A weighting-rating method to evaluate soil erosion for land use planning: a case study in Sagunto area (Spain)
L. Recatalá, J. Sánchez
Centro de Investigaciones sobre Desertificación-CIDE, Consejo Superior de Investigaciones Científicas, Universitat de València, Generalitat Valenciana, Camí de la Marjal S/N, 46470 Albal (Valencia), Spain
EMail: luis.recatala uv.es, juan.sanchez uv.es

Abstract
A weighting-rating method to evaluate qualitatively both present and potential soil erosion for land use planning in the Mediterranean Region (Recatalá & Sánchez) is applied to Sagunto area (Spain) on a scale of 1:25,000. The method takes into account the following factors: rainfall, soil, lithology, vegetation, topography, erosive morphology and soil conservation management. Both present and potential soil erosion of mapping units are classified using a classification reference system with five classes that express soil erosion from very low to very high degree. Sagunto is a dynamic coastal area in the east of the Valencian Mediterranean Region, where soil erosion is an issue to be considered by doing land use planning. Mapping units with high or very high present soil erosion represent 12.30% of the total area, and with high or very high potential soil erosion represent 28.78% of the total area. The evaluation and classification of present and potential soil erosion in the study area has provided a basis for addressing soil conservation by defining guidelines for land use allocation.

1 Introduction
Soil erosion is an important issue in the Valencian Mediterranean area that has intensively increased in the last decades by human activities such as agriculture, forestry, etc. (Rubio, Rubio et al., Sanroque, Sanroque et al.).

A preventive rather than reactive approach to undertake soil erosion relates to its incorporation into the task of land use planning. In this context, the characterisation of the areas most vulnerable to soil erosion should provide a basis for a land use allocation that prevents the loss of soil by erosion (Caver Farias et al., Recatalá).

Several approaches have been used to study soil erosion in the Valencian Mediterranean Region such as the USLE method (Rubio et al.),
approaches based on erosion plots (Andreu et al.) and weighting-rating methods (Andreu et al.\textsuperscript{1}, Bordás & Sánchez\textsuperscript{2}, Sánchez et al.\textsuperscript{3}). However, the weighting-rating methods seem to be the more useful methods to study soil erosion when doing land use planning due to their feasibility and simplicity, two important requirements in such a context (Recatalà & Sánchez\textsuperscript{4}). The other methods seem more adequate at project level, although there are several difficulties associated with the use of the USLE method in the Valencian Mediterranean Region (Recatalà\textsuperscript{5}, Recatalà & Sánchez\textsuperscript{6}).

A weighting-rating method to evaluate and classify soil erosion for land use planning in the Mediterranean Region is applied in Sagunto (Spain) on a scale of 1:25,000. Sagunto is a dynamic coastal area where agriculture, forestry and industrial-urban uses cause soil erosion and compete with conservation. The evaluation and classification of both present and potential soil erosion in the study area has allowed the definition and application of planning guidelines for land use allocation that address the issue of soil erosion.

### 2 Methodology

For evaluating soil erosion in mapping units (see below) the methodology (Recatalà & Sánchez\textsuperscript{7}) takes into account the following factors: rainfall, soil, lithology, vegetation, topography, erosive morphology and soil conservation management. The parameters considered to measure qualitatively these factors are respectively: rainfall erosivity, soil erodibility, erodibility of lithology, type of vegetation, slope, type of erosive morphology and type of soil conservation management. Several classes are established for each parameter considering the environmental characteristics of the Mediterranean Region. These classes allow the classification of mapping units according to their own characteristics. In order to evaluate qualitatively present soil erosion, firstly conventional values are assigned to the different classes of each parameter giving the higher numbers to the classes that determine more soil loss. Secondly, differential weights reflecting importance of the different parameters in defining soil erosion are established. Finally, present soil erosion can be evaluated using the following mathematical expression:

\[ V_{Eu} = \sum_{i} p_i \times v_{iu}, \]  

where \( V_{Eu} \) = value of present soil erosion for mapping unit “\( u \)”, \( p_i \) = weight established for parameter “\( i \)”, \( v_{iu} \) = value of soil erosion assigned to mapping unit “\( u \)” by parameter “\( i \)”, and \( n \) = number of parameters. The higher the “\( V_{Eu} \)” value is the higher the present soil erosion on mapping unit “\( u \)” is. However, “\( V_{Eu} \)” values have only a qualitative and relative meaning that allows the comparison of different mapping units in a region in terms of present soil erosion. For comparison purposes, a classification reference system is defined through the maximum (“\( V_{Eumax} \)” and minimum (“\( V_{Ein} \)” values of
present soil erosion that mapping units can achieve considering the values and weights established. Five classes were established to express present soil erosion from very low to very high degree.

Potential soil erosion of mapping units is evaluated and classified using the same procedure as for present soil erosion but considering that some factors involved in the soil erosion process reach a state of maximum degradation as consequence of environmental changes. For instance, in non-agricultural mapping units with a slope greater than 5%, it is considered that both soil and vegetation reach a state of maximum degradation in order to evaluate potential soil erosion. Furthermore, the abandonment of soil conservation systems is also considered if such mapping units were ancient agricultural units with soil conservation systems. Several situations of mapping units are contemplated to evaluate and classify potential soil erosion.

A more detailed and commented description of this methodology can be found in Recatalá & Sánchez\textsuperscript{10}.

3 Sagunto study area

Sagunto is situated in the east of the Valencian Mediterranean Region (Figure 1). The 114 square kilometre study area is bounded by 0°11’W longitude and the coast, and latitudes 35°45’N and 35°40’N. This area abuts with Castellón de la Plana province in the north, L’Horta and Camp de Turia regional areas in the south, Vall de Segorbe regional area in the west and the Mediterranean sea in the east.

The study area has a temperate dry Mediterranean climate characterised by a dry summer. Mean annual rainfall ranges from 450 to 550 millimetres. Mean annual temperatures range from 15-18 °C decreasing with the distance from the sea. Climatic variability within the area results mainly from the influence of local topography and distance from the sea.

The geology of two-thirds of the area (coastal plain) is dominated by sediments of Quaternary including river alluvium, colluvium, alluvium-colluvium, coastal sands and lagoon deposits. Minor areas of Triassic materials occur inland. There are very small areas from the Tertiary and Jurassic age.

The study area comprises some mountains and hills of foothills of the Iberic chain, and the coast is drained by the Palancia river. Three major successive topographic zones run north-south roughly parallel with the coast. The western zone which covers one quarter the area consists of mountains up to 400 metres elevation. East of this zone there is a belt of hills of altitude rarely exceeding 250 metres, followed by a broad coastal lowland. The coastal plain encompasses alluvium deposits, as well as lagoons and sand dunes.

Quaternary sediments are associated with a great variety of soils. The extensive alluvium sediments are associated with clay and fluvial soils. Sediments of lagoons support saline and/or hydromorphic soils. Dune sands have weakly developed shallow and sandy soils. Calcareous reliefs (limestones)
with relatively gentle slopes form calcareic and chromic soils. Siliceous reliefs (sandstones and claystones) are associated with poorly developed soils, and with sandy soils when Bundsandstein facie occur. Calcareous sediments in the hilly country support gravelly and calcareous soils.

Potential climatic vegetation belongs to Querceta ilicis class (Costa). Three broad vegetation types are recognised. The predominant vegetation type is sclerophyll brushwood pine trees. The second broad category is scrub combined with transitional communities. The third broad category is pasture associated with transitional communities. Non-climatic vegetation comprises sequences of communities which occupy characteristic habitats of distinct local environmental conditions such as lagoons and coastal sand dunes.

There are three primary land uses in the study area: agriculture, forestry and industrial-urban uses. Irrigation crops are the most broad land use in the coastal zone, where an intensive and technified agriculture of citrus take place. Dry land uses occur inland even on quite steep slopes with soils subject to erosion. Apart from towns, industrial-urban uses are mainly found along the coast line, where residential and tourism blocks have increased quickly in recent years. Residential cottages are also found in the hilly and mountainous country. Forestry is an extensive and minor inland activity.

All of these land uses are in conflict with soil conservation. Erosion of soils in the coastal zone is being affected by irrigation crops and industrial-urban uses. However, erosion of forest soils, which occur on steeper slopes than coastal soils, is being more substantially affected by both the broadening of dry land uses and uncontrolled forestry activities. Fires have also affected intensively erosion of forest soils. Furthermore, in recent years residential urban uses have become an additional threat to erosion of forest soils.

A base map on a scale of 1:25.000 corresponding to the study area has been used (Figure 2) to carry out the study of soil erosion. The map was prepared by the Diputación Provincial de Valencia, Universitat de València & Consejo Superior de Investigaciones Científicas. This base map was divided in a comprehensive non-overlapping set of polygons (hereafter mapping units) using an integrated mapping method (Sánchez et al.).

Data for the assessment of soil erosion in the mapping units of the study area are described and detailed in Recatalá. Specifically, such data were collected and elaborated from several report and map sources.

4 Results

Table 1 shows the percentage of total surface area achieved by each class of both present and potential soil erosion in the study area. The map in Figure 3 shows the distribution of present soil erosion of mapping units in the study area,
Ecosystems and Sustainable Development

Figure 1. Maps showing the situation of the study area.

Figure 2. Base map of the study area.

Legend:
- Boundaries between resources units
- Hydrographic unit
- Towns or villages
- Highway
- Motorway
- Palancas Ayra

Figure 3. Present soil erosion of mapping units in the study area.
and map in Figure 4 shows the distribution of potential soil erosion of mapping units in the study area.

<table>
<thead>
<tr>
<th>Present soil erosion classes</th>
<th>Percentage of the total surface area (%)</th>
<th>Potential soil erosion classes</th>
<th>Percentage of the total surface area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I (Very High)</td>
<td>2.11</td>
<td>Class I (Very High)</td>
<td>6.08</td>
</tr>
<tr>
<td>Class II (High)</td>
<td>10.19</td>
<td>Class II (High)</td>
<td>22.70</td>
</tr>
<tr>
<td>Class III (Moderate)</td>
<td>14.69</td>
<td>Class III (Moderate)</td>
<td>18.46</td>
</tr>
<tr>
<td>Class IV (Low)</td>
<td>13.33</td>
<td>Class IV (Low)</td>
<td>1.78</td>
</tr>
<tr>
<td>Class V (Very Low)</td>
<td>59.68</td>
<td>Class V (Very Low)</td>
<td>50.98</td>
</tr>
</tbody>
</table>

Table 1. Percentage of total surface area achieved by each class of present and potential soil erosion in the study area.

5 Discussion

Soil is of vital importance to the maintenance of a healthy natural environment. The 1972 European Soil Charter (Council of Europe) recognized that any biological, physical or chemical degradation of soil should be of primary concern and that appropriate measures to protect soils should be implemented.

Soil erosion occurs mainly where land is used over-intensively, and the resulting losses are irreversible over time-scales of tens or hundreds years (Blum). From table 1, it can be noticed that mapping units of high or very high present soil erosion represent 12.30% of the total area, and with high or very high potential soil erosion represent 28.78% of the total area in the study area. This indicates the need for a conservative use of soils in the study area.

The results achieved in the study area applying the methodology allow mapping units to be ranked from least to more soil erosion, and also from least to more vulnerable in terms of soil erosion. This information provides a basis for addressing soil conservation by defining guidelines for land use allocation. Specifically, in a land use planning exercise carried out in the study area (Recatala) the following planning guidelines were defined:

1. Exclude agricultural land uses from mapping units of high or very present soil erosion.
2. Exclude industrial-urban uses from mapping units of high or very high present soil erosion.
3. As far as possible to give preference to reforestation or natural regeneration in mapping units of high or very high present soil erosion.
4. As far as possible to avoid agricultural uses in mapping units of high or very high potential soil erosion.
Figure 4. Potential soil erosion of mapping units in the study area.
5. As far as possible to avoid industrial-urban uses in mapping units of high or very high potential soil erosion.
6. As far as possible to give preference to reforestation and natural regeneration in mapping units of high or very high potential soil erosion.

The application of these planning guidelines allowed the generation of several alternative land use plans addressing the issue of soil erosion in the study area, making compatible the land use allocation with the conservation of soil. A detailed description of the planning exercise in the study area can be found in Recatalá.

6 References


530 Ecosystems and Sustainable Development


