one. The sample of the first stage consists of those land use units which contain a measuring point of the UTM grid while those of the second stage consists of plots the system of which varies according to the variable to be measured or the properties of the land use unit. This second stage sampling may be systematic or not, may be intersection sampling, ricochet sampling and so on. This two stage sampling is favorable because we needn't insist to the same measuring place and besides the data collection can be left to the user of the land since the land use unit is a well defined piece of land. In case of stratified sampling in Hungary the Transdanubia, the Hungarian Low Land and the northern hilly regions of the country are possible stratifications.

In case of point evaluation we use only one grid preferably an UTM grid of measuring points. This can be used according to the following ways:

- Averaging the environment values for the whole evaluation area or displaying the UTM squares on a map with their environment value score categories (model d)). This is the easiest way for evaluating since we take the value scores into account independently from the environment type which contains the measuring point therefore we don't have to know the map of the evaluation area. The scope of the value scores is the UTM square.

- Averaging the environment values separately for each environment type or displaying UTM squares not only with the value score categories but also with the environment types on a map. The scope of scores is the whole UTM square and the environment type of the measuring point is accepted for the whole UTM square.

- More accurate evaluation or displaying of state of the environment types regarding their exact boundaries. For this we need the map of the evaluation area. The scope of the environment scores is the environment type within the UTM square that contains the measuring point in the middle of UTM square.

These solutions will be displayed on Fig. 3.

The t' intervals between two measurements as well as the exact date of the measurement depends on the nature of the variable to be measured and should be specified together with the definition of the variable and method of its measurement. Most variables are to be measured yearly in the critical season(s) characteristic of the variable. However if we suspect the type and rate of the change in the variable then we can single out two cases:

$$t' = \frac{a \cdot \Delta u^{kc}}{\Delta u^k / \Delta t} \quad \text{for linear and } t' \leq T/2 \text{ for periodical}$$

changes, where Δu^{kc} is a critical change in variable u^k , a coefficient of security $a = 0.1-0.2$, $\Delta u^k / \Delta t$ the rate of change in variable u^k , T the estimated period of change.

4. DATABASE AND APPLICATIONS

It is also important that we fix the baselines for designing a GIS data storage. In this system the major covers for the map can be those of evaluation areas, environment types, grid of measuring points (UTM squares), grid of second stage plots, sets of similar UTM squares. (Two UTM squares are to be considered similar when the measurements of the same variables within them produce the same values.) Accordingly relationships can be defined between alfanumerical record type of measuring points and the above territories. The formers contain basic data of and measured values on that point, while the later contain basic data of the territories. (Fig. 3) This solution supports the point evaluation and the area evaluation as well.

Finally we show an example for the scopes of point evaluation on the base of a research in which we tried to apply the "biotope goodness" method to the complex evaluation of the environment in the north-western corner of Hungary. (Fig. 3). So this part of the country can be seen on this map with 10x10 km UTM grid. In case of squares XN18, XN28, XN27, XN37

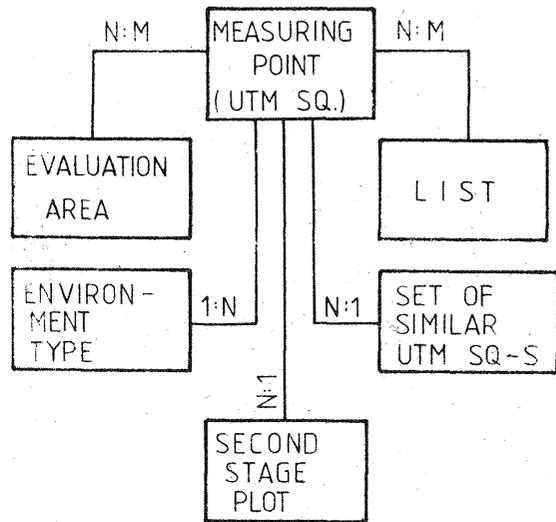


Fig. 2 Relations between alfanumerical records

and XN25 the environment scores are accepted for the whole square. We may characterise these squares also with the environment type to which their middle belongs. So the first four of above squares are "agricultural" ones while XN25 is an "inhabited place" square. In case of squares XN47, XN36, XN46, XN35, XN45 the scope of environment scores is the environment type within the UTM square (hatched areas). There are algorithms to calculate scores for the parts of this environment type out of the UTM square.

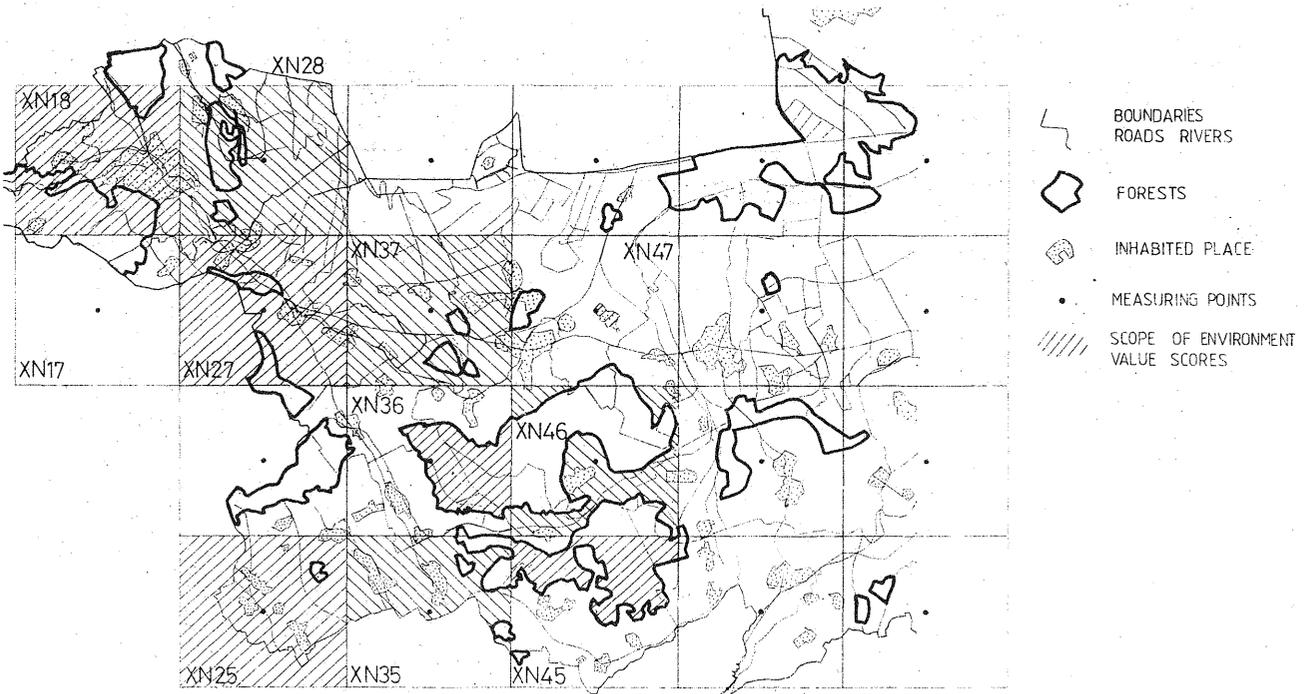


Fig. 3 Examples for the scopes of environment value scores using the UTM grid in Győr-Ménfőcsanak-Sopron County, North-Western Hungary

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