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YIELD FORECASTING FOR OLIVE TREE BY METEOROLOGICAL FACTORS AND POLLEN EMISSION

Aferdita LASKA MERKOCI[1], Albana HASIMI[2], and **Mirela DVORANI[3]**

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ABSTRACT

The paper aims to forecast the olive product based on the application of a statistical model by use of meteorological factors and pollen emission. Nowadays there are a number of models and approaches related to the yield forecasting. All of them have their advantages and disadvantages and moreover different behaviours for climate conditions of Albania. Thus, after a preliminary evaluation the best fitted model was chosen and its result were analysed. The model was based on the multiple equations of regression, which took into consideration some climate factors. These factors are rainfall in May followed by rainfall in June. Minimum temperatures during spring and summer were also an important consideration due to the influence of night temperature on energy collected for fruit development.

The use of pollen emission and monthly meteorological data from 1985-2004 as predictive variables has enabled the production of a forecast up to 8 month prior to the end of harvesting.

The forecasting of yield production in this study has been made in November, which reflects the EPP and the meteorological factors like minimum temperature, maximum temperature, rainfall from May to October etc.

In addition, as the model requires, the most significant periods for this plant were chosen and evaluated for the Vlora region of Albania with the highest productivity in the country.

Results were compared with real olive crop data and estimates from the equation resulted to have a correlation coefficient about 0.77 and SE=3.0.

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[1] **PhD. Aferdita LASKA MERKOCI,** aferditamerkoci@yahoo.it, Polytechnic University of Tirana, Albania, Institute of Geosciences, Energy, Water and Environment, Department of Climate and Environment

[2] **PhD. Albana HASIMI,** alhasimi2000@yahoo.gr, Polytechnic University of Tirana, Albania, Institute of Geosciences, Energy, Water and Environment, Department of Climate and Environment

[3] **Msc. Mirela DVORANI**, mndrit@yahoo.com, Polytechnic University of Tirana, Albania, Institute of Geosciences, Energy, Water and Environment, Department of Water Economy

Key words: equations of regression, forecasting, meteorological factor, olive, yield product.

INTRODUCTION

The study of the effects of meteorological factors on crop production and the development of models for forecasting the yield has been the concerns of agro meteorologists worldwide. Crop yield forecasting is important for national food security including early determination of the import/export plan and price. It is also important in providing timely information for optimum management of growing crops (Varga-Haszonits,1983). Therefore, the initiative to study, evaluate and estimate olive production based on the most favorable model for the conditions of Albania was undertaken.
In agro meteorological studies different models are used to evaluate expectancy yield. All of them have their advantages and disadvantages. Hence, after a thorough evaluation, the most appropriate model was chosen and its results were analyzed (WMO, 2004).
The model of multiple regression equation that takes into account all climate elements is used for conditions of Albania.

MATERIAL AND METHODOLOGY

Study Area. Overview of Albania's olive culture
Albania is a Mediterranean country where the olive tree is thought to have originated from. For more than 3,000 years olives and olive oil have been one of the most celebrated food products; they represent a traditionally valued source of healthy nourishment.
Different parts of Albania have a great potential for olive cultivation and it can raise employment opportunities in rural areas. Thus, a new program on sustainable development of this sector aims at approaching the Albanian legislation with the European Union (EU) framework.
During 2015, farmers all over Albania increased investments on olive plants and their sub-products. A total of 12,000 tons of olive fruit was produced and half of it was exported.
Experts from the agricultural sector say that Vlora region ranks first in the country for olive oil production and export. The same specialists say that if farmers would invest more in this sector, the Region would have more incomes from agriculture (Dodona *et al*.2004)

Not only Vlora but also the Riviera and the entire southern region had a plenteous harvest during the last year. The olive oil produced in the region is recognized as a high-quality product.

Since 2010, over 450 farmers received financial support for olive oil cultivation, while production in 2015 was twofold compared to the previous year. According to USAID Albania there are about ten million olive trees in the country.

For more than 3,000 years olives and olive oil have been one of the most celebrated food products; they represent a traditionally valued source of healthy nourishment.

Figure 1: Geographic distribution of olive trees by districts.

Olives are among the most important fruit tree crops grown in Albania, covering an estimated 8% of the arable land. As shown in Figure 1, the Albanian olive production zone covers the entire coast from Saranda (South) to Shkodra (North) and inland river valleys in the districts of Peqin/Elbasan, Berat/Skrapar, and Tepelene/Permet.

At the end of the Second World War, Albania had about 1.5 million olive trees. By 1990, the number of olive trees increased to 5.9 million covering 45,000 hectares (Saranda, Vlora, Berati, districts etc. During the privatization of farm land in 1991 and 1992, 45,000 hectares of olive groves were distributed to 110,000 households, resulting in highly fragmented olive production. In this paper is taken in study of Vlora Region. This town is surrounded by gardens and olive groves. Vlora has a Mediterranean climate with cool wet winters and hot, (Grup autorësh, 1978), dry summers with temperatures exceeding 30°C (86 °F) in July and August. Table 1

Table 1: Climate conditions of Vlora region

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average High ^{0}C	13	14	16	19	23	27	30	30	27	23	19	15	21.3
Average Low ^{0}C	6	6	8	10	14	17	19	19	16	14	11	8	12.3
Daily Mean ^{0}C	9.5	10.0	12.0	15.0	19.0	22.0	25.0	24.5	22.0	19.0	15.0	11.5	17.0
Average Precipit mm	120	106	92	79	54	28	9	26	32	116	192	142	995
Mean Month. Sunsh. hours	133	147.9	173.6	225.0	272.8	318	368.9	344.1	279	210.8	117	99.2	2689.6

STATISTICAL AND MODELING ANALYSES

The study was performed in the Vlora area (South West) in a territory characterized by olive groves. The early olive yield, considered as a dependent variable in the study, expresses the total olive production for these regions (Clementi et al., 2001). The data used for the regression analysis were obtained from the data bank of the Institute of Geosciences, Energy, Water and Environment.

The pollen was monitored using volumetric pollen trap, located at the Agricultural University of Vlora about 530m above sea level. Phenological observations in the field were made at the same time as the pollen monitoring to test the significance of the monitoring itself (Edmonds, 1979).

The pollen monitored in the atmosphere has been captured continuously since 1985 and is reported as the number of daily pollen grains/m^3 (Galan *et al*. 2008) , during the entire flowering period. Starting with daily data, annual EPPs where constructed (1985-2010) by ending pollen concentration peak in the atmosphere. This period corresponds to maximum flowering. The EPPe was derived from the interaction between the EPP values and the mean values of precipitation, maximum and minimum average temperatures during the EPP. The EPPe value was derived from the direct proportional ratio [EPPe=(EPPxT)/1000, where T – Temperature in ^{0}C] and the inverse [-EPPe = (EPPxT/100] between the EPP values and the mean values of the meteorological variables indicated (Galan *et al*, 2004)

Meteorological data were obtained by, IGEWE (ex Hydrometeorological Institute), which registers a series of meteorological parameters (e.g. precipitation, temperature, solar radiation, atmospheric pressure, wind, etc. (Laska *et al*. 2014). The meteorological station has been located in the regions under study and collects this data. Daily values were elaborated to obtain chilling units (CU), growing degree hours (GDH) and GDD for the year being studied, t, and the preceding year, t-1, for all years considered.

Chilling units were calculated using the Utah method (Anderson *et al.*, 1986). A thermal range of 3^{0}C to 9^{0}C was considered optimal, and the maximum chilling value was assigned. Above and below these temperatures, the chilling effects were reduced. The chilling amounts were calculated starting from two different dates (1 December and 1 January) until six final dates (15 January, 1 February, 15 February, 1 March, 15 March and
1 April), giving 12 different values (Laska, 2008). The onset was determined in other studies taking into account the biological cycle of olive in the investigation area (Candau *et al*., 1998).

The GDH were calculated by using the method of Anderson (Anderson *et al.*, 1986) while the GDD were calculated using the method proposed by Baskerville and Emin (1969), which uses 12 threshold temperatures from 4^{0}C to 15^{0}C.

The GDH and GDD amounts were calculated from daily values starting from two onset dates (1 January and 1 February) until the dates of maximum pollen concentrations in the atmosphere (peak of pollination).

Regarding the meteorological variables, the sums of the monthly and total cumulative values were calculated for the maximum, minimum and average temperatures in the summer (June-September) to obtain a summer thermal stress indicator and indirectly, a water stress indicator. A linear regression model was constructed using the S-Plus statistical software to apply the normal test for verifying the robustness of the model (Cammen *et al*.2008).

RESULTS AND DISCUSION

In Table 1 are presented the annual values of EPPe used in the forecasting model. For the periods under study (1985-2004), better results were obtained using the average temperature in the direct proportion ratio with the annual EPP values compared with the values obtained using the precipitation and the minimum and maximum temperatures values. This is probably due to the fact that the average of temperature expresses the thermal trend better for a given period by mediating the extreme values that can be recorded with the other temperature variables. In addition, in a summer-flowering, the precipitation is not correlated with the event while it plays a determining role in the phases immediately proceeding the phenomenon (Fornaciari *et al.*, 2005). At the Table 2, certain annual variability can be observed that are closely linked to the production variability.

Table 2: EPPe Effective pollination period elaborated values realized calculating the direct proportionality ratio between EPP- effective pollination period and meteorological data (average variable in the same periods)

Year	EPPe			
	T_{min}	T_{max}	T_{mean}	Precipitation
1985	213	460	336	16
1986	120	180	150	92
1987	305	820	562	8
1988	120	215	167	0
1989	110	225	167	0
1990	150	310	230	0
1991	80	145	112	0
1992	125	192	158	160
1993	260	430	345	0
1994	305	480	392	0
1995	240	465	351	0
1996	715	1210	962	24
1997	350	632	491	0
1998	108	172	140	0
1999	854	1387	1120	0
2000	187	198	192	8
2001	120	215	167	0
2002	165	278	221	0
2003	172	280	226	0
2004	270	468	369	20

The high performance values of the pollen parameter confirm the relationship between the flowering event and the phases of fruit formation. It also explains the particular collaboration used in this study. It can also be said that with higher average temperature, the pollen transport capacity increases.

The analyses of correlation between production and meteorological variables (CU, GDD, GHD) in the years t and t-1 showed the best result with the cold accumulation December-February t-1 period while scarcely relevant results were obtained with the two parameters related to heat accumulation in both years. Therefore, it can be deduced that there exists a strong relationship between cold and olive production in the region of Vlora on the Albanian territory. This relationship could also be determined by the regime of the climate (Laska, 2008).

The use of pollen emission Figure 2 and monthly meteorological data from 1985-2004 as predictive variables has enabled the production of a forecast up to 8 months prior to the end of harvesting.

The forecasting of yield production can be made in different phenological periods. But in this study the forecast has been made in November, which reflects the EPP and the meteorological factors like minimum temperature, maximum temperature and rainfall from May to October.

According to the results of table 2, the independent variables of multiple regressions were chosen. The regression coefficients were calculated using the meteorological data of the period 1985-2004.The equation for the region under study is presented as follows:

$$Y = -129234 + 6592x_1 + 51x_2 - 7198x_3 + 1498x_4 + 7698x_5 - 7192_6 - 85213x_7$$

R=0.77 SE=3.0 F=2.6

Where:

Y – product;

X_1- rainfall in May (RfMy);,

X_2-pollen (EPP);

X_3- maximum temperature in October (MxTO);

X_4-rainfall in October (RfO);

X_5-rainfall in July (RfJl);

X_6-maximal temperature in October;

X_7-minimum temperature in July (MnTJl)

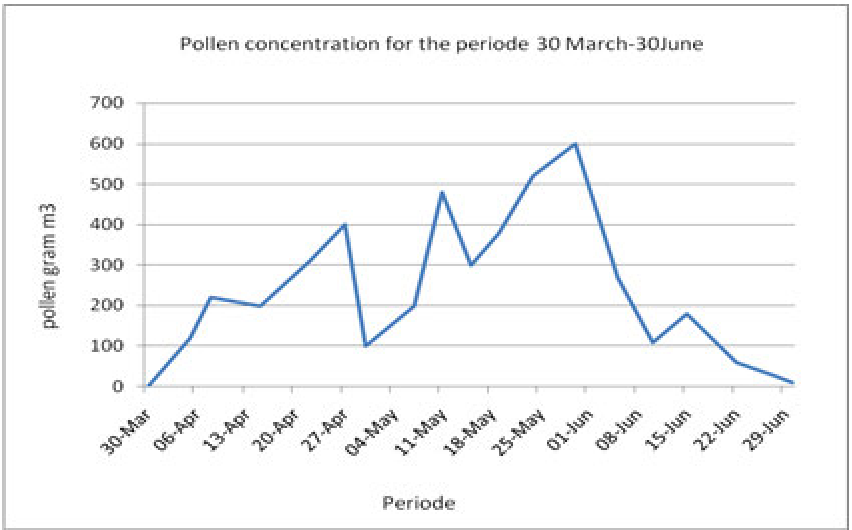

Figure 2: The daily pollen emission 30 March-30 June

It can be observed that the EPP and precipitation values that have been entered in the equation are positive. Other parameters that were taken into account were the air maximum and minimum temperatures, with minimum temperature affecting crop development negatively and maximum temperature favoring fruit production Figure 3. During October, the temperature exerted an opposite effect with maximum temperature negatively influencing crop development and minimum temperature being positive for crop production.

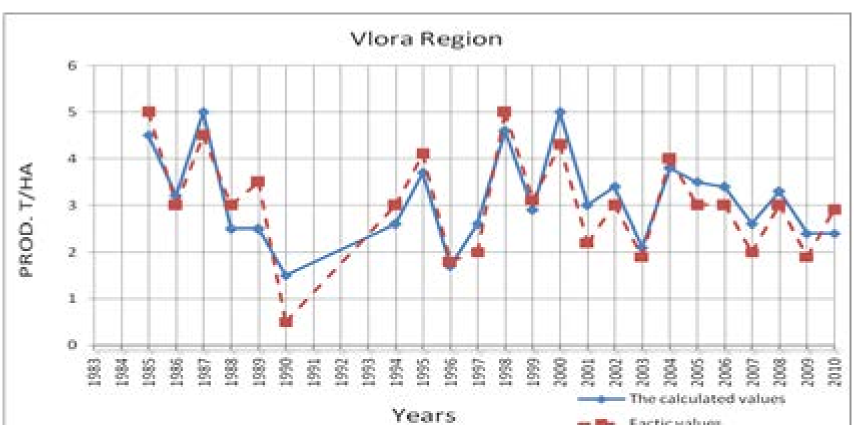

Figure 3: Yield forecasting for Olive Trees in Vlora region

Integrating aerobiological, field phenological and meteorological data is an important advance in estimating olive crop production. The reliable results confirm the validity and accuracy of the globally used Hirst volumetric traps as a tool for olive crop yield forecasting in high density olive-growing areas. Pollen content in the air can provide accurate predictions of expected olive yield up to 8 months in advance. These are an asset in enabling farmers and governments to better plan marketing strategies and define agricultural policies in Albania and the Vlora region specifically.

CONCLUSIONS

The pollen data gained from aerobiological monitoring was necessary for the construction of a forecasting model for olive plants. The method notes that only a certain amount of pollen has real reproductive in the fruit formation. In the growing and maturation phenological phases the relationship between the meteorological data became evident.
Influenced by meteorological parameters prior to the flowering period (rainfall, and to a lesser extent temperature) in Vlora region. Nevertheless, meteorological parameters during and after the flowering period have the most influence on final olive crop production. The main meteorological factor in the model was rainfall in May, followed by rainfall in June. Minimum temperatures during spring and summer were also an important consideration due to the influence of night temperature on energy collected for fruit development. And, autumn is the key season for fruit development. For this reason, different equations were constructed for different periods of the year. Results were compared with real olive crop data and estimates from the equation has a correlation coefficient about 0.77 and SE=3.0.This results confirm the validity of regression equation for forecasting of product of olive by Pollen emission and meteorological factors.

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DATA QUALITY COMPARATIVE ANALYSIS OF PHOTOGRAMMETRIC AND LiDAR DEM

Dimitrije KANOSTREVAC[1], Mirko BORISOV[2], Željko BUGARINOVIĆ[3], Aleksandar RISTIĆ[4], Aleksandra RADULOVIĆ[5]

UDC: 528.7:528.8.044.6(497.11)

ABSTRACT

Photogrammetry and LiDAR are best-known technologies of mass data collection. In this research, comparison of two DEMs (Digital Elevation Models), created from data collected by LiDAR and photogrammetric technology, was done. In that way it was tried to analyze these two technologies and discuss about their advantages and disadvantages. Research area was area of Petrovaradin (Novi Sad, Republic of Serbia). It was examined difference in heights between the two models, slope, minimum, maximum and mean height. Also, transversal profiles of some objects (the rampart and the tunnel) and places (terrain cover by forest and the coast), from the both models were compared. Statistics was approximately the same, but during the examination of transversal profiles some objects hadn't been detected on photogrammetric model. LiDAR model has better approximation of terrain in areas covered by forests, because of more ground points, which were detected thanks to laser beam capability to pass through tree canopy and reach the ground. Based on facts obtained during this study, LiDAR technology may be especially useful in archeology, during exploration in dense forests. Based on the performed analysis and the obtained results, in conclusion given are advantages and disadvantages of the obtained height models as well as their areas of application.

Key words: Photogrammetry, LiDAR, DEM, quality data, comparative analysis.

[1] **B.Sc. Dimitrije KANOSTREVAC**, dimitrije94_bn@yahoo.com, University of Novi Sad, Faculty of Technical Sciences, Adress: Trg Dositeja Obradovića 6, 21 000 Novi Sad, Serbia

[2] **PhD Mirko BORISOV**, mborisov@uns.ac.rs, University of Novi Sad, Faculty of Technical Sciences, Adress: Trg Dositeja Obradovića 6, 21 000 Novi Sad, Serbia

[3] **M.Sc. Željko BUGARINOVIĆ**, zeljkob@.uns.ac.rs, , University of Novi Sad, Faculty of Technical Sciences, Adress: Trg Dositeja Obradovića 6, 21 000 Novi Sad, Serbia

[4] **PhD Aleksandar RISTIĆ**, aristic@.uns.ac.rs, , University of Novi Sad, Faculty of Technical Sciences, Adress: Trg Dositeja Obradovića 6, 21 000 Novi Sad, Serbia

[5] **PhD Aleksandra Radulović**, sanjica@uns.ac.rs, University of Novi Sad, Faculty of Technical Sciences, Adress: Trg Dositeja Obradovića 6, 21 000 Novi Sad, Serbia

1 INTRODUCTION

Considering the technology advancement in the digital terrain modeling and increasing trend of using laser scanners in collecting data and creating DEM from the same, it is of great importance to compare it with older, reliable techniques that have been used for a couple of decades in data collecting. Photogrammetry and LiDAR are today one of the best-known technologies of mass data collection. LiDAR is an active technology because it emits energy source (laser beams) rather than detects energy emitted from objects on the ground. And on the other side photogrammetry, based on images that are transformed from 2D into 3D models uses the same principle as 3D videos do (stereo photogrammetry).

The main advantage of LiDAR technology in comparasion with other techniques of remote researching is that the details on relief are directly measured, they are not gained with extra stereo restitution (Čekada, M. T., 2010). Point density of LiDAR recording affects on final result, more detailed analysis can be found in paper (Čekada, M. T. et. al. 2010). Also, LiDAR beam as an active sensor can penetrate through gaps in tree canopies and reach the terrain so it could be useful for digital terrain modeling (Buckowski, A. 2018). This fact is interesting for comparing two DEMs created from data collected by both technologies and for examination how photogrammetry approximates terrain in dense forest areas, i.e. what are the main differences in quality between these two technologies when we are talking about terrain modeling, that was done in this study.

Some researches dealt with similar topics, when we are talking about comparing these two technologies. Their subject of research was mostly focused on comparing the accuracy of forest inventory attributes estimated from high-density Airborne lasser scanning (ALS) (21.1 pulses m^{-2}) point cloud data (PCD) and PCD derived from photogrammetric methods applied to stereo satellite imagery obtained over forest in New Zealand. For mean top height ALS produced better estimates (RMSE = 1.7m) than those obtained from satellite data (RMSE = 2.1m). The satellite-derived CHM (Canopy Height Model) showed significantly lower detail than the ALS-derived CHM, reducing the usefulness of these data for tree-level metrics and delineation (Pearse et al., 2018). The comparative analaysis of photogrammetric and LiDAR data was done on flood example in Slovenia (Čekada, M. T., & Zorn, M., 2012). Analysis of LiDAR and multispectral Ikonos stereopairs on the example of DSM, revealed an overall vertical difference between the models of 8.2m, where only one third of the differences were below 3 m (Marsetič, A., & Oštir, K. 2010). With combination of LiDAR and ortophoto data, a high-quality visualization of area of interest can be obtained (Lunar, M. et. al. 2016). Laser scanning can be used for accurate characterization of forest properties (Shao et al., 2018, Shi et al., 2018a, Shi et al., 2018b, Hall et al., 2005, Naesset, 2002, Shao et al., 2018, Moran et al., 2018, Gu et al., 2018) or individual tree level (Chen et al., 2006, Holmgren and Persson, 2004, Persson et al., 2002, Roberts et al., 2005, Liu et al., 2017, Pierzchała et al., 2018, Hu et al., 2018). Study in the paper (Salekin et al., 2018) clearly shows that point density of vegetation affected on the quality of DEM. At the most demanding cases (steep downhills and urban areas), different methods for DEM creation based on concepts of mathematical morphology, result with accuracy higher than 90 % (Mongus, D. et. al., 2013).

Today is also in usage UAV - LiDAR (The Unmanned Aerial Vehicle - LiDAR), it is promising technology and attempts to be used for forest management due to its capacity to provide highly accurate estimations of three-dimensional (3D) forest structural information with lower cost than airborne LiDAR. A study in wich are evaluated the effects of UAV - LiDAR point cloud density on the derived metrics and individual tree segmentation results and evaluated the correlations of these metrics with above ground biomass (AGB) by a sensitivity analysis (Ginkgo platanation in east China). The results showed that, in general models based on both plot-level and individual-tree-summarized metrics performed better than models based on the plot-level metrics only (Liu, K. et al., 2018). Application of UAV technology during estimate of earthwork volumes determination of landfill or excavation of the building material was done in the paper (Urbančič, T. et. al. 2015).

Through few papers the comparative analysis of different methods of interpolation was done.These methods are commonly used in software packages.Some examples of these methods are: Inverse Distance Weighting (IDW), Nearest Neighbour (NN), Radial Basis Functions (RBFs), Local Polynomial or Kriging. Research in the paper (Arun, P. V., 2013). They revealed that, Kriging's method gave the smallest value of RMSE in most of cases. Besides Kringing method in paper (Szypuła, B. 2016), method NN gave good results too. On the other side, at impact of DEMs on the time which is analyzed for public transport in Warsaw, methods NN and Spline gave the worst results (Bielecka, E., & Bober, A., 2013). Conclusion that there is not optimal method of interpolation, can be found in several papers (Arun, P. V. 2013; Kienzle, S., 2004; 2000; Susetyo, C., 2016) and on the first place it depends on the focus of reserch. It is important to mention that application of visual methods has good impact on quality estimation of DEM (Asal, F. F., 2012).

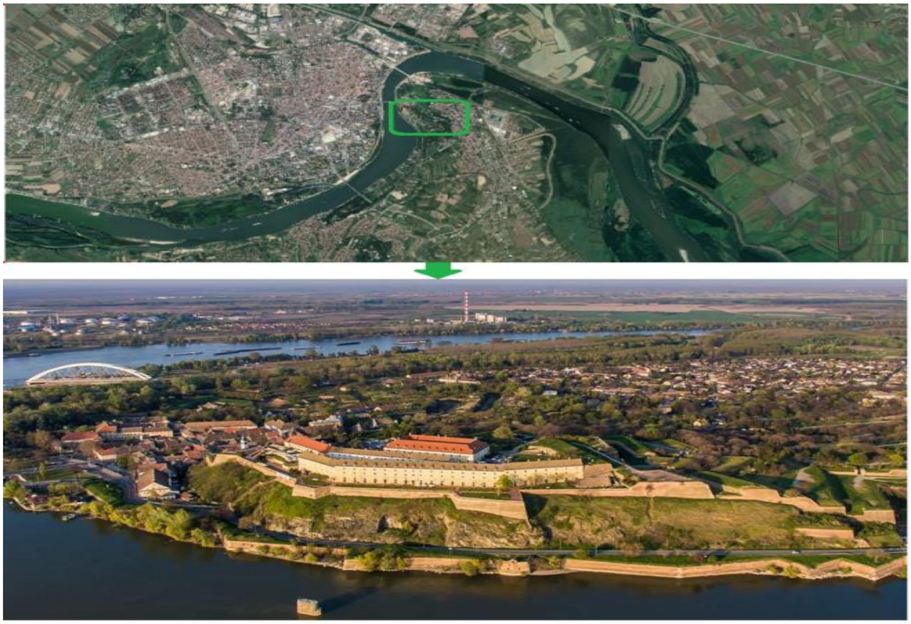

Fig. 1: *Area of interest*

In this paper, a comparison between two DEMs, created from data collected by LiDAR and photogrammetric technology, was done. On that way we tried to analyze these two technologies and discuss about their advantages and disadvantages. In some previous papers about similar topic, it was concluded that the LiDAR data were able to reflect more accurately the true ground surface in areas of dense vegetation, especially in places where the ground was invisible to photogrammetric operators (Alejandro Lorenzo Gil, 2012). Also, it was shown that LiDAR can reveal different geomorphological structures in densely vegetated regions (R.M. Landridge, 2013). That means that one of advantages of using LiDAR is detection change and measurement of large-scale geomorphological processes (Jason R. Janke, 2013). In this paper were compared models not only in forest areas but also in other places, including a general comparasion (over the entire area). The area of recording was Petrovaradin (Autonomus Province of Vojvodina, Republic of Serbia), one of two municipalities of Novi Sad (**Fig. 1**). It was built around fortress carrying the same name, during the 17th century. Research area covered the coast of the Danube river and the bed of the Danube.

2 DATA AND METHODOLOGY

Photogrammetric DEM used in analysis was obtained in its final form. Next, LiDAR DEM was created during the laser data processing step, and data were collected by the laser scanner *RIEGL LMS-Q680i*. The Number of recorded points was 66 million. Data acquisition was done by Laboratory for geoinformatics, Faculty of Technical Sciences and Italian company GEOCART S.p.A. The Scale of photogrammetric recording was 1:50 000. *Terrasolid* applications such as *TerraScan*, *TerraModeler* and *TerraPhoto*, which are specialized for laser data processing within *Microstation* software, were used.
Using different algorithms in classification process over cloud points and verification of the classification, besides other classes, class "ground" was created too and from that one, DEM was constructed within software *Microstation*. The model was exported as a lattice file in *GeoTiff* float format, with a resolution of 1 meter. To make comparison possible, it was necessary to overlap the models, i.e. to position them in the space on their real geographic location. The Positioning of the model, i.e. georeferencing and further analysis was done within *ArcGIS* software (**Fig. 2**).
Comparative analysis between two digital elevation models requires, among other things:

- slope calculation, minimum and maximum height, mean height and calculating other statistical data;
- calculating height difference and volume difference between two DEMs;
- drawing longitudinal and transversal profiles;
- visibility analysis (derivation of viewsheds)
- visualization of digital model (3D visualization and animation for better interpretation of terrain model) (Li, Z. et al., 2004);

Statistical calculations are obtained automatical for both models loaded in raster form.

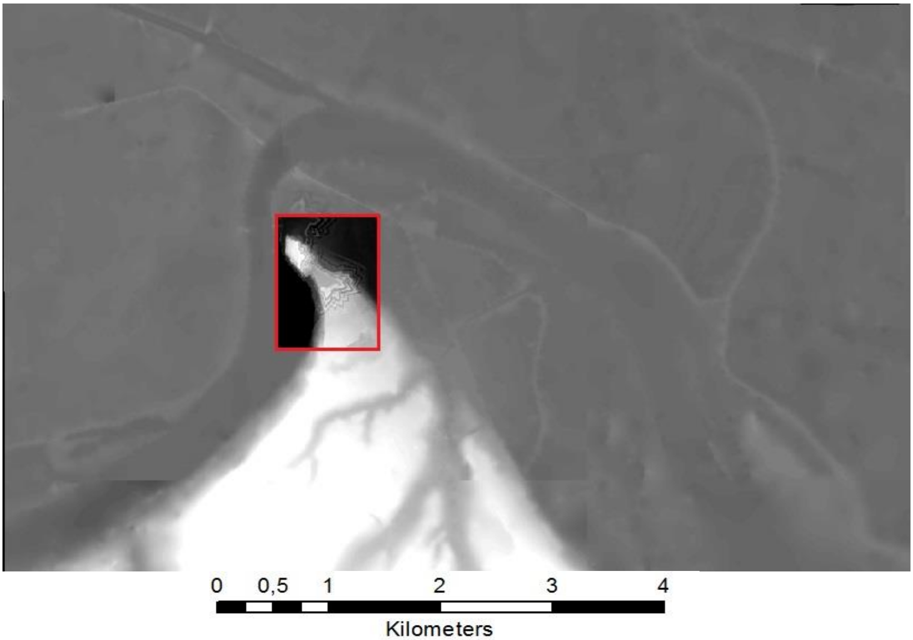

Fig. 2: *Overlap of two DEMs in raster form*

There are two opportunities for comparing two DEMs and calculating height difference between them, using an options *Cut Fill* and *Surface Difference*. Option *Cut Fill* is used for comparing two rasters. Software compares or deducts every pixel of the first image with the corresponded pixel of the second image. As a result, raster with display area where the input rasters match and where they don't, is obtained, i.e. where is one raster above or bellow the other one (Desktop.arcgis.com, 2018).

This method is commonly used during erosion examination of ground in a longer span of time in order to determinate where erosion occurred and where deposition or sedimentation occured. However, due to a more detailed analysis and better review of results, option *Surface Difference* was used because of a possibility of showing results in TIN format too (with hypsometric display of height differences), besides vector shp format(Desktop.arcgis.com, 2018). This tool requires that DEMs be displayed as surfaces, so conversion has been made from raster to TIN format before its use.

After conversion, used the tool *Surface Difference*, that works by perforimg a geometric comparison between triangles of both input surfaces. Triangles from the LiDAR DEM (**Fig. 3** Left) were classified based on checking if they were above or bellow the photogrammetric model (**Fig. 3** Right).

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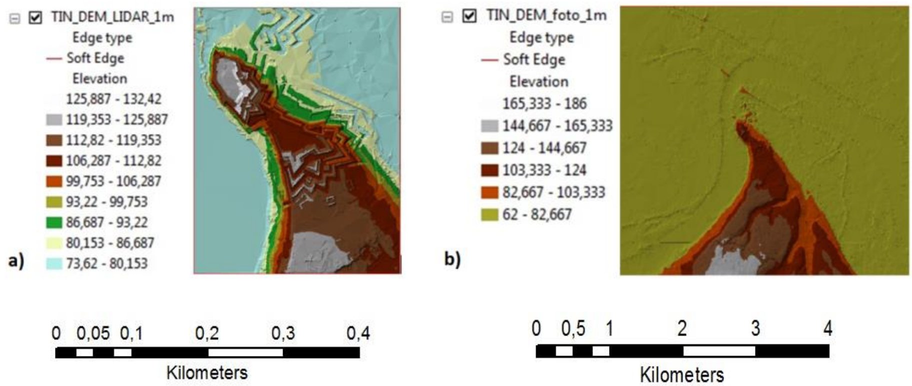

Fig 3: *Lidar DEM (a) and Photogrammetric DEM (b) after converion to TIN format with display of heights*

If intersection of one triangle from the first model with a triangle from second model is detected, then that triangle is split in smaller portions (triangles) in way that new triangles are above or bellow the second (photogrammetric) model with entire its surface, and after that, they can be classified into class "Above" or "Bellow". Neighbouring triangles that are classified in same class are groupped into polygons, and volumes of triangles (volume space above or bellow the referent surface) are summed, creating in that way a good overview of the surfaces that are over or under the referent model. As a result, shape file is obtained in the output, with previosly defined and classified polygons and values of their surface area and volume. The difference surface is constructed using constrained Delaunay triangulation (Desktop.arcgis.com, 2018).

In order to get better review of difference between two models and find advantages of using different technologies on smaller localities, it is necessary to compare them on "local" level too, not just on global. That means that these two models should be analysed in some specific places and see which model better aproximates terrain in that specific area. For the purpose of this anaylsis as specific places we used a tunnel on right side of Kamenichki road, coast of Danube nearby (**Fig. 4** Center) and ramparts of the Petrovaradin fortress (**Fig. 4** Left). It is important to mention that ramparts of fortress that are covered in vegetation, taking into account their age and material from which they are built, were considered as an integral part of the terrain, so they were included in digital model. Also for analysis purposes, small forest area was observed (**Fig. 4** Right), on the north of the recorded area, in order to understand how presence of forest vegetation affects creation of DEM and which technology is more accurate in such cases.

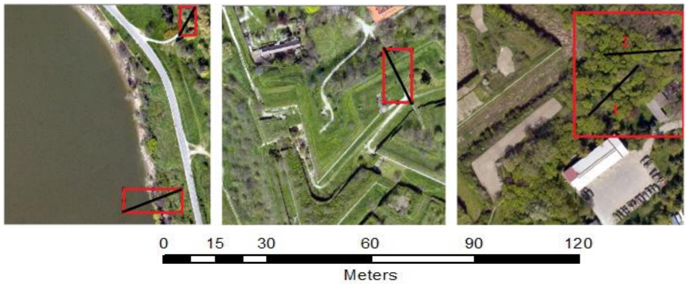

Fig. 4: *Marked profiles (areas of digitazed lines) for examination (tunnel, coast, rampart and forest*)

For this part of the task, *3D Analyst toolbar* was used with its tools for creating charts of longitudinal and transverse profiles of terrain models. Previosly, orthoimages of the tunnel, the fortress ramparts and the forest were georeferenced, in order to determine precisly the position of the tunnel and specific rampart on the model that will be analyzed. After that, using the tool *Interpolate Line*, we digitazed 3D line on the surface of that specific places. This tool allows turning off the display of the TIN model even during the digitization process, which can be particulary useful for better view and more accurate positioning of drawn objects. Also, digitization and analysis can be done on models in raster format too.
An important apsect of analysis and intepretation of digital terrain model is visibility analysis. Therefore, it was done in this paper too. Observation point was set up on the top of bulwark facing the Srem side which was detected on both models (Srem, serbian Срем/Srem is one three districts of the Autonomus Province of Vojvodina, Republic of Serbia). Tool *Observer Points* was used, that tool counts points that are visible on DEM in raster form, from the location that we specified earlier.

3 RESULTS AND DISCUSSION

Table 1 shows the statistical indicators analyzed for the area of interest (minimum and maximum height, mean height, slope calculation, and other statistical data).

Table 1:*Statistical data for both models*

	Photogrammetric model	LIDAR model
Minimum height [m]	71,00	73,62
Maximum height [m]	132,00	132,44
Mean height [m]	90,83	91,27
Standard deviation [m]	17,43	17,52
Minimum slope [̊]	0,00	0,00
Maximum slope [̊]	62,88	80,01
Mean slope [̊]	5,67	7,43

It was noticed that height range and standard deviation are aproximately same for the both models. However, value of minimum and maximum slope significantly differ, which may indicate that photogrammetric model is "smoother" than LiDAR model. Also value of the mean slope indicates that LiDAR model is more hilly than photogrammetric. Calculating height difference and difference in volume between two DEMs shows in the **Fig. 5**.

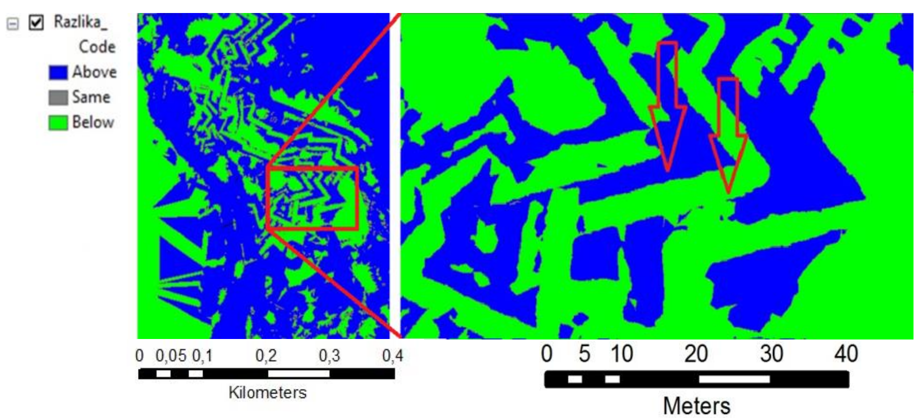

Fig. 5: *Feature class of differences with drawn polygons with example of height difference between rampart and the interspace between ramparts*

It is clear that the walls of the fortress are above the photogrammetric terrain model, while interspace is between them (green surface) lower than same space on the photogrammetric model (**Fig. 5**). It can be concluded that height differences between the top and the bottom of the wall are much bigger on the LiDAR model. The space on the northwest, that is inhabited, is mostly above, while the surface of the Danube is mostly bellow the photogrammetric model.

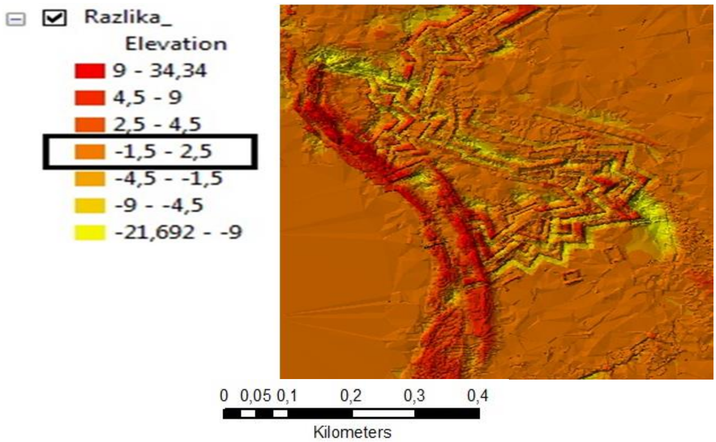

Fig. 6: *Model TIN with hipsometric display of height differences*

The value range of height difference classes was determined manually. Biggest differences according to the image above (**Fig. 6**) are on the west, along the coast of the Danube, on the right side, where differences are from 9m to 34m and near the southeast part of the fortress where they are from -21 to -9m. Considering that, accuracy of photogrammetric process of recording is 5m and accuracy of classification, it can be concluded, with certain degree of caution, that an "error/mistake" has occurred on the edges of Petrovaradin near the Danube and on the southeast. The height differences in other areas are in normal range and it can be noticed that models differ on biggest part of their surface, in a range from -1,5m to 2,5m. Sign minus suggests that in LiDAR DEM is lower than photogrammetric model in that region.
Based on graph profiles (**Fig. 7**), it was concluded that the tunnel is quite well detected on LiDAR DEM, compared to the photogrammetric model, where it was not detected. Such results justify a slight rise of the road before entering the tunnel, which corresponds to the actual situation on the ground.

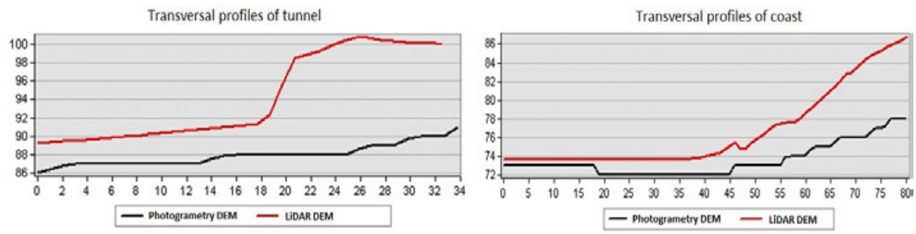

Fig. 7: *Transversal profiles of tunnel and coast*

It should be taken into account that the accuracy of photogrammetric model is 5m, so it is quite possible that the object on this model doesn't even exist. Profile of the coast (**Fig. 8**) is especially interesting for this study. Height differences between two graphs are not significant, and on 30-35m from the beginning , tilt change can be seen (border between water and the coast) on both profiles. The main difference is that on the LiDAR model, water height is fixed on constant value (it was done before creating the LiDAR DEM, within Microstation software, during the laser data processing step). So we can see a clear boundary in coastal area between the water and ground, and that is not case with the photogrammetric model.

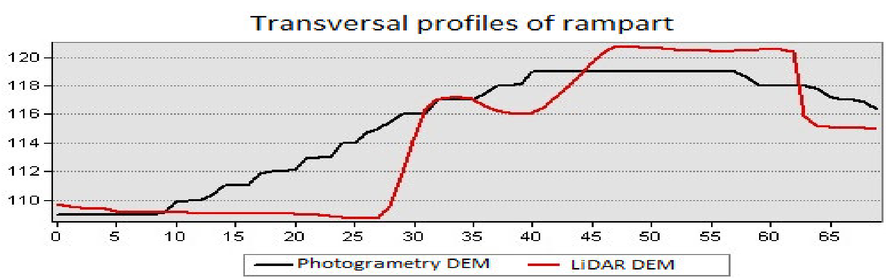

Fig. 8: *Transversal profile of the rampart*

On the transversal profile of rampart (**Fig. 8**), differences in height between these two models are in a range from few centimeters to 3m at the end of graphs. Similar change of altitude (height)on both graphs is noticeable, but with a different slope. Also we noticed that this slope is much more realistic (considering a fact that this is the transversal profile of rampart) on LiDAR model. The existance of the hillock and hollow (udoline) before the rampart, between 30th and 40th m indicate on interspace (path between the fence and rampart), where former austrian guards were passing during the time (Petrovaradin fortress was orginally built for military purposes as a fortification on Danube, during the austrian rule). The hillock, that is 1m high from the ground (hollow) and that is located near the "interpsace" or

path, played the rule of protetective fence or wall, but in time it is collapsed and overgrown with vegetation.
Such structure of rampart on Petrovaradin, are confirmed by the ramparts near the Danube that are not overgrown with vegetation and that are preserved in a perfect condition. Finaly, it can be noticed that these profiles are not matching completely, based on the height change at the begging and at the end of the profile, that happens around 63rd m on the LiDAR model, and around 59rd m on the photogrammetric model. However, the structure of the terrain in this area on both graphs, despite the height difference, is similar, so it can be said that rampart was detected on both models.

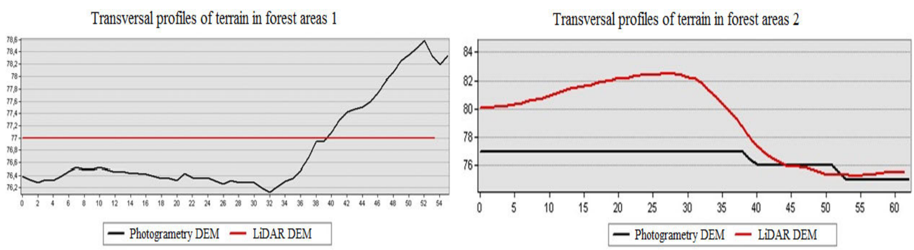

Fig. 9: *Transversal profiles of terrain in forest areas*

On these two profile graphs (**Fig. 9**) it can be easly noticed that, the height on the photogrammetric model does not vary significantly, it's even constant on the first profile graph and on the second it reminds on discrete function. That fact tell us about a small number of recorded points that represent a model in this area, collected by the photogrammetric technology. This indicates the impossibility to detect points in areas covered by dense forest vegetation. Unlike the photogrammetric method, laser beams easly pass through the vegetation reaching the ground, so based on few reflections tree canopy and terrain are detected (Rising, J. 2018).

3.1 Visibility analysis

It has been concluded that visibility on both models is similar (**Fig. 10**), but it's more clearly defined on LiDAR model. Still, it should be taken into consideration that these models couldn't be perfectly matched, so eventual divergence in visibility is possible from some other observation points which are not discovered in this research.

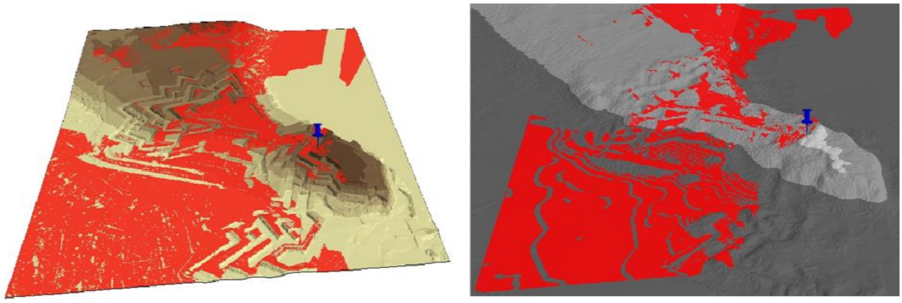

Fig. 10: *Visible surface from observation point on the LiDAR DEM (left) and on the photogrammetric DEM (right)*

4 CONCLUSION

Using different algorithms in classification process of cloud points in this paper and verification of the same, besides other classes, class “ground” was created too and from that one Digital elevation model was constructed within software *Microstation*. Such a model was exported as a lattice file in *GeoTiff* float format with a resolution of 1m. The lattice file unlike the raster one, represent a surface using a square net of points, of which, each keeps its original Z value (in this case its elevation)(Blogs.ubc.ca, 2018). This information is particulary significant during export to raster file. Scaling range of pixels was done, based on the whole area taking into account possible gaps that occurred during classification.

Considering that the goal was comparing two DEMs, export in the form of lattice file was used, to make the analysis more credible, by corresponding to real differences between models. Furthermore, the photogrammetric model contains surface of Danube river too, with mean value of 74m, the surface of the Danube is included in LiDAR model as well. Previously, the mean height on the surface of river was calculated, as the average Z value of 20 000 points, classified as water during classification. Calculating the mean height was necessary, as the height of the river surface varied at different places, due to the appearance of waves caused by wind and passing ships. Based on the calculated data, the height on the surface of Danube is fixed as 73,62m.

To make comparison possible, it was necessary to overlap the models, i.e. to position them in the space on their real geographic location. Positioning of model, i.e. georeferencing and further analysis were done within *ArcGIS* software. Georeferenced raster image is usually liable to distorsion, i.e. it loses data on its edges, due to fitting into coordinate system. The value of pixel on these places is null, so the height differences would be enormous on the edges, between two DEMs. In order to avoid this phenomenon, *Elevation Void Fill* function was used (**Fig. 11**). This function creates pixels in the elevation models, on regions where gaps with no data exists. Gaps i.e. holes appear due to the lack of points (in this case on the edges) within the surface that are represented in raster form. Function uses Plane Fitting/IDW (*Inverse Distance Weight*) method that estimates the value of created pixel or cell, that is based on the average value of neighbouring cells(Desktop.arcgis.com, 2018). Before execution this function we used *Mask* function that specifies areas (regions without data) over which function *Elevation Void Fill* should be executed (Desktop.arcgis.com, 2018).

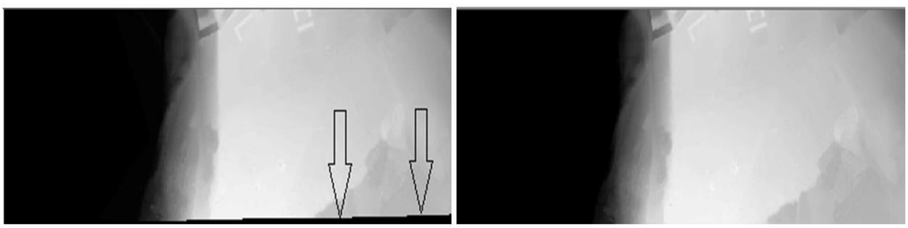

Fig. 11: *Before and after the using the function Elevation Void Fill*

After georeferencing of DEM and defining the spatial reference, filling “gaps (areas with no data)” caused by distortion during georeferencing, changing the resolution of photogrammetric DEM, valid overlap of two models is provided, and it is accurate enough so the comparason could be done.

Differences between two models are not latge in the majority of areas. The smallest differences were noticed on areas without vegetation that have the smallest slope. Increasing of the slope and appearance of dense forest vegetation caused increase in height differences. Based on these presented facts, it can be concluded that photogrammetric model gave quite solid results on majority of places, representing the ground in accordance with its accuracy. However, during the analysis of the transverse profiles, we noticed that some anomalies of the ground are not detected on photogrammetric model. This indicates a bad aproximation of terrain in these regions, comparing to DEM created from LiDAR data. The advantage of between these two technologies in areas with dense forest vegetation is given to the LiDAR technology because of the possibility for better terrain detecting, and that estimation was given, during the study of these transversal profiles of terrain in forest areas. Also this technology, based on examination of terrain model in forests in this paper, can be useful in archeology during discovering ancient cities and places in regions such as Amazon, equator and other areas covered by dense vegetation.

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THE CARTOGRAPHIC CITIZEN UNIVERSITY FROM THE UNPRECEDENTED CIVIC TOPO-CARTOGRAPHIC MODEL MADE IN PALESTINE (BATTIR FROM PARIS 2012-2019)

Jasmine DESCLAUX-SALACHAS[1]

UDC: 528.93(569.4)

ABSTRACT

This paper presents the framework and the issues of an unexpected encounter between '*les Cafés-cartographiques*' and an unknown Palestinian Laboratory of Ideas: the Battir Landscape Management Plan[2], a citizen-based palestinian experience recognized as one of the most relevant contemporary digital mapping projects. From heterogeneous topographic data handled on the spot at the end of April 2012, an unexpected universal topo-cartographic adventure took place, spreading ever more the simple complexity of the meaning 'to be a cartographer'. Offering a visible definition of what is 'a topographic map', a huge and complete collective work, usually confidential, followed-up. Managed from the local aerial photography, AutoCad primarily and ArcGis files were at first opened in ®Illustrator, then harmonized through art mapping in order to render accessible training tools in cartography. The students of the National School of Geographic Sciences cleaned the original databases and rectified the data through the orthophotography of the region, geolocating its informations. Since then, this local topo-mapping works in correlation with all our professional cartographic systems, through all possible cartographic aspects and uses. Battir self-produced the very first space topographic data of its country, Palestine, where no institutional data was available. Working in cartography at small scales in order to produce the best map aiming at informing its readers, our trades have always remained confidential. The commonal result is visible, not the means to reach it. Today, when all seems to be available through a keyboard click, this body of knowledge shifts dangerously. Battir provides an exceptional efficient range of living tools that demonstrate this.

Key words: Body of knowledge, Survey, Topography, Cartography, Geographic Information, Deontology.

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[1] **Jasmine DESCLAUX-SALACHAS**, jasmine.d.salachas@orange.fr, University Denis Diderot Paris 7- UMR Géographie-Cités 8504, PhD "Cartography, Education & Citizenship"/ National School of Geographic Sciences (ENSG) — Founder of '*les Cafés-cartographiques*' (Paris, 1999), Tel. +33 6 87428432.

[2] The plan includes an anthropologic study and a local survey managed in the frame of the Battir Landscape Ecomuseum (BLE, 2007—2011)

BEING CARTOGRAPHER IS AT FIRST A TEDIOUS COLLECTIVE WORK DIFFICULT TO EXPLAIN

Mapping offers the occasion to do so many digressions about passion, admittedly often flattering, but not useful in the usual meaning sense, since it ignores the real work involved in mapping.

Cartography encompasses a whole set of techniques aiming at presenting, on specific formats how, over the years, we inhabit (together) our territories and our societies. This is done through any possible projections, whatever the scale of our approach, whatever its thematic.

Those techniques change continuously according to the progress of sciences and improved creativity levels, according to what has to be said, to whom it has to be said and how, in order to remain accurate and make the map that must be created clearly understood. Today, at the digital era, we need ever more to explain our unique collective processes to reach the correct map available to inform its users.

Fig. 1: **Each map is an iceberg**.
The villagers and the scientific wonders: the cartographer, a perfect go between.

To create a map, *a fortiori* a topographic map, means to manufacture an iceberg (figure 1). Cartographers, working side by side with the different disciplines involved on the space and territory measurements and their representations, are living for months and long under a waterline in order to complete a tedious collective work ending by specific editing processes. Always checked out, step by step, following a planned management, respected by each collaborator, this incredible amount of expensive procedures is carefully coordinated in order to produce the final document to spread: the map, top of the iceberg which will eventually surface.

A JOB TO LEARN BEFORE BEING A "PASSION": TO MAP MEANS TO PRODUCE COLLECTIVE COMMUNICATION TOOLS IN ORDER TO SHARE UNDERSTANDING

Drawing maps means having broken down data in order to reorganize it by prioritized layers of information. Playing with the strength of the pencil strokes, with colors, their transparencies, creating graphics from a scale to another in order to underline and bring forward what would be needed to be able to memorize the content of the mat at a glance. Drawing, it means to study the best modeling of a subject, and that means to study it first in order to understand, and then, be capable of explaining and transmitting its meaning. Drawing maps supports the underlying understanding, patiently acquired, about what has to be learned in order to share it.

A map is a document designing knowledge in order to transfer it. To create it, the cartographers must necessarily share their thinking with interlocutors who are specialists in each specific topic of their discipline, depending on what the map they work on has to convey.

Collecting data, measuring them, interpreting images and learning to report very precisely each delineated information at readable small scales, using specific tools to obtain the intended result... drawing, engraving and photoengraving, transitioning from one time period to another, until the emergence of digital tools, which have constantly progressed. In a nutshell to map means to learn. One of the strong points of a cartographer, if not the most essential one, is to be capable of adapting any production methods to the most modern and rational tools ever in our process, to reach the expected collective goal. In the world of mapping, nothing can be improvised, and everything is always transformed in order to offer its best outcomes, that can then be archived and always prepared to be updated and enhanced.

HOW TO TRANSFER A LANDSCAPE INTO A MAP? AN INVITATION TO SHARE PEDAGOGY

Founded in 1999, '*les Cafés-cartographiques'* are informal meetings open to all publics and aiming to share this infinite wealth of our cartographic professional worlds. It is a friendly way to get out of our inner circles and address everyone, to explain to what extent cartography is a discipline in itself, which cannot be mixed into any other, neither into geography, nor into history, but which requires everyone's contribution. In our meetings, authors from all disciplines have a say but the conductive wire remains the map.

Through a request received in October 2011 from landscape design students in Lille (ENSALP, France), *'les Cafés-cartographiques'* were invited 6 months later, end of April 2012, in a Palestinian village named Battir – it remains important to specify that this place was not mentioned before and ignored by our collective mapping activities. The aim of the journey was supposed to help them answer their question: HOW TO TRANSFER A LANDSCAPE INTO A MAP? (figure 2).

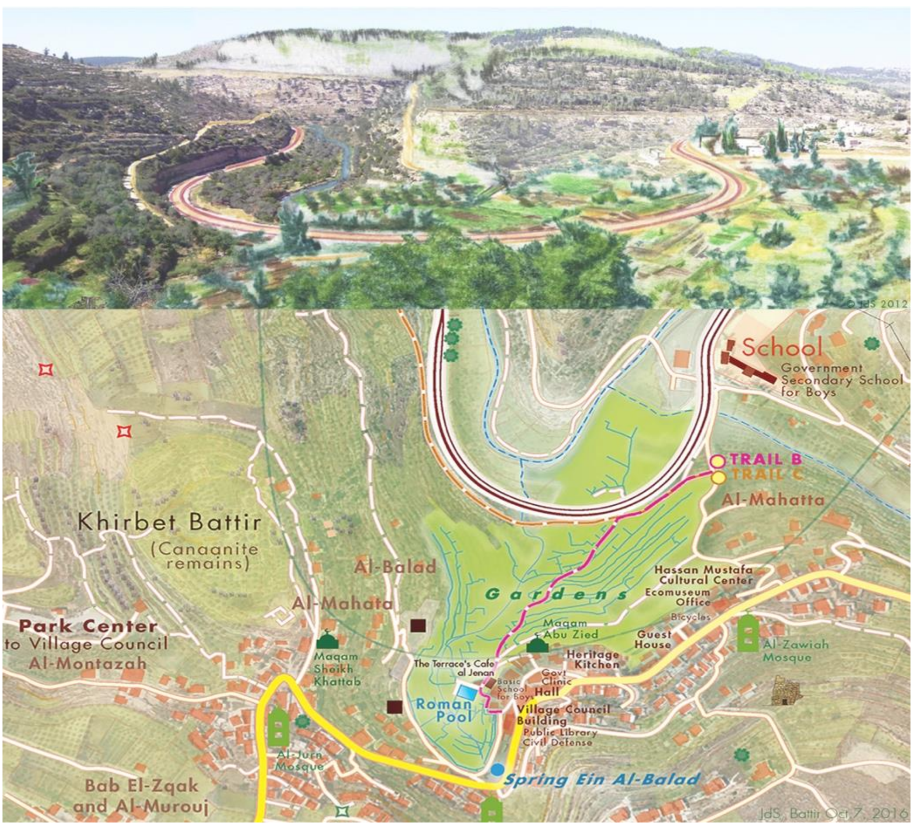

Fig. 2: **From the landscape to the map**: **sizing the reality in order to map it (Mapping Battir 2007—2011 / 2012—2019)**.

The objective was to explain the students how maps could be drawn through immersing into those landscapes of Palestine. What has happened since has never been anticipated.

Lille is twinned with Nablus in Palestine. In the context of this town-twinning frame, the students had participated in a Summer university course in 2010. At that time, they had the opportunity to spend 3 days in Battir and meet with the Ecomuseum team, to see the maps under preparation. While they did not totally understand what all that work through the survey meant, they had a feeling that something was happening there, that would be important to understand and disseminate. The activities of '*les Cafés-cartographiques'* triggered their initiative and the answer simply was "Yes" to their invitation.

Therefore, the trip was prepared without really knowing what would be found out there. To seize the cartographic frame of Battir, all available maps of the region were collected from the national Library of France (BnF), from the National Geographic Institute (France Maps Library), from the Department of Defense Historical Resources, BRGM (French Geological Survey), etc. From our side, this historical maps funds represented the first mapping data base of this exceptional topographic adventure. The best location of Battir first appeared in the Bethlehem sheet 16/12 produced in 1944 by the Ordnance Survey Cartographic Department (figure 3).

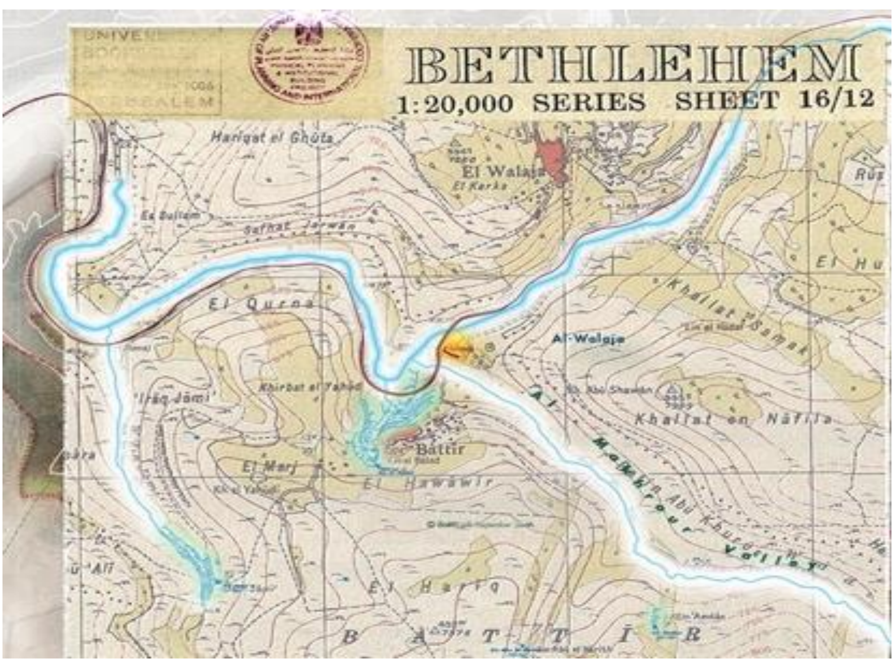

Fig. 3: **Battir located in Bethlehem sheet 16/12**
Ordnance Survey, **1944 (1:20 000 abstract)**.

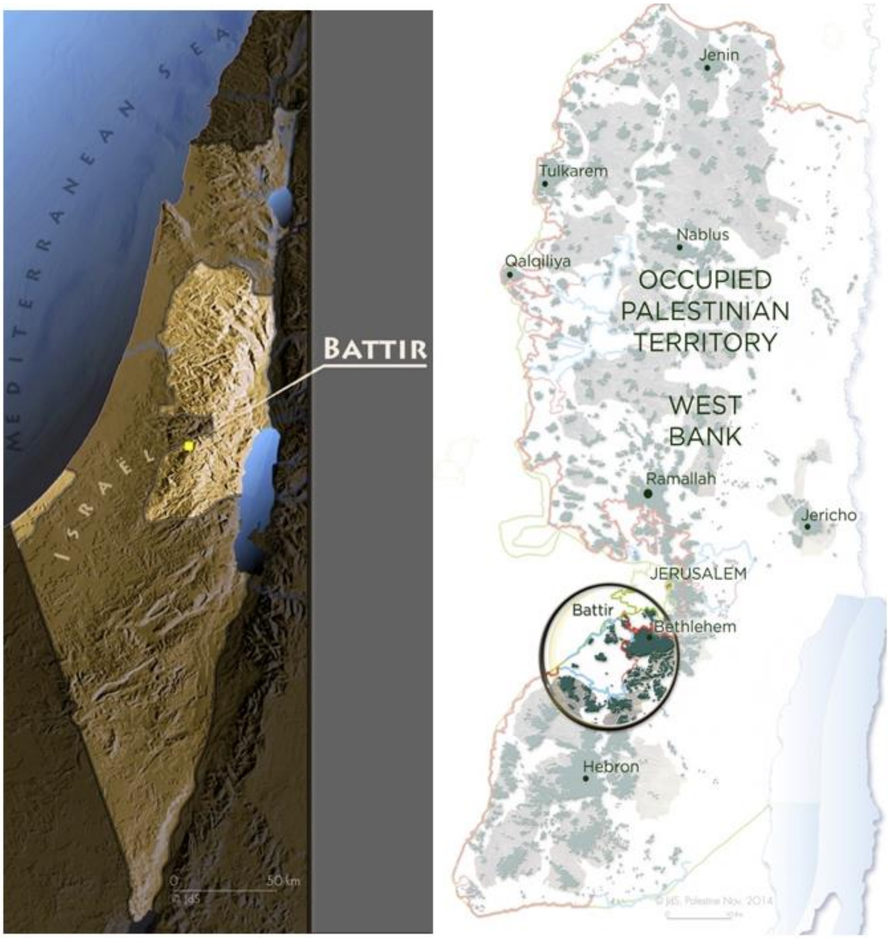

Fig. 4: **Battir, location in West Bank**.

The trip began with a few days in Nablus where the students have therefore exposed their 2010 landscape studies. The actual encounter with Battir took place from April 24 to May 5, 2012 (figure 4). 12 short days to assess the wide scope of those unprecedented but yet unknown topographic works, under the best auspices of the civil engineer who was a member of this visionary Ecomuseum team - which in the meantime had left Battir (since November 2011), but no one was yet aware of that.

AN ANTHROPOLOGIC STUDY AND A CITIZEN SURVEY IN ORDER TO MAP THE TERRITORY

The anthropologic study completed by a local survey above mentioned constitutes an unprecedented cultural program set up after the Second Intifada, thought as soon as in 2003, in this occupied village, Battir:

> *"In terms of perceptions and representations of the changes and the transformation that occurred on the local historical landscape in the last decades, communities express generally negative feelings and evaluations about them, and this specially in rapport of the disruptive effects of the Israeli occupation on the Palestinian territorial, economical and socio-cultural integrity. One of the main changes caused by Israeli occupation is identified in the dramatic decrease of the value of the agricultural sector, that resulted in the impoverishment of the population, in the increasing high rates of unemployment specially amongst new generations, in the deterioration of valuable agricultural land or its use for uncontrolled urban development, in the loss of important traditional knowledge and abilities, in the disruption of the bonds of solidarity that were at the base of the socio-cultural fabric of the communities, and in other negative repercussions at the material and symbolic levels" (Cancellotti, Cirino, Harb, 2009).*

The historical part of the village is split by the Armistice Line (per the Rhodes Agreements of 1949). Battir is located 5 kilometers West of Bethlehem and 7 kilometers South-West of Jerusalem (figure 5).

Today, more or less 6000 inhabitants live there, essentially a rural population. A very high unemployment rate plagues its young people, as it is the case everywhere else around.

Fig. 5: **Battir, a palestinian village 5 kilometres west of Bethlehem, 7 kilometres south-west Jerusalem (April 2012)**

At the time of the survey, Battir established an Ecomuseum in order to develop as well as to protect this ongoing cultural program: a social-anthropological project initiated over 12.5 Km^2 of its territory and surrounding areas (figure 6, 7).

Photo: Unesco Working Team (BLE 2007-2011, abstract)

Fig. 6: **UNESCO working group, Battir Landscape Ecomuseum (2007—2011) Civilian Cartography is, at first, to make peace**.

The aim was to react to the planned progress of the Separation Wall, to refuse the eradication of a culture going back thousands of years (figures 8, 9), to explain how the untouched equilibrium of its landscape has nourished its population up until today, based on a pattern maintained since ancient times:

> *"[...] through survey and the exploration of the available land registries, from photographs, from maps, from aerial photos; all of this to reconstruct a 'map' that makes the different forming processes of he landscape visible, whether the landscape is built upon or not. This takes place through the recognition of permanent things and remains of buildings in the territory" (Serrini, Zagaglia, 2012).*

The aim was to demonstrate why nothing of it should be destroyed but that, on the contrary, this sustainable economy should be preserved and extended far beyond Battir.

Project	Protection Plan, management and valorisation of Battir landscape		**Nicola Perugini**, Planning policy and relations with the local community
Location	Battir (Parts of Beit Jala and Husan territories), District of Bethlehem, Palestine	Ordering Institutions Chronology Extension of the Project	Municipality of Battir and UNESCO Ramallah Office (Funding from Norwegian Government) 2008-2012 12 Km2
Landscape Experts	**Giovanni Fontana Antonelli**/ Coordination of the plan, vocational trainings and participation	Cost of the Project	150 000 USD
Other experts and consultants	**Lino Barone**/Landscape planning **Claudia Cancellotti** and **Patrizia Cirino**/ Anthropology of Landscape, **Francesco Cini**/ Geology and hydrology	Awards and recognitions Management and Maintenance	2011: Melina Mercouri International Prize for the safeguarding and management of cultural landscapes Landscape Eco museum of Battir
Collaborators	**Samir Harb**, and **Mohammed Hammash**/ territorial analysis, GIS **Hassan Muamer** / territorial engineering and territorial analyisis	Visitors opportunities Management and Maintenance	Yes (possibilities of local guides)

Fig. 7: **UNESCO team for an unpublished Laboratory of Ideas, Battir Landscape Ecomuseum (2007—2011)**

Fig. 8: **Battir Landscape Ecomuseum. Terraces presentation (April 2012)**

Fig. 9: **Battir, the Gardens are named 'Al-Jenan' / 'Paradise' (April 2012)**

This study as well as the survey itself have been supervised by the team of young professionals, without any support from any institution related with geographic information. In spite of all the local complexities deriving from the policy of occupation, this team was capable of together reinventing what characterizes « Civilian Cartography »:

> *"The main objective is building a collective conscience geared towards the necessity of protecting resources and consequently to control the alteration of the landscape; that interventions are not uncontrolled or irreversible, and that they allow the use of the same resources to present and future generations. This is followed-up with the diffusion of acquired knowledge on these themes and their constant updating" (Fontana Antonelli, 2007).*

The guiding principle of the study was driven by G. Fontana Antonelli, an urban planner, architect and landscape expert, who at that time managed the Culture Desk at UNESCO Office in Ramallah. After nearly 4 years of joint reflection, the work was carried out from 2007 to 2011, within the frame of the UNESCO activities, supported by a Norwegian fund, by the World Heritage Fund and by an Italian cooperation program contributing to the development of municipalities in Palestine.

The study, its ins and outs, its authors and their respective functions, are presented in the synthesis drawn up by G. Fontana Antonelli in 2014 for *'les Cafés-cartographiques'*; it has been translated from Italian into Arabic, English and French to allow for the widest possible promotion of all the work achieved: « Battir, a Laboratory of Ideas for the Safeguarding of the Landscape of Battir, District of Bethlehem, Palestine ».

SIZING THE SPACE AND THE TERRITORY

In order to study and qualify this territory, it has been necessary to measure it, so to survey it in order to map it: to measure each plot, each object in the landscape, each line that it comprises. To measure and to report… the young professional citizens who designed those works with the aim to protect the future of this village were neither geodesists, nor topographers, nor cartographers; they were urban architects, later joined (in February 2010) by a civil engineer, the only Battirian citizen in the team.
In the beginning, they sort of stumbled around. They searched for the best methods for mapping without having access to our standard tools (which were not available to Palestinian citizens), without orthophotography to build up the geometry of their topographic reports… They worked tirelessly for years in order to obtain their results and to guarantee the quality of their topographic mappings with the team of young anthropologists who supported the project, working closely together, side by side.
At the time, H. Muamer, the local civil engineer of the team, was still a convinced defender of this mapping study for the sake of the future of his village and his country. He remained the only Battirian citizen that had contributed to conduct this topographic survey, knowing perfectly well all the collective works done within the frame of this single Ecomuseum in Palestine, the study documents, their uses, each of its data and characteristic. The study with its survey was perfectly explained.

A LIVING ENCOUNTER: CARTOGRAPHY BETWEEN GEOHISTORY, GEODESY AND ART

During those 12 days, he often said how much he was just wearing himself out, all alone, explaining over and over again to a deaf audience the quality and the necessity of those works no one cared about. He got no support whatsoever and feared that it would all be lost down the drain.
Of course, to exhibit those works as part of the activities of ‘*les Cafés-cartographiques*‘, purpose of which being to make available to all publics anything related with cartography, particularly civil cartography, seemed immediatley an urgent evidence. To be in Battir was not for any ulterior motive, but to support and spread around the importance of such works was the least that had to be done.
To be in Battir, welcomed in such a preserved peaceful environment (figure 10), was to answer the questions of the students.

Fig. 10: **Battir, first walk (April 26, 2012).**

However, in order to understand how maps should be drawn – in a professional way - one has to start with a survey measuring the landscape and the data items in it (figures 11, 12).

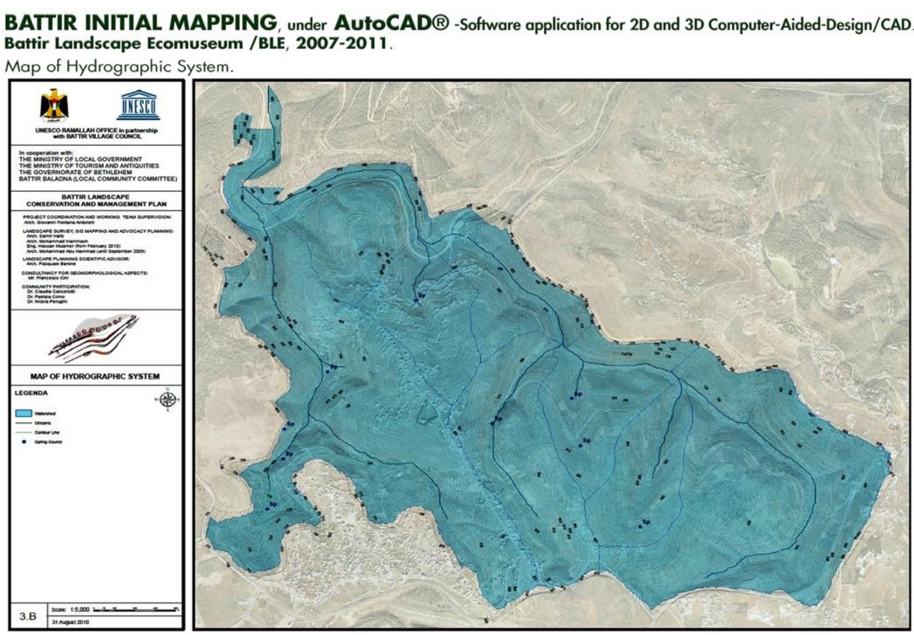

Fig. 11: **The very first topographic map of Palestine. Hydrographic System (BLE, 2007-2011).**

It was not expected to find such a wealth of educational material collected in such poor production conditions, altogether constructive, extremely encouraging, astounding, optimistic but totally spoilt as a result of the inertia of local decision makers who simply had no interest for their innovative citizen project.

Fig. 12: **Civilian Cartography re-invented (BLE, 2007-2011)**.

It would have been useless and rude to spend 12 days in those landscapes with the students and try to re-design everything. Best was therefore to stay concentrate in order to understand precisely what had been done on the ground in Battir throughout all those years (figure 13, 14).

Fig. 13: **an anthropologic study and its survey carried out within Battir**: **explanations by Eng. H. Muamer (BLE, April 2012)**.

Fig. 14: **12.5 Km2 have been studied and mapped through each thematic of the battirian terroir and its surroundings between 2007— 2011. Explanations by Eng. H. Muamer (BLE, April 2012)**.

The utmost importance of those works shows how dramatic it would be to just give them up and how disheartening all was about such a dereliction – although Eng. H. Muamer was preparing for supervising in spartan conditions the restoration management in the valleys and in the historical center of Battir, totally convinced to obtain all targeted results.
At first, each data transmitted was rebuilt in a wide ®Illustrator file (software used in cartography for the quality of its graphic functionalities and easily accessible to the students). The entire data contents were opened from their .PDF recordings in order to harmonize each contour, each line, each drawing, always retaining their axis through hundreds of processes to protect their geometry, in order to reproduce the map of the territory of Battir in its entirety, layer by layer, element by element, to eventually make available a simple-to-use, comprehensive educational material (figure 15).
The idea was to later explain our mapping processes and the graphic semiology through this exceptional model: to explain it to those students who were the heart and soul of this trip, and also to Eng. H. Muamer who wished to understand it all in order to, in turn, share it with the people around him and teach them our state-of-the-art practices, thus spreading such surveys to other villages.
Then, it was simply proposed to adjust, from Paris, the geographical data of Battir related to the orthophotography of the region, so that the whole data collected from the Ecomuseum could be geolocated and provide everyone with a professional cartographic approach, new and innovative to the Palestinian people.

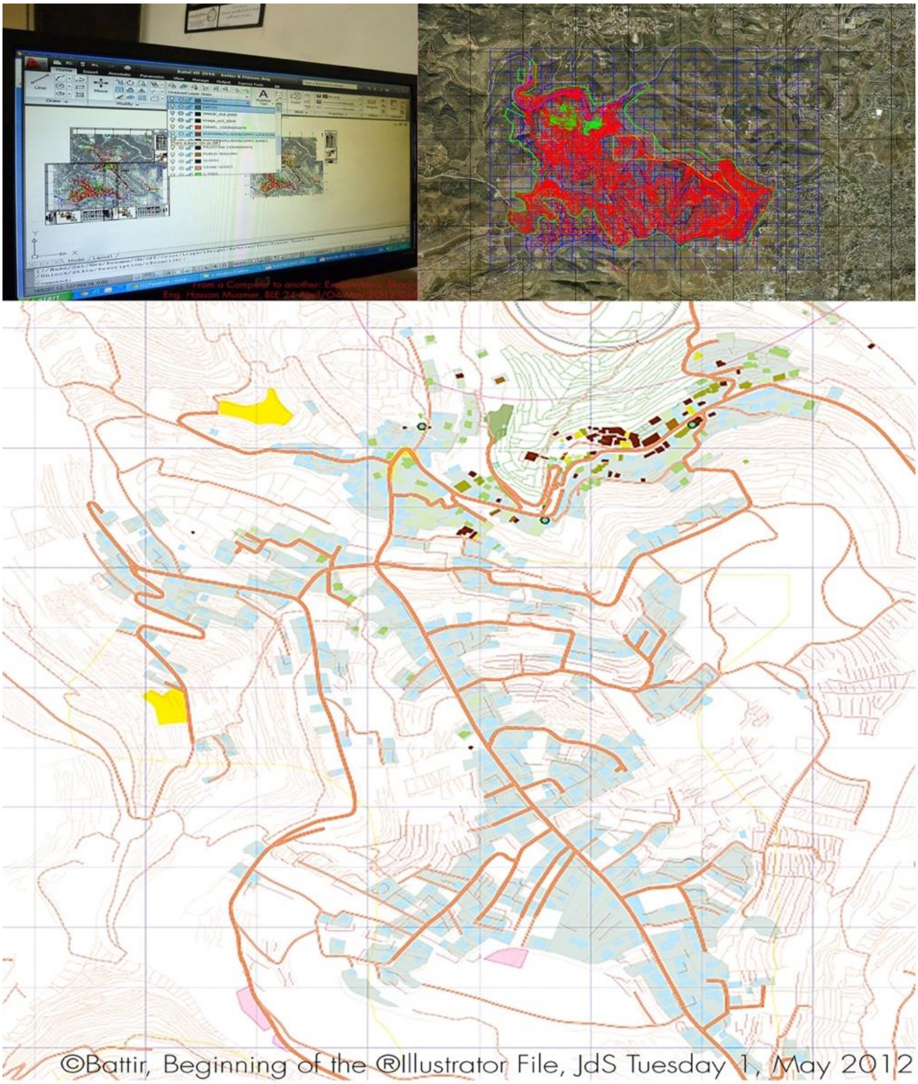

Fig. 15: **From a computer to another, at first an encounter between AutoCAD® and ®Illustrator (BLE 2012)**.

It is not possible to design topographic maps based on an aerial photography which was the sole image of the territory made available in 2007 for the construction of their works. Topography is based on an « orthophotography » of the landscape, of which the geometric shape is rectified.

Eng. H. Muamer answered that it was exactly what he had been dreaming about, but that in reality such work could not be done in Battir. So, he shared his collective files in order to obtain back this Battirian data geolocated, to develop its mapping as a teaching model, to explain the study widely in order to fight the ignorance about it.

Convinced that our professional circles would react also rationally in front of so many years of civic efforts to obtain the best local civilian mapping, it seemed evident that all of us together, we would do our best to give back to this village people their exclusive institutional cartography, which is their property in the fairest way, showing their outstanding landscapes (figure 16, 17, 18).

Fig. 16: **Battir from the Valley of Makhrour (Quinquenel, 2014)**.

Fig. 17: **Battir towards the Valley of Makhrour (D. Salachas, April 2012)**.

Fig. 18: **Battir from the meander and its rail road (Quinquenel, 2014)**.

INTELLECTUAL PROPERTY AND COPYRIGHTS: A QUESTION OF DEONTOLOGY

When in Battir, one the very first things needed to be confirmed was this: Battirian citizens, whether adults or children, are the sole owners in their own right on their topographic data – something unique in the history of cartography, both amazing and fascinating, reassuring. That type of citizen wealth does not exist anywhere else in such terms. There is simply no equivalent in the whole world. Usually such institutional data would belong to States or armies… that is how the whole story started, without any previous notice.

NETWORKING AND SHARING, AN UNUSUAL CONCEPT GOING ON TO PROTECT THIS COLLECTIVE CARTOGRAPHIC PROPRIETARY DATA

As soon as May 2012, in order to exchange and stream files and data, specific pages relating to the activities of '*les Cafés-cartographiques'* were created on social networks, particularly on Facebook since anyone can access it (figure 19). And then one thing led to another and everything else just happened.

Fig. 19: **Battir historic village, the Roman Pool**.
Network front page illustration available since May 2012.

SOCIAL AND CULTURAL MAPPING NETWORKING EFFECTS AND STAKES

The stakes of these maps are multiplying at the rate of the dangers threatening the region and its inhabitants, ever made more invisible by all in principle. It is the very first time that topographic maps are made available to mirror the realities of this territory nurturing its own history and the people who live there, a 12.5 km2 territory where all topics are discussed. No less than 80 topics of our 5 thousand-year-old history have been mapped here, with the objective to be shared with others. No topographic data is available anywhere in this part of the world, neither for the Palestinian citizens nor even for us all outside Palestine, for the quality of our information.

Battir is a model for us all, a Laboratory of ideas that has never ceased to function, that shares with delicacy information that has not been studied nor disseminated anywhere else. But neither the precision resulting from years of work, taking measurements in order to enhance the value of their common millennium heritage, nor the civic and civilian value of that collaborative work overall, have received any consideration locally in Palestine.

The major challenge from Paris then, remained to restitute that collective Battirian unprecedented cartographic patrimony. Battir has lost the knowledge pertaining to the management of its data and topographic maps since 2011, losing the achievable benefits to which this village community was entitled. It was fundamental to give back to Battir what belongs to its citizens. Institutional data cannot be negotiated but must be ever more explained through ever more available pedagogy in order to acquire on site the demanded means in skills and technical tools to manage it home.

Today, the reality of this territory and its inhabitants echoes through its cartographic exhaustive representations, sharing a life experience usually invisible, expressing what does exist in reality and is maintained by all of them… The more apposite, fair and beautiful the maps are, the more they get around the world and the more they stick in people’s minds, far beyond our professional frames. An incredible amount of ties has been forged since May 2012, universal and indefectible, which must be accounted for. Battir was declared UNESCO World Heritage Patrimony on June 20, 2014, after 2 years of continuous efforts that any worldwide recognition implies.

However, the whole thing undoubtedly and precisely relies on that exhaustive work initiated in Battir, which belongs to its authors and to the citizen community of Battir as a whole, who have been able to obtain something no one else had ever achieved up until now. Our professional field is unique, uncommon, civil, civic. The data ownership and their usage are not negotiable.

Today, 7 years later, those collections of maps are seen and shared throughout the world and appear in more and more international scientific publications, international conferences and referenced studies.

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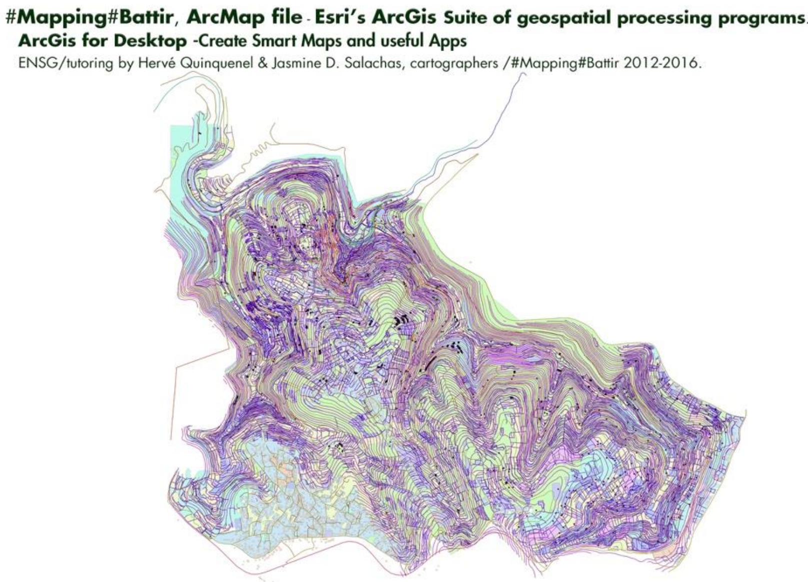
FROM A CITIZEN SURVEY TO A CARTOGRAPHIC CITIZEN UNIVERSITY

Since 2012, its topographic data geolocated allowed to record Battir in any of our professional cartographic systems, non-open source and open source licensed, offering worldwide a remarkable set of available mapping collections dedicated to training in cartography (figures 20 to 30):

> *"Battir topographic data and files have been used to design innovative and motivating pedagogical projects at the National School of Geographic Sciences in Paris. One of the main outcomes has been to diffuse this information on web collaborative open-platforms, thereby giving back to Battir citizens the use of this precious works" (Quinquenel, 2013).*

Fig. 20: **Battir topographic database orthorectified from the aerial photography to the orthophotography of West Bank: clean-up the data on heterogeneous entries, harmonization and organized layers.**



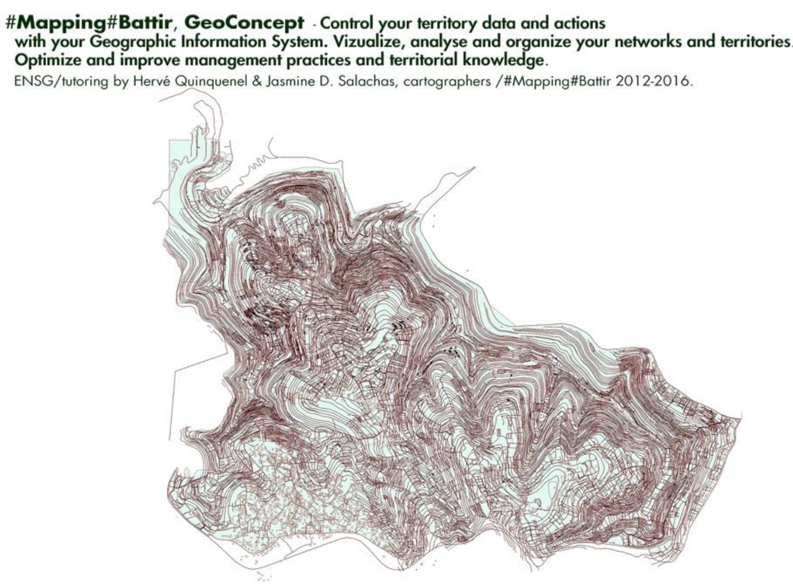
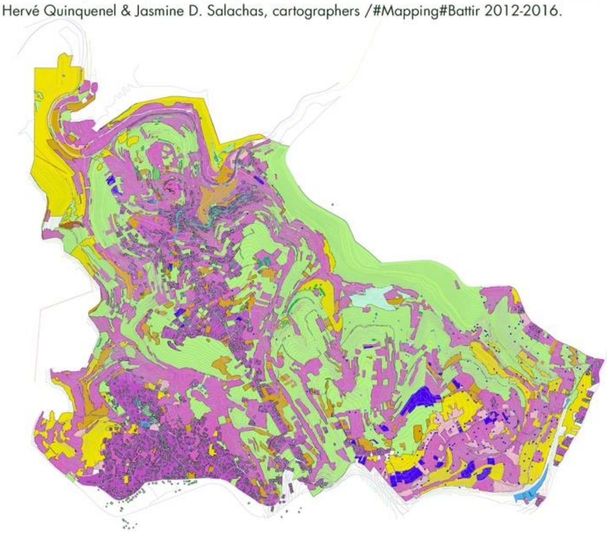


Fig. 21 & 22: **Gathering data in ArcGis & GeoConcept, (Battir /ENSG, France 2012)**.

#Mapping#Battir, QGIS - Free and Open Source Geographic Information System.
Create, edit, visualize, analyse and publish geospatial information on Windows, Mac, Linux, BSD (Android coming soon)
ENSG/tutoring by Hervé Quinquenel & Jasmine D. Salachas, cartographers /#Mapping#Battir 2012-2016.



#Mapping#Battir, OCAD file for Orienteering - Smart software for cartography, to produce orienteering maps.
by Hervé Quinquenel, cartographer - Battir April/May 2014.

Fig. 23 & 24: **gathering data in QGIS & OCAD,**
(Battir /ENSG, France 2012).

Fig. 25: **Battir orienteering map, OCAD file. The historic center by H. Quinquenel, cartographer-GIS engineer, ENSG-IGN (2014)**.

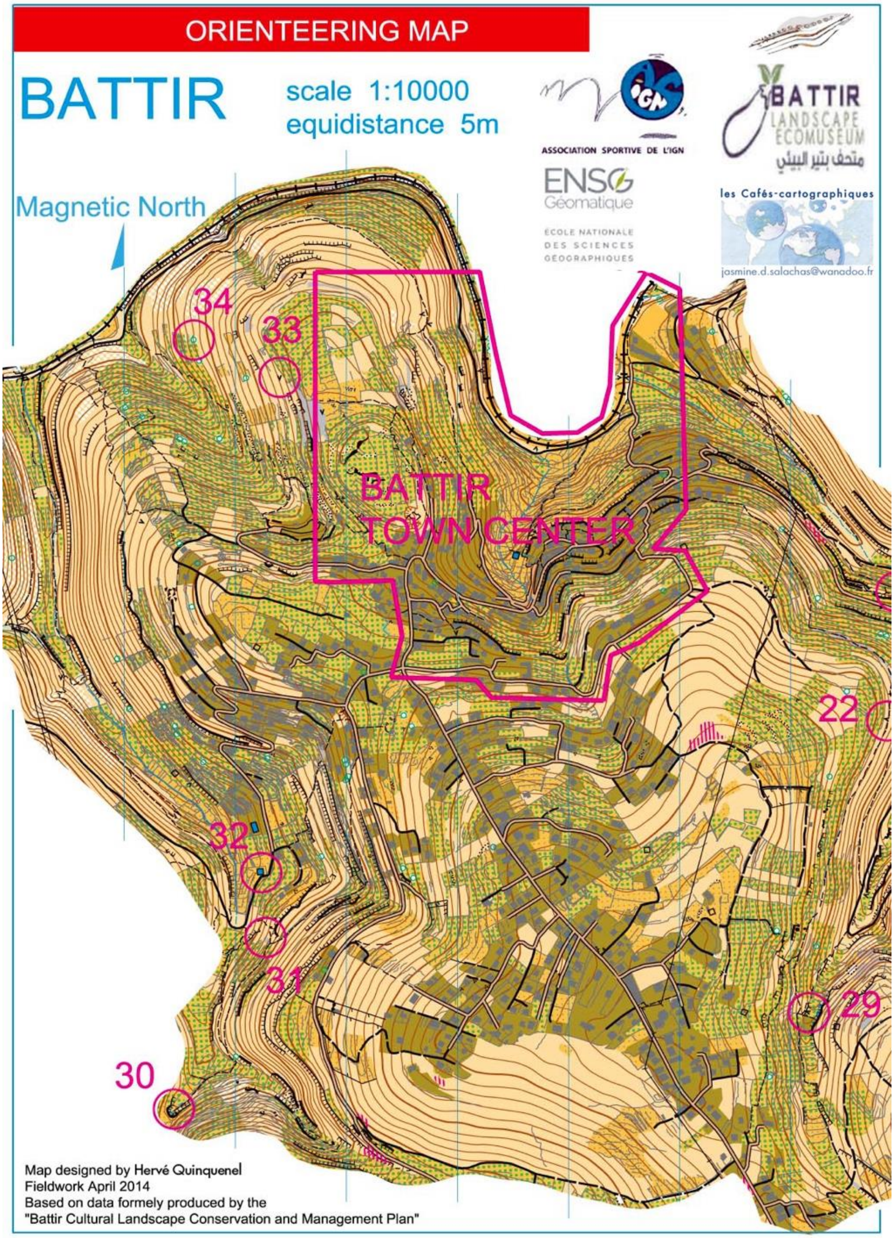


Fig. 26: **Battir orienteering map, OCAD file**
by H. Quinquenel, cartographer-GIS engineer, ENSG-IGN (2014)..

"Introduction to orienteering with children: *this section is designed to share orienteering maps and courses on the village of Battir. These maps were created using data produced by The Battir Cultural Landscape Conservation and Management Plan project of UNESCO/Battir Village Council, that I have adjusted and updated by a rapid fieldwork survey (2 weeks) in April- May 2014. These maps and data are freely available, copyright free, and intended to be improved by any competent and motivated person wishing to go on site to continue this volunteer and philanthropic work supported by crowdsourcing. The principle is simple: you get the files from this website, update them, you send them back to us and we upload the new version with your data. In addition, racing courses were designed to explore the village and the surrounding valleys, their cultural, historical and remarkable natural heritage. If you like orienteering, racing, beautiful landscapes and friendly people, go there! This information has already been used by the school children of the village classrooms for educational activities related to mapping and understanding of the representation of their territory* [*http://www.coasign.fr*](http://www.coasign.fr)*" (Quinquenel, 2014).*

Fig. 27: **Battir in ®Illustrator file by J. Desclaux-Salachas, cartographer (July 2016)**.

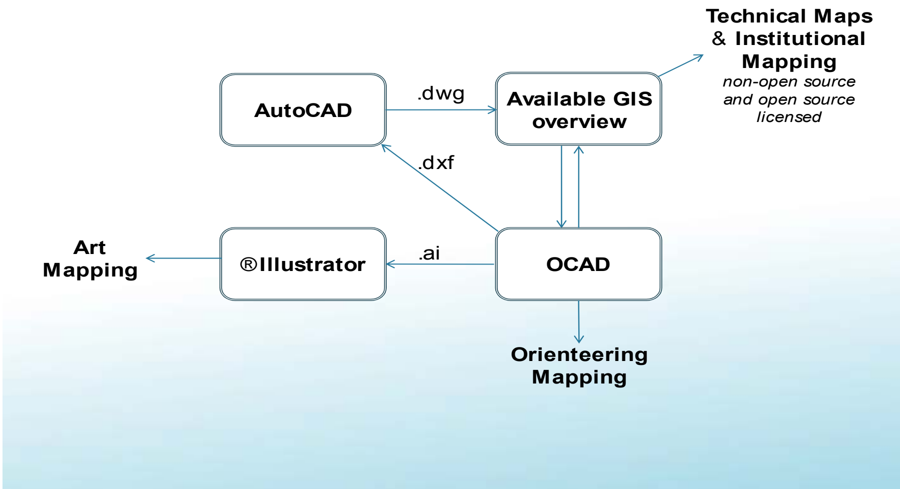


Fig. 28: **Battir, the revealed citizen cartography between geodesy and art (*les Cafés-cartographiques* & *ENSG* since May 2012)**.

Fig. 29: **Battir in OpenStreetMap since January 2015**.

Fig. 30: **Battir from OSM to F4map — 12.5Km^2 of geolocated data layers, available in open source as in 3D since October 2015**.

Through its citizen experience, Battir made its land accurately visible, giving a worldwide living resonance to its inhabitants for the first time of their history.

But Battir also makes visible our institutional cartographic procedures ever confidential that we must explain publicly, here for the first time, in order to return to its owners their rights on their local Palestinian data.

The case of this cartographic framework is unprecedented in our common history. This topo-cartographic patrimony is a Battirian common good requested by all citizens in Palestine, much beyond this village:

> *"The map of Battir, as it was designed by palestinian, italian citizens, represents much more than a simple cartographic tool only used to locate oneself or to move in a place.*
>
> *Here, beyond the cartographic object restituted, it is the way the work was made since 2003 in Battir witch promote a universal peaceful achievement: measuring the area where anyone is living, drawing the landscape, mapping, studying shapes and their history, all these actions as an ongoing process, help for building or rebuilding a strong individual identity, to finally be reassured by one's place in our world, and then to approach with serenity the other one, the others, without fear, in peace" (Couillet, 2015).*

In December 2016, this Battirian Topographic Patrimony was recorded in the process ‘Year Of Map’ managed by the United-Nations and the International Cartographic Association ‘We Love Map’ (figure 31).

Fig. 31: **‘We Love Map’ (UN/ICA 2014-2016)**
http://www.akimbo.fr/cafescarto/cafescarto/we-love-mapsmapping-battir/

Linking its observers to the representations of their space from their topography understanding, modelling a mental dialog between geodesy, cartography, art and sensitive mapping, Battir offers to us all today a travelling Cartographic Citizen University, where students and inhabitants of their neighborhoods map together:

> *“Between geodesy and art, our crossing point was to seize each step in the conception of a topographic map. Usually, topographic maps are implemented and handled by governmental institutions, without any (public) access to data. This is what the battirian topographic civic survey has overturned, offering to all to seize institutional cartography through its available citizen space data and pedagogic deconstructed mapping, drawing its landscape and its human history from their measurements. Since 2012, Battir has become our crossing point to accurately explore the construction of a map following the rules-of-art of institutional cartography. In Brussels, Ixelles-Athénée, beyond our usual professional practices in cartography and the process to teach it, the well known battirian cartographic ‘Laboratory of ideas‘ became a training support to produce sensitive maps. The challenge was to produce a one week survey onto the sites of the concerned neighbourhood, in order to create a consistent mapping approach expressed in a series of layers per the format A0, prepared so as to be later enriched with the inhabitants. This sensitive mapping preparation was implemented by the students through the topographic reality understanding, following the rules of institutional cartographic process. The mapping representations they produced aimed to be accurate tools*

to discuss during exchanges between the inhabitants, the local associations and with the youths of the local schools, together with several partners in the project, elected representatives and policymakers in charge of public developments of our living spaces, thus giving body to the participatory democracy" (Desclaux-Salachas, 2018).

To map, it is to think together. Together students and inhabitants produce series of maps aiming to build discussions between the citizens and their representatives, making their own maps their tools of decision support in their land use and living development (figure 32).

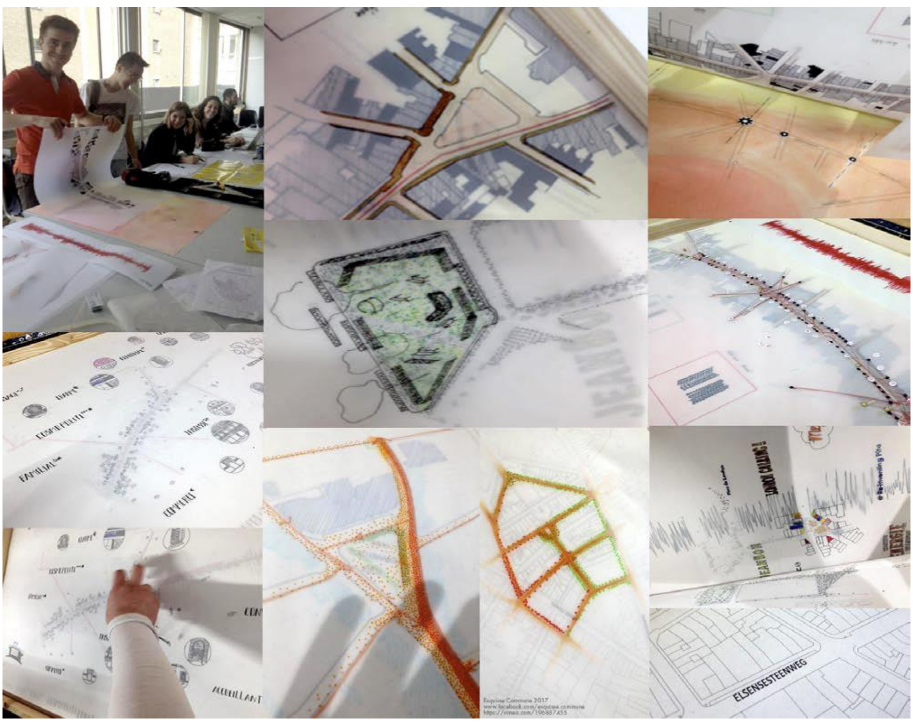


Fig. 32: **'*Esquisse Commune*' Survey 2017 (*Ixelles-Athénées, Brussels/ ULB)***
To map is to think together.

CONCLUSIONS

Cartographic-workshops and orienteering activities ever grew up the children of Battir their maps in hand. Pupils as students from neighboring villages are regularly invited as part of the Public activities and projects.
Today, science is taking over a new position with the Palestine Museum of Natural History in Bethlehem, through several scientific studies within the

Battirian valleys, in particular the Valley of Al-Makhrour (figure 33), involving students from several universities. Students have started to implement a new survey concerning animal, vegetal, mineral and hydrographic resources in the valleys of Battir, managing their reports through different mapping applications. The high definition files are ever available to be shared in order to sustain new local studies, but not the geolocated data itself, exclusive property of this village community.
The work is ever further extended by sharing and explaining the issues of civilian cartography in general, demonstrating the impact of such communication tools and to what extent they bring us, together, into federative projects, for ever more openings through culture and education.
Topography is most often a discipline restricted to the military sphere. Here in Battir, it is the expression of citizenship and civic responsibility that drove to this comprehensive work, a unique, collective and collaborative civic master-piece, offering universally its multiple applications, helping to develop more educational material based on a model of living cartography.

Fig. 33: **Battir, Valley of Makhrour, a life expectancy. To map is a civic act**.

In 2016, in order to protect the intellectual property of the topographic measurements carried out at Battir, as to protect the copyrights on these collections of maps in respect of the battirian community, the association '*les Cafés-cartographiques'* submitted to the vote of the Norwegian Nobel Committee the Collective Nomination to the Nobel Peace Prize of their authors-inventors. Since, in order to sustain their universal practices and their impact in the longer run, as to overtly preserve their memory, this ongoing process is updated every year.

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REVIEW OF FEASIBLE CONSTRUCTED WETLAND SYSTEMS FOR DEVELOPING COUNTRIES

Vlerë KRASNIQI[1]

UDC: 628.29:627.81.05

ABSTRACT

Considering the constantly decreasing quantity of clean water and the very high cost of conventional water treatments, there is an increasing need for more affordable and practical wastewater treatment methods. As a solution to this problem, decentralized wastewater treatments were introduced, among them Constructed Wetland Systems. The purpose of this paper is to analyze 5 wastewater treatment systems which include constructed wetlands as primary treatment. The analysis was conducted using detailed design projects, regular rapports from owners or inspecting authorities, or otherwise anyone affiliated with the projects. Some of the technical aspects regarding capacity and hydraulic performance of the systems have been calculated based on existing data. Using a comparative analysis, it is concluded which of the systems is more effective regarding treatment performance and cost. After analyzing parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD), Nitrogen and Phosphorus; design parameters such as area, hydraulic loading rate – HLR, hydraulic retention time – HRT, organic loading rate – OLR) and cost, a system was chosen as the best and most feasible system for a developing country or those without large financial means.

Key words: Constructed Wetland, Wastewater treatment, Treatment Performance, Cost, Evaluation

1 INTRODUCTION

Lately, the lack of clean water is constantly on the rise. Currently 844 million people live without clean water, approximately 1 in 9 people. Conventional wastewater treatment plants are huge constructions, expensive and not feasible for countries in a poor financial state. The large necessity for clean water, has yielded on-site decentralized wastewater systems. These systems

[1] **Vlerë KRASNIQI**, vlerekrasniqi@gmail.com ,
University of Prishtina "Hasan Prishtina", Faculty of Civil Engineering and Architecture, Environmental Engineering, https://fna.uni-pr.edu/
Address: Isa Kastrati, Prishtina, Kosovo 10000. Tel. +38345517002

are cost effective, environmentally friendly while at the same time offering the same quality of water as conventional treatment plants. Such systems are constructed wetland systems. Nowadays, constructed wetland systems are a common alternative for wastewater treatment in rural areas of Europe. In upcoming years, it is expected that their number will surpass 10'000 in Europe only. (United Nations Human Settlements Programme (UN-HABITAT), 2008). They are designed in such a way as to benefit from many of the processes that occur in natural wetlands, but in a more controlled environment. (Vymazal, 2010). These systems are most often used as primary or secondary treatment for household wastewater. (Davis, n.d.). For this exact purpose, 5 systems have been reviewed so that the most feasible one for a developing country can be chosen and implemented while maintaining water quality. In choosing the systems to be reviewed, their adaptability and ease of implementation in developing countries has been of utmost importance.

2 METHODS

To evaluate the effectivity of a system, one must first be aware of certain basic parameters. Such parameters are shown below:

- System Design
    - Type, area, population equivalent PE, dimensions
    - Construction (Structure), materials
    - hydraulic loading rate – HLR, hydraulic retention time – HRT, organic loading rate – OLR

- Operating and Maintenance
    - Treatment performance
    - Maintenance

- Cost
    - Construction, operating and maintenance costs

The figure below shows a typical constructed wetland system.

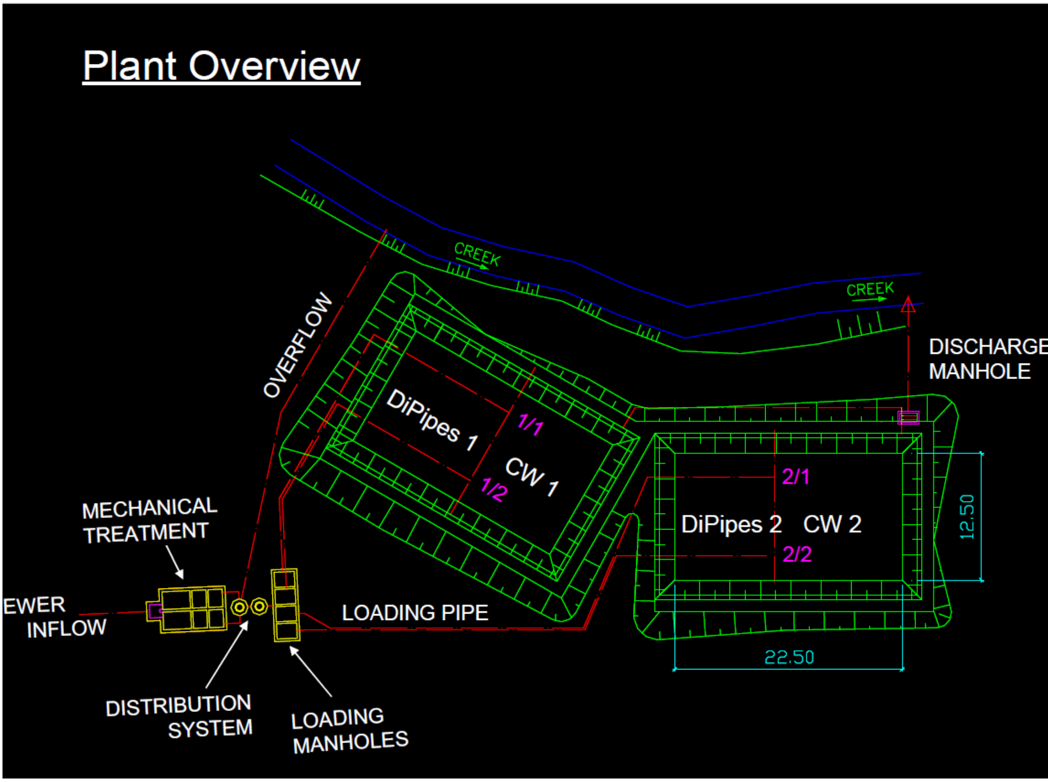

Figure 1. Schematics for a typical constructed wetland system (Knoll, 2005)

To answer the question of which system is the most effective and feasible, all 5 systems were reviewed, and the comparative analysis was implemented regarding performance and cost.

The five systems chosen are:

- **System 1,** a combination of sedimentation tank and vertical sub-surface flow constructed wetland, used for treating domestic wastewater (kitchen, toilets, laundry) by a center for people with special needs. It is operating actively from 2011. The center has a total capacity of 95 beds. (Albold, et al., 2011)

- **System 2,** a process that combines a screen and a sand channel as preliminary treatment, followed by an Imhoff tank as primary treatment, and a horizontal sub-surface flow constructed wetland with two parallel beds as secondary treatment. The system treats domestic wastewater of a region with 800 PE capacity, where the main activities are agriculture, agroindustry and tourism. (Albuquerque & Marecos do Monte, 2010)

- **System 3,** a system that combines a screen followed by a septic tank as primary treatment, and a vertical sub-surface flow constructed wetland with two beds. The system is designed for 249 PE. Consumption quota is 150 l/PE*d. The system treats wastewater from a hospital. (Bramberger, et al., 2017)

- **System 4,** has a sedimentation tank as preliminary treatment, followed by a hybrid constructed wetland with three beds (1 HSSF + 2 VSSF) and a phosphorous filter at the end. (GAJEWSKA & OBARSKA-PEMPKOWIAK, 2008). The treated water is discharged in a pond of a national park, which allows gradual infiltration of the water in the ground. The system is built for 20 PE and treats the wastewater of a small village. (Jozwiakowski, et al., 2014)

- **System 5,** a system that uses a sedimentation tank as preliminary treatment. A hybrid constructed wetland with 2 beds, one with horizontal sub-surface flow, the other vertical, is used as primary treatment. The system treats wastewater from an orphanage and the water is slotted for reuse as nitrogen enriched water for irrigation for the orphanage’s orchards. The system is designed for 220 PE. (Gjinali, et al., 2011)

Regarding treatment performance, that depends firstly on system design parameters. Special importance was put on area, PE, water quantity and organic loading rate as seen on Table 1. The table also introduces briefly every system and their basic characteristics.

Table 1. Comparing design parameters for 5 systems

System	1	2	3	4	5
Type	VSSF[2]	HSSF[3]	VSSF	Hybrid (1 HSSF + 2VSSF)	VSSF + HSSF / Hybrid
Preliminary treatment	ST[4]	SR[5]+SC[6]+ Imhoff tank	SR+ST[7]	ST	ST
Area of the wetland (m^2)	266	1550	665	180	550
Volume (m^3)	172.9	1550	932.4	180	495
PE	76	800	249	20	220
Water quantity(m^3/d)	11	96	37.35	2	16.8
HLR (cm/d)	4	7-15	6	4	3.05454
OLR ($gBOD/m^2/d$)	9	15	11	7	12
Plants	Reed	Phragmites Australis	Phragmites Australis Typhia Latifoia	Phragmites Australis Glyceria Maxima Salix Viminalis	Reed
Filter medium	Sand 0/4	Gravel	Sand/Gravel 1/4	Soil	Sand 0-2 mm
HRT	8 days	4.5 – 9 days	10 days	N/A	N/A
Dosage	2-3 times/day 3m³/dose	N/A	every 3-6 hours	N/A	3-4 times/day with 5 m³/dose
Discharge	River	N/A	Field	Infiltration pond	Reuse/irrigation

Considering that all these systems are active, the operating aspect has been evaluated regarding treatment performance. Treatment performance depends on the removal percentage of all substances in the water that ought to be removed.

This was done by comparing the values of each substance from analysis done in influent water and effluent water. An example of such analysis is shown in Table 2.

To compare systems with different capacities, their performance was graded from 1 to 5, with one 1 being the worst performance to 5 being the best. Worst performance meaning the least amount of change between values of influent and effluent water on particular substances or parameters. Grading was done by comparing the effluent analysis with European Standards 91/271/EEC (Table 3).

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Table 2. Water parameters for system 2, (Albuquerque , Arendacz, Obarska-Pempkowiak, Borges, & Correia, 2008)

Parameters	Unit	Influent	Effluent
pH		6.4 - 7	7 - 7.4
Temperature	°C	19 ± 2	20 ± 2
DO[2]	mg/L	1.0 ± 0.2	1.2 ± 0.3
BOD_5[3]	mg/L	286 ± 16	15 ± 4
COD[4]	mg/L	344 ± 44	110 ± 15
NH_4-N	mg/L	33 ± 3	7 ± 3
NO_3-N	mg/L	1.5 ± 0.6	0.7 ± 0.1
Total Phosphorous	mg/L	7 ± 1	3 ± 1
TSS[5]	mg/L	116 ± 20	34 ± 10

T*able 3. European Standards for post-treatment effluent* (COUNCIL DIRECTIVE, 1991)

Parameters	**Standard**	**Boundary value**
BOD	EN 1899-1	40 mg/l
COD	ISO 6060	125 mg/l
TSS	ISO 11923	35 mg/l
Phosphorus	EN ISO 11885	2 mg/l
Nitrite	[6]	1 mg/l
Nitrate		10 mg/l
Chloride		750 mg/l
Sulfate		750 mg/l
Phenols	EN ISO 14402	0.5 mg/l
Nitrogen	EN ISO 11732	15 mg/l

[2] Dissolved oxygen
[3] Biological Oxygen Demand, measured for 5 days
[4] Chemical Oxygen Demand
[5] Total Suspended Solids
[6] (Anon., n.d.) for Nitrite, Nitrate, Chloride and Sulfate

For each parameter, during grading, 2 things were considered: 1) Are effluent values within the acceptable standards? and 2) What was the removal percentage after treatment? The grade was given firstly based on how close to the standard maximal value allowed was a parameter, and then it was increased or decreased based on removal percentage of a parameter during treatment as seen on Table 4.

Finally, a little leeway was allowed for those systems that measure and monitor more parameters than the others, meaning a small increase in points.

Table 4. Comparing treatment performance parameters for the 5 systems

%	System 1	System 2	System 3[7]	System 4	System 5
DO[8]	**N/A**	**Class V**	**Class II**	**N/A**	**N/A**
BOD_9	**N/A**	**5**	**4.5 / 4.5**	**5**	**5**
COD	**N/A**	**4.5**	**4.7 / 5**	**3**	**5**
TSS	**N/A**	**3.5**	**0**	**2.5**	**5**
Nitrite	**N/A**	**N/A**	**2 / 4.7**	**N/A**	**N/A**
Nitrate	**N/A**	**4**	**0**	**N/A**	**0**
Ammonia	**N/A**	**3**	**5 / 5**	**N/A**	**3.5**
Total Phosphorus	**N/A**	**4**	**N/A**	**4.5**	**1**
Chloride	**N/A**	**N/A**	**4**	**N/A**	**N/A**
Sulfate	**N/A**	**N/A**	**0 / 3.7**	**N/A**	**N/A**
Performance	**N/A**	**3.6**	**3.5**	**3.55**	**3.35**

To review the systems based on cost, coefficient β - cost/area, was calculated (smallest number was graded with a 5, the other systems were graded by taking the cheapest system as a reference point). (Table 5)
Lacking concrete data, costs for systems 2 and 4 were calculated approximately from data regarding the standard cost of such systems in respective countries.

[7] System 3 has 2 separate sets of analysis

[8] Class I (>7 mg/l), Class II (6 – 7 mg/l), Class III (4 – 6 mg/l), Class IV (3 – 4 mg/l) , Class V (<3 mg/l) (Enderlein, et al., n.d.)

Table 5. Cost comparison for the 5 systems

Cost€	System 1	System 2	System 3	System 4	System 5
Construction Costs	49’500 €	95'009.5 €	91’900 €	85'553.40 €	50’000 €
Operating and maintenance costs/year	100 €	0	0 €	0	500 €
Other costs	0	0	0	N/A	10’000 €
Total	49’600 €	95'009.5 €	91’900 €	85'553.40 €	60’500€
Coefficient β (€/m²)	186.46	61.296	138.195	475.296	110
Coefficient α[10]	1.65	5	2.78	0.65	3.97

Another component that has been taken into account during the grading of the systems, is maintenance. Depending on whether maintenance was done or not, the systems either gained a point (+1) or lost a point (-1). Maintenance most often means the undertaking of actions often specific for the system, but also in general activities such as:

- Inspecting the sedimentation tank for structural damage (the concrete),
- Recording the exiting amount of sludge (date and volume),
- Monitoring dosage intervals and volume per dose of the pump,
- Monitoring pumps and floating valves, and, if necessary, cleaning them,
- Maintenance of plant growth (reaping the reeds),
- General pump maintenance, cleaning and oil changing, etc.

Data shows that the lack of maintenance in a system has caused certain issues as listed below, hence the downgrading.

- Uncontrollable growth of plants and blockage of preliminary treatment pipes,
- Blocked screen,
- Defects in hydraulic valves,
- Dosage not done right in connection points,

Operating procedures not conducted right, etc. (Bramberger, et al., 2017)

[10] Grade given for cost

3 RESULTS

According to the analysis of the 5 systems, the table below is a summary of the results reached regarding performance, maintenance, and coefficient α. The table also shows the ultimate grade of a system as the average with ± 1 depending on maintenance done or not.

Table 6. Evaluation of the 5 systems

Parameters	*System 1*	*System 2*	*System 3*[11]	*System 4*	*System 5*
Treatment performance	**N/A**[12]	**3.6**	**3.5**	**3.55**	**3.35**
Maintenance	+	N/A	-	+	+
Area m²	266	1550	665	180	550
Coefficient α	1.65	5	2.78	0.65	3.97
Grade point average	N/A	4.3	2.14	3.1	4.66

Ranking of the systems based on the evaluation has been shown below:

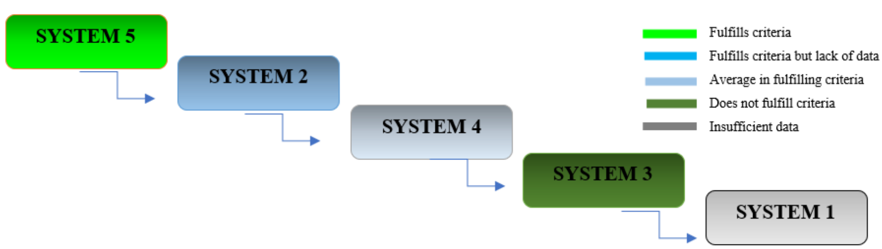

Figure 2. Ranking of the systems

As shown by the table, system 5 is in the lead with a score of 4.66/5, meaning it fulfills all necessary criteria for implementation and use. System 2 follows with a score of 4.3/5, fulfilling necessary criteria, but lacking the data regarding the occurrence of maintenance. System 4 follows with a good score

[11] System 3 has 2 pairs of independent analysis. An average of both was taken.
[12] No data regarding performance of System 1, but due to a really low coefficient α, no matter the value, it still would not rank 1st or 2nd.

of 3.55/5, with good performance but less favorable in financial aspects. System 3 and system 1 are both found lacking.

4 CONCLUSIONS

After reviewing all five systems, their treatment performance, cost and maintenance, it was concluded that system 2 and system 5 are the preferred systems with respective grades of 4.3 and 4.66. System 2 is mostly preferable for tropical climate conditions, while system 5 is adaptable to changing climate. System 5 is also preferable if the available area is not very large seeing that System 2 requires a vast swath of land.

However, in choosing a system, performance and cost are not the only parameters evaluated. Other parameters such as available area, density of population, type of land and soil, destination of the effluent etc., are necessary for evaluation. However, this paper is a useful tool in decision making when choosing a practical system to implement in developing countries, countries or areas with lack of finances, small budget and so on.

Also, due to the lack of data noticed during this research, it is recommended that further analysis and monitoring of the system be conducted.

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