HILLSIDE WATER MANAGEMENT AND POSSIBILITIES OF MELIORATION IN THE CSATÁRI-VALLEY

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1. INTRODUCTION AND OBJECTIVE

Hillside water management is an important issue of our present and future. The more extreme weather, the rashly raining and the runoff of those are not provide harmony in the next decades.
It is urgent to recognise the problem in time and to act in case of to have a better and safer tomorrow.
The importance of surface and ground waters, also the effects to the direct environment are controversial cases for years. Unfortunately, few people deal with the question of water management or drainage. What can we do for our local environment? How can we improve the ecosystem of our town? These questions motivated me, to start my research, which is about my hometown, Szekszárd.
Szekszárd – county town of Tolna county – is located at the meeting of the Szekszárd Hills and the Great Plain. Its hillside part consists of ridge canals which are frequently segmented with valleys and glens. On the other hand, the east part is plain far until the Danube. Rainwater of the town is collected by the catchment canals of the valleys. There are two major rivers in the town: the west-east oriented Szekszárd-Séd and Parászta-Séd. All the catchment streams, collector ditches and drainage systems flow into these rivers.[1]
Hills can be divided into four valleys: Parászta, Séd, Csatári and Tót valleys. At the first two, there were water management measurements, while the last two are waiting for developments. That is why I chose the Csatári-valley to propose solutions about its surface waters.

The Csatári-valley (see Figure 1) lies in the southern part of Szekszárd, between the Bartina and the Őcsény Hill. Its area is near 8 km^2. Characteristic viticulture and wine production going on in the region, by a lot of noted oenologists and more private owners. Most of the area is vinery or forest. The valley has other sub-valleys, which are (from east to west) the Iván, Cinka, Gyűszű, Porkoláb, Csötönyi, Gesztenyés, Faluhely and Baranya valleys. The valley has a catchment stream at the floor called Csatári-stream. This collects the rainwater of the sub-valleys and flows into the Szekszárd-Séd.

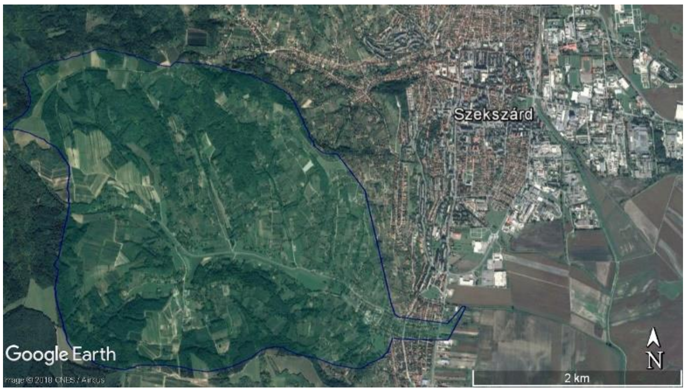


Figure 1– The Csatári-valley and Szekszárd

This area had not been monitored in point of water management. However, it plays a major role in the production of excellent Hungarian wine. Hence the protection and sustainment of this agricultural area are very important. The main problem is that the valley is not prepared for the extreme weather conditions and it cannot retain surface waters for the droughty periods. The aim of my research was to find and suggest a solution for a stable future with considering the parameters of the valley.

[1] ÖKO-ECO Bt. (2001)

2. ANALYSIS OF THE SITUATION WITH A QUESTIONNAIRE

The opinion of the owners about the importance of the valley and the experiencing of extreme weather conditions were asked in a questionnaire with 20 questions. This was filled in by more than 50 owners of the area. The target group was the group of the owners and oenologist of the Csatári-valley, which is less than 100 people.

2.1. GENERAL DATA

In the first part of the survey, I asked the size and the present state of their lands and their opinion on the valley. Most people (~34%) filled the survey from the Porkoláb. the number of the people from the other valleys was proportionally shared (~10-14 %) [see App. 12.2.1.]. The average land-size was ca. 4500 m^2 for one capita, however, the actual answers showed a bigger scatter because the greater land was 40000 m^2, while the smallest was 200 m^2 big. The areas are usually used as vineyards, orchards or gardens. Based on the survey, I can state that 30% of the people would you use their estate as a permanent home place, 20% already use is like that, although 50% do only want to use it as a farm [see App. 12.2.2.].

Most participants take their supply of water from catchment bowls (water tanks), but not less, bring the water from the town. The 46% of those people who take the water from their own lands, state that the amount of that is not enough. The sixth question connects here, which revealed that only the 36% of the participants have a tube or dug well.

2.2. VIEW ON EXTREME WEATHER CONDITIONS

The second section was about the extreme weather and the experience of that. First, the difference between the years and the annual distribution of precipitation was questioned. Approximately 90% (88%<) already experienced that the weather gets more extreme in the area, during the year and compared to the past years [see App. 12.2.3.]. Furthermore, a huge amount of them said that the rashly rainfalls (70%) and the droughty periods (66%) caused problems at their own land [see App. 12.2.4.]. Rainfalls principally produced property damages, for example, destroyed plants, more necessary spraying. At the end of the section, they should sign, how important they think the problem is on a 1 to 5 scale. The average rating was 4, so they believe it is a significant question.

2.3. WHAT DO THEY THINK ABOUT SOIL EROSION?

I asked them about their views on soil erosion and their known and used methods against that. First, they rated on a 1-5 scale, how much they feel the negative effects of that. There was a huge difference between the answers, although, the average was 2.6.

After, they chose the methods, which was used or known by them. The most known method was grassing, that 82% knew and used as well. Secondly, the bench terracing was known by 40%. The others were recognised less [see App. 12.2.5.].

2.4. Tourism of the valley

In the last section, I asked the participants about the touristic value of the valley. This got an averaged 3.7 value on a 1-5 scale. The last question was about the improvements which should be taken, for example: making more hiking trails and maintenance of them, developing public roads, organizing summer programs. Most of them gave new ideas like expanded, better bus schedules, more pavements and the cleaning of desolated areas/buildings [see App. 12.2.6.].

3. My advice

Based on the questionnaire I can state that the owners can experience the changing of the weather. These changes can provide an unpredictable water supplement in the future. To avoid this, we should apply the principle of water retention, so instead of letting surface waters towards, we must concentrate on retaining them.

One possible solution for retaining surface waters is to make five lakes by swelling back the water of the Csatári-stream [see App. 12.1.]. The surface of the lakes could be 0.1 km^2 big in all. The places of the lakes were determined with the help of Google Earth and on-spot altitude measurements. As a result, two lakes could be formed in the Baranya-valley, two at the beginning of Porkoláb-valley and one at the Csötönyi-valley. From these, the biggest could be one of the lakes at Porkoláb, which estimated area is 0.05 km^2. The formation of the lakes could be done with the help of weirs, which would let the human manipulation too.

4. Research methods

4.1. Stream gauging

Stream gauging was done in case of to reveal if the Csatári-stream could serve enough water for the lakes.

During my research project, seven gauging was done: six at the lower part of the Csatári-stream, only some kilometres far from its estuary, at the bridge of the public road number 56 and one at the upper part of the stream, at a bridge at the beginning of Csötönyi valley.

The circumstances of the measurements were different but were specific for the actual season. Four gauging was done with bowl method, three with float method.

While using bowl method I measured the filling-up of a bowl with known capacity. I worked with bowls with the capacity of 27, 40 and 42 litres (0.027 m^3; 0.04 m^3; 0.047 m^3). Every time the time of the filling-up of the bowl was measured three times, in seconds. After I averaged the data and as the quotient of the capacity and the average time, could I got the discharge in m^3/s. This method was not used anymore, because of the formation of the stream.

The float method was different: at this, the cross-section area was determined first, with the measurement of the average depth and the width of the stream. The flow-velocity was measured three times, on a five-meters-long section with a ping-pong ball. After, I had to calculate the time for a one-meter-long section and average the data. In this way, I got the discharge in m^3/s.

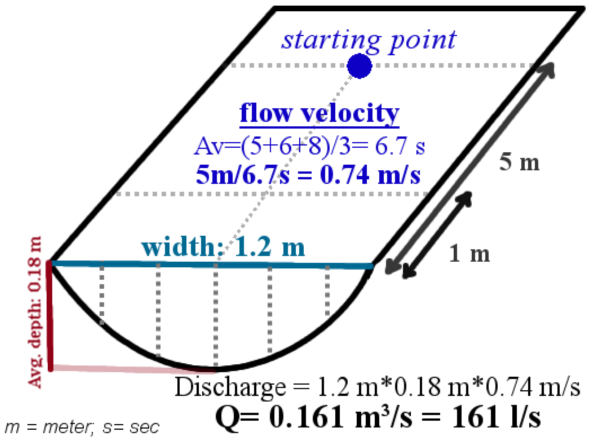


Figure 2 – The cross-section area and the float method

The discharge of the stream changed properly depended on the current season and environmental conditions. The highest discharge was measured in February when it was 0.161 m^3/s, because of the melting of snow and ice precipitate of January. By comparison, the lowest was 0.003 m^3/s (3 l/s), in September 2016.

The average discharge of the Csatári-stream, without extreme cases (like the 0.161 m^3/s) was 0.008 m^3/s (8 l/s). With this average discharge, the water of all the five possible lakes (with 0.1 km^2 surface and average 140 cm depth) could change in 2-4 weeks. The results of the stream gauging can be found at Appendix 12.3.

4.2. Analysis of water

To determine the actual and the possible quality of the water of the stream water analyses were made.

4.2.1. Chemical water analysis

The sampling took place in February and December 2017. The February one was after no raining, the December one was after a long period of winter rainings.

Picture 1 – Chemical water analysis was done in my school laboratory

Four surface water samples were collected, two from the water of the stream and two from artificial lakes (Bodri and Lepke lake). I examined them in Győző Kovács Scientific Laboratory of my school with colourimetric method and school science equipment [see Picture 1]. During the analyses, my purpose was to determine the quality of the water, to examine the effect of agricultural activities and to study what changes could happen in the water of the stream if my solution becomes real.

The final samples were gotten with the help of reagents and after were rated due to the Hungarian standard of the quality of surface waters, number MSZ12749 [the results can be found at App. 12.2.4]. The clearest was the water of Bodri lake (existing artificial lake), which is supposedly because of chemical cleanings.

The concentration of orthophosphate (PO_4^{3-}) was outlying, in case of the other samples. It can show a diffuse agricultural pollution. Contact with sewage can be excluded. The difference between the two dates can be explained by the variance of the agricultural methods during winter and autumn seasons.

Both samples of the Csatári-stream had a high concentration of nitrite ion (NO^{2-}). This also can refer to the agricultural pollution, but this can reveal the slow winter nitrification too.

Also, the concentration of ammonium ion (NH_4^+) at both sampling was in the perfect zone (based on the standard), so we can state that the water of the stream has not got any point source pollution (e.g.: sewage).

4.2.2. Biological study

To define the water of the stream more perfectly, we examined the waters with microscopical study. The sample was collected on March 4, 2017. At the laboratory, it was filtered on a micro-membrane filter (0,45 µm) and the obtained sample was centrifuged. After this, I checked each sample under a microscope and counted every species. The original volume was 1 litre (1 dm^3), the final volume was 0.3 ml. The droplet size was 0.04, the number of drops was 1.

Picture 2 – The microscopical study

As a result, 34 different species were counted. Most of them were Phytoplankton, like diatoms, for example, *Amphora ovalis*, *Navicula gastrum*, *Pinnularia microstauron* or the *Frustulia vulgaris*. There were numerous green algae as the *Closterium aciculare*, *Closterium strigosum* or the *Closterium cornu*. Some other species were discovered too, like a few euglenas (*Euglena viridis*), some roundworms (*Nematoda sp.*) and a huge amount of *unknown bacterias.*

As a conclusion, it can be stated, that the water of the stream is not heavily polluted. By the swelling up the microbiological variegation would increase. The high concentration of nitrite ion and orthophosphate, also the species determined by the biological study shows eutrophication, which can be experienced at the scene too. After the formation of the lakes I assumable that the eutrophication would risk only the parts of them.

4.3. Analyses of soil

Five different types of soil samples were collected on February 23, 2017, with soil sampling equipment. The samples were forest, vineyard, freshly ploughed and near the stream characterised.

The samples were weighted at the spot, after, were brought to the laboratory of my school, where I dried them for two weeks on room-temperature. Physical and chemical quantities of the soil samples were examined, such as structure, texture, pH(H2O), lime- and humus-content, also their water-holding capacity.

The texture was determined with finger test, the structure with a sieve. The water-holding capacity was the comparison of the weight of fresh and the dried samples. The pH of the soil was measured two times: at the sampling point with litmus paper and in the laboratory (after drying) with distilled water with potentiometric method. Humus content was studied based on the colour of the compound of the sample(s) and 2% concentrated ammonium-hydroxide (NH_4OH). During the discovering of lime-content, the samples were placed on watch glasses and 10% concentrated hydric chloride (HCl) was dropped onto them [see Picture 3]. The actual content was figured out based on the intensity of fizzling of the samples.

Picture 3 – Discovering lime-content with HCl

Most typical soil type of the valley is sandy-loam loam textured, alkalescent, with low humus and middle-rated (5-8%) lime content. The structure was based on the using of them: the freshly ploughed land and the soil next to the stream had a blocky structure, while the old plough soil and the vineyard sample was granular, beside these, the forest soil was crumby.

The results of the analyses of soil can be found at Appendix 12.5.

4.4. Soil erosion estimation

Besides eutrophication and the higher nutrient content, the soil from the hills can also risk the formation of the lakes.

4.4.1. Method of soil erosion estimation

The erosion was estimated with Universal Soil Loss Equation (USLE)[1]. However, this is a special equation for American regions, we can calculate with European conditions.

The most difficult part was, to find a right method because USLE has a lot of versions which are working with different parameters. After reading literature and sources from the internet, finally, I chose USLE, because of the simplicity of this method and the availability of the data which must be known to count the rate of erosion. Dissertation of Csaba Centeri gave me the major information about the process of calculation. The document only studies one specific factor, although, all versions and a huge number of general notes are included.

Universal Soil Loss Equation:

$$A = R * K * L * S * C * P$$

Where A = average annual soil loss (t/ha/year), R = rainfall erosivity index, K = soil erodibility factor, L = topographic factor for slope length, S = topographic factor for slope (%), C = cropping factor and P = a conservation practice factor.

[1] Wischmeier and Smith, 1960.

4.4.2. STEPS OF ESTIMATION

The different factors were determined with different methods, also there were cases when I counted with the Hungarian averages. Like the factor R, which was determined as the average 160, because of the lack of local data.

Factor K (the soil erodibility factor) was figured out based on my soil analyses. The sandy-loam textured areas got 0.3, the loam textured 0.27.

L and S factors usually defined together. These were calculated with Google Earth Pro software, where I measured the length and the angle of the slopes in the valley. As a result, the length was 3280 ft (ca. 1 km), the tilt angle was 12%. So, factor LS was defined as 10.45.

Cropping factor (C) could be assigned from *Corine Land Cover database*[1] for four kinds of areas: forests = 0,05; plough lands = 0.28; vineyards = 0.75; meadows = 0.56.

Factor P (practice factor) was only calculated at vineyards and ploughlands. The value of these were estimated based on Csaba Fazekas's dissertation and my knowledge about areas.

As a result of my estimated soil erosion, I got that the average annual soil loss of the forest areas are 22 t/ha/year, the ploughlands 84 t/ha/year, the vineyards 301 t/ha/year, the meadows 253 t/ha/year. However, the result shows an estimated number, I can state that the soil erosion is huge in the area.

As a conclusion of this and the analyses of soil and water, it can be seen that the huge erosion can erode the nutrients from the soil, so these easily can raise the concentration of orthophosphate and nitrite ions in the water of the Csatári-stream.

4.5. THE MEASUREMENT OF THE LEVEL OF GROUNDWATER

I measured the level of the groundwater in the valley in case of to visualize the future of ground waters. Five wells were measured four times with home-made tools, in autumn. Then, the data were averaged, and the figure of the present groundwater was made [see App. 12.6.1.].

This figure shows the possible current state of the valley. Nowadays the level of the groundwater and the soil moisture are truly sufficient for the viticulture. However, this level can decrease.

If the lakes will be formed, then it would provide a stable groundwater level and a favourable soil moisture [see App. 12.6.2.]. On the other hand, if no change will happen, the stream would be a periodic stream, as the level of the groundwater would decrease. Unluckily, it would cause a negative effect on the agriculture [see App. 12.6.3.]

5. ADDITION OF MY SOLUTION

There should be some improvements against soil erosion because the more often and more extreme rainfalls would increase effects of that. The most important is to make integrated farming, although, this has the smallest chance.

[1] Centeri, 2001.

I recommend making bund ditches and benches at every type of areas, with the consideration of the angle, the location and the agricultural activity. There should be some more developments of the catchment canals.

5.1. The sample valley

Figure 3 – The sample valley (green=forest, yellow=ploughland, purple=vineyard)

The possible places of bund ditches and benches are presented at a sample valley, which is the Iván valley. I drew them with knowing the preferences of sub-valley and with the help of Google Earth Pro software, as can be seen in Figure 3. The places, where little ditches can be made is signed with white colour, the urgent areas are signed with red/red-white stripes. Based on this sample valley, it is true that a huge region should be developed.

5.2. Using of biochar

Also, I recommend the using of biochar. This is a man-made soil amendment, a *arbonised biomass obtained from sustainable sources.* [1] The using of this has many benefits, for example, more fertile and well-structured soils. The water quality of the surface and groundwaters could increase because the increasing soil retention so more nutrients stay in the soil instead of leaching into waters.
With the development of the local waste management, we can make a biochar for vine waste system: the owners can hand down their green waste and they can get biochar exchange.

6. Comparison

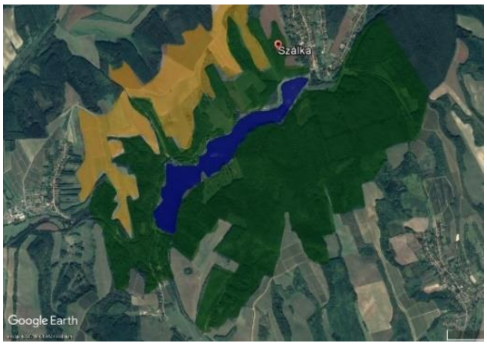


Figure 4 – Szálka lake and the composition of (yellow=ploughland, green=forest)

A similar solution was applied at Szálka, 12 km far from Szekszárd, in 1978. Szálka lies on the southern part of the Szekszárd Hills. The village surrounded by forestry, ploughed hills and valleys. At the end of the settlement is the Szálka lake, which was formed with the swelling back of the Lajvér-stream. The quality of the water of this lake was also examined. The surface water sample was collected on March 4, 2017, and similar to others, it was also studied with colourimetric method and was rated due to the Hungarian MSZ12749 standard. As a result, I got that the water of the lake is unpolluted, neither the angling is not polluting it. With the help of Google Earth Pro software, I compared their composition of areas [see Figure 4]. In the case of Szálka, neither the soil erosion nor the agricultural pollution risks the being of the lake. If we could decrease the effect of soil erosion at the Csatári-valley, then we can reach the Szálka situation.

[1] http://www.biochar-international.org/

7. SOCIAL FEEDBACK

A significant part of my research is to tell the people that the future of every drop of water is also their responsibility. So, I made an action at Celebration of St. Martin's Day in Szekszárd, which is one of the most visited events of the town.

Picture 4 — My stand at the Celebration of St. Martin's Day

I wanted to point the importance of surface and groundwaters out to the inhabitants with the co-operation with the participating oenologies at the gastro event. During the celebration, I had a stand [see Picture 4], where I used different tools to visualize the problem and my solution. I designed a project logo for the event, which popularized the lakes and main topics in the circle of the visitors. This was printed as a sticker and was placed on every glass of wine there.

The occasion gave me a social feedback. A lot of interested people came to me and told positive thoughts. Also, they strengthen the fact that extreme weather conditions can be experienced nowadays. My technical knowledge was improved too, because during the meetings with the oenologists I learnt a lot from them, which I built into my research.

7.1. LOGO

The logo of the project is my own design. The final emblem was drawn after weeks of opinion research. More than four version had been made. The final emblem has two main elements: the human and the glass of wine while representing that both of them are nearly 70% of water. The human symbolizes the individual, the customer and the society, while the glass the local values, the culture, the viticulture and the importance of the Szekszárd Hills. Its colours are the blue-red (like water-wine). The logo gives back that we should do for a safer future.

Figure 5 — the logo

Next to the emblem, there is a slogan, also this is the most emphasised part of the sticker. From the created mottos the best was the „Save the water, build lakes". Besides this, there were "Save water, drink good wine" or „Think of future, save waters" sentences too. The sticker was in English, however, the understanding of this is not caused problem for the visitors.

7.2. WEBSITE AND WATER BUDGET CALCULATOR

By adding informatics to science, I also created the „Save water - Build lakes" website (http://ibela.sulinet.hu/buildlakes). Its aim is to let people know about water protection and let them track the water budget of their own lake with the help of my online calculator.

This calculator works easily for the users because it is like a simple table. The curious user can choose the automatic filling of the data or can write them manually. So, at the first, only the preferences of the planned lake should be known, while at the second exact data is preferred to calculate with. The result is only an estimated water budget, the real calculation consists of more factors, and require wider knowledge. Also, it does not replace the experts, and there are always weaknesses which can be improved.

I tried to validate the water budget calculator with my own research. The known data were filled in (catchment area [8 km^2], water surface [0.1 km^2] and average depth [~1.4 m]) after the calculation was run. As a result, I got that the lakes (between the average weather conditions) would be sustainable, and because of the through-flowing system the formation of it also possible.

8. Who am I?

My name is Bence Zsolt Rappay. I attend I. Bela Grammar School in Szekszárd. I am in year 12. I have always been an eco-friendly person. During my four grammar school years, I have taken part in many projects like environmental or communal projects. I love travelling, learning languages, making films, but my real hobbies are my researches. Nowadays I am interested in economics and water engineering, I haven’t decided which will be my future job. My research made me like the natural science, but I like the practical side more than the theoretical one.

9. My work

My research involved the combination of data and sample collection; visits to the area; analysis in laboratories, counting, the usage of different software, and data processing. My mentor, Zoltán Barocsai coordinated the work. György Baka (Zöldtárs Association of Szekszárd) was my partner in getting to know the area. Helga Horváth laboratory assistant and Csaba Kirchkeszner Chemical Engineer PhD helped me with the water analyses.

10. Summary

10.1. Shorter

The focus of my research is one of the valleys of Wine Region of Szekszárd, called Csatári-valley. This area plays a major role in the production of excellent Hungarian wine. Hence the protection and sustainment of this agricultural area are very important.

My suggestion is to make lakes by swelling back the water of this stream. I examined the workability of this with stream gauging, water and soil analyses also with soil erosion estimation. As an addition, I recommend improvements against soil erosion. If my suggestions will be developed, then the valley would have a safer, more stable water management.

10.2. LONGER

The focus of my research is one of the valleys of Wine Region of Szekszárd, called Csatári-valley, which gives place for different agricultural activities. This area had not been monitored in point of water management, also the problem of the valley it is not prepared for the extreme weather of the next decades and the owners are not careful, so the risk of soil erosion is huge at the area. My purpose was to find and suggest a solution which can provide a stable future for the valley.

The valley has a catchment stream at the floor called Csatári-stream. This collects the rainwater of the sub-valleys. The first part of my solution is to make lakes by swelling back the water of this stream.

The workability of my suggestion was examined different ways. My stream gauging, water and soil analyses, the measurement of groundwaters, soil erosion estimation all buttress up my conception. On the other hand, I added a part to my solution, which puts the emphasis on making developments against soil erosion (for e.g.: bund ditches, benches, application of biochar).

As a part of the project, I made an action at Celebration of St. Martin's Day in Szekszárd, where I wanted to point the importance of surface and groundwaters out to the inhabitants. I designed a project logo for the event, also created a website where the users can estimate the water budget of their own lake.

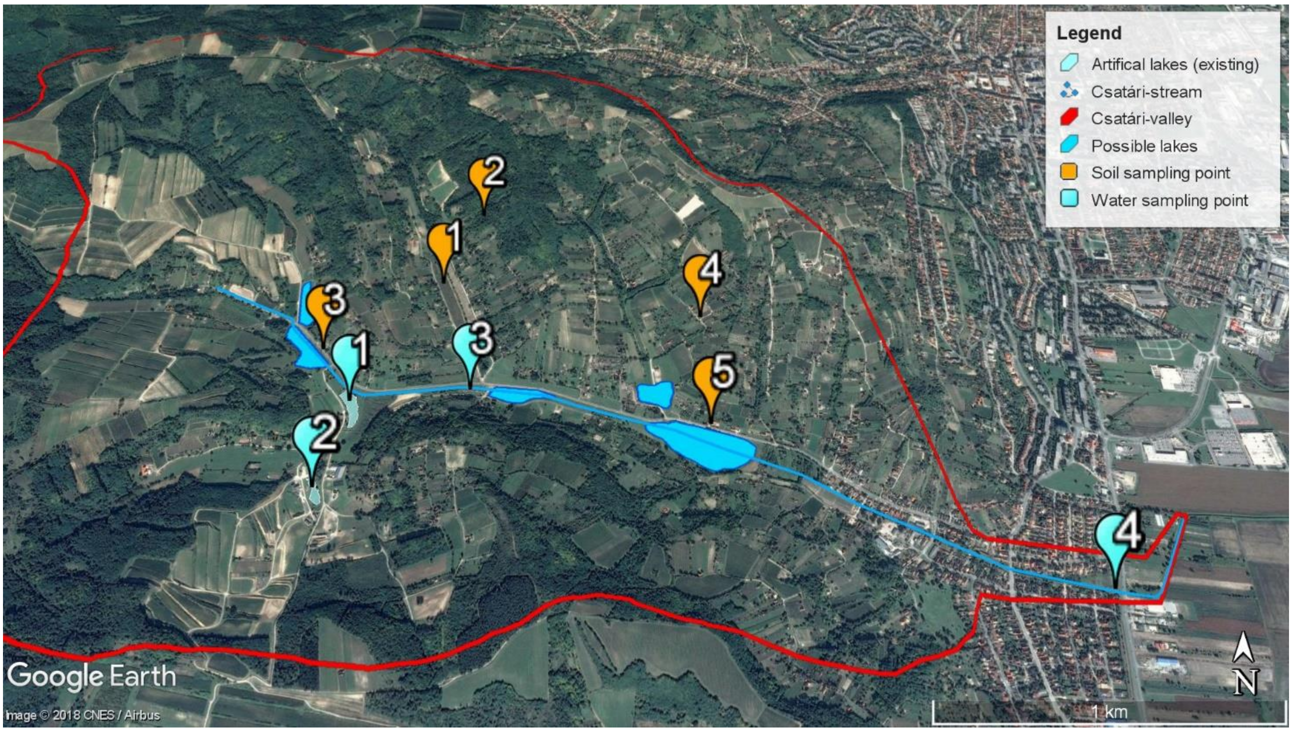
If my solution was materialized, then the agronomical potential of this valley would have more stable in the long term.

11. BIBLIOGRAPHY

1. ÖKO-ECO Bt.: Szekszárd Megyei Jogú Város Környezetvédelmi Programja.
2. Wischmeier W. H. - Smith D. D. (1960): Rainfall energy and its relationship to soil loss, Vol. 39, No. 4. Transactions, American Geophysical Union.
3. Dr. Dömsödi János (2010): Tájrendezés és tájvédelem 4., Nyugat-magyarországi Egyetem Geoinformatikai Kar.
4. Dr. Gribovszki Zoltán (2010): Mezőgazdasági infrastruktúra alapjai 9., Sík-, hegy- és dombvidéki vízrendezés, Nyugat-magyarországi Egyetem.
5. László Péter (2003): Agrokémia és talajtan 427-442. oldal, MTA Talajtani és Agrokémiai Kutatóintézet.
6. Centeri Csaba (2001): Az általános talajveszteség becslési egyenlet (USLE) K tényezőjének vizsgálata, Gödöllő.
7. Fazakas Csaba (2013): A talajerózió és a suvadás közötti kapcsolatok vizsgálata térképezési módszerekkel a Nyárádmagyarósi-medence mintaterületein, Debrecen.
8. Zsuffa István (1996): Műszaki hidrológia I-II., , szerkesztette: Brezdán Mária; Műegyetemi Kiadó, Budapest.

12. APPENDIX

12.1. Map of the Csatári-valley



12.2. Charts

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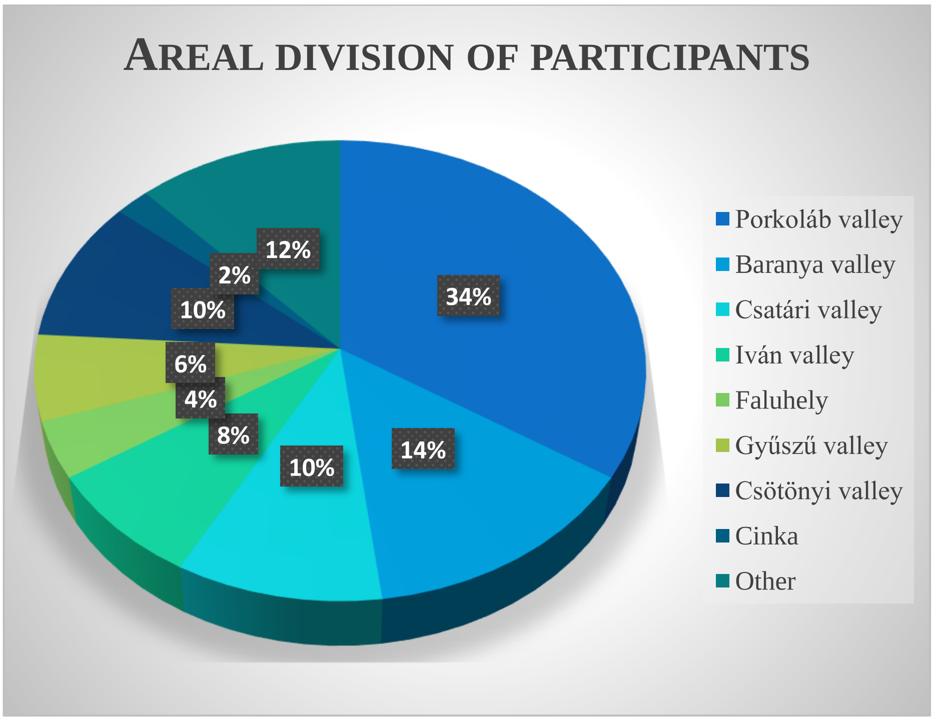

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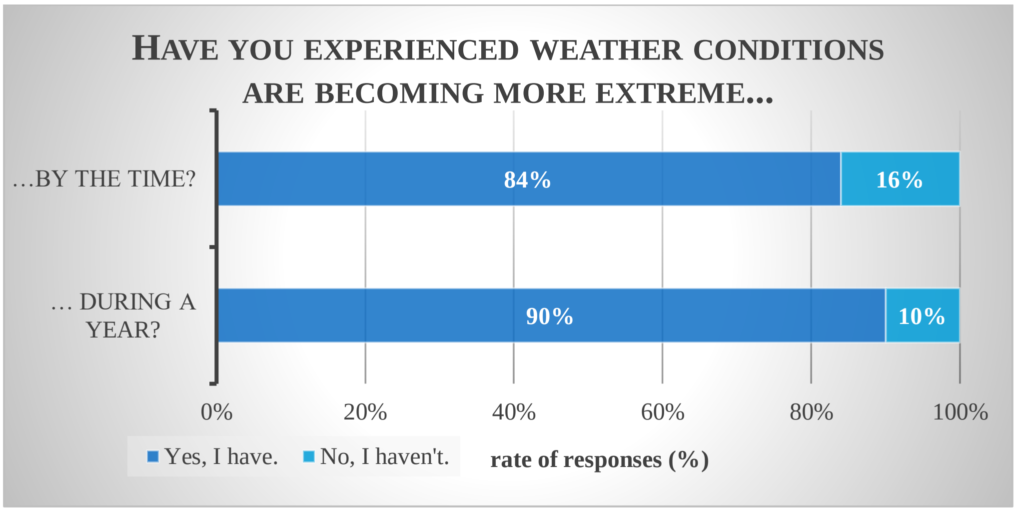

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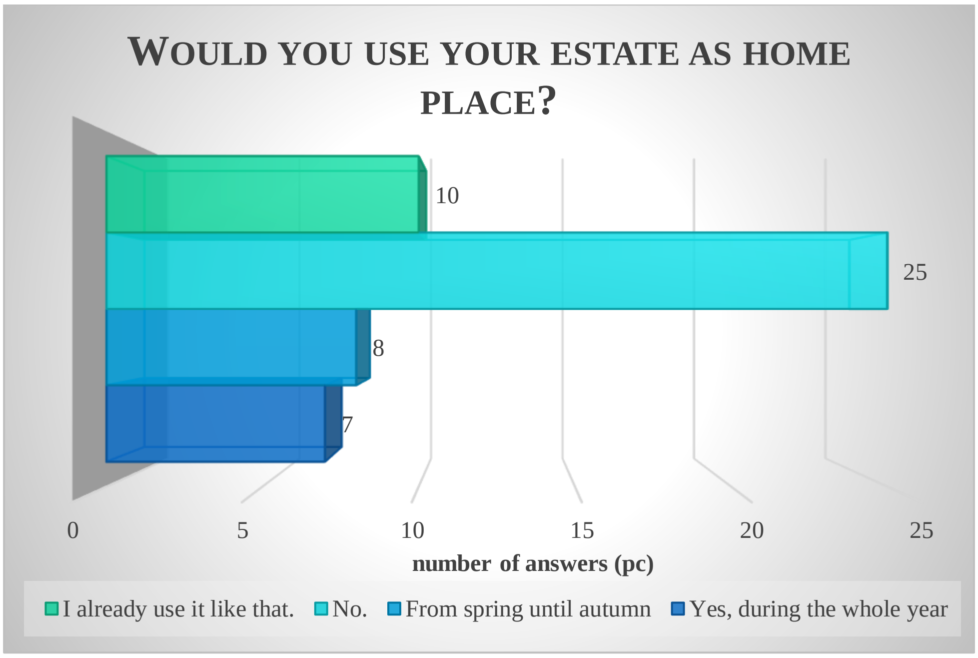

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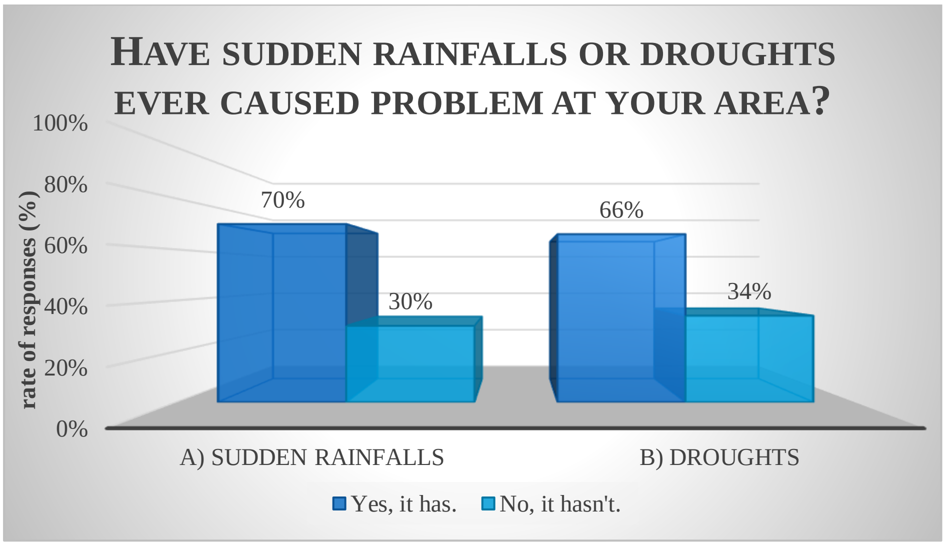

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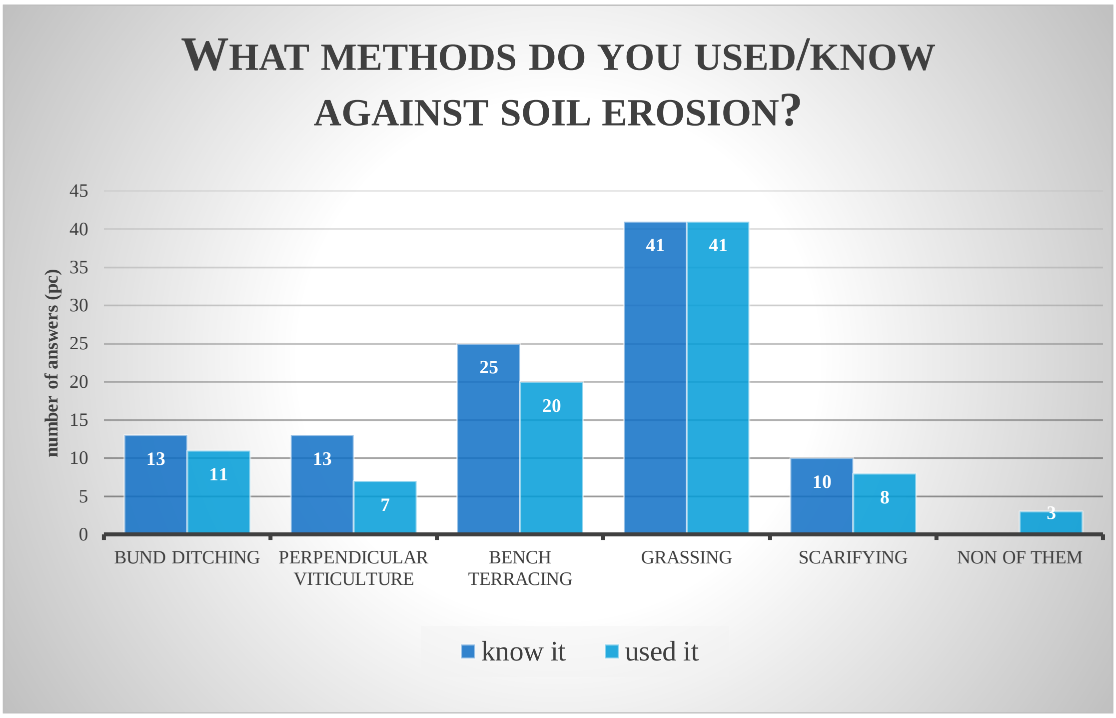
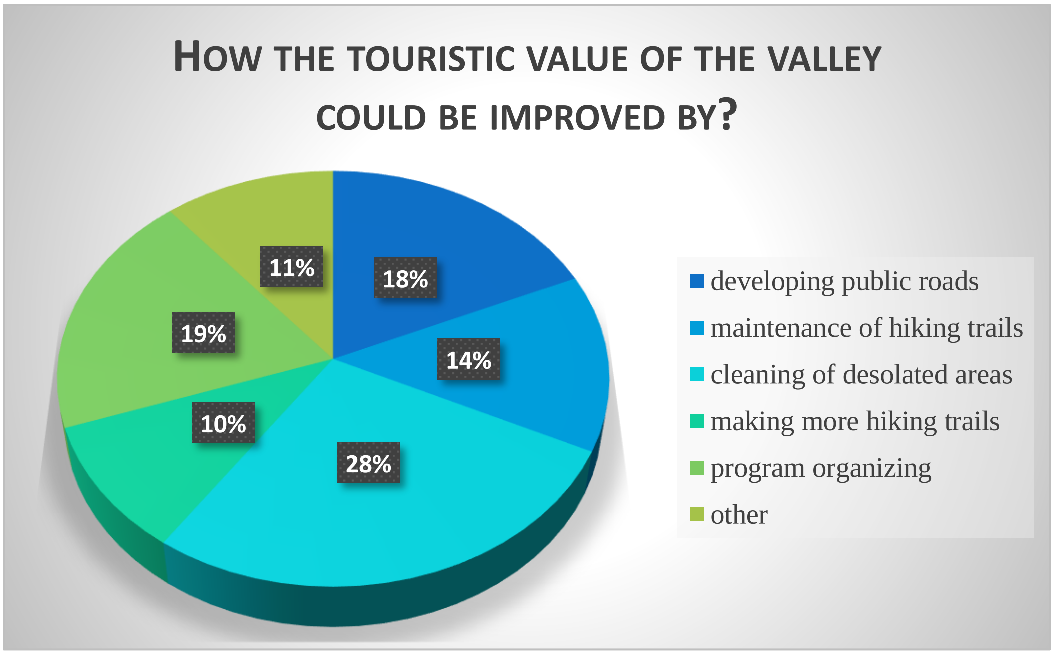


12.2.6. Chart no. 6.



12.3. THE RESULT TABLE OF STREAM GAUGING

Date	30/9/2016	17/12/2016		5/2/2017	2/3/2017	27/8/2017	31/10/2017
Spot	lower	lower	upper	lower	lower	lower	lower
Method	bowl	bowl	bowl	float	bowl	float	float
Conditions	late autumn, days after weak raining	winter, days after snowing		spring-like, after the snow started to melt	spring, after sunny days	muggy summer day, after a long drought	cold autumn, sunny, but muggy
size of bowl/area	27 l	40 l	40 l	0.22 m^2	42 l	0.08 m^2	0.04 m^2
1st measurement (s)	9:56	5:71	7:28	5:43	3:61	28	18
2nd measurement (s)	8:46	4:54	7:56	6:54	3:94	30	14
3rd measurement (s)	9:03	3:06	7:35	8:25	3:98	27	17
Average time (s)	9:02	4:44	7:40	6:74	3:84	28	16
Discharge (dm^3/s)	**3**	**9**	**5**	**161**	**11**	**5**	**10**
Discharge (m^3/s)	**0.003**	**0.009**	**0.005**	**0.161**	**0.011**	**0.005**	**0.010**

s = sec; m = meter

12.4. THE RESULTS OF WATER ANALYSIS

Sampling point	**1. Lepke lake**		**2. Bodri lake**		**3. Csatári-stream (upper)**		**4. Csatári-stream (lower)**		**5. Szálka lake**	
Date	**February 2017**	**December 2017**	**February 2017**	**December 2017**	**February 2017**	**December 2017**	**February 2017**	**December 2017**	**February 2017**	**December 2017**
NO3-N (mg/dm^3)	< 0	< 0	< 0	< 0	< 0	< 0	< 0	< 1	< 0	N/A
NO2-N (mg/dm^3)	< 0.02	< 0	< 0.02	< 0.02	0.1	0.3	< 0.02	0.4	< 0.02	N/A
NH4-N (mg/dm^3)	0.05-0.2	0.05-0.2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05-0.2	N/A
PO4-P ($\mu g/dm^3$)	290	250	0	0	270	500	300	500	0	N/A
pH*	8.2	8.2	8.4	8.3	8.2	8	8.3	8.2	8	N/A

Legend**			
perfect	good	passable	polluted

** at 25 °C*

*** rating due to Hungarian standards (MSZ 12749)*

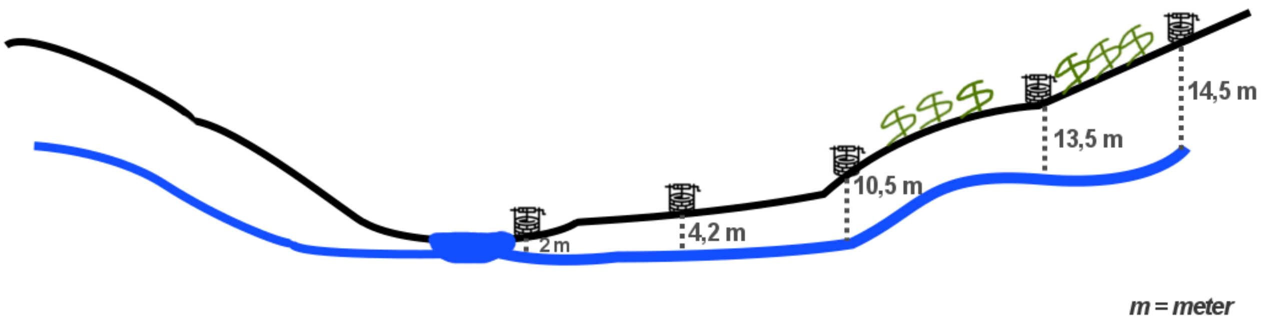
12.5. Result table of soil analyses

Soil analyses	1. Freshly ploughed soil		2. Old plough soil		3. Forest soil		4. Vineyard soil		5. Near the stream	
spot	Baranya-valley		Baranya-valley		Csötönyi-valley		Porkoláb-valley		Csatári-valley	
structure	blocky		granular		crumb		granular		blocky	
texture	sandy-loam		sandy-loam		loam		sandy-loam		loam	
pH	man.: 7	comp.: 8.43	man.: 8	comp.: 8.29	m: 7.5	c: 8.4	m: 8	c: -	m: 8	c: 8.39
lime-content	middle-rate (5%)		middle-rate (5-6%)		middle-rate (5-6%)		middle-rate (5-6%)		middle-rate (7-8%)	
humus-content	low		low		low		low		low	
water holding capacity	80 %		79 %		81 %		80 %		80 %	

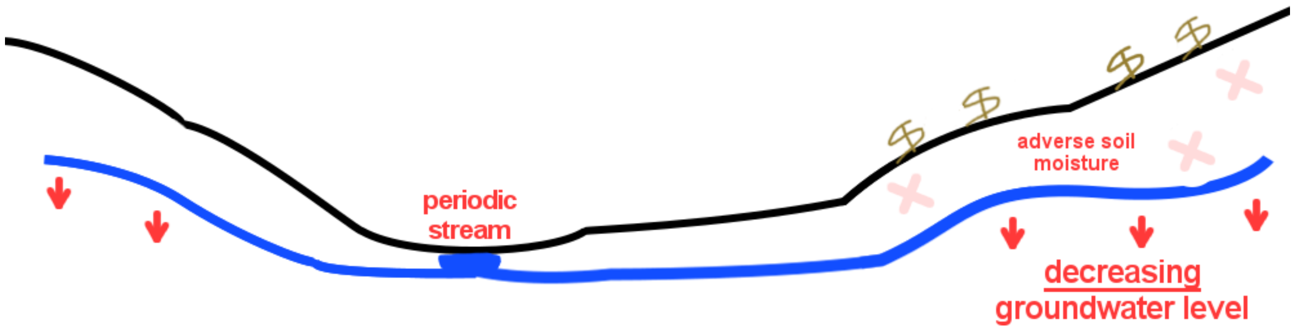
man. = manual measurement with litmus paper; comp. = measured with computer

12.6. Figures of groundwater

12.6.1. Present level



12.6.2. Possible future if no change will happen



12.6.3. Possible future with my solution