FROM LOCAL CLASSIFICATION TO REGIONAL ZONING – THE USE OF A GEOGRAPHIC INFORMATION SYSTEM (GIS) IN FRANCONIA / GERMANY. - PART 1: SPECIFIC GIS APPLICATIONS IN VITICULTURE.

DE LA CLASSIFICATION LOCALE AU ZONAGE REGIONAL - UTILISATION D'UN SYSTÉME D'INFORMATION GÉOGRAPHIQUE (SIG) EN FRANCONIE / ALLEMAGNE. - PARTIE 1: UTILISATIONS SPECIALES DU SIG DANS LA VITICULTURE.

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ABSTRACT

For an economically production of optimal grape quality, the knowledge of different types of information is important. New computer software such as a GIS enables the compilation of information on topography, soil, erosion risk, climate, vegetation, infrastructure, and the occurrences of pests and diseases. Based on digital topographic maps, a GIS allows a synoptical analysis of complex correlations and their representation on maps. Based on a three-dimensional terrain modelling with the GIS, recorded data sets and their local classification can be used to establish a regional zoning of viticultural relevant factors as e.g. favourable climatic zones combined with best soil conditions. The GIS data deliver information for fields like soil and water conservation, climatic classification, vine protection, selection of suitable grape varieties and rootstocks, green cover capacity, irrigation planning, yield and quality recording, etc. Main objectives of the GIS application in Franconia are the recording and analysis of local data sets as soil parameters, erosion risk and climatic conditions in vineyard sites. With help of the GIS, these local information enables the creation of a regional zoning of the respective data set, e.g. the generation of regional erosion risk maps or the definition of regional climatic zones. The 3D-terrain modelling allows the determination of flow-off paths of cold air and 'mapping' of frost endangered areas like depressions and valleys. Therefore, the viticultural GIS is an excellent aid to researchers and consultants, grape producers and wine growing estates for recording, analysing and assessing viticultural relevant factors in vineyards. This enables a new perspective of vineyards for a better planning of new plantings and also for an improvement of the vineyard management.

RESUME

En vue d'une production économique de qualités des raisins optimales une connaissance des informations les plus différentes est importante. Les nouvelles technologies, telles qu'un SIG, permettent de réunir les informations sur le terrain, la nature du sol, le danger d'érosion, le climat, la végétation, l'hydrographie, l'apparition de nuisible et de maladies, etc. Sur la base de cartes topographiques un SIG permet une vaste analyse, une appréciation des rapports complexes ainsi qu'une représentation cartographique. Sur la base de modélisations en trois dimensions du terrain avec le SIG, les ensembles de données saisies ainsi que leur classification au niveau local peuvent être utilisés dans la production de zonages régionaux. Les données du SIG délivrent des informations liées à la protection du sol et de l'eau, la classification climatique, la protection de la vigne, la possibilité d'enherbement, la planification d'irrigation, etc. Les aspects principaux de l'utilisation du SIG en Franconie sont l'enregistrement et l'analyse des données locales, comme les paramètres du sol, le risque d'érosion et les conditions climatique, dans le but d'élaborer des classifications locales des zones à appellation communale et des petits terroirs. A l'aide du SIG, ces classifications locales permettent la création de zonages régionaux, comme par exemple la formation de cartes régionales du risque d'érosion ou la définition de zones de climat local. La modélisation du terrain en trois dimensions permet de déterminer les couloirs d'écoulement de l'air froid et la modélisation des régions soumises au risque de gel, comme les creux et les vallées. Pour cette raison, le SIG en viticulture est un excellent instrument de travail dans la recherche et la consultation viticole ainsi que pour les producteurs de raisins et des domaines viticoles afin d'enregistrer, d'analyser et d'évaluer les influences que des zones régionales déterminées ont à subir. Ainsi le SIG montre aux vignerons leurs surfaces viticoles sous une perspective permettant de mieux analyser le milieu.

INTRODUCTION

In viticultural research and extension 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, infrastructure, hydrology, the occurrences of pests and diseases, etc. (Fig. 1). Based on digital topographic maps, these data sets are detailed and clearly recorded and organised. Present-day aerial photographs and satellite imagery may complement this information. All the influences relevant for a high quality grape production should be analysed in order to reach the best starting conditions for new vineyards. 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 for a better analysis and planning of new plantings and also for an improvement of their vineyard cultivation and quality management (PFEIFFER 1999).

CAPACITY OF A GIS

Based on digital topographic maps or geographic co-ordinates, large data sets of various viticultural relevant factors can be detailed recorded and clearly organised in a computer-based GIS software. These digital data sets represent the basic item of a GIS and can be easily read back at the computer. Various aspects that are relevant for viticulture, as e.g. topography, vineyards, waters, roads, geological units, soil types, or climatic conditions, are recorded in the GIS in different themes which are arranged in 'layers' one upon the other (Fig. 2). Each

theme is divided into geometric data, defining the spatial position of objects (e.g. vineyards) on a map, and accompanying attribute data, comprising descriptions of objects (e.g. grape variety or soil type of a specific vineyard) in a table (Fig. 3). The different types of information can be graphically illustrated on the PC-screen in different windows of the GIS software (e.g. in the view or table window; Fig. 3) which allows a simplified data processing. Data sets of objects from different themes can be combined with each other in many ways, e.g. by an intersection. Such a combination results in a new theme and an accompanying attribute table with all the describing data of the two (or more) original themes (Fig. 2). This can be used for local analyses or regional classifications of specific aspects like soil types or climatic conditions which enables comprehensive analyses of complex relationships and a clearly representation on maps. In addition, recorded data as e.g. climatic diagrams (Fig. 3), photographs of vineyards, soil profiles, present-day aerial photographs, satellite imagery, etc. can be read back at the computer for further information.

On the basis of topographic height information (contour lines), the GIS enables a three-dimensional terrain modelling to determine elevation, slope, and exposition of specific areas as well as run-off patterns of surface waters. Furthermore, flow-off paths of cold air and 'mapping' of frost endangered areas like depressions and valleys can be modelled.

FIELDS OF VITICULTURAL GIS APPLICATIONS

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. The digital compilation and synoptical analysis of local soil parameters can be used for the creation of a regional zoning of soil types. 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 erosion model PC-ABAG (a German software version of the USLE = *Universal Soil Loss Equation*) (KÖNIGER & SCHWAB 2000, 2001).

Three-dimensional terrain modelling with the GIS enables the determination of slope, exposition, length and shape of vineyards. A combination of these topographic factors and precipitation data allows a local classification into erosion risk groups and subsequently the generation of regional erosion risk maps of viticultural regions (for further information see SCHWAB, KÖNIGER & MICHEL in this volume).

Due to local variations of slope and exposition, the climatic valuation of vineyards and viticultural regions in northern regions has a high importance for the cultivation of grape varieties with different ripeness development. Many different informations have to be compiled and analysed to work out the optimal locations of grape varieties within specific areas. A GIS helps to determine a climatic classification of vineyards and allows to establish a regional climatic zoning. Thus, an excellent aid for climatic analyses can be created and can be used by researches and consultants 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 combination of topographic factors, recorded information (e.g. soil types), and modelled data sets (e.g. direct radiation) and their local classification within the GIS can be used to establish a regional zoning of viticultural relevant factors as e.g. favourable climatic zones for late ripening varieties or zones with best soil conditions (e.g. high water-retarding capacity).

The GIS data further deliver information for fields like vine protection (Fig. 1). A combination of the recorded occurrence of pests and diseases with climatic factors may show spatial relationships which can result in a restriction or reduction of plant-protective agents within specific areas. Erosion protective measures based on three-dimensional terrain modelling contribute to water conservation because of the reduction of eutrophication in waters due to a decrease of nutrients transported out of vineyards into waters. GIS analyses help in the selection of suitable grape varieties and rootstocks, determination of the green cover capacity of soils, irrigation planning, yield and quality recording, etc. A combination of GIS and GPS (Global Positional System) can help in the exploration of the viticultural potential of specific regions (BOYER & WOLF 2000). Various local factors as e.g. average annual precipitation, soil type and structure, rock content, thickness of the soil horizon, and humus content in the top soil layer can be recorded and individually valued in the GIS which allows a general valuation of local conditions in vineyards (HÖRNER & KUBIAK 2001). A combination of these factors ('layers') in the GIS results in a classification enabling the determination of the optimal soil cultivation system of a specific vineyard management (KÖNIGER, SCHWAB & MICHEL 2002), e.g. a full cover permanent green cover or the tillage of a green cover in every second row.

A combination of GIS and GPS also enables a large-scale farming using GPS-supported agricultural production methods and an exact geographic localization of factors in vineyards that influence the growth of vines, e.g the local occurrence of diseases. In addition, a GIS is also helpful in the viticultural and operational administration by the incorporation of digital areas from the agricultural land register into the GIS.

GIS APPLICATION IN FRANCONIA

Main objectives of the GIS application in Franconia with the GIS software ArcView are the recording and analysis of local data sets as soil parameters, erosion risk, and climatic conditions to work out respective local classifications and valuations of vineyard sites and zones. With help of the GIS, these local information enables the creation of a regional zoning of the respective data set. The erosion risk potential of vineyard sites with 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 (see SCHWAB, KÖNIGER & MICHEL in this volume). The combination of topographic factors and modelled climatic data enables the creation of a regional climatic classification for the entire viticultural region of Franconia (see MICHEL, SCHWAB & KÖNIGER in this volume). The three-dimensional terrain modelling with the GIS allows the determination of flow-off paths of cold air and 'mapping' of frost endangered areas like depressions and valleys.

CONCLUSION

All the influences relevant for a high quality grape production should be analysed in order to reach the best starting conditions for new or replanted vineyards. Data of viticultural relevant factors are often connected with geographic and spatial information. Based on recorded local information, a GIS allows a synoptical analysis of large data sets and complex relationships, the establishment of a regional zoning of the respective data set, and a detailed representation on maps. Thus, a viticultural information system can be constructed based on a GIS (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 also 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 generated local and regional zones. The GIS application can contribute considerably to improve and optimise the vineyard management and economy.

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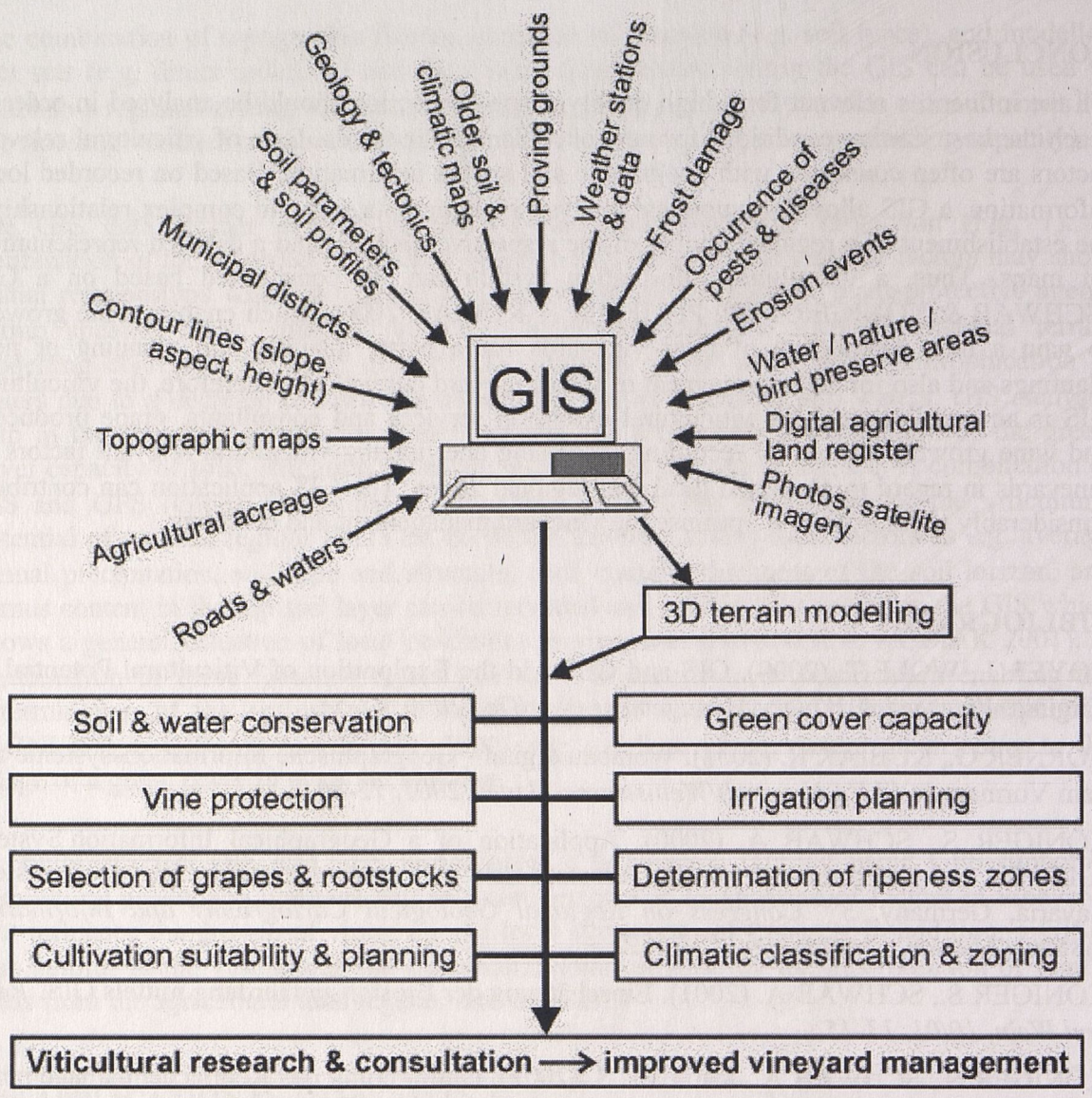

Fig. 1 Improved viticultural research and vineyard management based on GIS: Recorded aspects (themes) and fields of application.

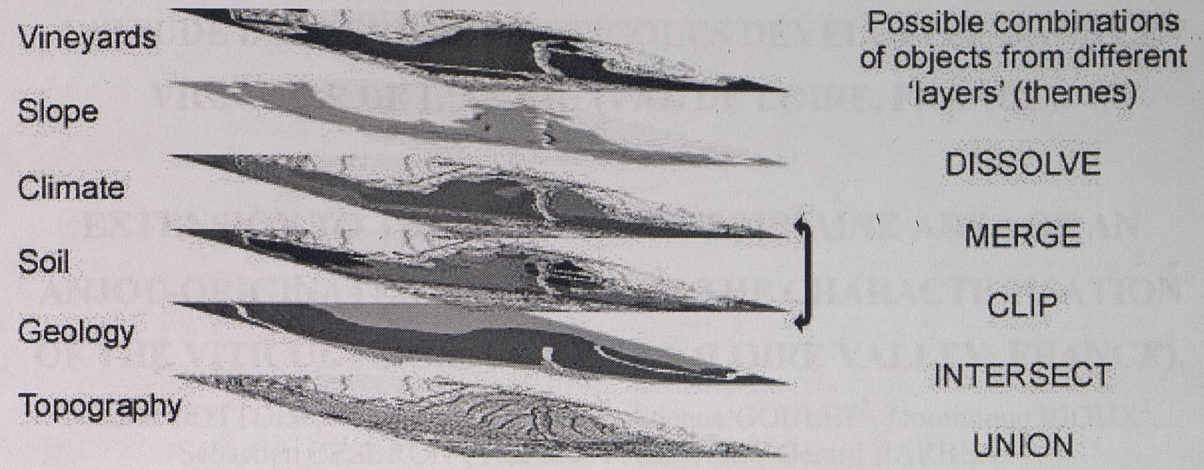

Fig. 2 Schematic data structure of a GIS with several thematic 'layers' (themes) arranged one upon the other (left side). Data sets of objects from different themes can be combined with each other in many ways (right side).

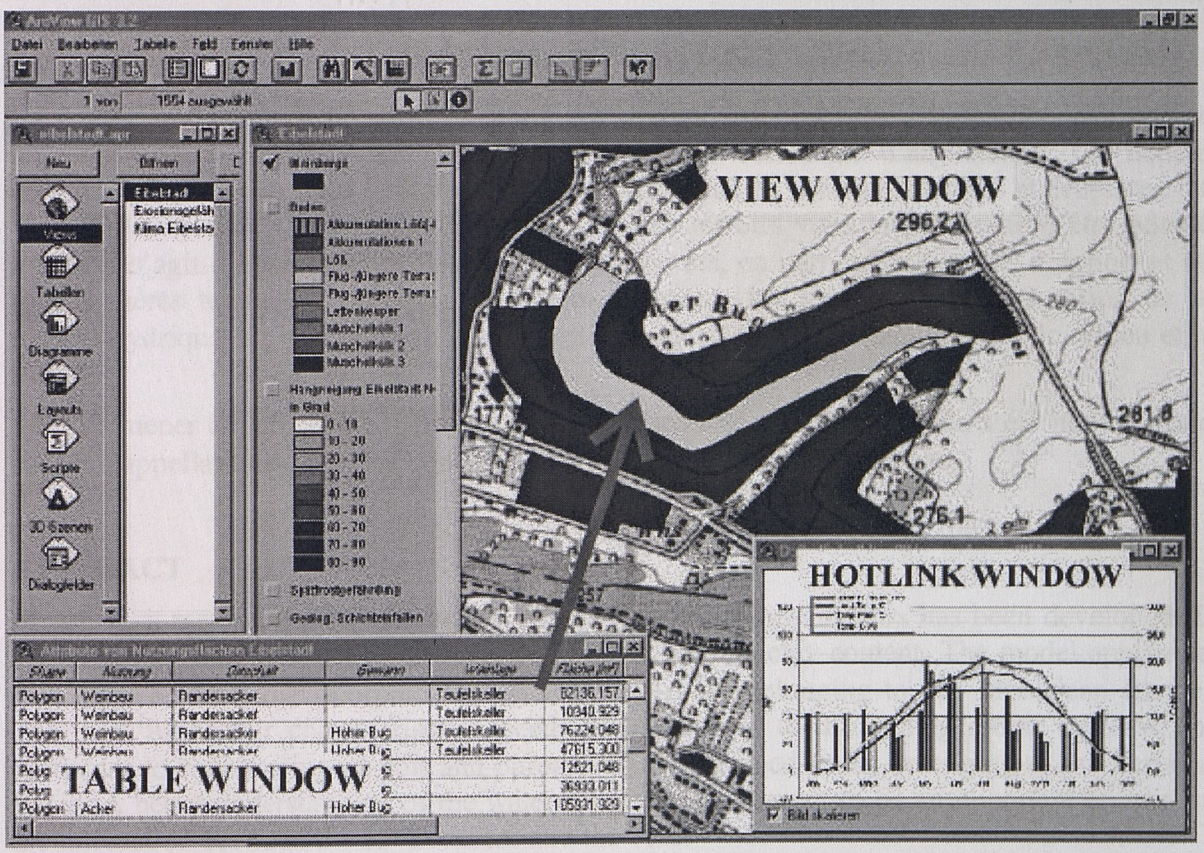

Fig. 3 Exemplary screenshot of a viticultural project in the GIS software ArcView showing spatial positions of objects (e.g. vineyards) in the 'view window', accompanying attribute data (e.g. size or site name) in the 'table window', and additional graphical information (e.g. climatic conditions) in the 'hotlink window'.