# SITE SELECTION FOR NEW BUILDINGS WITH GIS & MCDM

F. Batuk [a] , M. Yalcin [b]

[a] Yildiz Technical University, Department of Geomatic Engineering, Istanbul, Turkey
[b] Impek Engineering Ltd. Co., Istanbul, Turkey

**KEY WORDS:** GIS, Multi Criteria Decision Making, Disaster Management, Site Selection, Re-Construction

**ABSTRACT:**

The process of site selection and construction of new buildings is one of the phases of disaster management in many countries. Many criteria including the risk of disaster in particular, take into account the new housing areas will be selected. One of the scientific ways is combination of GIS and Multi Criteria Decision Making (G-MCDM) methods to make a decision with many criteria. To meet with the desired objectives, spatial data is associated at the different alternatives and the sites are compared by using G-MCDM methods.In this paper, the G- MCDM method was presented for related to housing site selection. Criteria's were density of employment and population, proximity to highways, large shopping centre, green area, schools and health organizations. Firstly spatial data was prepared, normalized than their weights were calculated by using the pairwise comparison method. Each criterion raster layers were multiplied by weights and pixel's value were aggregated according to locations. The highest value land area has been selected among ten alternative lands. The site selection of new buildings has been completed for the recovery and re-construction phase of disaster management.

## 1. INTRODUCTION

Spatial decision problems typically involve a large set of feasible alternatives and multiple, conflicting and incommensurate evaluation criteria. The alternatives are often evaluated by a number of individuals (decision-makers, managers, stakeholders, interest groups). The individuals are typically characterized by unique preferences with respect to the relative importance of criteria on the basis of which the alternatives are evaluated. Accordingly, many spatial decision problems give rise to the GIS-based multicriteria decision analysis. (Malczewski, 2006).

Integrated use of GIS with MCDM methods, the location ensures the participation in decisions about optimization techniques. Also, the geographic information technology is made available directly to decision-makers for policy or scenario development (Eastman et al., 1993; Malczewski, 1999; Jankowski et al., 2001; Ascough et al., 2002). G-MCDM approaches were most often used for tackling land suitability problems (Malczewski, 2006). Determination of risk and vulnerability analysis in disaster management by using G-MCDM, in recent years is one of the most widely used methods (Quesada et al., 2007; Zerger, 2007; Komac, 2006, Rashed et al., 2003; Ayalew et al. 2004). The other applications are emergency (Levy at al., 2007) and reconstruct planning (Opricovic et al., 2002).

In this paper, the G- MCDM method was presented for related to housing site selection which will be required at re-construction phase of disaster management. It is assumed that alternative lands are not the risk of disaster.

## 2. METHOD AND MATERIAL

In this paper, the G- MCDM method was presented for related to housing site selection. Project's flow diagram was depicted in Figure 1.


Figure 1. Project flow diagram

Initially, according to the specified purposes, literature researches were done and expert opinions were taken. As a result of these, the criteria were selected as density of employment and population, proximity to highways, large shopping centre (LSC), green area, schools and health organizations and chosen ten alternative suitable areas for new housing sites.

The layers were established for each criteria, using as a base belonging to the Istanbul-Bakirkoy district boundaries and the selected alternative areas data were processed in ArcMap platform. The city blocks of the criteria have been converted to point data. Than Euclidian distance and kriging tools were used to analyze proximity and density among the alternatives. With these tools, the vector data has been converted into raster data according to extents of the density and proximity. The results of the pixel sizes in the raster data were selected '20 m' optionally. After that the application were started and normalization, weighting, simple additive weighting stage were carried out respectively. Classifications and comparisons were made over the synthesis of data, as a result of these, final recommendations were composed. Model Builder application has been developed to watch the process steps controlled and to maintain the workflow on a regular basis (Figure 2.).

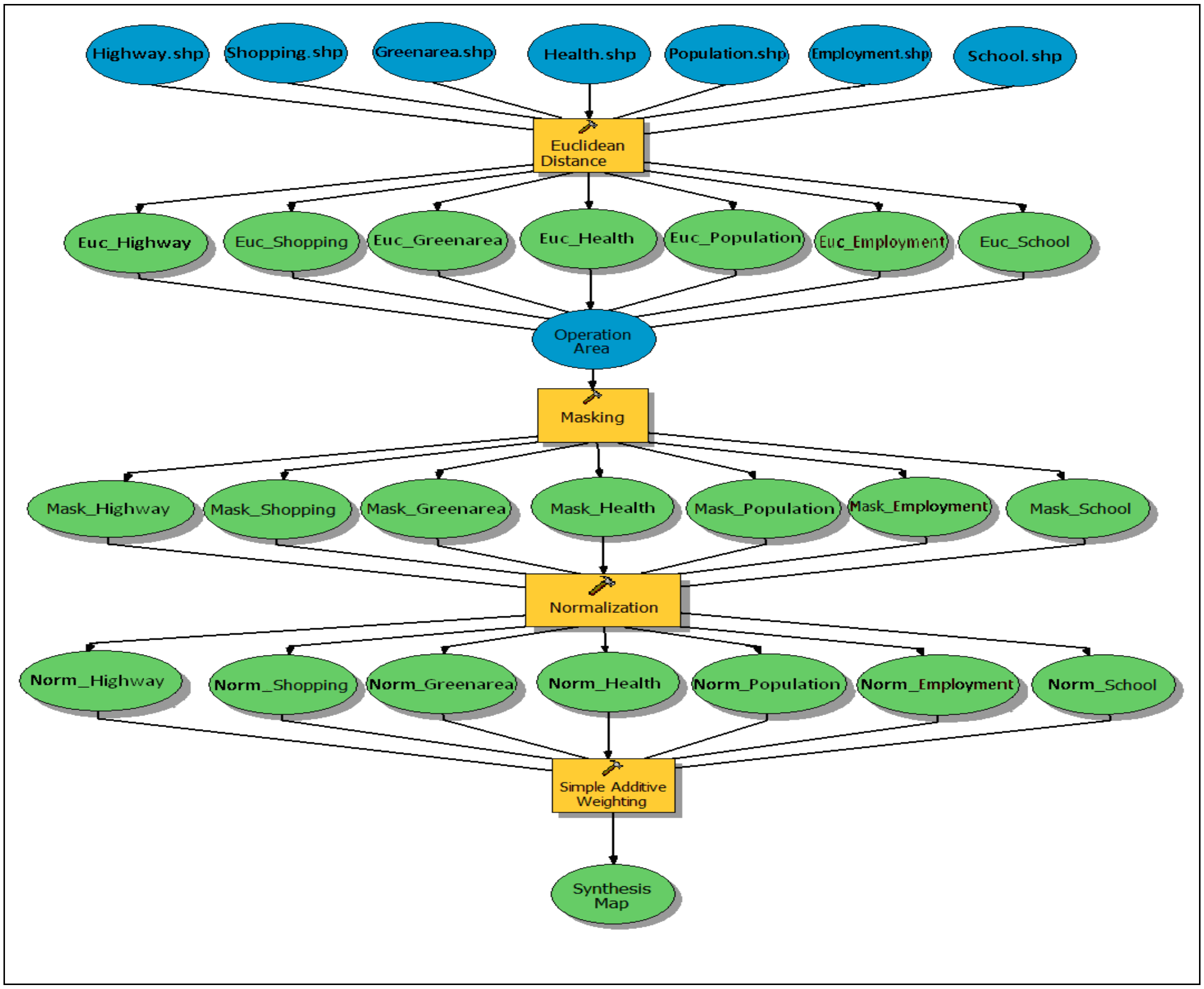


Figure 2. Developed interface program

### 2.1 Normalization

During normalizing criteria layers, "Maximum Value" method is used in order to synthesis of all layers in the same denominator. With the help of ArcGIS Map Algebra tool, the formula shown in (1) is applied in the density of population, proximity to highways, large shopping centre, green area, schools and health organizations layers. Thereby, new pixel values of all criteria layers are defined varying between 0 and 1 which are converging to 0, is furthest to criteria layers and which are converging to 1 is closest to criteria layers.

$$x_{ij}^{'} = 1 - \frac{x_{ij}}{x_j^{\max}} \qquad (1)$$

In contrast, pixels values increase by getting away from the layers of density of employment. Hence, the formula shown in (2) is applied the layer in order to provide the pixels of the new values which are converging to 1, is furthest to criteria layers and which are converging to 0, is closest to criteria layers.

$$x_{ij}^{'} = \frac{x_{ij}}{x_j^{\max}} \qquad (2)$$

Normalized pixels on the layers of criteria, [0,1] has received new values in the range of values. Normalized layers of criteria in Figure 3 are also shown for each criteria.

### 2.2 Weighting

Weight values were constituted by decision makers according to their importance to synthesize among each criteria. Each criteria were compared in pair groups with pairwise comparison method (Table 1). This method checks the consistency of the weights and to determine how extent is consistent. Consistency Ratio was calculated as: 0.012 for 7 criteria. This value is less than 0.10, thus, the weights were found to be consistent.

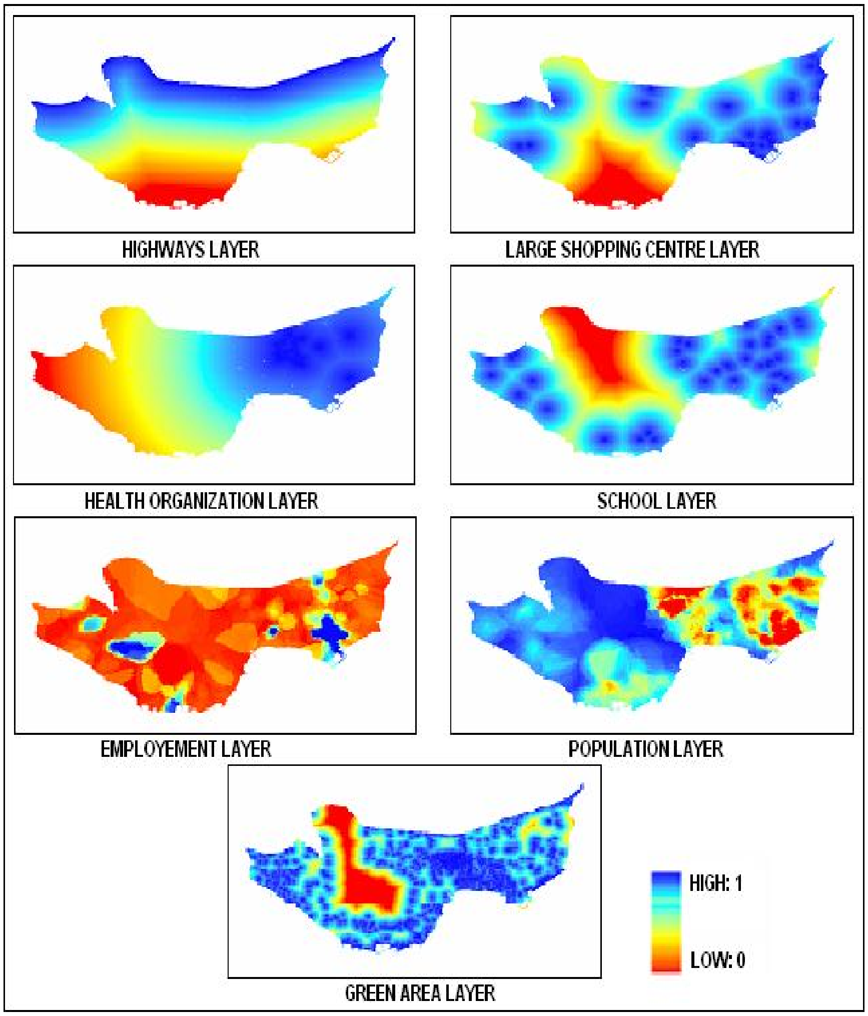


Figure 3. Normalized criteria layers

| | Highways | L.S.C | Green Area | School | Health Org. | Population | Employment | w |
|---|---|---|---|---|---|---|---|---|
| Highways | 1.000 | 5.000 | 7.000 | 9.000 | 7.000 | 5.000 | 3.000 | 0.4056920 |
| L.S.C | 0.200 | 1.000 | 3.000 | 5.000 | 5.000 | 3.000 | 0.333 | 0.2209120 |
| Green Area | 0.143 | 0.333 | 1.000 | 3.000 | 0.333 | 0.333 | 0.200 | 0.1438552 |
| School | 0.111 | 0.200 | 0.333 | 1.000 | 0.333 | 0.200 | 0.143 | 0.0990018 |
| Health Org. | 0.143 | 0.200 | 3.000 | 3.000 | 1.000 | 0.333 | 0.200 | 0.0603744 |
| Population | 0.200 | 0.333 | 3.000 | 5.000 | 3.000 | 1.000 | 0.333 | 0.0450778 |
| Employment | 0.333 | 3.000 | 5.000 | 7.000 | 5.000 | 3.000 | 1.000 | 0.0250868 |
| | 2.130 | 10.067 | 22.333 | 33.000 | 21.667 | 12.867 | 5.210 | 1.000 |

Table 1. Pairwise comparison matrix of assessment criteria and calculated weights

### 2.3 Simple Additive Weighting

Simple additive weighting method was used to create the results of data by associating weight with criteria of the layers. In this method, layers of normalized criteria values were multiplied with the weight values and by taking the sum of these multiplied. Finally, the result data was created (Figure 4. and Figure 5.).


Figure 4. Working area

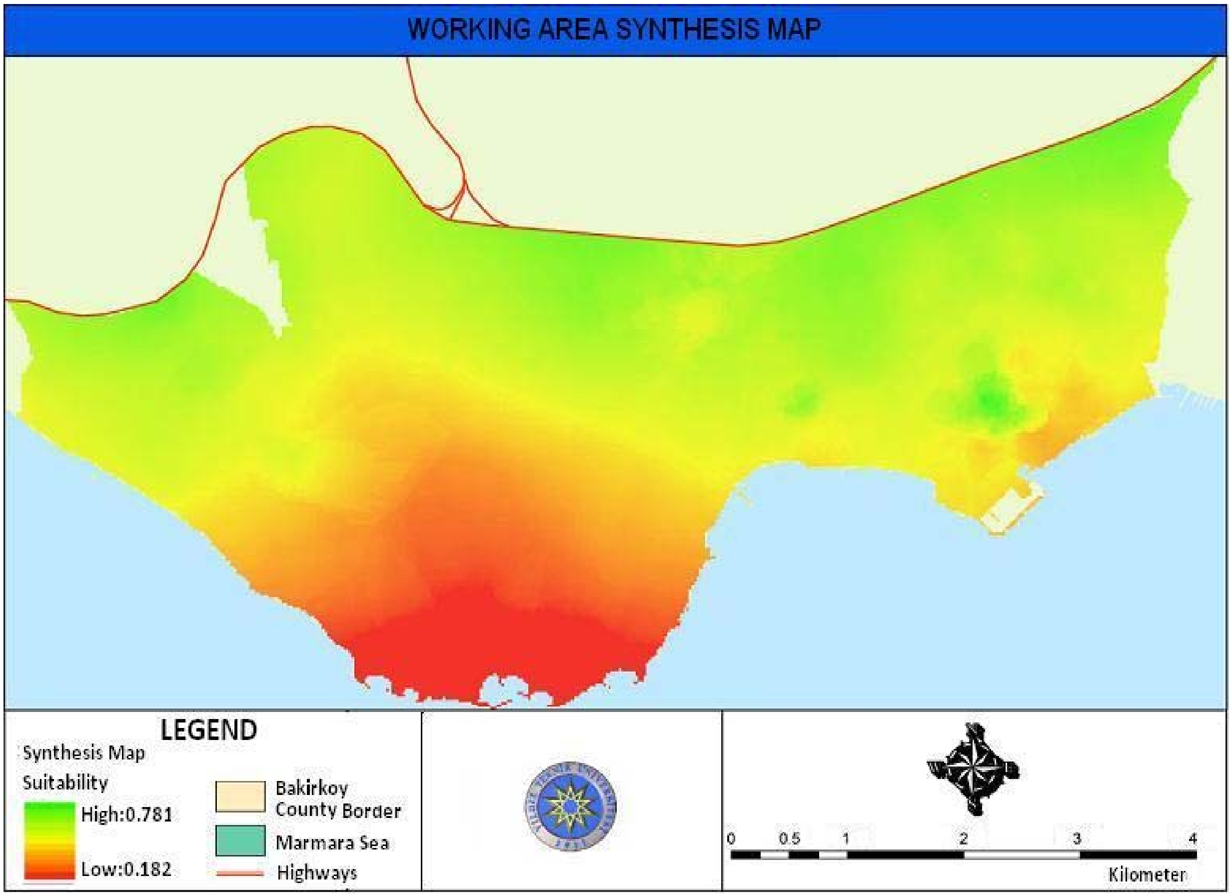


Figure 5. Synthesis Map

The places that are suitable for the mass housing site selection are indicated as raster layer by the interface prepared via Model Builder in ArcGIS context (Figure 5.). Here, the green area that has the highest values demonstrates the convenient areas, and the dark red area that has the lowest values demonstrates the inconvenient areas.

## 3. RESULT

The pixel values within the designated alternative areas of synthesized data, vary from each other in the alternative areas related to the proximity or distance according to the criteria. In this case, a common pixel value is needed to define for the each alternative area. For this reason, the pixel values within alternative areas are treated statistically. As a result of this process, all pixels have had the same value within each alternative area. Zonal Statistic tool was used to perform this operation in ArcMap platform and all the normalized criteria layers- in all alternative areas-have been transformed into a single pixel value (Table 2).

### 3.1 Classification

The classification was created by using the resulting value for each alternative area. Classes shown with different colors, created a more open and understandable data integrity about the alternative area on the layer result and more comfortable ability to comment gained.
These classifications were constituted by writing each alternative's resulting values matching with classes in ArcMap platform (Figure 6).

| Alternative No | Synthesis Values |
|---|---|
| 1 | 0.644282 |
| 4 | 0.636356 |
| 8 | 0.629699 |
| 6 | 0.629429 |
| 9 | 0.625839 |
| 10 | 0.614053 |
| 5 | 0.612828 |
| 7 | 0.574758 |
| 3 | 0.407964 |
| 2 | 0.285688 |

Table 2. Values and alignment of alternative lands on the synthesis map

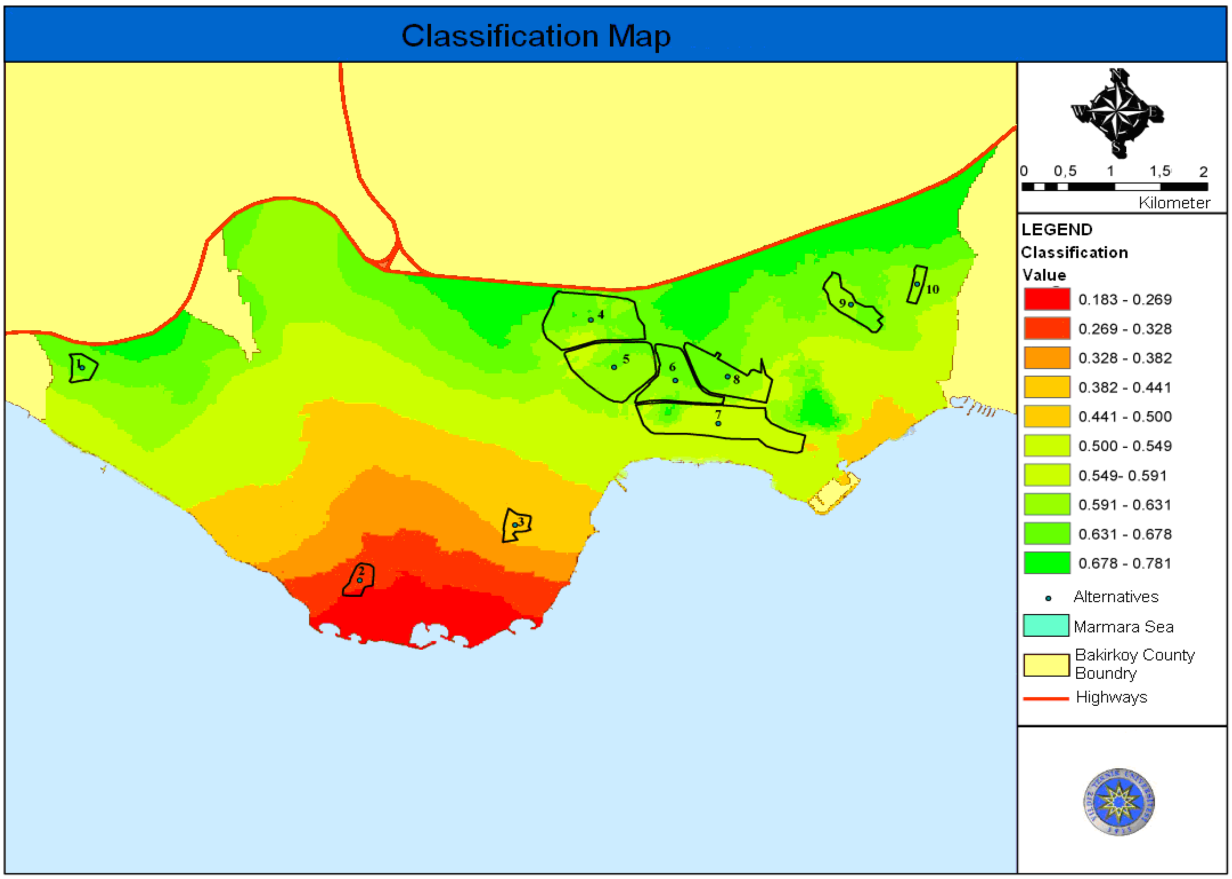


Figure 6. Classification map

## 4. CONCLUSION

This paper, aims to determine the most suitable place among different alternatives for the purpose of mass housing projects after disaster through the use of MCDM and with the help of GIS.

It is aimed to execute a healthy decision making process on the most appropriate place for the planned post-disaster new housing project by defining different alternatives within Bakirkoy district boundaries.

In this process, definition of the problem, identifying for criteria weight with method of pairwise comparison, Euclidian distance and kriging method, normalization, creation of results data with

SAW method, classification, and comparisons are described in detail. Synthesis of data obtained with SAW method, were organized with classification and comparison and the most appropriate alternative was decided among them.

As a conclusion, the best place suitable to purpose was found alternative 1 and second suitable place was found alternative 4. In planned new housing project, the most unsuitable place was found alternative 2.

## REFERENCES


Aceves-Quesada, J. F., Diaz-Salgado, J., Lopez-Blanco, J., 2007. Vulnerability assessment in a volcanic risk evaluation in Central Mexico through a multi-criteria-GIS approach. *Natural Hazards*, 40 (2), pp. 339–356.

Ascough, J.C., Rector, H.D., Hoag, D.L., Mcmaster, G.S., Vandenberg, B.C., Shaffer, M.J., Weltz, M.A., Ahjua, L.R., 2002. Multicriteria spatial decision support systems: overview, applications, and future research directions. In: *Proceedings of The International Environmental Modelling And Software Society*, Lugano, Switzerland, pp. 175–180.

Ayalew, L., Yamagishi, H., Ugawa, N., 2004. Landslide susceptibility mapping using GIS-based weighted linear combination, the case in Tsugawa area of Agano River, Niigata Prefecture, Japan. *Landslides*, 1 (1), pp. 73–81.

Eastman, J.R., Kyem, P.A.K., Toledano, J. And Jin, W., 1993. GIS and decision making. *Explorations in Geographic Information System T echnology*, **4** (Geneva: UNITAR).

Jankowski, P., Nyerges, T., 2001. *Geographic Information Systems For Group Decision Making: Towards A Participatory, Geographic Information Science* , Taylor & Francis, New York.

Komac, M., 2006. A landslide susceptibility model using the analytical hierarchy process method and multivariate statistics in Perialpine Slovenia. Geomorphology 74 (1-4), pp. 17–28.

Levy, J. K., Taji, K., 2007. Group decision support for hazards planning and emergency, management: a group analytic network process (GANP) approach. *Mathematical and Computer Modelling*, 46 (7-8), pp. 906–917.

Malczewski, J., 1999. *GIS and Multicriteria Decision Analysis*, Wiley, New York.

Malczewski, J., 2006. GIS-based multicriteria decision analysis: a survey of the literature. *International Journal of Geographical Information Science,* 20 (7), pp. 703–726.

Opricovic, S., Tzeng, G.H., 2002. Multicriteria planning of post earthquake sustainable reconstruction. *Computer- Aided Civil And Infrastructure Engineering,* 17 (3), pp. 211-220.

Rashed, T., Weeks, J., 2003. Assessing vulnerability to earthquake hazards through spatial multicriteria analysis of urban areas. *International Journal of Geographical Information Science,* 17 (6), pp. 547–576.

Zerger, A., 2002. Examining GIS decision utility for natural hazard risk modelling. *Environmental Modelling & Software*, 17(3), pp. 287–294.