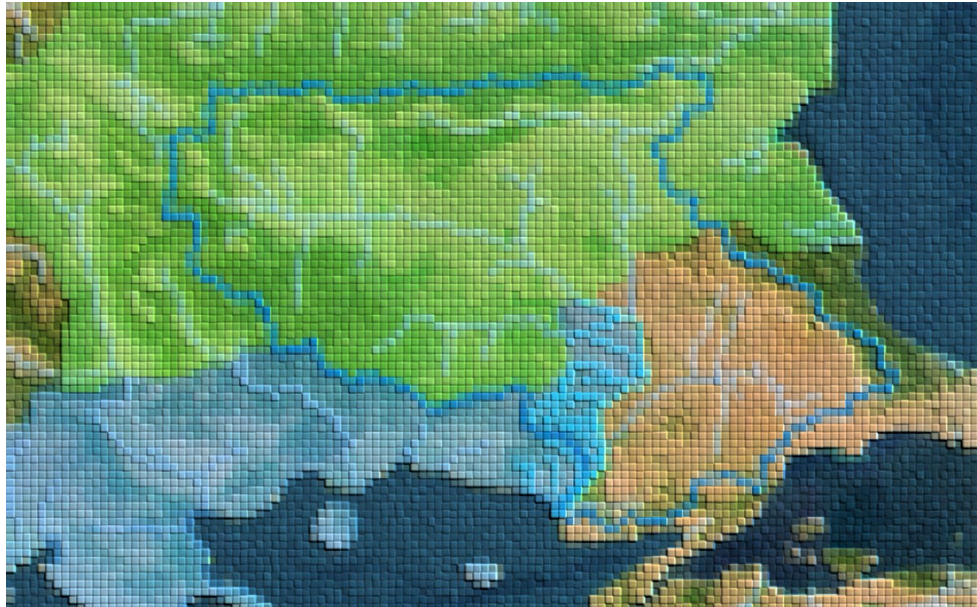




HELLENIC REPUBLIC



MINISTRY OF ENVIRONMENT AND ENERGY
GENERAL SECRETARIAT FOR NATURAL
ENVIRONMENT AND WATER
DIRECTORATE GENERAL FOR WATER



Interreg

Greece-Bulgaria

European Regional Development Fund



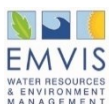
EUROPEAN UNION

FLOODGUARD

Integrated actions for joint coordination and responsiveness to
flood risks in the Cross Border area

DELIVERABLE 4.6.1.B

HIGH RESOLUTION DIGITAL TERRAIN MODEL (DEM) FOR THE RIPARIAN AREA OF EVROS RIVER



EMVIS Consultants SA

July 2023

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1.0	May 22, 2023	1 st version
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This report was compiled by EMVIS Consultants SA on behalf of General Secretariat for Natural Environment and Water, Directorate General for Water, under the frame of the INTERREG Project “Integrated actions for joint coordination and responsiveness to flood risks in the Cross Border area – FLOODGUARD”

Disclaimer: The contents of this report are sole responsibility of *General Secretariat for Natural Environment and Water, Directorate General for Water* and can in no way be taken to reflect the views of the European Union, the participating countries the Managing Authority and the Joint Secretariat

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LIST OF ACRONYMS

Acronym	Definition
CB	Cross-Border
DSM	Digital Surface Model
DTM	Digital Terrain Model
FRMP	flood risks management plans
GCP	Ground Control Points
RMS	Root Mean Square
SGM	Semi-Global Matching

1 INTRODUCTION

1.1 THE FLOODGUARD PROJECT

The project focuses on the challenges of flood risk management via integrated actions for joint coordination and responsiveness to flood risks in the Cross-Border (CB) area of Greece and Bulgaria. This area is vulnerable to climate change and its negative impacts, which needs adequate coordination for cross-border management. The territories covered by the project need to increase significantly their adaptive capacity to climate change, i.e. the international river basins of the cross-border rivers - Strymon-Struma, Nestos-Mesta, Ardas-Arda and Evros-Maritsa. The effective management of flood risks is of high importance and affects high number of population and surface area. The project actions are directly oriented to joint coordination of five flood risks management plans (FRMP) for international rivers - two plans for Bulgarian territory (FRMPs of East Aegean and West Aegean) and three plans for Greek territory (FRMP of Eastern Macedonia, Thrace Water District and Evros river).

The project, which started on Apr 01, 2019, has as a main objective to strengthen the capacity of authorities to ensure effective, integrated joint coordination and responsiveness to flood risks in the CB area. The project addresses different aspects of flood risk management in order to provide integrated results and the following sub-objectives have been defined:

- (1) introducing a joint institutional approach for assessment, planning, prevention and fighting against floods of authorities;
- (2) increasing the technical and administrative capacity of civil protection services for joint actions in the field of preparedness and response in cases of floods;
- (3) introduction of effective information exchange structures and systems for flood risk assessment, mitigation and management;

The project introduces the latest achievements in information systems and will add value by combining the capacity, planning and future development of national policies from the two countries in the field of flood risk management.

The objectives for improved administrative capacity will be achieved through provision of training facilities and joint trainings of first responders, supply of equipment and training software, as well as elaboration of bilateral standards and operational procedures for actions in cases of floods. The introduction of a joint institutional approach for flood risk management will be achieved through the establishment of a Joint Working Group for prevention and reaction in cases of floods. Introduction of effective information exchange structures and systems for flood risk assessment, mitigation and management will be achieved through development of data collection, analyses and assessment tools, as well as development of information tools and structures for flood risk mitigation via GIS functionalities, early warning systems, transfer lines, flood forecasting systems, development of a common regional database management system.

1.2 SCOPE OF PRESENT REPORT

The Evros River basin is subjected to flooding quite frequently, therefore the provision of a high-quality Digital Terrain Model (DTM) is necessary to assist in planning and mitigation efforts. For the development of the

Evros river Early Warning System, a new DTM is developed as part of the work, based on high resolution satellite imagery. The satellite images originate from stereopairs of the WorldView3 satellite. The imagery qualifications are shown in **Table 1-1**. The delivered products comprise WV3 and SuperView Neo¹ satellite stereopairs with 0.3 m spatial resolution. Data from the Superview-2 neo satellite was used for the region near Orestiada (central – North Evros; **Figure 1-1**). **Figure 1-1** shows the mosaic of all satellite acquisitions over the study area.

The list of images is shown in **Table 1-2**. Each image was assigned a code in order to facilitate quality checking. A map to visualize the separate images is shown in **Figure 1-2**.

Table 1-1. Characteristics of the high-resolution imagery used in the project.

Stereo product Level	OR2A Stereo
Stereo Product	Native (no multiple dates)
Spectral bands	Panchromatic band 30cm + Multispectral Bands (4 band bundle) - NO PANSHARPENING
Product Format	GeoTIFF
Pixel Size	30 cm
Pixel coding	16 bit
Radiometric Processing	Basic / 4 × 4 Cubic Convolution
Projection	UTM zone 35 WGS84

Table 1-2. List of high-resolution satellite imagery scenes used in this study.

code	Image id
01	22EUSI-1237-03-FIN-I157520_440598
02	050125937020_01
03	SV2-02_00122122380001_01-20230710T120139Z-001
04	22EUSI-1237-01_I157500_ST01-P01E5JW-20230711T095812Z-001
05	22EUSI-1237-01_I157500_ST02-P01E5JX-20230712T154931Z-001
06	22EUSI-1237-01_I157500_ST03-P01E5JY-20230711T140909Z-001
07	050110009010_01-20230718T133924Z-001
08	22EUSI-1237-02_FIN_I157501_440599-20230720T131745Z-001
09	050111490030_01-20230714T095837Z-001
10	050111490020_01-20230721T085924Z-001
11	050111490010_01-20230721T164850Z-001

A field campaign was conducted during April 2023 to collect cm-precision Ground Control Points (see **Figure 2-2** in section 2 of this report). The campaign was conducted by three (3) teams by use of dual-frequency GNSS receivers and the provision of the METRICA SA RTK service.

The satellite data was processed by the ERDAS Imagine 2022 software. All satellite products (DSM and orthoimages) were quality checked against the KTIMATOLOGIO basemap² and the DTM (pixel-size 5 m) produced by KTIMATOLOGIO, as well.

¹ https://space.oscar.wmo.int/satellites/view/superview_2

² <http://gis.ktimanet.gr/wms/ktbasemap/default.aspx>

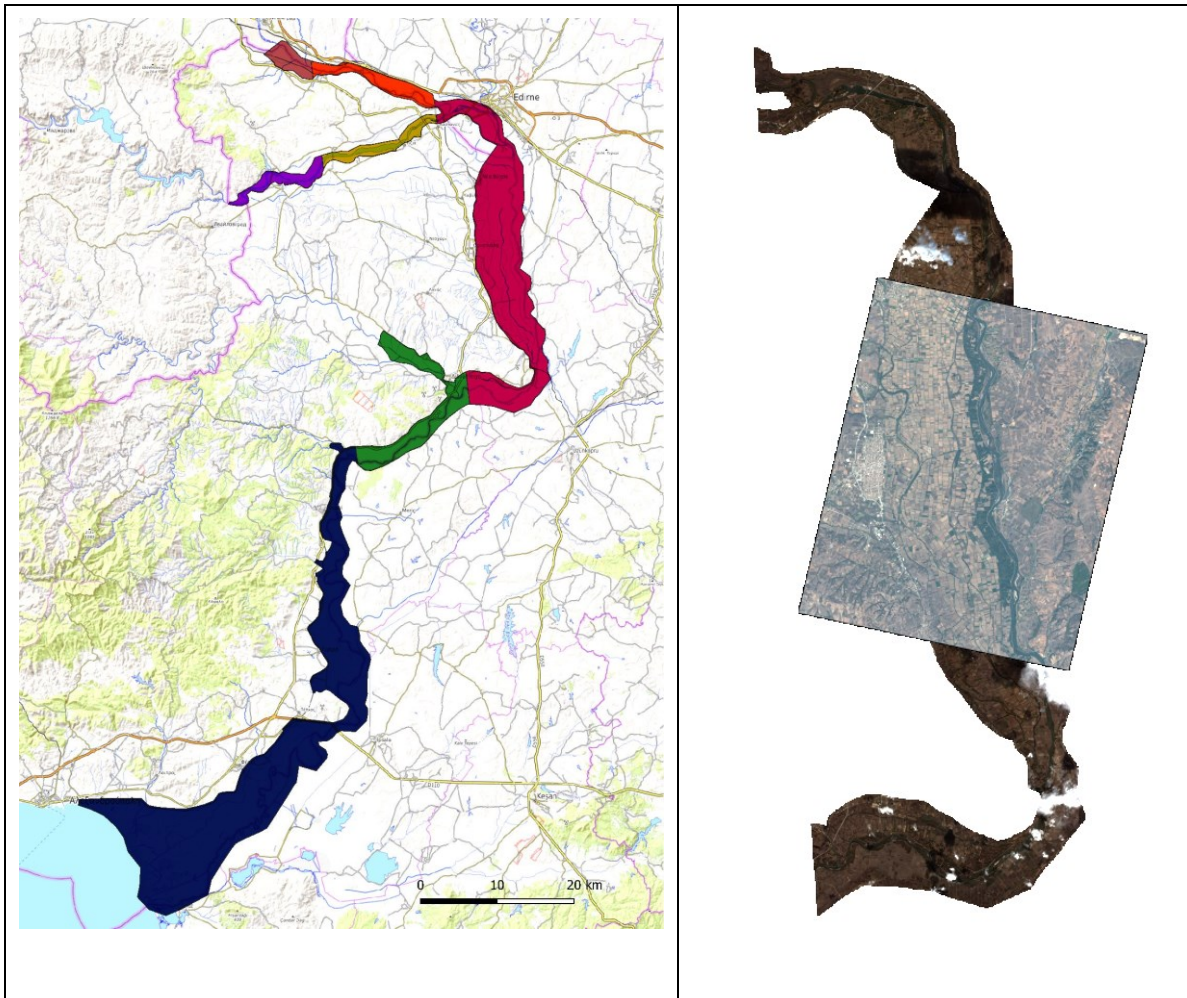


Figure 1-1. Left) Map of Evros river showing the mosaic of satellite coverage. Right) image map showing the extent of Superview-2 neo imagery.

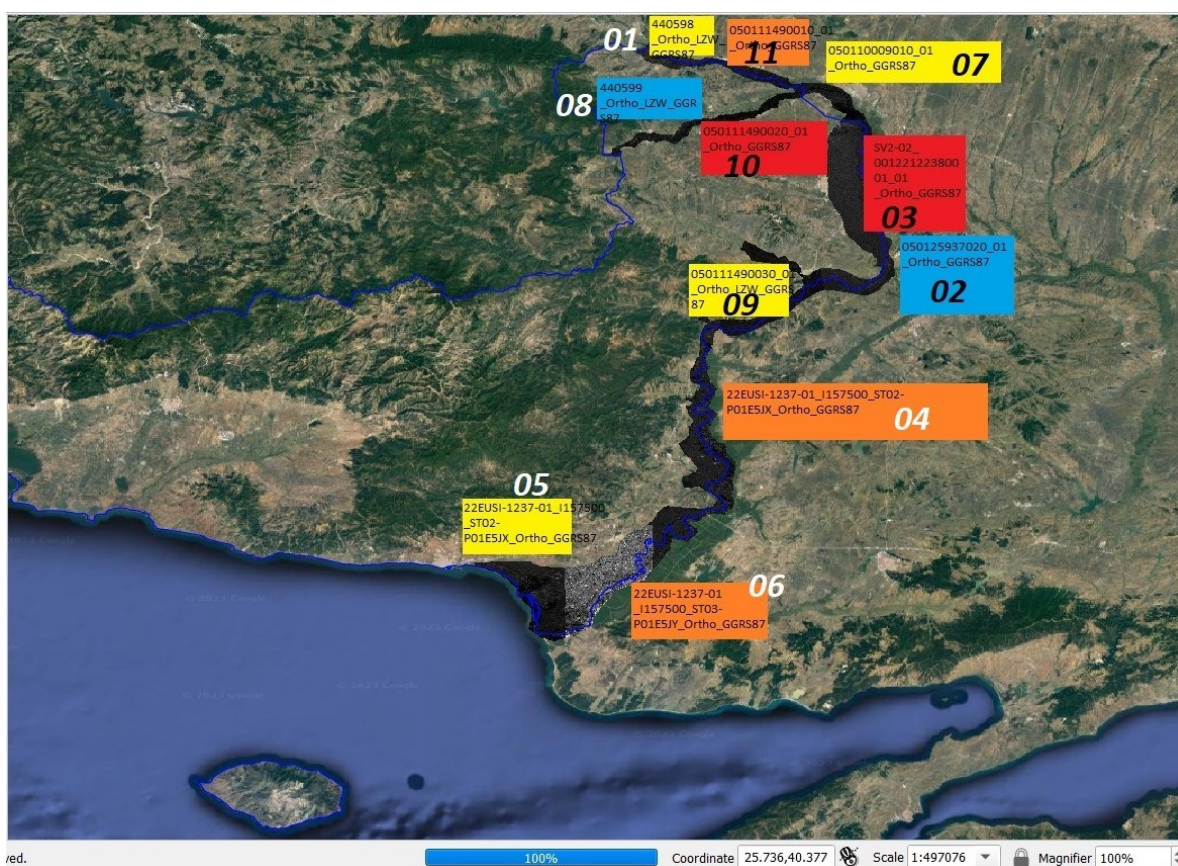


Figure 1-2. Google Earth Image with overlain polygon showing imagery extent along Evros.

Table 1-3. Working group.

NAME	QUALIFICATIONS
Apostolos Tzimas, Coordinator	Civil Engineer, MSc in Science and Technology Policy
Alexandros Ziogas	Civil Engineer, PhD, MSc Water Resources and Environment
Christina Tsimi	Geographer, MSc
Dr Athanassios Ganas	Geology, MSc (Research) in Structural Geology, PhD in Remote Sensing and Earth Sci
Dr Dimitris Paronis	Physicist - Remote Sensing Specialist
Dr Sotiris Valkaniotis	Geologist, PhD
Dr Panagiotis Elias	B.Sc. in Electronic Eng., M.Sc. in Signal Processing for Telecommunications and Multimedia, Ph.D. in Geosciences
Dr Dimitris Anastasiou	Rural and Surveying Engineering, PhD NTUA
Ioannis Karamitros	Geological and Earth Sciences/Geosciences, MSc
Nikoleta Andritsou	
Konstantinos Exarchos	

Table 1-4. Review and Receipt Committee of the Contracting Authority.

Permanent Members	
Dr Eleni Athanasiou	Head of Department of Flood Risk - Water Scarcity Management & Management of Water Demand, General Secretariat for Natural Environment & Water, Ministry of Environment & Energy
Konstantinos Papaspyropoulos	Department of Costing and Pricing of Water Services, General Secretariat for Natural Environment & Water, Ministry of Environment & Energy
Stylianos Koutrakis	Department of Flood Risk - Water Scarcity Management & Management of Water Demand, General Secretariat for Natural Environment & Water, Ministry of Environment & Energy
Reserve Members	
Athanasia Pardali	Department of Flood Risk - Water Scarcity Management & Management of Water Demand, General Secretariat for Natural Environment & Water, Ministry of Environment & Energy
Anna Fokaefs	Department of Flood Risk - Water Scarcity Management & Management of Water Demand, General Secretariat for Natural Environment & Water, Ministry of Environment & Energy
Dr Dionysios Marinos	Department of Flood Risk - Water Scarcity Management & Management of Water Demand, General Secretariat for Natural Environment & Water, Ministry of Environment & Energy

2 COLLECTION OF GROUND CONTROL POINTS

The satellite imagery comprising 11 image pairs (**Figure 1-1** and **Figure 1-2**) was examined for suitable ground features such as sharp corners with bright reflections, building edges etc (see **Figure 2-1** for two examples). The application for security clearance from the Greek Army was processed by the Army and a list of authorized personnel to execute the field work was provided. Field campaign was initiated on 22 March 2023.

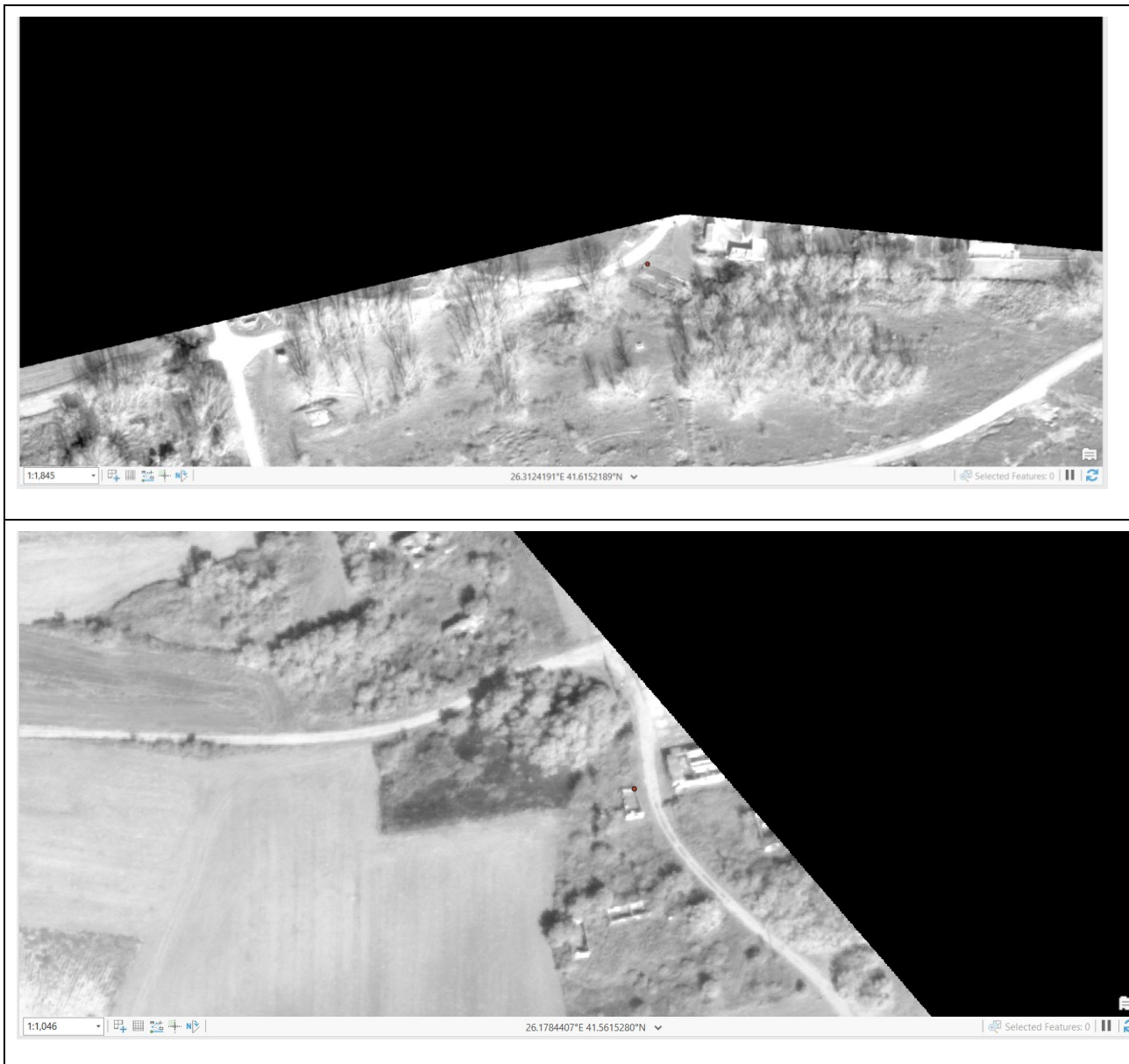


Figure 2-1. Example of GCP selections (red dots) in the northern Evros: top) point #40 on the corner of the basketball court, village Elaia bottom) point #56 village Galini by the Greek-Bulgarian border.

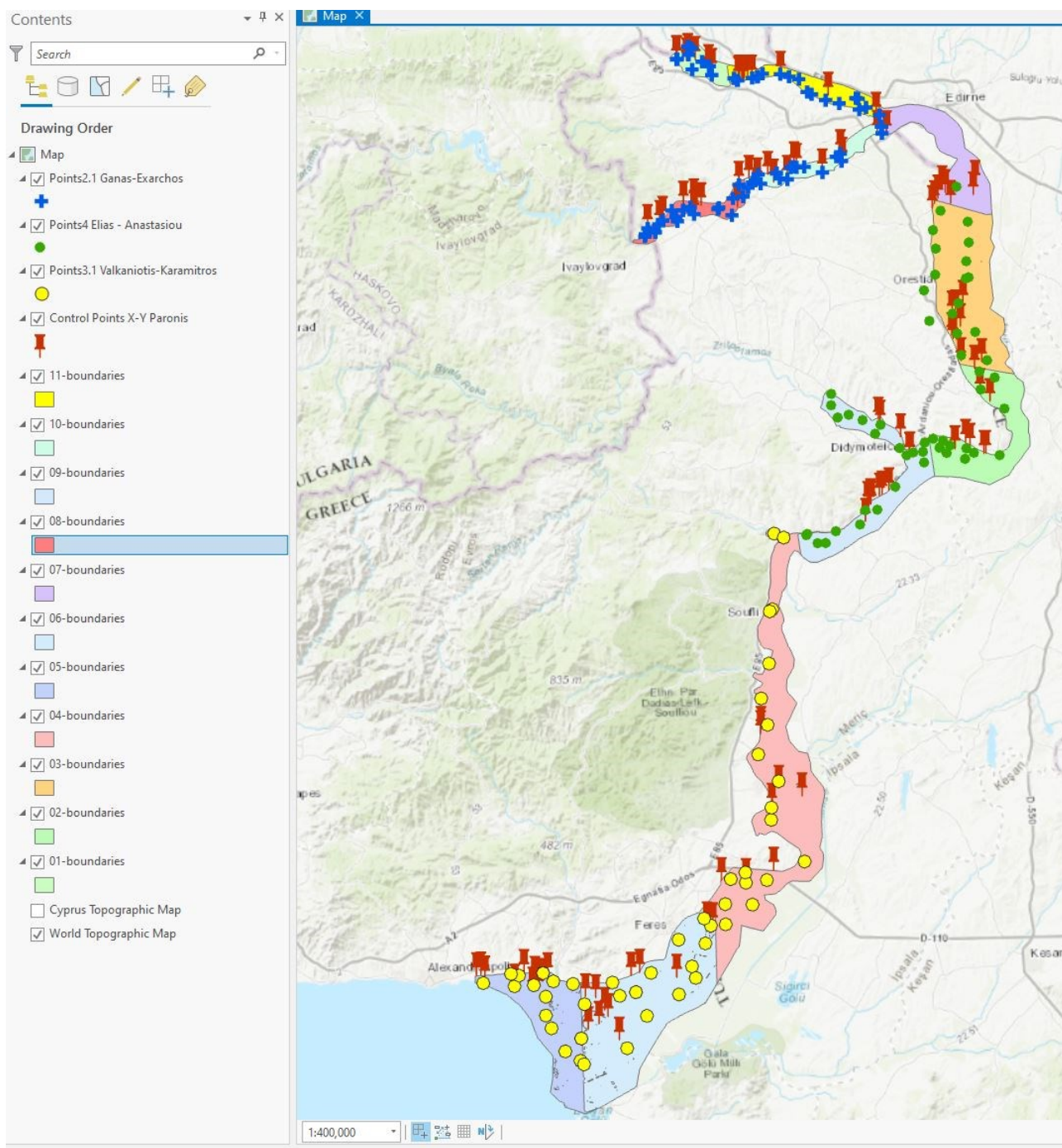


Figure 2-2. Map of the study area along river Evros showing the distribution of GCPs (55 solid green circles, 51 solid yellow circles, 84 crosses) and the location of the independent control points used for quality checking (115 red pins). The background colours represent the 11 different image sets.

The field plan comprised the division of the study area into three sectors (from North to South) and each team worked independently to collect the data. Due to bad weather the field campaign started on 1 April 2023 (central and north sectors) and finished on 11 April 2023 (southern sector). The collection of the GCPs was done by use of Leica GS08+ receivers & geodetic antennas. The antennas were mounted on 2-m high steel bars (**Figure 2-3**). The receivers were connected real-time to the METRICA's SmartNET Greece to receive RTK corrections with cm-accuracy. The reference system of the data is the Greek National Projection System (EGSA 1987). The distribution of the GCPs is satisfactory and covers all the study area (**Figure 2-2**).

The point distribution per sector of work was: 84 for north (blue crosses in **Figure 2-2**), 55 for central (green solid circles in **Figure 2-2**) and 51 for south (yellow solid circles in **Figure 2-2**).

All GCP data are provided in Appendix A.



Figure 2-3. Map of the study area along river Evros showing the distribution of GCPs (55 solid green circles, 51 solid yellow circles, 84 crosses) and the location of the independent control points used for quality checking (115 red pins). The background colours represent the 11 different image sets.

3 DEM EXTRACTION

Satellite images of the study area were provided as stereo pairs. Stereo pairs can be used to produce detailed digital surface models (DSM; e.g., Ganas, 1998; Panagiotakis et al. 2018; Wang et al. 2019) which in turn can be converted into digital terrain models (DTM) after post-processing.

We used the ERDAS IMAGINE 2022 software suite to extract digital surface models (DSM) from each stereo pair. The Semi-Global Matching (SGM) tool was preferred for DSM extraction as it provides the necessary detail in DSM files and produces point cloud files that are easier to filter, clean and post-process than raster files. For each stereo pair, a suitable number of ground control points (GCP) was selected from the surveyed list (Appendix A, [Figure 2-2](#)). The GCPs were manually picked and inserted into ERDAS for each pair until the final interior accuracy achieved was much lower than 1.0 m in X, Y and Z axis, and providing an optimal geographic distribution within the image boundaries. It should be noted that a few areas were not possible to get covered by GCPs due to inaccessibility, especially the north-easternmost corner (Kastanies region; [Figure 2-2](#)) that is outside the Greek borders. Not all the surveyed ground control points were used for DSM extraction, as described. Remaining ground control points are used for independent accuracy control of the final product.

The point cloud files for each stereo pair were filtered and cleaned to remove residuals and errors. DSM raster files (Geotiff) were then produced from the point cloud files and were inserted back into ERDAS software to extract the ortho-photomap file that accompanies each stereo pair DSM.

The multiple DSM products were then merged and mosaicked to eliminate overlapping areas and a final tiled raster file (geotiff) is provided.

DSM files can be post-processed to produce digital terrain maps (DTM), with as much as non-ground features removed. There are multiple methods of DTM production, but in this study, the limitations of input material and ground resolution (stereo satellite imagery) makes the application of DTM filters as a more suitable method. DTM filters are a series of morphological raster filters (slope gradient, size, median filters etc.) that can be combined to remove possible non-ground objects.

4 QUALITY CHECK

All processed ortho-images were quality checked against the KTIMATOLOGIO base map. It should be noted that the spatial resolution of the base map is 0.5 m while the overall geometry and quality of the basemap may vary along the Evros river (i.e., from Ormenion to Evros delta). The following 11 tables show the statistics in terms of root mean square errors in X, and Y (east and north; planimetric comparison). All units are in m. X and Y coordinates on compared images are in EGSA 1987. We used 115 independent control points for that (see red pins in [Figure 2-2](#); [Figure 4-1](#)).

The results of the quality check are presented in [Table 4-1](#). RMS errors for X positions range from 0.56 m (images #05 & #06) to 5.38 m (image 02). RMS errors for Y positions range from 0.58 m (image #05) to 5.04 m (image #10).

As an example of a control point selection feature, we show a building corner near village Praggion included in image #02 ([Figure 4-1](#); see A/A #4 in the table IMAGE02).



Figure 4-1. Image feature used as control point. Left) DSM right) KTIMATOLOGIO base map. See point #4 in the table of IMAGE 2 for comparison.

Table 4-1. Statistics of the quality check on the planimetric error of the delivered ortho-photos by means of 115 independent control points.

IMAGE name	RMS-X (m)	RMS-Y (m)
01	1.02	1.24
02	5.38	2.03
03	2.87	2.77
04	1.44	1.41
05	0.56	0.58
06	0.56	0.69
07	2.54	3.08
08	0.96	1.45
09	3.66	3.12
10	3.47	5.04
11	1.36	1.30

IMAGE 01: 22EUSI-1237-03-FIN-I157520_440598 (0.32 x 0.32 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	683829.62	4621655.62	683830.18	4621655.67
2	690908.79	4619439.00	690909.48	4619439.46
3	684869.05	4621405.77	684868.68	4621407.61
4	687598.21	4620278.11	687597.33	4620278.53
5	683777.80	4621628.10	683777.36	4621626.25
6	690415.80	4619430.93	690416.80	4619432.80
7	685803.32	4621548.32	685801.16	4621546.92
8	687234.92	4620664.69	687233.75	4620663.22
9	685233.74	4621545.80	685234.76	4621545.87
10	685007.98	4621858.51	685007.40	4621857.70

RMSE-X=1.02 m - RMSE-Y=1.24 m

IMAGE 02: 050125937020_01 (PIXEL SIZE: 0.5 X 0.5 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	713544.70	4579957.20	713539.17	4579960.06
2	713575.22	4579997.83	713582.15	4579995.02
3	715163.92	4580240.32	715169.10	4580239.40
4	714685.85	4580660.02	714692.54	4580658.44
5	716651.14	4579472.43	716657.18	4579472.76

IMAGE 02: 050125937020_01 (PIXEL SIZE: 0.5 X 0.5 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
6	716859.04	4579493.04	716863.42	4579491.29
7	715641.36	4588578.22	715646.20	4588576.10
8	717295.01	4585015.98	717301.07	4585014.58
9	716224.96	4586058.77	716229.28	4586056.18
10	714188.75	4589372.00	714191.00	4589369.60

RMSE-X=5.38 m - RMSE-Y=2.03 m

IMAGE 03: SV2-02_00122122380001_01-20230710T120139Z-001 (PIXEL SIZE: 0.4 x 0.4 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	711355.65	4606165.10	711357.05	4606162.31
2	711127.01	4605617.68	711130.19	4605614.97
3	713255.44	4594377.63	713258.10	4594374.86
4	713603.31	4594495.30	713606.55	4594492.69
5	714137.77	4593016.67	714140.07	4593014.62
6	716417.70	4589259.63	716420.12	4589256.40
7	713341.05	4591784.55	713344.70	4591781.60
8	713384.47	4591774.33	713387.90	4591772.10
9	713209.81	4592069.51	713212.96	4592067.18
10	714407.53	4595519.77	714410.09	4595516.12

RMSE-X=2.87 m - RMSE-Y=2.77 m

IMAGE 04: 22EUSI-1237-01_I157500_ST01-P01E5JW-20230711T095812Z-001 (PIXEL SIZE: 0.4 x 0.4 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	687063.94	4529130.34	687065.63	4529133.24
2	687671.96	4529048.78	687671.72	4529049.57
3	691229.13	4533753.26	691229.40	4533752.65
4	688610.89	4533872.22	688611.97	4533873.39
5	694190.05	4534975.61	694190.90	4534974.16
6	692828.41	4550004.71	692830.94	4550005.64

IMAGE 04: 22EUSI-1237-01_I157500_ST01-P01E5JW-20230711T095812Z-001 (PIXEL SIZE: 0.4 × 0.4 m)

A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
7	692792.94	4549544.38	692795.54	4549542.78
8	693989.96	4541808.72	693991.21	4541807.86
9	697220.35	4542903.75	697221.78	4542901.93
10	694736.54	4543719.93	694738.79	4543719.66

RMSE-X=1.44 m - RMSE-Y=1.41 m

IMAGE 05: 22EUSI-1237-01_I157500_ST02-P01E5JX-20230712T154931Z-001 (PIXEL SIZE: 0.4 × 0.4 m)

A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	666526.60	4522482.74	666527.57	4522481.81
2	670039.61	4523709.86	670038.70	4523709.94
3	668679.00	4523319.08	668679.28	4523318.42
4	668438.85	4522174.84	668439.36	4522174.62
5	667511.45	4524049.60	667512.10	4524048.81
6	663331.79	4523348.50	663331.89	4523347.87
7	662426.40	4523711.13	662426.10	4523710.79
8	662911.81	4523786.31	662911.43	4523786.31
9	669485.97	4523090.94	669485.84	4523090.65
10	669069.13	4522259.40	669069.32	4522258.89

RMSE-X=0.56 m - RMSE-Y=0.58 m

IMAGE 06: 22EUSI-1237-01_I157500_ST03-P01E5JY-20230711T140909Z-001 (PIXEL SIZE: 0.4 × 0.4 m)

A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	677698.04	4516826.75	677696.70	4516826.09
2	674382.63	4517937.78	674383.00	4517937.50
3	675534.53	4518528.90	675534.50	4518528.94
4	676496.39	4519331.51	676497.03	4519331.25
5	676153.24	4519995.60	676152.70	4519995.64
6	675171.58	4521362.81	675171.74	4521363.01

IMAGE 06: 22EUSI-1237-01_I157500_ST03-P01E5JY-20230711T140909Z-001 (PIXEL SIZE: 0.4 × 0.4 m)

A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
7	674080.13	4521465.40	674080.96	4521465.75
8	678960.61	4523757.55	678960.72	4523757.63
9	679873.38	4524073.75	679873.08	4524073.57
10	683828.75	4523541.44	683829.11	4523539.42

RMSE-X=0.56 m - RMSE-Y=0.69 m

07: 050110009010_01-20230718T133924Z-001 (PIXEL SIZE: 0.3 × 0.3 m)

A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	705246.92	4613667.03	705252.48	4613663.74
2	706234.66	4613611.78	706238.12	4613609.21
3	712518.57	4607340.93	712518.88	4607339.04
4	715708.13	4608325.82	715710.51	4608320.12
5	712061.52	4667874.68	712059.53	4667872.42
6	712203.19	4607752.18	712204.34	4607748.81
7	712111.92	4667420.28	712113.79	4667417.72
8	711728.92	4606757.84	711731.12	4606754.80
9	715512.76	4607089.85	715514.24	4607087.18
10	713102.86	4606188.89	713103.00	4606187.50

RMSE-X=2.54 m - RMSE-Y=3.08 m

IMAGE 08: 22EUSI-1237-02_FIN_I157501_440599-20230720T131745Z-001 (PIXEL SIZE: 0.3 × 0.3 m)

A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	686432.23	4605932.93	686431.78	4605931.84
2	680718.87	4603611.37	680718.67	4603609.16
3	682003.92	4604042.84	682003.77	4604040.58
4	682316.13	4604472.46	682315.80	4604470.86

IMAGE 08: 22EUSI-1237-02_FIN_I157501_440599-20230720T131745Z-001 (PIXEL SIZE: 0.3 × 0.3 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
5	684545.94	4606104.45	684546.63	4606103.50
6	685681.24	4605135.91	685682.43	4605134.93
7	690328.62	4605766.37	690327.46	4605764.93
8	690475.28	4608223.91	690473.69	4608223.07
9	685651.67	4606346.90	685652.73	4606346.01
10	681542.20	4663192.09	681543.57	4663190.69

RMSE-X=0.96 m - RMSE-Y=1.45 m

IMAGE 09: 050111490030_01-20230714T095837Z-001 (PIXEL SIZE: 1.0 × 1.0 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	707447.02	4580644.24	707450.41	4580642.04
2	707532.75	4580539.86	707535.96	4580537.48
3	702134.48	4583257.77	702137.95	4583256.71
4	700581.19	4585794.26	700583.59	4585797.71
5	700336.84	4585838.98	700339.35	4585835.58
6	700914.63	4584044.59	700917.12	4584037.84
7	700966.06	4582782.53	700968.95	4582781.97
8	702195.41	4583703.94	702198.58	4583702.25
9	705765.13	4575156.54	705770.69	4575155.34
10	706490.89	575512.56	706496.59	4575509.08

RMSE-X=3.66 m – RMSE-Y=3.12 m

IMAGE 10: 050111490020_01-20230721T085924Z-001 (PIXEL SIZE: 0.3 × 0.3 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	691533.41	4608859.27	691534.22	4608859.28
2	693553.69	4609270.94	693554.64	4609269.70
3	696365.87	4610298.03	696366.82	4610297.91
4	696633.60	4610125.42	696632.51	4610124.74
5	701307.41	4611588.10	701308.60	4611589.35
6	699390.80	4609549.08	699383.20	4609541.53
7	701514.13	4610785.13	701511.38	4610778.28
8	695645.42	4608851.50	695639.60	4608845.10
9	694178.69	4608463.02	694181.35	4608453.88
10	692437.49	4608588.82	692434.47	4608584.12

RMSE-X=3.47 m - RMSE-Y=5.04 m

IMAGE 11: 050111490010_01-20230721T164850Z-001 (PIXEL SIZE: 0.3 × 0.3 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
1	690524.11	4619553.80	690523.60	4619553.66
2	690907.91	4619539.87	690909.76	4619540.00
3	691056.74	4619552.40	691057.34	4619551.96
4	690433.84	4619411.74	690434.74	4619412.68
5	691411.05	4619519.03	691411.84	4619518.59
6	691851.75	4619567.88	691853.53	4619567.86

IMAGE 11: 050111490010_01-20230721T164850Z-001 (PIXEL SIZE: 0.3 × 0.3 m)				
A/A	X-KTHMAT.	Y-KTHMAT.	X-ΟΡΘΟΦΩΤ.	Y-ΟΡΘΟΦΩΤ.
7	694921.37	4619966.28	694922.91	4619964.45
8	700012.45	4617727.37	700013.20	4617727.30
9	705132.35	4615605.80	705134.77	4615602.30
10	690781.66	4619412.59	690782.70	4619412.34

RMSE-X=1.36 m - RMSE-Y=1.30 m

5 ACKNOWLEDGEMENTS

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APPENDIX A - List of GCPs used in this study (April 2023)

"X" "Y" "Z" "Date" "Time" "gcp code"

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