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GEOGRAPHIC INFORMATION SYSTEMS (GIS) AS TOOLS FOR BETTER INTEGRATED COASTAL ZONE PLANNING AND MANAGEMENT (ICZP/M)

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ABSTRACT

Geographic information systems (GIS) has practical applications in many areas, one of them being integrated coastal zone planning and management (ICZP/M). GIS can help combine several types of data from different sectors and may provide an overview over the various uses of the coastal zone. However, if full benefit is to be gained from GIS there are a number of problems and considerations that must be addressed. Some of the most important ones are briefly described in the paper and include lack of standardisation on various levels, problems when choosing the themes to be analysed and lack of data quality assurance. As an example of the application of GIS in coastal zone management we have chosen the identification of suitable areas for marine fish farming.

INTRODUCTION

During the past ten years Norwegian aquaculture has become a highly regulated industry in almost every way. Every step of production is performed in accordance with regulations and standards and all effluents, chemicals and wastes from fish farms are either collected and reused or are monitored (Anon. 1993). However, one area remains to be standardised;

aquaculture as an aspect of integrated coastal zone management and planning (ICZM/P). So far, local authorities have utilised their own individual criteria giving permission for the localising of fish farms in the coastal zone. However, conflicts occur between different users of the coastal zone and many local authorities have begun the process of integrated coastal zone planning. A very practical tool in this process is the use of geographic information systems (GIS). This method has been used in various other connections and has many advantages. In this paper we discuss some of the advantages and problems of using GIS in coastal zone planning, with special reference to the aquaculture industry.

ADVANTAGES AND PROBLEMS OF USING GIS IN COASTAL ZONE PLANNING

In Norway the use of coastal areas for various activities is defined in the legislation "The Planning and Building Act" of 1985 which regulates both terrestrial and marine areas, the latter extending to the "grunnlinjen", a line connecting the outermost skerries along the coast. This legislation provides a basis for the development of coastal zone planning.
A standard definition of GIS is a system for the collection, storage, analysis and communication of data, from original data to the production of maps. The most obvious characteristic of GIS is the unique ability to combine several types of data from different sectors, utilising geographic location as the common parameter. GIS is also unique in the way it relates map geometry to specific attributes in a database. It is a powerful analytical tool and one of its most useful functions is its ability to overlay various topics or activities (called geodata themes) in order to identify conflict, or to identify available areas that meet some or all of the requirements for a specific use.
GIS provides an excellent tool, which can be used to obtain an overview over the various uses of the coastal area and to compare the consequences of the various activities involved.
There are, however, a number of problems and considerations that must be addressed in order to derive full benefit from the system.

- A common problem in GIS is the lack of standardisation with regard to input data, analysis functions and map presentations. There are no common, consistent standards for sampling, classification and exchange of planning-related geodata. The data used may be obtained from a wide range of sources not all of which have quality-assurance routines. To ensure that the documentation of the data is preserved a meta-database must be produced. Such a database holds tabular information about the quality of the geodata and has multiple entries for each theme. The lack of a suitable framework for meta-databases may be attributed both to confusion about who is responsible for producing them, and to the situation that existing standards have a very high number of attributes, which renders the task of filling them in very laborious.
- Another problem is the procedures in connection with data analysis, which include choosing the themes to be used and how to combine them. Combinations of themes with weak or no causal relationships must be ruled out.
- Other problems are that some topics may be difficult to map (e.g. the value of a wilderness landscape or the value of a species) and that the available information may not fit the questions asked. When the maps have finally been produced the problem of different map projections and formats arise. Here too, standardisation is needed, as with the symbols used, to ensure that maps from different contractors are comparable.
- Poor-quality data, arbitrary combinations of topics in analyses, and misleading use of symbols for map presentations, may provide results that are not completely reliable. New desktop GIS and communication technology combined gives the opportunity to easily manipulate information. The results of GIS analyses are often regarded as

rational answers, and a visualisation in the form of a map can appear very convincing. However, if we take into account the above-mentioned lack of data quality assurance, the arbitrary combination of themes in analysis, and inconsistent use of symbols for map presentations, the maps themselves may be misleading and less useful as a decision-support tool.

Recently, the EU Interreg IIC project "Seagis" has attempted to solve some of these problems by encouraging the exchange of best practice among regions around the North Sea. The project has produced a series of suggestions for standardisation at all levels in the process and a method for visualising the individual steps in an analysis by means of flowcharts. This will improve the description of input data, clarify the criteria for combining them and provide documentation of the results. Furthermore, it will make it possible to follow the process in reverse step by step and to easily find out where the various sets of data came from. This project is currently in its final stage, and information about the outcome can be found at: http://www. hordaland-f. kommune. no/seagis.

AN EXAMPLE – FINDING SUITABLE AREAS FOR FISH FARMING

Finding suitable areas for expansion of the fish farming industry has been an important topic in Norway for a number of years. The first systematic attempt was done during 1987-90 by the development of the LENKA approach (Kryvi et al., 1991). This project led to the development of a simulation model ("Fjordmiljø"), which calculates the recipient capacity of fjords with threshold areas (Aure and Stigebrandt, 1990). Then a system called MOM was developed which includes both a model for prediction of impact and a monitoring programme for measuring impact at a potential or operating fish farm site (Ervik et al, 1997). Finally, the appearance of GIS provided the toolbox for multicriteria area-based analysis.

The following is an outline of the process of finding suitable areas for fish farming in Norway and it will be tried out in 200 1. In order to visualise the process the procedure is presented here in a flowchart as suggested by the EU-project "Seagis".

The first step in the process is development of a conceptual model. Such a model involves the identification of physical, social, demographic or environmental criteria and describes an ideal situation in which all essential information is available in database form. However, in reality it is often necessary to perform the analysis on the basis of less information either due to lack of data or because certain information is impossible to map. Therefore a 'real' model is developed on the basis of the conceptual model and can be used in the actual analysis. The conceptual model does not become part of the following procedure, but is important in shaping the decision regarding how to solve the question.

Figure 1 is a demonstration of the procedure of moving from the model to the actual map. From the available databases a number of relevant themes must be identified. In this example, we select themes that are of relevance for the localisation of fish farms. These includes a long list of themes such as distances from sewage outlets, recreational areas, other fish farms, public transport networks and nature conservation areas, in addition to depths, currents and recipient status etc.

The next stage in the process is a transformation, in one or more steps, of the data of the individual themes before they are combined into a final analysis. We use here the LENKA approach and have divided the themes into two groups: one concerning area capacity and one concerning recipient capacity. The following example is kept at a very general level. With regard to area capacity two themes have been chosen to illustrate the process: underwater topography (U/W DTM: Under Water Digital Terrain Model) and existing fish farms, and all the other relevant themes are merely indicated. Restrictions may be placed on both themes;

e.g. the depth must be large enough for net pens and therefore most likely be more than 10m and there is a l-km buffer-zone around existing fish farms due to veterinary regulations in Norway. Furthermore, technical transformations may have to be performed. These may include converting occupied areas to unoccupied. Finally, the individual areas are compared though the process of ‘overlay’ and the area capacity is determined.

To find the recipient capacity the relevant themes are identified including all types of organic and inorganic input. In this example only sewage outlets are mentioned and all other themes are indicated. If the area in question is a threshold fjord, which is very common in Norway, the data from the themes can be entered into the "Fjordmiljø" model, which is now an integrated part of the MOM-model, and the recipient capacity is calculated. If the area in question is more open, the area is less sensitive and general transportation models may be used.

The two outcome of the process so far, the area capacity and the recipient capacity, are then combined and the result is a map that indicates the areas where there is available space for fish farms and where there is capacity for emissions from fish farms in the recipient.

However, the calculated recipient capacity is a gross capacity on a regional scale, and it is possible for smaller areas within the recipients, such as actual fish farm sites, to vary greatly in their capacity to accommodate a fish farm. Therefore, when an actual site for a future fish farm has been chosen, it is necessary to evaluate its local capacity for dealing with the organic material that is produced by the farm. This may be achieved by using the dispersion- and the sediment-submodel of the MOM system, and the MOM monitoring programme will ensure that the fish farm will not exceed the capacity of the site in the future.

CONCLUSION

In 200 1 Norway will issue new licences for fish farming for the first time since- 1986. This has emphasised the need to identify areas for fish farming with minimum conflicts with other users and without exceeding the capacity of an area with regard to organic and inorganic effluents. The procedures presented here will be used as guidelines by the regional authorities.

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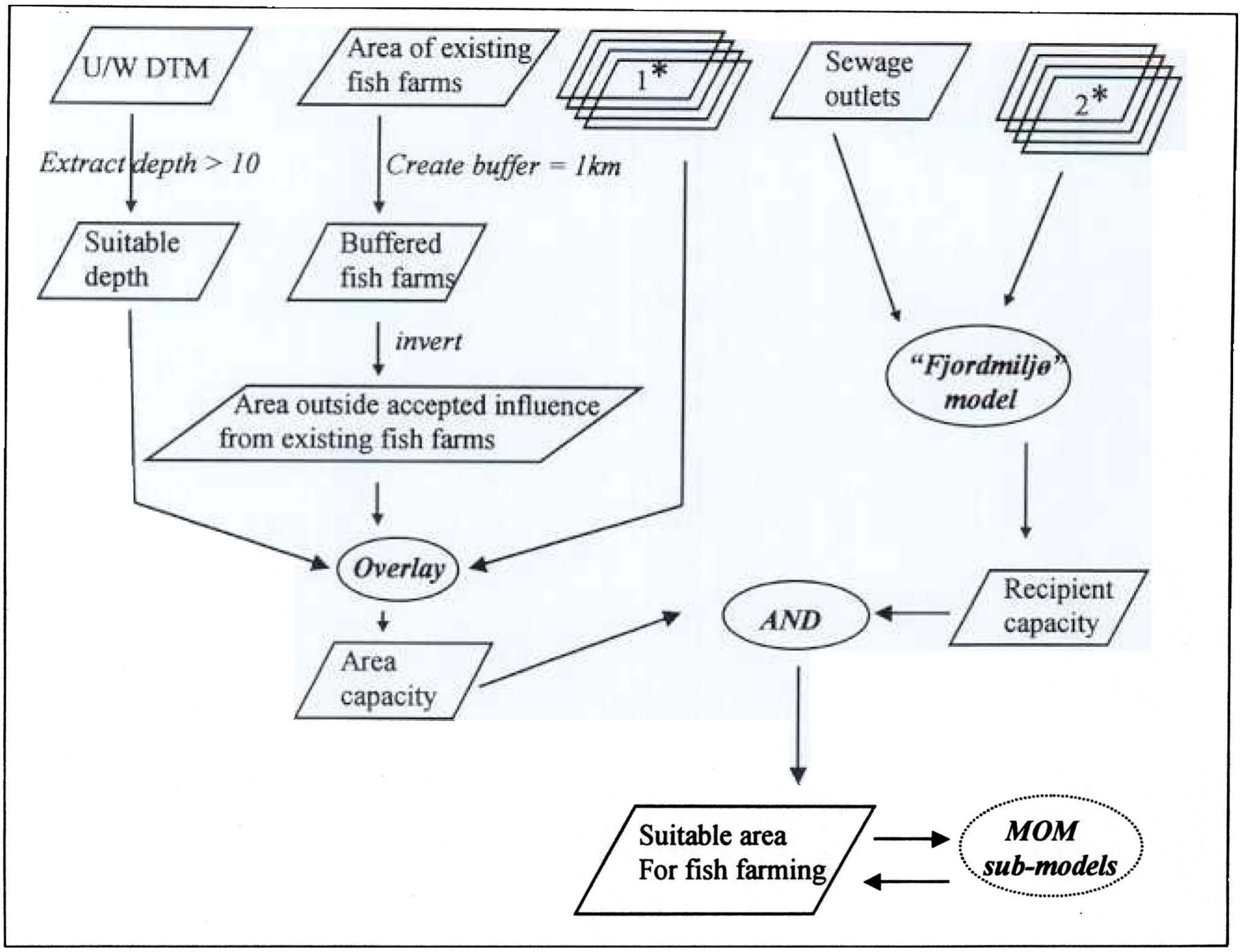

Fig. 1. An example of a flowchart showing the procedure to determine suitable areas for fish farming in a coastal area. Both the number of themes and the number of steps in the procedure has been reduced for clarification.
* Distance to infrastructure, wave exposure, temperature, fairways, nature reserves etc.
** Runoff areas, fjord basin topography, fish farm effluents etc.