# GIS MODELLING AS A TOOL FOR SPATIAL PLANNING DECISION- MAKING FOR STONE AGGREGATE SITES IN DALMATIA

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## INTRODUCTION

The aim of the paper is presentation of GIS based modelling for stone aggregates potential in Dalmatia. The low consumption of aggregate in the region (less than 30%) of EU average is putting pressure on local authorities for the access to new extraction sites. The GIS model allows resource management and priorities of potential mineral extraction areas and sites in Dalmatia while taking in account both environmental or marketplace needs.

## MINERAL RESOURCES OF CROATIA AND STUDY AREA OF DALMATIA

Mineral resource map of Croatia include more than 4000 mineral occurrences and deposits. The Croatian non-metals and stone industry are the most essential part of Croatian base industry.

Croatia has a wide range of non-metallic raw materials. The mineral deposits of non-metallic raw material include silica, sand, bentonite, ceramic and brick clay, gypsum, tuff, marl, dolomite, limestone and gravel used for building materials and architectural stone. Sea salt is also produced. The explored but non producing deposits consist of quartzite, barite, and graphite.

Croatia has 626 exploitation sites, covering less than 400 $km^2$ of territory, mostly crushed stone aggregate (253) sites, dimension stone (103) sites, and gravel and sand which are used as building materials.

The study area (Dalmatia) is located in southern part of the Republic of Croatia (covering 36,473 $km^2$, and with a population of 855,000). In Dalmatia there are 68 active crushed stone aggregate quarries (25% of sites in Croatia) and 82 active dimension stone quarries (80% of sites in Croatia).

Exploitation reserves of dimension stone are 13.5 mil. $m^3$ (80% in Dalmatia), and exploitation reserves of crushed stone aggregate are 350 mil. $m^3$ in Croatia (25% in Dalmatia).

The economic development of county as in general, is reflected with increase demand for stone aggregate in the region and their production from 1997 to 2003 (Fig. 1).

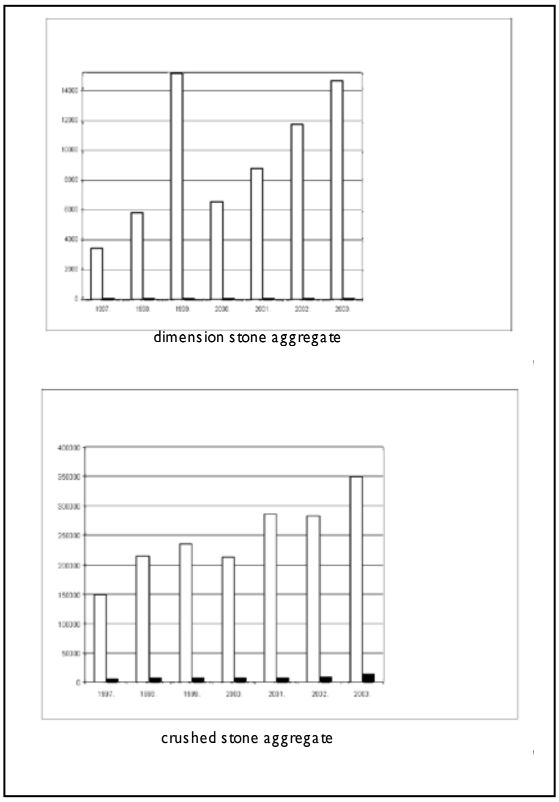


*Figure 1 – Graphs of increase production of crushed and dimensional stone aggregate in Croatia from 1997-2003*

## WEIGHT OF EVIDENCE (WofE)

Geographic Information Systems (GISs) are very useful exploration-oriented tools for processing of spatial data, which enables the production of potential maps for stone aggregates (ROBINSON et al. 2004). Weights of evidence analyses (WofE), modelling was used to measure associations between the sites and different spatial features in a way that their individual effects could be evaluated and used to infer relative influence on development.

The WofE analysis approach is a quantitative method using evidence to test a hypothesis. The results of this analysis can be used to describe and explore relations in spatial data from diverse sources, make predictive models, and provide support for decision makers. The WofE analysis method was adapted to GIS for mineral potential mapping by Bonham-Carter, Agterberg, and Wright (1988) and Agterberg, Bonham-Carter, and Wright (1990), and the method is summarized in RAINES, et al., (2000).

The method tests the hypothesis that the area is suitable for occurrence of a mineral deposits site, defined by a set of response variable point locations (termed *training sites*), relative to a set of predictor variables (termed *evidence*). In the mineral resource- potential mapping example presented here, the training points are the set of locations of active crushed stone quarries and the predictive evidence consists of geology, transportation network, and population distribution spatial data.

For each binary evidential theme, a pair of weights is calculated relative to the training sites, one for presence of the evidence criterion (w +), and one for absence of the evidence criterion (w-).

The magnitude of the weights depends on the measured spatial association between the evidence criteria and the training sites (crushed stone quarries) in the study area.

WofE analysis was used to analyze spatial associations among the training sites relative to the multiple evidence categories and to reclassify the evidence categories into binary or multiclass groups for optimal prediction.

Three evidential theme layers were used for predictive evidence:

(1) bedrock potential-geology map with general characteristics highly suitable for aggregate derived from 20 maps sheets in digital format from compilation of basic geological maps of Republic of Croatia in scale 1:100 000.

(2) proximity to the transportation network was into groups at distance intervals of 2 km and 4 km. Most of the crushed stone quarries are sited within 4 km of principal highway or a rail line in the region. These relations illustrate the importance of proximity of transportation corridors to the industry.

(3) spatial population density information (people pre km²), the population density distribution was divide into six intervals with similar range. In Dalmatia, 80 % of crushed and dimension stone aggregate occur in census tracts with population densities exceeding 50 people /km², illustrating the importance of proximity to the urban communities.

All evidential theme layers were prepared in grid format using ArcView 9.2. and Arc-SDM extension (KEMP et. al, 2001). Each grid has a cell size of 100 m, which is less than the minimum spatial uncertainty of the evidential theme source data.

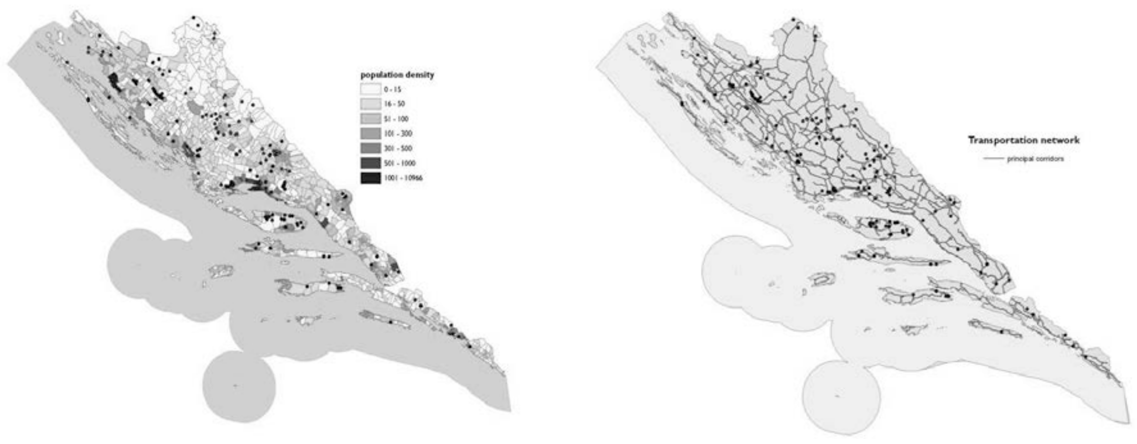


*Figure 2 – Study area with predictive evidence of spatial population density and proximity to transporation network*

## RESULTS

Geology provides the stongest predictive evidencefor crushed stone quarry locations followed by population density and transportation evidence based on the WofE contrast evaluated for both binary and muliticlass models. Final products are different suitable area for aggregate production, divide to four class high, moderate, generally and low suitability.

After administration restrictions have been applied on geological potential, we have restricted geological potential area whichs shows (dimensional and crushed stone aggregate quarries). The next phase would be application and validation of the devoloped model to the most suitable areas for extraction, so that it could be a method applicable and used on the whole teritory of Croatia as an aid to the spatial planners to manage better the use of mineral resources in based on identification of more suitable areas for stone production taking in account both environmental and marketplace restrictions.

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