FROM LOCAL CLASSIFICATION TO REGIONAL ZONING – THE USE OF A GEOGRAPHIC INFORMATION SYSTEM (GIS) IN FRANCONIA / GERMANY. - PART 3: CLASSIFICATION OF SOIL PARAMETERS IN VINEYARDS.

DE LA CLASSIFICATION LOCALE AU ZONAGE REGIONAL - UTILISATION D'UN SYSTÉME D'INFORMATION GÉOGRAPHIQUE (SIG) EN FRANCONIE / ALLEMAGNE. - PARTIE 3: CLASSIFICATION DES PARAMETRES DU SOL DANS DES VIGNOBLES.

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ABSTRACT

The conservation of soil fertility is the first objective in sustainable viticulture. Various parameters as e.g. slope and exposition of vineyards, soil composition, climatic conditions (precipitation), etc. influence the soil fertility of vineyard sites. Considering these parameters, new computer software such as a GIS enables the digital compilation of information on soil and climate. GIS-mapping allows the analysis of complex correlations, creation of local classifications and the establishment of a regional zoning. The synoptical compilation of information by a GIS improves the research and simplifies vineyard management.

About 20 % of the Franconian vineyards are planted on steep slopes. Here, soil conservation is important to preserve soil fertility. Many local soil parameters as type, composition and rock content, thickness of the soil horizon, type of soil covering, etc. are recorded in the GIS. Subsequently, a regional zoning of soil types and groups can be created with help of the GIS.

Besides that, slope, orientation, length and shape of vineyards are determined by a three-dimensional terrain modelling with the GIS. Connected with precipitation data, this enables the generation of local and regional erosion risk maps of viticultural regions. Soil and topographic parameters combined with other data recorded in the GIS, e.g. information on precipitation, type of vineyard (productive/new) and vegetation, allow a quantitative estimation of the average soil erosion per year within vineyards by using the erosion model PC-ABAG (equivalent to the USLE = *Universal Soil Loss Equation*). Thus, the erosion risk potential of steep slopes can be classified regionally with the help of GIS-generated erosion risk maps and the local quantitative estimation of soil erosion within individual vineyards. This allows planning of erosion protection measures. Therefore, the viticultural GIS is an

excellent aid to researchers and consultants, grape producers and wine growing estates for recording, analysing and assessing soil parameters and erosion risk in vineyards.

RESUME

La conservation de la fertilité du sol est un aspect primordial dans la viticulture durable. Différents paramètres, comme par exemple la topographie, la composition du sol, les conditions climatiques, influencent la fertilité du sol des surfaces viticoles. En ce qui concerne ces paramètres, de nouvelles technologies, telle qu'un SIG, permettent de réunir digitalement les informations sur le sol et le climat. Une représentation cartographique sur un SIG permet l'analyse de contextes complexes, une classification locale et la détermination d'un zonage régional. L'ensemble de ces informations améliore la recherche et simplifie la gestion des surfaces viticoles. Environ 20 % des surfaces viticoles franconiennes se situent sur des pentes escarpées. Ici, la protection du sol est essentielle à la conservation de sa fertilité. De nombreux paramètre du sol, comme sa texture, sa composition, sa teneur en éléments grossiers, l'épaisseur des horizons, le type du paillage, sont saisis dans le SIG. Ensuite, un zonage régional peut être effectué grâce à des types et des groupes de sol permettant par exemple des évaluations régionales de la capacité de stockage de l'eau. L'inclination, l'exposition, la longueur et la forme des surfaces viticoles ainsi que la direction d'écoulement des eaux de surface peuvent être déterminés par une modélisation de terrain en trois dimensions. Combinant les données pluviométriques ce système d'information permet la création de cartes régionales et locales sur le danger d'érosion dans les régions viticoles. Grâce aux paramètres du sol et autres données saisies dans le SIG, comme par exemple les informations sur les précipitations ou la végétation, il est possible d'évaluer quantitativement le déblayage annuel sur les terroirs utilisant le modèle d'érosion PC-ABAG (équivalent de l'USLE = *Universal Soil Loss Equation*). Grâce à cela on peut classifier le potentiel érosif sur des pentes escarpées à l'aide de cartes du danger d'érosion générées par le SIG et mener une évaluation quantitative du déblayage dans ces terroirs. Ceci permet une planification des mesures de protection contre l'érosion. Pour cette raison, le SIG en viticulture est un excellent instrument de travail pour les chercheurs et conseillers, et les producteurs de raisins en vue de l'analyse, l'enregistrement et l'évaluation des paramètres du sol et du danger d'érosion dans des surfaces viticoles.

INTRODUCTION

In viticultural research and in vineyard management, many different types of information have to be considered in order to reach optimal grape qualities and to operate economically. New computer technologies such as a Geographic Information System (GIS) enable the compilation of many spatial information on topography, soil, erosion risk, climate, vegetation, etc. Based on digital topographic maps, a GIS allows a synoptical analysis of complex correlations and their representation on maps. This shows a virtual reality and enables wine growers to gain a new perspective of their vineyards. All the influences relevant for a high quality grape production should be analysed for a better analysis and planning of new plantings and for an improvement of vineyard cultivation and quality management.

CAPACITY OF A GIS AND VITICULTURAL APPLICATIONS

Based on digital topographic maps, large data sets of different factors can be detailed recorded and clearly organised in a GIS. Various viticultural relevant aspects are recorded in different 'layers' (themes) which can be combined with each other in many ways, e.g. by an intersection, resulting in a new theme comprising the data of the original themes (for further information see KÖNIGER, SCHWAB & MICHEL in this volume). This can be used for local or regional classifications, e.g. of soil types or climatic conditions, and enables comprehensive analyses of complex relationships and a clearly representation on maps. In addition, elevation, slope, and exposition of specific areas can be determined with a three-dimensional terrain modelling with the GIS.

A main objective is the conservation of soil fertility. The digital compilation and synoptical analysis of local soil parameters can be used for the creation of a regional zoning of soil types. Soil, topographic, and climatic parameters enable a quantitative estimation of soil erosion and the generation of erosion risk maps.

The climatic valuation of vineyards has a high importance for the cultivation of grape varieties with different ripeness development. A GIS helps to determine a climatic classification and to establish a regional climatic zoning. This can be used for cultivation planning, determination of ripeness zones and a climatic valuation of vineyard areas (for further information see MICHEL, SCHWAB & KÖNIGER in this volume).

The GIS data further deliver information for fields like vine protection, water conservation, selection of suitable grape varieties and rootstocks, determination of the green cover capacity of soils, irrigation planning, yield and quality recording, etc. In addition, a GIS is also helpful in the viticultural and operational administration of viticultural regions (for further information see KÖNIGER, SCHWAB & MICHEL in this volume).

GIS APPLICATION IN FRANCONIA

The conservation of soil fertility is the first objective in sustainable viticulture. About 20 % of the Franconian vineyards are planted at steep slopes. Here, soil conservation is important to preserve soil fertility, which is influenced by various parameters as e.g. slope and exposition of vineyards, soil composition, and climatic conditions (precipitation). Thus, a main objective of the GIS application in Franconia is the recording and analysis of local data sets as soil and topographic parameters as well as climatic conditions to work out local and regional soil classifications and erosion risk valuations of vineyard sites.

Based on field mappings, many local soil parameters as type, composition and rock content, thickness of the soil horizon, type of soil covering, degree of surface covering with stones, direction of cultivation, etc. are digitally recorded in the GIS (Fig. 1). Subsequently, a regional zoning of soil types and groups can be created with help of the GIS, allowing e.g. analyses of the green cover capacity of soils in regard to their water-retarding capacity, which may also serve for irrigation planning.

Another main objective is the combination of topographic factors and modelled climatic data to create a regional climatic classification for the entire viticultural region of Franconia (for further information see MICHEL, SCHWAB & KÖNIGER in this volume).

CREATION OF EROSION RISK MAPS

Based on topographic altitude information (contour lines), slope, orientation, and erosive length of agricultural areas are determined locally by a three-dimensional terrain modelling with the GIS. This enables the creation of individual themes for each topographic factor. Depending on their differing influence on the soil erosion, e.g. the slope degree has the highest influence, each theme gets different valuation points. Connected with precipitation data, all themes are intersected with each other in the GIS to generate a new theme (Fig. 2). According to the total amount of valuation points from the individual themes, specific areas are classified into four erosion risk classes (low, medium, high, very high) within the new erosion risk theme which than enables the generation of local and regional erosion risk maps of vineyard sites with the GIS (Fig. 2).

QUANTIFICATION OF SOIL EROSION

Different soils have a different erodibility but especially individual strong rainfall events in summer often cause an increased soil erosion. To determine the endangering potential of soil erosion in vineyards, many factors have to be considered (Fig. 1): geology (source rocks); type, composition, and rock content of soils; depth of weathered zone; slope, orientation, length, and shape of vineyards; type of ground covering; degree of stone covering; precipitation; direction of soil cultivation; type of vineyard (productive/new); draining height of rainwater in the leaf-wall; drainage area and flow-off direction of surface water. These factors comprise numerous information, which can be best administrated with a GIS, enabling analyses of complex interdependences of large data sets. Some aspects like slope and orientation can be determined by a three-dimensional terrain modelling with the GIS.

An estimation and prognosis of the potential soil erosion is useful. The *Allgemeine Bodenabtragsgleichung* ABAG (the German version of the USLE = *Universal Soil Loss Equation* of WISCHMEIER & SMITH 1978) is a suitable instrument for an approximate quantification of soil erosion. Soil and topographic parameters combined with other data recorded in the GIS, e.g. information on precipitation, type of vineyard (productive/new) and vegetation, allow a quantitative estimation of soil erosion per year within individual vineyards by using the computer-based erosion model PC-ABAG 2.0, a modified version of PC-ABAG (AUERSWALD & PERGER 1998), was used for the viticultural application due to viticultural relevant modifications (AUERSWALD & SCHWAB 1999).

Due to software restrictions, only an approximate average annual amount of soil loss can be calculated with PC-ABAG, soil erosion caused by individual strong rainfall events cannot be determined. However, such calculations can be used to prognosticate potential amounts of soil loss in vineyards depending on the depth of the weathered zone, precipitation, type of soil, stone covering, slope/length/shape of vineyard, type of vineyard (productive/new), ground covering (e.g. open soil, grass/bark/straw mulch, natural permanent/temporary green cover), and direction of soil cultivation (KÖNIGER & SCHWAB 2000, 2001). Based on these

factors, approximate *actual annual soil erosion amounts* compared to a *tolerable annual soil erosion* are determined and can be illustrated in diagrams (Fig. 3). Here, the influence of different types of ground covering is clearly visible, allowing a simulation of the terroir-specific soil protection.

CONCLUSION

Based on recorded and modelled local information, a combination of GIS and PC-ABAG provides the basis for analysis and valuation of soil erosion in vineyards. This enables the local quantitative estimation of the average annual soil erosion within individual vineyards and the generation of regional erosion risk maps especially for steep vineyards. Furthermore, both programs together enable a simulation of the impact of protective measures against soil erosion, e.g. the construction of erosion-obstructive retaining walls or a change of the surface covering in vineyards (e.g. with bark or straw mulch). This helps in the planning of erosion protection measures. In addition, information on hill creeping and solifluction in vineyards are also considered. All the GIS data contribute to an improved soil conservation, which is an important aspect because loss of valuable soil either represents a depreciation of vineyards or eroded material has to be re-transported at high costs.

This contributes to a GIS-based viticultural information system (SCHWAB & KÖNIGER 1999; PFEIFFER & KUBIAK 2000) which enables wine growers to gain a new perspective of their vineyards for a better analysis and planning of new plantings and for an improvement of their vineyard cultivation. Therefore, the viticultural GIS is an excellent tool for viticultural extension services and consultants, grape producers and wine growing estates for recording, analysing and judging viticultural relevant factors in vineyards in regard to determined local and regional zones, e.g. soil types, erosion risk valuation, and climatic classifications. The GIS application can contribute considerably to improve and optimise the vineyard management and economy.

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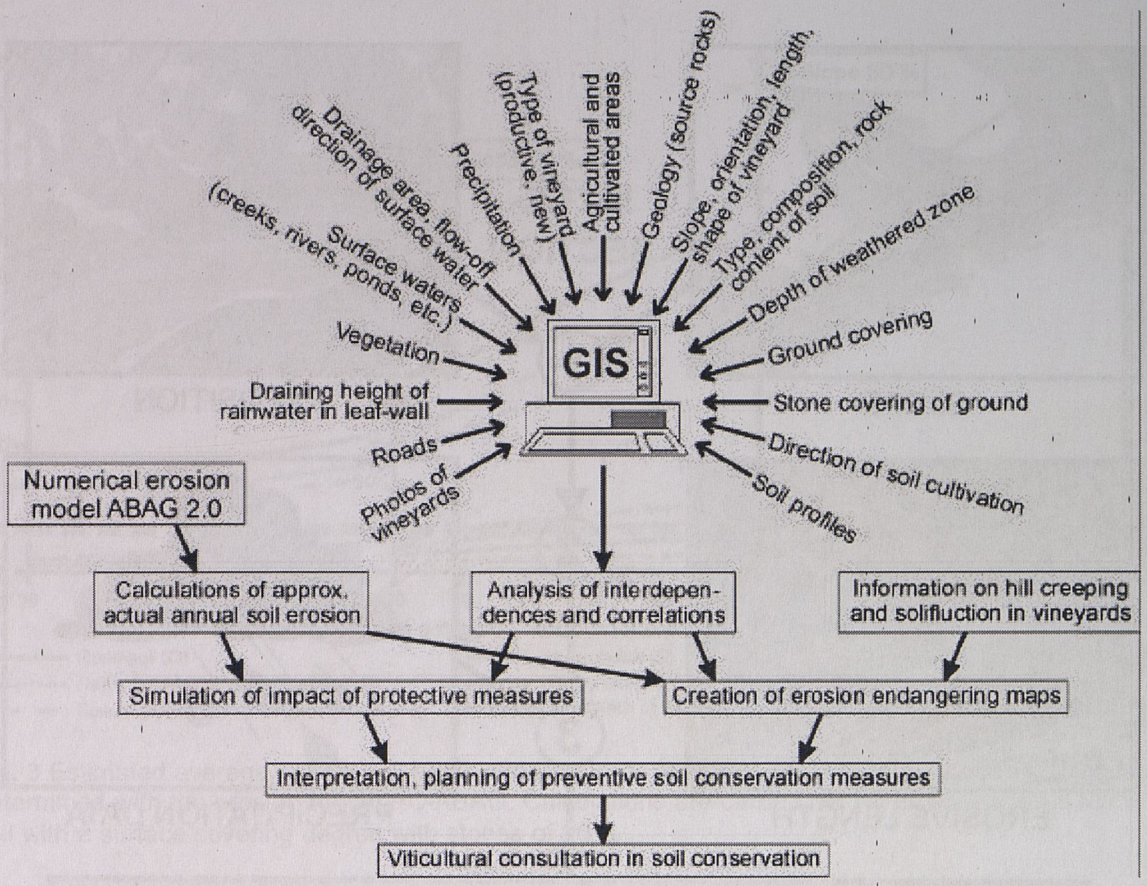

Fig. 1 Relevant aspects for the GIS application concerning soil conservation in vineyards.

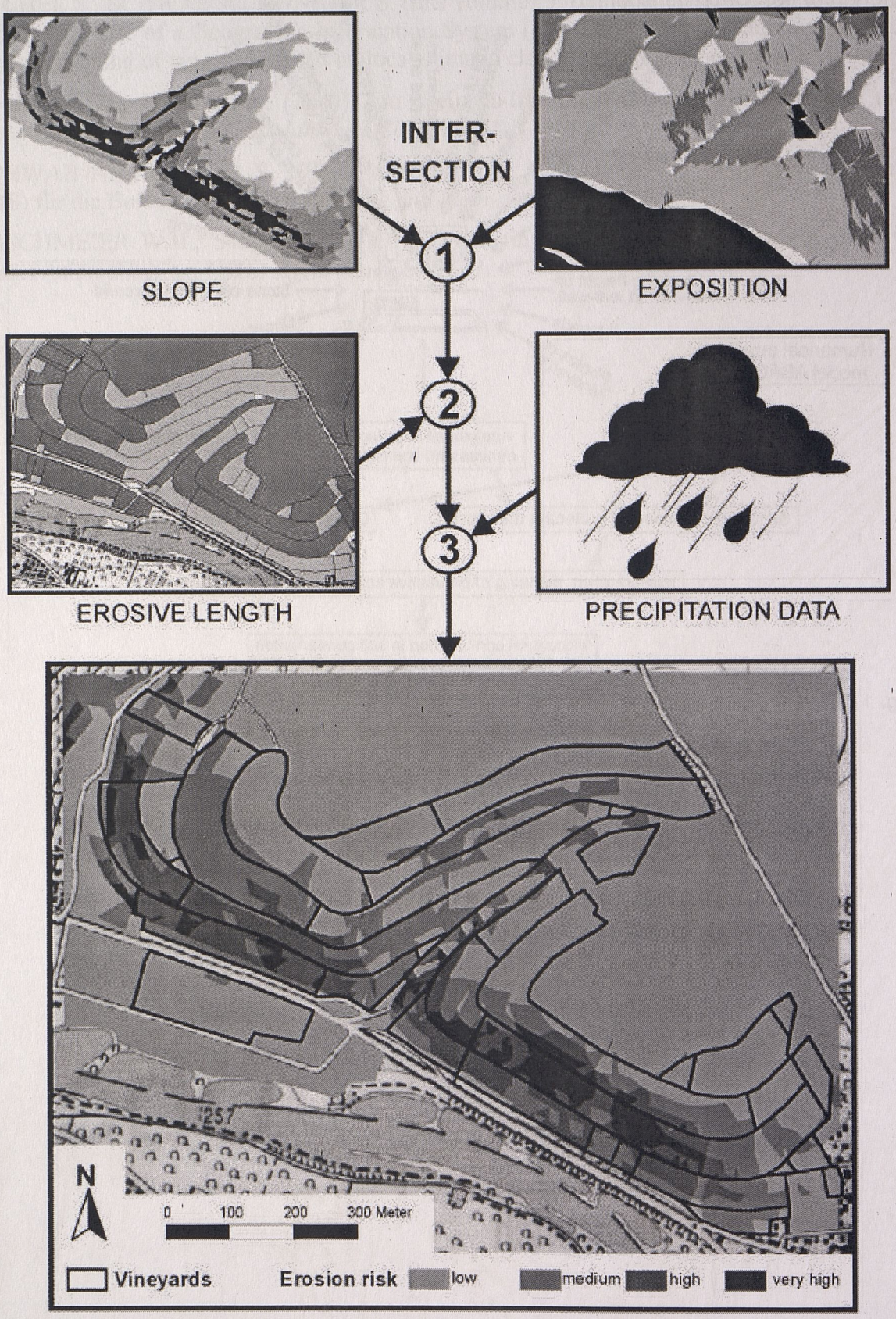

Fig. 2 Example for the generation of an erosion risk map by intersections of individual themes with a GIS.

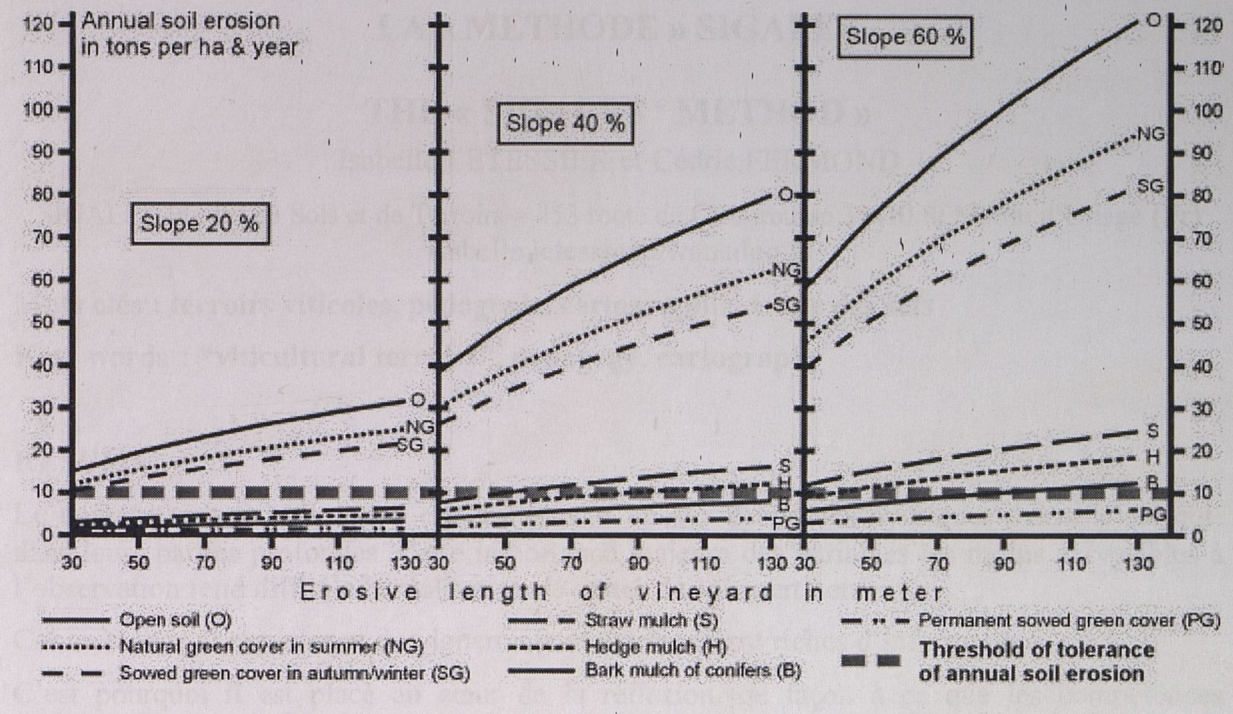

Fig. 3 Estimated average annual soil erosion in vineyards in the region of Würzburg (Germany) determined with the erosion model PC-ABAG. Calculations are carried out for an argillaceous loam soil with a surface covering degree with stones of 20 %.