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INVESTIGATION OF AGROGENIC LANDFORMS AND PROCESSES ON GEOMORPHOLOGICALLY DIFFERENT AREAS

Theses of Dissertation

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1. Introduction, aims

Agricultural activities with their millennial history, widespread extension and various methods had already induced (and currently are being induced) intense and serious changes in natural environment. The research of agrogenic processes in Hungary has a greater importance since agricultural areas have a major portion of the country.

Agrogenic landforms and processes are various and their development depends on several factors. Natural environment has the most significance as topography, soil properties climate (etc.) can as well defines the selection of agricultural sectors and techniques as the intensity and speed of agriculture derived processes. Different agricultural activities result different landforms and processes, therefore investigation of them cannot be performed by one unified method.

Among the studied landforms and processes there are exceptions as some of the landforms are not clearly agrogenic (bank-in roads, drainage canals). The development of these forms can be related to transportation and flood regulation works, nevertheless role of agriculture in these processes is certain (since they are service activities), hence study of these forms is necessary.

In my opinion, description and classification of agrogenic landforms and processes had been limited by the scientific advancements of contemporary eras. Nowadays classification of agrogenic landforms is well detailed, and the method of their development is also known. However rate of development and surface processes modified by micro-topography has not been investigated and quantified due to the lack of suitable methods. While in the 19-20th centuries only phenomena visible or measurable with handheld devices had been studied, to the end of the 20th century, the scientific advancements allow us to study previously unstudied or unknown landforms and processes. Good examples are the devices used to measure surface topography (totalstation, LIDAR sensor), that can measure surface differences with an accuracy of centimetres – which are especially characteristic of agricultural surface development. OSL dating can be also be referred as modern method, which – compared to ^{14}C methods – can be used to determine age of sand layers regardless the content of organic material. Spread of GIS applications is also a great progress, enabling the rapid process of – previously inconceivable amount of – data.

The aim of my dissertation is to determine the morphometric parameters of landforms and the rate of semi-anthropogenic processes created by three different agricultural activities (grazing, ploughing and viticulture), and their service activities (drainage and transportation). The different agricultural activities (grazing, ploughing, and viticulture) are usually occurs at areas with different geomorphology. Approaching from different activities, I was looking for the answers to the following questions:

Effect of grazing on the Bugac-sand region:

1. When and to what condition had the movement of sand started, and how the rate of accumulation changes over the morphologically different areas?
2. Could the movements of sand be related to human impact based on archaeological evidences?
3. How the pre-human surface looked like, and what geomorphologic changes had occurred due to the sand movements?

Ploughing over the floodplain of Tisza river:

1. What changes occur due to ploughing, and what are the morphometric characteristics of these landforms?
2. What are the morphometric parameters of ridges developed along drainage and irrigation canals?
3. How the microforms had modified the surface runoff, how large areas could have become a closed basin?

Effect of viticulture in the Hills of Szekszárd:

1. Could the morphometric characteristics (net volume, gradient) of tributary valleys be related to viticulture taking place since historic times?
2. What impacts can follow the land use changes in the area?
3. What is the rate of surface degradation along the bank-in roads, what is the amount of net eroded material, and what is the trend of the recent changes?
4. What is the current rate of soil erosion, and can the increase be related to the modification of surface runoff?
5. How much material have been excavated during the formation of agricultural terraces, what kind of micro-topography has been evolved over the terraces, and what processes can be related to it?

Summarizing, my aim is to compare how the different agricultural activities changes the surface, and these changes how affects processes (such as runoff). Finally temporality of surface changes can be compared referring the surface modifying impacts of societies. However I also want to determine the most suitable research methods for each process.

2. Methods

The agricultural activities require areas with different geographic conditions, thus research of activities stated before can only be performed on areas with different geomorphic conditions. The studied processes had developed by (over)grazing, lowland ploughing and viticulture, had started in different eras, has had a longer influence and has been producing diverse various landforms. Since these activities require different geomorphologic conditions, investigation had to be performed over three different study areas. Effects of overgrazing were examined near the town of Bugac (Danube-Tisza interfluve) on a dune field elevated from the former flood plain of River Tisza. The impacts of ploughing (and creation of canals as their service activities) were studied on the former flood plains of River Tisza. Terrace cultivation of vineries and their effects were studied on three catchments of the Szekszárd Hills.

Investigation of different effects of activities could have not been performed with one unified method. Though exploration of topographic conditions was a primary objective during my research – and the measurements have been preceded by the analysis of DEM of the study areas in all cases – the different morphology of landforms has made essential the widening of methods.

2.1. Investigation of effects of grazing

A DEM of the vicinity of the excavation site near Bugac (4.4 km^2) has been created with ArcMap by using contour lines of topographic maps (1:10000). After the identification of landforms I have created the geomorphologic map of the study area, which allowed me to measure the size and location of landforms. Along the excavation site, measurements with total station to acquire more detailed surface data were necessary.

For evaluating the geomorphic responses of the sand region to anthropogenic impacts, long profile of the sand layers along the excavation site have been surveyed by photography. The blown sand layers and paleosoils have been separated on the photos by their colour. Geomorhologically different sections of the long profile have been separated by the different topography of surface and sand layer parameters.

OSL samples were taken from 3 sampling sites along the excavation site, where 7-10 samples were collected depending on the number and thickness of the sand layers. The stratigraphic order and age of the blown sand and paleosoil layers were compared to archaeological results. By the order, extension and age of sand layers, the paleoenvironmental reconstruction of the study area has been made.

2.2. Investigation of the effects of lowland ploughing

As investigation of lowland surface alteration, the effects of ploughing and canal excavations were measured (e.g. parameters, location or orientation of microforms). The earlier studies near Mindszent (0.1 km^2) being taken place between 2007 and 2009 had required field elevation measurements (by total station), since detailed surface data was not available from this area. During the later studies a high resolution DDM (77 km^2) was available (Szatmári et al 2011), thus additional field measurements and data processing were not needed.

During the measurements of morphometric parameters of microforms, the height and width parameters were determined by terrain fractures (break lines of the surface). Topographic character of plough ridges have been measured over 6 hectare plot-parts (300*200 m), while parameters of canal ridges have been examined along 37.6 km long canal sections. Beyond the morphometric parameters, 30 undisturbed soil samples were taken to prove the water retention impact of the microforms, measuring the hydraulic conductivity. Sampling sites were selected along canal ridges, and 40-50 m further off the canals. Hydraulic conductivity has been measured by Eijkelkamp soil conductivity meter, by decreasing pressure conditions. Extension and location of areas without drainage outlet were compared with the situation and parameters of plough- and canal ridges and inundations visible on satellite images, thereby runoff preventing effect of microforms could be determined and quantified.

2.3. Investigation of the effects of viticulture

Measurements of the location of the vineries before the 19th century are only applicable from literature data. From the 19th century maps of the area are being available to more detailed study the location of vineries and land use changes. For performing the map based measurements the maps of the I., II. and III. Military survey (scale = 1:28800, 1:25000), cadastral maps from the 1860s (scale = 1:2880), topographic maps from 1970 and 1988 (scale = 1:10000), and Quickbird satellite images from 2007 (resolution ~ 0.6 m) were applied.

Different scale of measurements was used during the research. Investigation of parameters of tributary valleys (14.8 km^2) were performed with smaller scale (1:10000), while morphometric analysis of terrace surfaces (0.35 km^2) and modelling were executed in a larger scale, based on the data achieved by RTK GPS. Resulted data of field surveys were processed with ArcGIS and MS excel software.

Morphometric measurements were followed by the determination of the (modified) rate of semianthropogenic processes, which are probably main factors in the development of the hill region nowadays (and probably earlier as well). In the author's opinion the most important factors are accelerated soil erosion, which was also estimated over catchment and parcel (terrace surface) scale, and modification of surface runoff due to the microforms developed by cultivation, which can be related to the increase of erosion and appearance of flash floods.

Estimation of soil erosion was performed by the DEMs of catchments and terrace surfaces using the USLE equation developed by Wischmeier and Smith (1978).

Runoff modifying effect of bank-in roads were examined by discharge calculations, simulated on a summer rainfall event occurred in 18th June 2010. In this measurement the changes of discharges and occurrence of flood peaks of streams were estimated by the comparison of runoff on natural and altered surface. The topographically undisturbed (natural) conditions were compared with the actual (altered) conditions, namely that surface is currently dissected by bank-in roads.

Runoff modifying effect of microforms was examined by the comparison of flow accumulation maps derived by the natural surface (without microforms) and the altered surface (dissected by ridges).

3. Results

3.1. Effects of sand movements induced to overgrazing

3.1.1. Orientation and size of sand layers suggests that during the deflation periods sand sheet formation was typical around the archaeological site. Overgrazing can affects only smaller patches (Mezősi and Szatmári 1998), however, more extensive deflation might reactivate the sand dunes on larger areas (Bateman and Godby 2004). Numerous amount and extension of sand sheets over the Bugac study area reflects that deflation had not only modified surface on spot-like patches but on larger areas, however the impact was not that intense to reactivate dune development or dune migration (e.g. Sahel – Tóth 2006). Geomorphology of the study area suggests, that deflation had initiated over the elevated and therefore more arid hummock-fields on the north-eastern part of the area. Accumulation of blown sand had filled the deflation flat of the study area by about 2 meters, halving the relief of the area (from 1.6 m to 0.8 m), thus sand movements reinitiated due to overgrazing (as proven later) primarily resulted in the flattening of the surface. The results also pointed out that aeolian landforms formerly suggested to be residual ridges had been developed by superposition of sand sheets, thus regardless of its elongated shape and parallel situation to wind direction suggested to be accumulated forms. Therefore genetic of landforms cannot properly be determined only by the shape of the sand forms (what was a good practice of former geomorphologic studies).

3.1.2. The oldest sand layers of the profile still had been accumulated in natural conditions. The OSL dating revealed that the oldest sand layer, laying 2.0-2.6 m below surface deposited during the Late Glacial and the Younger Dryas (OSL dates: 14.23±2.38, 13.72±3.03 and 12.73±1.95 ka respectively) periods, and lime mud content suggests that it had been formerly a humid (deeper situated) area. Later pre-historical sand movements occurred during the Preboreal (9.97±1.87, 9.20±1.32, 9.96±3.04 and 10.86±1.47 ka) possibly by changes of climatic conditions. The youngest historical deflation periods (4 events) can be related solely to the anthropogenic effect since sand movements usually occurred when nomad tribes moved into the area (Benyhe et al. 2012). The earliest overgrazing induced deflation occurred during the Bronze Age (4.78±0.70, 4.18±0.78 ka). The next sand movement can be related to the immigration of sarmatian population (1.47±0.34, 1.41±0.31 ka) resulting a 0.3-0.4 m thick, local sand sheet. The 8th century migrations were followed by the third deflation period – possibly induced by herds of Avar tribes (1.15±0.29 ka) – and the accumulation of sand covered the southern part of the excavation site with a 0.6 m thick sand sheet. The last remarkable grazing induced sand movement took place during the settlement of cumanian people (0,86 ±0,16 ka), and filled the southern (higher) part of the area with a 0.5 m thick sand layer. The OSL ages point out that the youngest sand moving period occurred during the late middle age (0.55 ±0,08, 0.54±0,09, and 0.50±0.07 ka respectively), filling up the northern part of the excavation by about 0.6 m.

3.1.3. The OSL ages of the samples highlighted that the entire study area is covered by late Holocene sand layers, and Pleistocene layers can only be found 1.5-2 m below surface, thus recent topography of the studied area mainly developed by Holocene (primarily human induced) aeolian activities. This is contradicting the suggestions of Borsy (1977, 1991) and Lóki (2009) that the landforms of the Danube-Tisza Interfluve mainly developed during the Pleistocene, since nearly all of the examined sand sheets of the Bugac study area had accumulated during the Holocene. The extension of the sand ridge built up by sand sheets (0.4 km^2), reflects that Holocene human induced sand movements had affected larger areas, regardless their short duration.

3.2. Effects of lowland ploughing on former floodplains

3.2.1. Morphometric analysis of plough ridges revealed that these microforms has an average height of 0.09 m and a width of 28 m, while larger forms can be 0.19-0.26 m high and 60-100 m wide (Benyhe and Kiss 2012). The density of the plough ridges is about 35 km/km^2, however on plots with two-way plough directions this can be higher (39 km/km^2). To evaluate the runoff modifying effect of the microforms a parameter was calculated by the division of the height of the landforms with the relief of the corresponding field (height-relief ratio), showing whether the ridges are higher or the profile relief, which has a huge importance in the appearance of inland excess waters. The height of the plough ridges are about 2.5 times higher than the relief of the agricultural plots. As a result, plough ridges with higher (> 1) height-relief ratio can be situated on plots with higher relief (> 200 cm/km), therefore ridges can block runoff, regardless the slope conditions of the area.

3.2.2. The plough ridges can have opposite effect on runoff, since ridges parallel to the slope direction of plots have drainage functions, while ridges perpendicular to slope directions having water retention functions. Plough marks are mainly parallel to slope direction, thus ridges typically have water retention function, however ridges perpendicular to slope direction could have been also determined on 14 % (3.5 km^2) of the studied plots, therefore they can have contribution in the inundation of inland excess waters. Beside this, the 19 % of the studied area have transversal ridge pattern, dissecting the plot into parallelogram-shaped closed units.

3.2.3. Runoff decreasing effect of plough ridges is described by Tóth (2006), in relation to nesting, while excess water forming effect of these microforms was studied by the examination of stripe-shaped pattern of inundations by Patay and Montvajszki (2011). Research related to excess water usually deals with smaller scale (1:10000 – 1:25000) data (Rakonczai et al. 2001, Tóth et al. 2004, Körösparti and Bozán 2010), therefore, importance of agrogenic and hydrotechnogenic microforms was ignored, despite the effects of these microforms (roads, railroads, canals) were visible in the unusual shape of the water patches, even on the smaller scale inundation maps.

3.2.4. Canal-ridges are significantly larger landforms than plough ridges, with an average height of 0.4 m, and a width of 18 m approximately, and can be identified along almost all canal sections (32.1 km – 85 %), thus their water retaining function can be even more significant. Canal ridges has a height-relief ratio of 4.5, thus they are much higher than the natural relief. In most of the cases (28,4 km – 76 %) there are ridges on both sides of the canals (Kiss and Benyhe 2009, Benyhe and Kiss 2012). Canal sections without surrounding canal ridges usually located along natural riverbeds, however they contribute only the 14 % (5.5 km) of the total studied sections.

3.2.5. Diversion of symmetry conditions of canal ridge parameters suggests that these microforms in some cases had suffered subsequent alteration. In the author’s opinion, the symmetry or asymmetry can relate to the purpose of the canal ridges, namely if they are dedicated to have water retention functions (preventing inundations on the plots initiated from the canals), since in this case ridges should have similar parameters on both side of the canals. Symmetric and some semi-symmetric canals have closed beds (regarding to the connectivity with agricultural plots), since their canal ridges have the same water retention effect. However, in the cases of asymmetric canals, the role of canal ridges in runoff modification can highly vary depending on the situation of the (higher) canal ridge, more precisely: on which side of the canal the higher ridges is located. Those canals, which have their higher ridge (with more significant water retention capabilities) along the higher side, are designated top-closed, since along these canals, the higher microform is in the way of runoff (contributing greater water retention role), thus water accumulated on the plots (e.g. excess water) can not reach the canal. In contrast, if the higher canal ridge is located along the lower side of the canal, the canal bed is bottom-closed. In this case runoff from the plots encounter minor obstacles, moreover, along sections with a single ridge, they reach the canal freely. The results have shown that 13 % (4.9 km) of the canals are closed, thus possibility of runoff is insufficient on both sides. Most asymmetric canal sections (22 km – 59 % of studied sections) are bottom closed, however height difference is usually low (average difference is around 0.1 m), suggesting that asymmetric condition is not is not intended, but can be related to the subsequent alteration of their shape (dredging, trampling, ploughing). Measurements highlighted that open canal sections with the most preferable runoff conditions contribute only the 14 % (5.5 km) of the studied sections.

3.2.6. Runoff modifying effects of plough ridges and canal ridges are slightly differs, since canal ridges always have runoff blocking effect, along the canals conducting inundations along canals, plough ridges can lead to the appearance of excess waters along the furrows even on the higher parts of plots. Plough ridges disconnect various parts of agricultural plots, leading to scattered inundations, while canal ridges disconnect the plots from the canal bed, terminating the drainage function of the canal. Plough ridges have negative effects on runoff on 14 % (3.4 km^2) of the studied area, while canals are disconnects on 16 % (4.0 km^2) plots, moreover on 8 % (1.9 km^2) of plots is affected by the negative effects of both microforms enhancing their effects. The measurements has shown that high proportion of closed basins are situated along canals, where numerous extended inundation patches can be located on satellite images, therefore role of drainage function of canals is questionable.

3.2.7. The water retention effect of microforms can be amplified by the low hydraulic conductivity of the soils, as measurements of hydraulic conductivity showed very low (~0.1-1 mm/h) values, which is two orders of magnitude lower than the values described for clay (60 mm/h) by Várallyay et al. (1980). Moreover compacted soil layers (hardpans) follow the surface changes along microforms preventing lateral subsurface flow of water. Formerly it was not known that compacted soil layers with poor conductivity follow the topographic changes, therefore this effect of hardpans has not been not evaluated during excess water studies.

3.2.8. Importance of plough marks in inundation of excess water is changing proportionally to the intensity and duration of land use, since although natural relief is decreasing due to the flattening of surface, size of microforms compared to it is increasing, thus over time plough ridges can be significant runoff modifying factors on lowland agricultural plots.

Field cultivation could have appeared only after the flood control works (1855-1867), thus most of the plots have been cultivated for no more than 100 years. Considering that large-scale agriculture began at the 1960s, plot structure may have changed, therefore current ridge and furrow pattern is no older than half a century. In contrast the main canals had been established during the river regulation works, thus canal ridges along them are 120-130 years old, however along the Kéró-ér, 160 years old ridges (so called tow-paths) can be located. Runoff modifying effect of plough ridges and canal ridges was not known before modern field survey, and remote sensing methods. In the authors opinion, this is the reason to that micro-topography can be related to several present day agricultural and hydrologic problems.

3.3. Effects of viticulture on hilly areas

3.3.1. Literature review has proven that vine production in the area has already been a common agricultural activity in the 4th century, and was continuous from the 13th century, however spatial distribution of vineries (derived from maps) can be followed only after the 19th century. At 1860 the studied catchments were covered by a homogenous area of vineyards (10.8 km2 – 73 %). By the end of the 19th century almost all of the studied catchments were covered by contiguous vineries, and development of new bank-in roads and loess-gullies was typical. Area of vineries had not been changing significantly till the middle 20th century, but till the end of the 1960s, the proportion of vineyards decreased dramatically (from 73 % to 35 %) and distribution had also became fragmented. Later, between 1971-2007 area of vineyards increased to 51 % (7.47 km^2). Spatial distribution of proportion changes show that during 1-2 decades, not only reestablishment of vineries was crucial (1.4 km^2 – 19 %), but abandonments were also common (1.2 km^2 – 17 %). Historical land use changes related to forests and vineries shows similar trends in other parts of the country (e.g. Káli-Basin – Szilassi 2003), however researchers usually not address with the possibility that a specific area can be taken into use multiply times. Re-cultivation of fallow lands during vine production was a common technique. In the authors opinion, this resulted that the tillage-induced accelerated erosion usually coupled with surplus net erosion as the effect of terrace establishment and earthworks, which have significantly increased the rate of surface degradation in the area.

3.3.2. Morphometric analyses of tributary valleys revealed that the central catchment (Bartina-valley) located closest to the settlement shows differences in morphometric parameters compared to the other two studied catchment. The central catchment had divided into smaller tributary valleys. Furthermore the gradient of tributaries is also different. Concavity indexes of tributary valleys of the sub-catchments closest to Szekszárd are higher (0.59) than the values of other investigated sub-catchments (-0.2-0.18) suggesting that a higher rate of surface denudation was higher over the northern side (with southern exposure) of the central catchment. The concavity of intercollin ridges shows a similar trend, sub-catchments of the central catchment has an average value of -0.03, while other sub-catchments usually have a value between -0.1 and 0.4, showing that intercollin ridges of the central catchments are more eroded along the mid-slopes.

3.3.3. The 40-50 % maximum and moderate net erosion rate of the sub-catchments (rate of denudation calculated by the volume derived from the area and relief of the main- and sub-catchments) shows low distribution. However minimal net erosion rate (calculated by the volume derived from the valley bottoms and comb lines of the intercollin ridges) was higher on the northern and southern catchments (Parászta- and Csatári-valley) where rates of net erosion were between 16-23.9 %, while in the central catchment the average value was only 10.5 %. However, because in the central catchment the intercollin ridges are also already incised (Benyhe and Kiss 2010), low value of net erosion is not suggesting low rate of erosion, but rather shows that in this catchment tributary valleys and intercollin ridges suffered higher rate of erosion compared to the other two catchments, that can be explained by the longer and more intense viticulture (terrace excavation, development of bank-in roads) in the vicinity of the settlement.

3.3.4. Measurements have showed that the overall density of bank-in roads of the catchments is 1.72 km/km^2, and the total volume of the material eroded during their development is about 0.8-1 million m^3. Assuming that most of the bank-in roads have been developing since the middle of the 19th century, the erosion rate is 2.4 times higher than the values derived by Jakab (2008a) measured along gullies (435 thousand m^3 in 34 years). Situation and size of bank-in roads is not in connection between the slope conditions, thus their development can mainly be related to anthropogenic impact coinciding with the results of Jakab (2008b) concerning the development of bank-in roads. Bank-in roads have been concreted in the 1980s, therefore they deepening had stopped. However their walls are still collapsing, resulting 0.47 tons/hectare/year loss of material. Network of roads and bank-in roads have a significant effect on surface runoff, resulting a shorter lag time for the studied catchments. Model results simulated to the summer rainfall event occurred in 18th June 2010 showed that lag time of the studied catchments had decreased about 1-3 minutes due to the runoff modifying effect of road network. The reason of decrease is the lower roughness values of the pavements (increasing flow speed along bank-in roads by about 100 %), but running direction can be also crucial, since in several cases bank-in roads cut intercollin ridges. Former studies dealing with flash floods usually concerns the hydrologic circumstances, e.g. extreme rainfall (Szlávik 2005, 2007, Czigány et al. 2010), however role topography changes (such as bank-in roads) were not taken into account.

3.3.5. Morphometric measurements of terrace surfaces have pointed out that vine terraces in the Baranya-valley (eastern part of the southern catchment) are usually oversized holding 9-12 vine rows (50 m width), instead of 4-8 rows (20-32 m width) that can reduce their resistance against surface degradation. Furthermore natural slope of the hillsides (8-10°) were only reduced by about 2-3° during the creation of the terraces, hence a significant cross slope (5-8°) is still allowing rapid erosion of terrace surfaces parallel to natural slope direction, but terraces have a remarkable longitudinal slope (0.3-5.2°) as well. Since runoff over terrace surfaces is not ensured by drainage network, erosion can easily damage them. Wrong selection of terrace sites can lead to similar problems since as the results suggest, concave terrace surfaces can concentrate runoff to the centre of the terrace, initiating rill erosion along the surface.

3.3.6. Micro-topography of terrace surfaces contains several agrogenic landforms (micro-terraces, ridges). These landforms are 7-20 cm high and about 30 cm wide, and since they conduct the flowing water along the vine rows, they can significantly increase (by about 3 times higher) the runoff along the lowest part of the terrace, increasing the risk of rill erosion. Measurements of a 0.25 m deep and 1 m wide erosional rill revealed that later field works had partially filled the rill, however this action did not terminate the possibility of rill erosion. Suffusion of agricultural terraces in loess regions are well studied processes (Kerényi 1983, 1990, Boros 1995), however runoff modifying effect of agrogenic microforms have not been investigated and quantified.

3.3.7. Considerable slopes of terrace surfaces results in significant (8.9-22.8 tons/hectare/year) soil erosion (Benyhe and Kiss 2011), which is one order of magnitude larger than the measured erosion of Huszár (1999) and Kitka et al. (2008) on agricultural areas with different land use. Model results shown that terrace surfaces are degrading 0.6-1.6 mm/year, however field measurements to determine the rate of exhumation of grapevines resulted in a much a greater value (0.3-1.1 cm/year). A possible explanation to the significant difference is that rainfall erosivity factor derived from Bacsó (1970) is not suitable, since the published annual rainfall erosivity (R=650 MJ*mm/hectare/h/year) can be exceeded by a single summer rainfall event (R=838 MJ*mm/ha/h/year), furthermore such heavy summer storms had occurred more often (several times a year) in the last three years. In the author's opinion rapid surface erosion is not the most crucial problem, but the considerable effect of terrace excavations and field works prior to the occurrence of soil erosion. Results shown that direct erosion due to excavation of terraces may reach 1-1.5 m^3/m^2 (14-21 thousand tons/hectare) on certain terrace surfaces (1.4 hectare), thus prior earthworks are degrading surface of hills three orders of magnitude more intense than annual accelerated soil erosion.

3.4. Conclusions

My final conclusions are that, by using modern field survey and GIS methods I could have revealed landforms and processes that were not examined before. The studied agricultural activities (regardless of their type) are generally leading to surface flattening, while several microforms can develop modifying or strengthening geomorphological processes. The larger-scale flattening and the runoff modifying effect of microforms can result remarkable changes in surface runoff, leading to soil degradation in any environment. In sandy areas the blown sand can bury the fertile soils, while the disappearance of local depressions can result in drying of the sandy area. In lowland agricultural plots (with usually compacted soils) the low gradient and the appearance of microforms can have a significant role in the appearance of inland excess waters, that can lead to the devastation of crops, but also can cause the further degradation of soil structure (Kun et al. 2012). The agricultural alteration of hilly areas (such as vineries) in larger scale led to the concentrated runoff, decreasing the lag time, and increasing the peak discharge of flash floods. At micro-scale the situation of vineyards and the landforms uncontrollably concentrating runoff can increase the rate of erosion over the agricultural terrace surfaces.

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