Deliverable C1.2: Spatial and Bio-Physical mapping

LIFE URBANPROOF

CLIMATE PROOFING URBAN MUNICIPALITIES

Acknowledgements

This report was produced under co-finance of the EC LIFE programme for the Environment and Climate Action, in the framework of Action C.1 "Recording of the existing situation in the partner municipalities" of the project LIFE UrbanProof (LIFE15 CCA/CY/000086) "Climate Proofing Urban Municipalities".

The project is being implemented by the following partners:

Coordinator Beneficiary	
	Department of Environment, Ministry of Agriculture, Rural Development and Environment *(Cyprus)*
Associated beneficiaries	
	National Technical University of Athens *(Greece)*
	National Observatory of Athens *(Greece)*
	University of Venezia *(Italy)*
	Municipality of Reggio Emilia *(Italy)*
	Municipality of Strovolos *(Cyprus)*
	Municipality of Lakatamia *(Cyprus)*
	Municipality of Peristeri *(Greece)*

Contents

1 FOREWORD

The activity **C.1.2. Spatial and bio-physical mapping** has been carried out by the IUAV team. The main purpose of this mapping is to provide **input data** to Actions **C.3** and **C.4** for the vulnerability assessment. The mapping activity mostly focuses on creating new layers of information about the morphological, hydrological and natural systems.

The mapping has been carried out with the aim to deliver the most comparable and uniform results as possible, however the initial dataset was very heterogeneous. Based on different data available, the methodology followed to address results has been adapted and revised case by case. For example, since the partner municipality of Peristeri had very few data available, we integrated the initial dataset with data available through open sources. The resulting dataset was still incomplete (e.g. missing building height, etc.) and this lead to the inability to deliver all the output layers.

This report presents input data, methodology and results of the two kind of data collect carried on for each municipality:

- Water-Related Data Collect
- Heat-Related Data Collect

Attached to this report there are layer packages that represent the spatial and bio-physical dataset useful to Action C.3 and C.4 . Layers are named according to the municipality they represent:

- **C_** for Cyprus. Lakatamia and Strovolos
- **At_** for Athens. Peristeri
- **Re_** for Reggio Emilia

So long, the analyses were completed in 3 out of 4 partner municipality. Reggio Emilia dataset, derived from a recent remote sensing analysis, still has to be sent to the IUAV team.

Contacts:

Denis Maragno

dmaragno@iuav.it

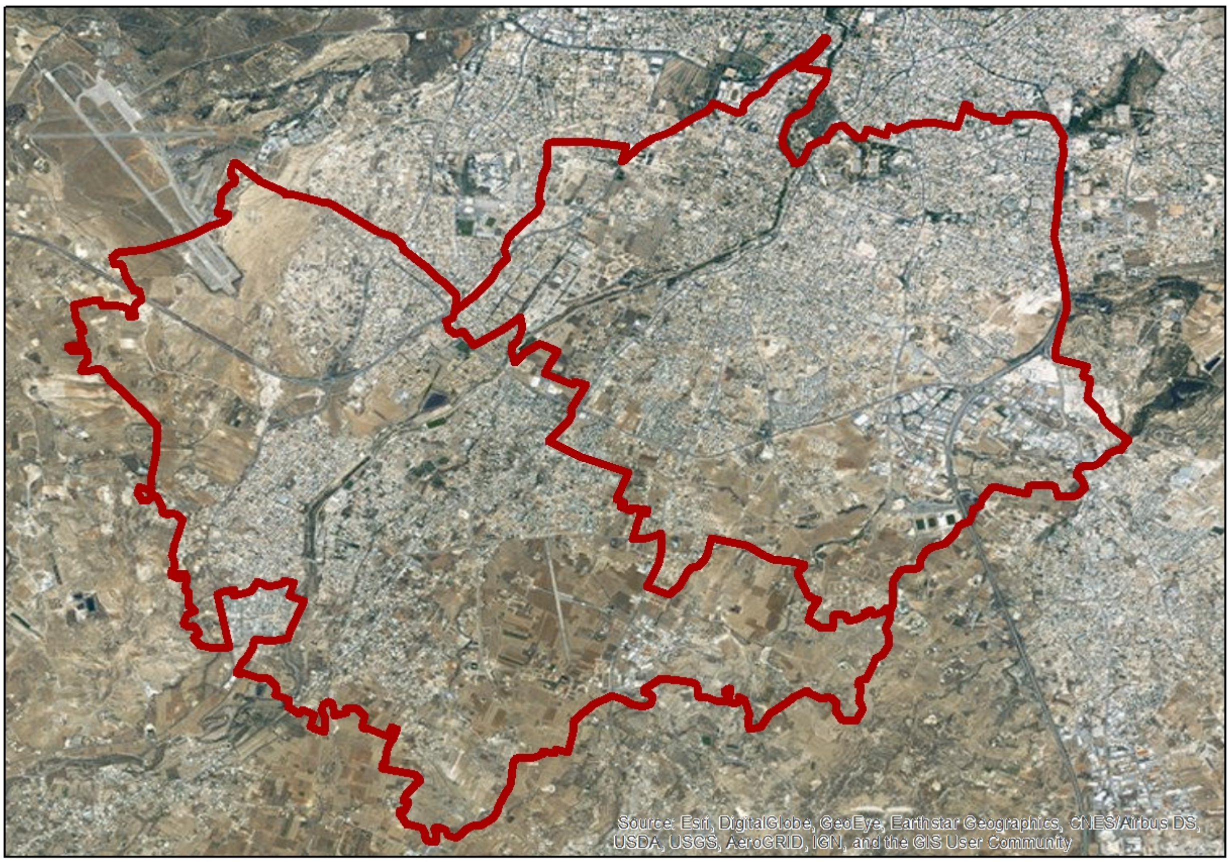
Vittore Negretto

vnegretto@iuav.it

2 LAKATAMIA AND STROVOLOS

Since the partner municipalities of Strovolos and Lakatamia are next to each other, most of the data collected has been joint together

Figure 2-1:Administrative Boundaries of the Municipalities



2.1 Water-related Data Collect

The water-related analysis has the aim to investigate the surface composition, identifying barriers, gradient and path that can influence the water flow. The resulting layers can serve as inputs for activity C.3.2 Floods.

2.1.1 Input Data

To carry-out the analysis, these initial data have been used:

- Shape files from the Inspire GeoPortal of Cyprus.
- Satellite images from the Inspire GeoPortal of Cyprus.
- DTM and DSM models – Courtesy of the Department of Lands and Surveys of Cyprus.
- Data manually recognized from satellite images (e.g. rivers)

2.1.2 Method

First, an analysis to understand the composition of the surface was carried on. This led to identify wherever the surfaces were permeable or not, mapping all the green areas (public and private) and the urban elements (buildings, roads. etc..).

Then, a static analysis of the morphological composition of the area was run through GIS technologies and the Arc Hydro Tool. This led to understand the flow of water, where the streams and their related catchment basins are and where the slopes are. These analyses are based on the methodology of *"Watershed and Stream Network Delineation using ArcHydro Tools" Prepared by Venkatesh Merwade School of Civil Engineering, Purdue University.*

Finally, through a cross analysis of these two previous steps, the most impervious catchments basins were identified and their streams were analyzed identifying the nearest low-lying areas that could potentially host excessive water.

2.1.3 Results

2.1.3.1 Impervious Surfaces

The analysis of impervious surfaces is based on satellite images. Impervious surfaces include all areas that do not absorb water as cemented, asphalted and built surfaces. For Strovolos and Lakatamia Municipal areas, the impervious surface was extracted through a series of operations. The starting point was recognition through a land cover mapping software (eCognition). This software allows to operate with three-band (Red, Green, Blue) start data as the satellite images of Strovolos and Lakatamia. The first raw data contains information on all impermeable surfaces identified, then it cleans up subtracting the buildings, roads and agricultural field came from official cartographic sources (Cyprus Geoportal, Corine Land Cover). Some existing layers, such as roads and hydrography, were manually recognized based on the satellite images since the input shape file was a line and not a polygon.

Deliverable – Layer name: **C_impe**

Figure 2-2:Impervious surfaces

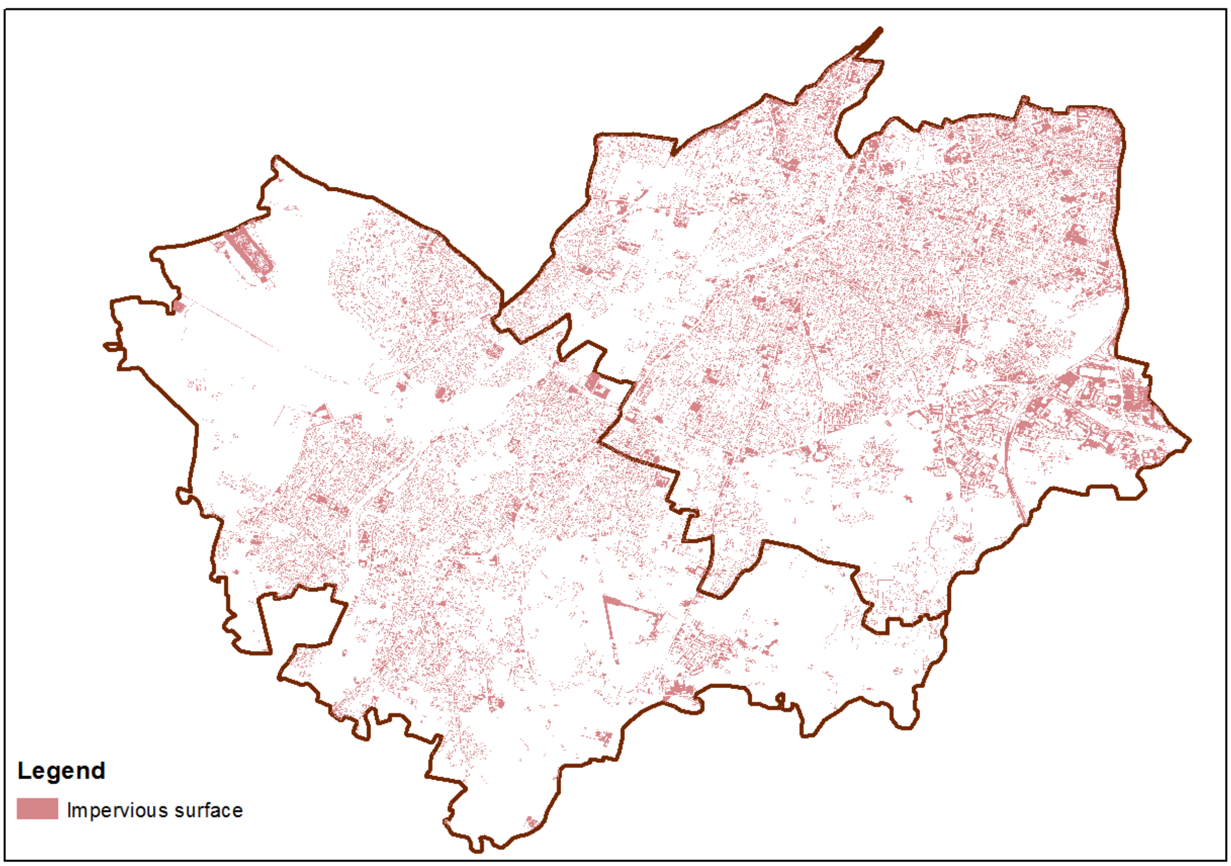


Figure 2-3:Impervious surfaces – Detail at neighborhood scale

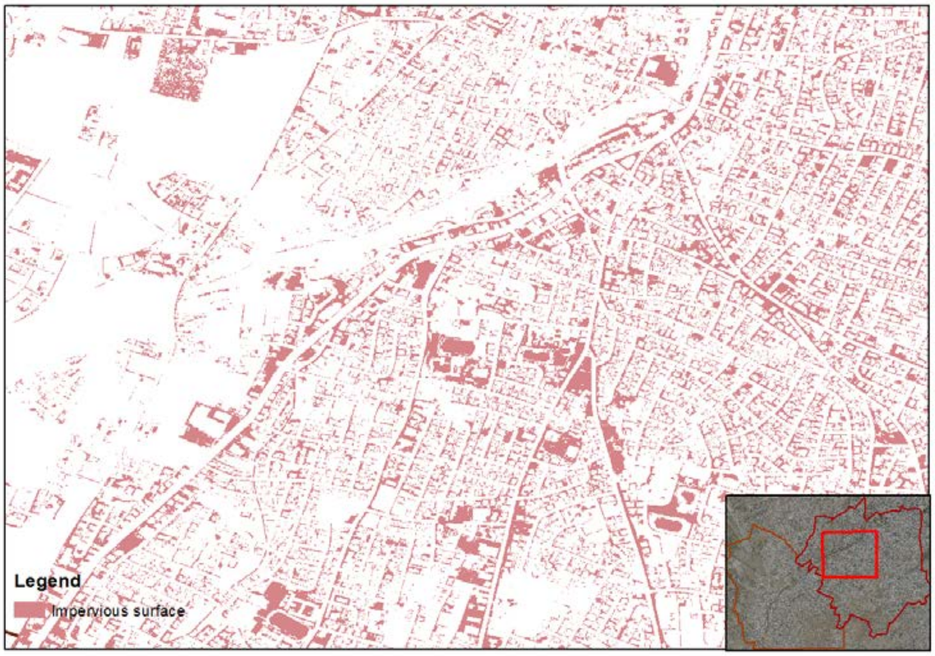


Figure 2-4:Impervious surfaces – Detail at neighborhood scale

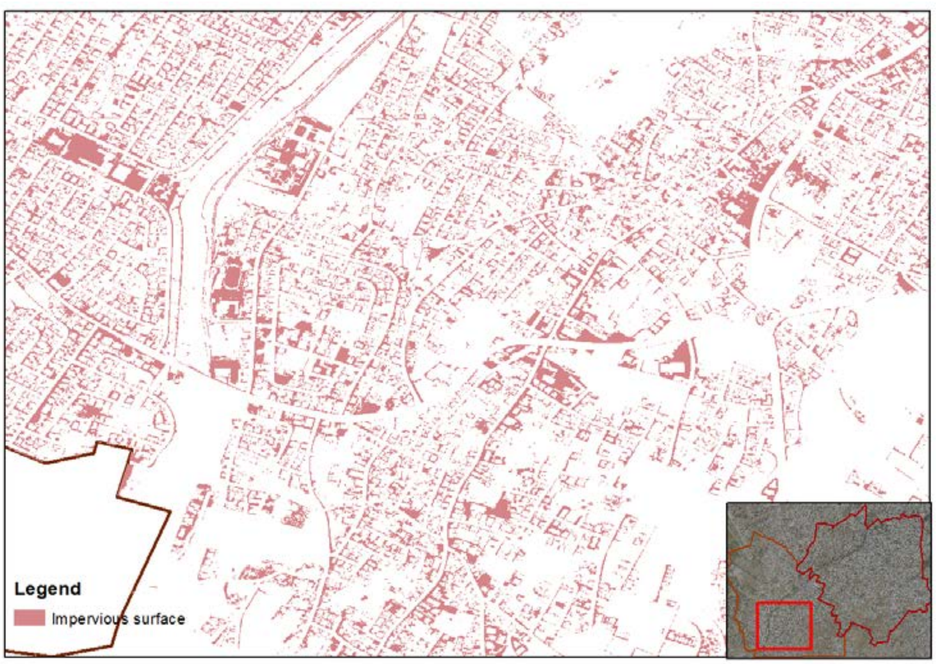


Figure 2-5:Impervious surfaces – Detail at building scale

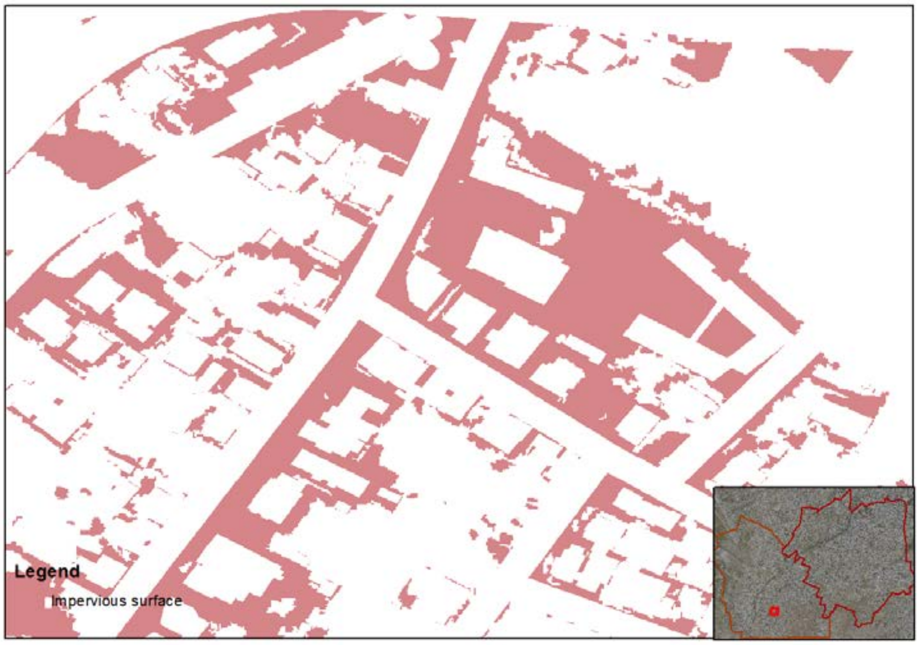
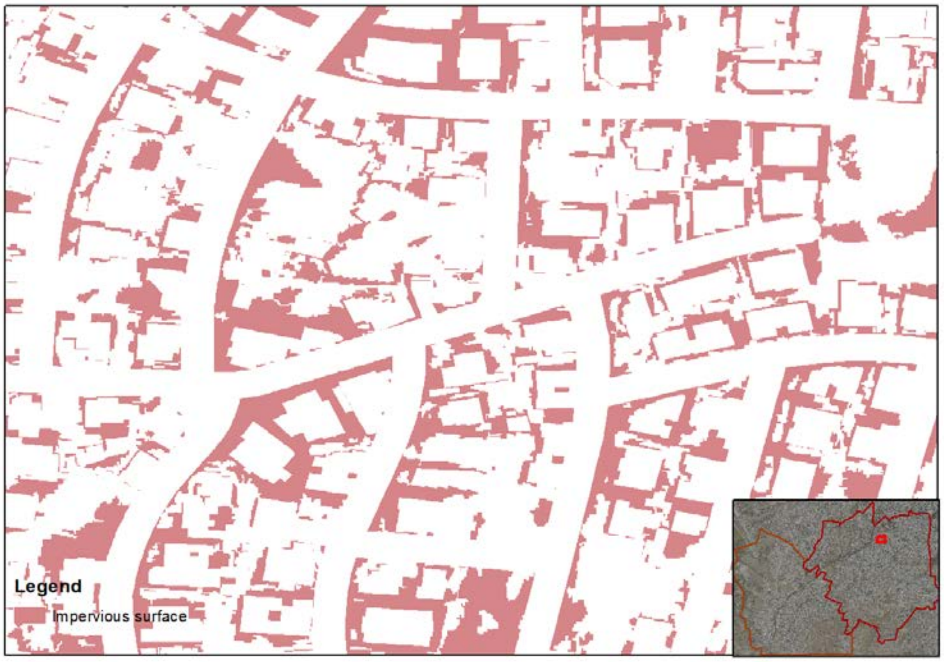


Figure 2-6:Impervious surfaces – Detail at building scale

Figure 2-7:Impervious surfaces – Detail at building scale

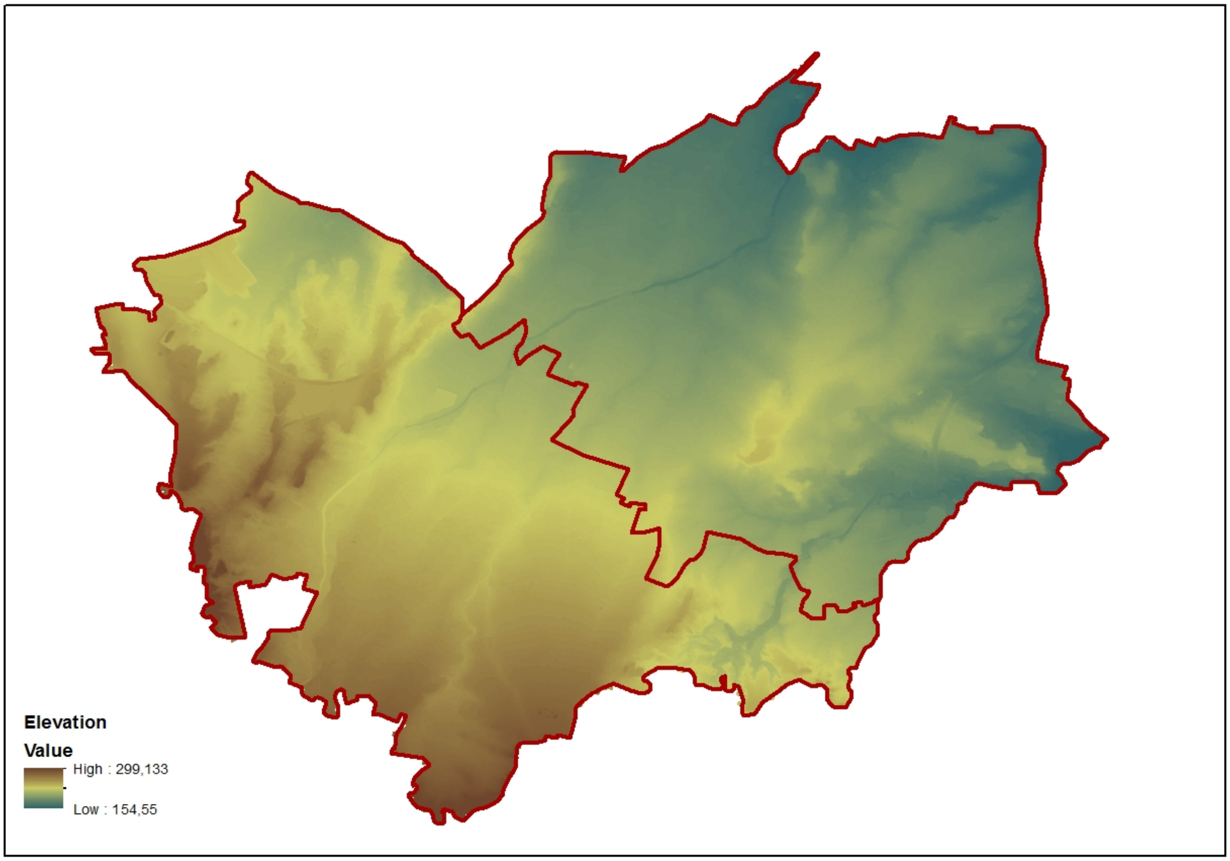


2.1.3.2 *Elevation*

Elevation for both municipalities, derived from the DTM model, is the initial framework to understand the flow of water.

Deliverable – Layer name: **C_Elevation**

Figure 2-8:Elevation

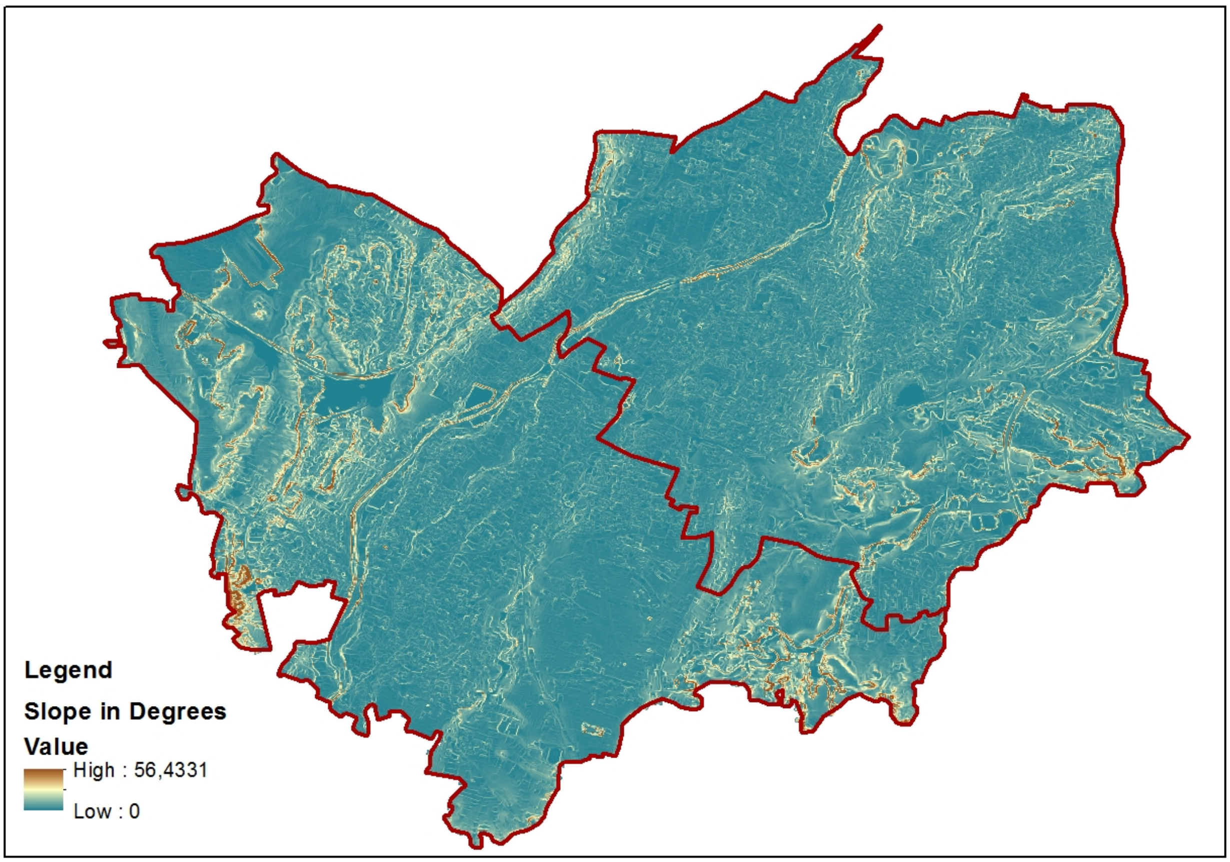


2.1.3.3 Slope

Slope in degrees for both municipalities, derived from the DTM model and GIS processing. Helps to point out which are the natural and artificial barriers for water flow. Identifies low-lying zones and horizontal gradient zones.

Deliverable – Layer name: **C_Slope**

Figure 2-9: Slope in degrees



2.1.3.4 Flow Direction

Flow direction for both municipalities, derived from the DTM model, has been calculated through GIS processes. Through chromatic classes, this layer represents in which direction the water flow from each cell. This dataset is the base to calculate the following paths.

Deliverable – Layer name: **C_Flow_Direction**

In the layer, each number refers to a direction:

1=E;

2=S-E;

4=S;

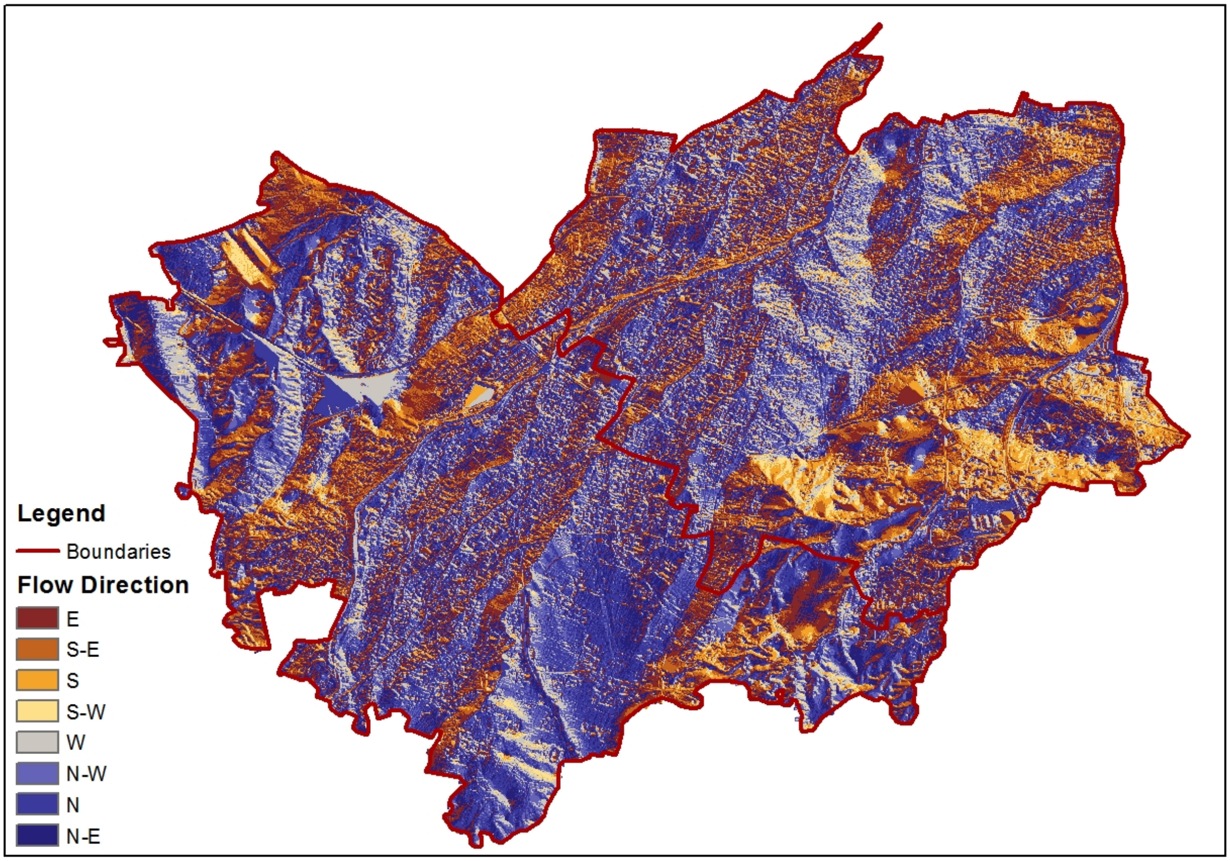
8=S-W; 16=W;

32=N-W;

64=N

128=N-E

Figure 2-10: Flow Direction


Legend
Boundaries
Flow Direction
E
S-E
S
S-W
W
N-W
N
N-E

2.1.3.5 Flow accumulation

Flow direction for both municipalities highlights the hierarchy of the flow streams, classifying them by the dimension of the area they drain. The classes in the layer are:

1= Stream with drainage area smaller the 0,025 Km^2

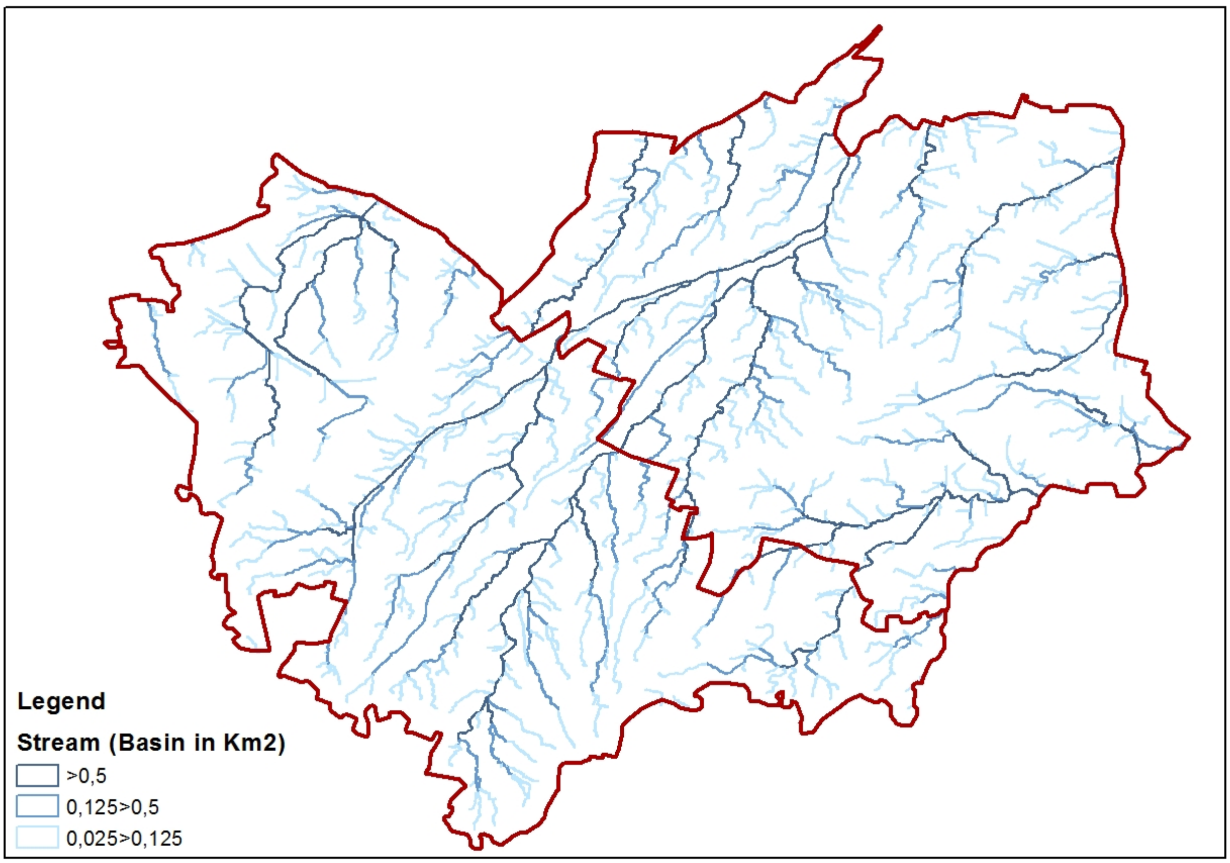
2= Stream with drainage area between 0,025 Km^2 and 0,125 Km^2

3= Stream with drainage area between 0,125 Km^2 and 0,5 Km^2

4= Stream with drainage area bigger than 0,5 Km^2

Deliverable – Layer name: **C_Flow_Accumulation**

Figure 2-11: Flow Accumulation

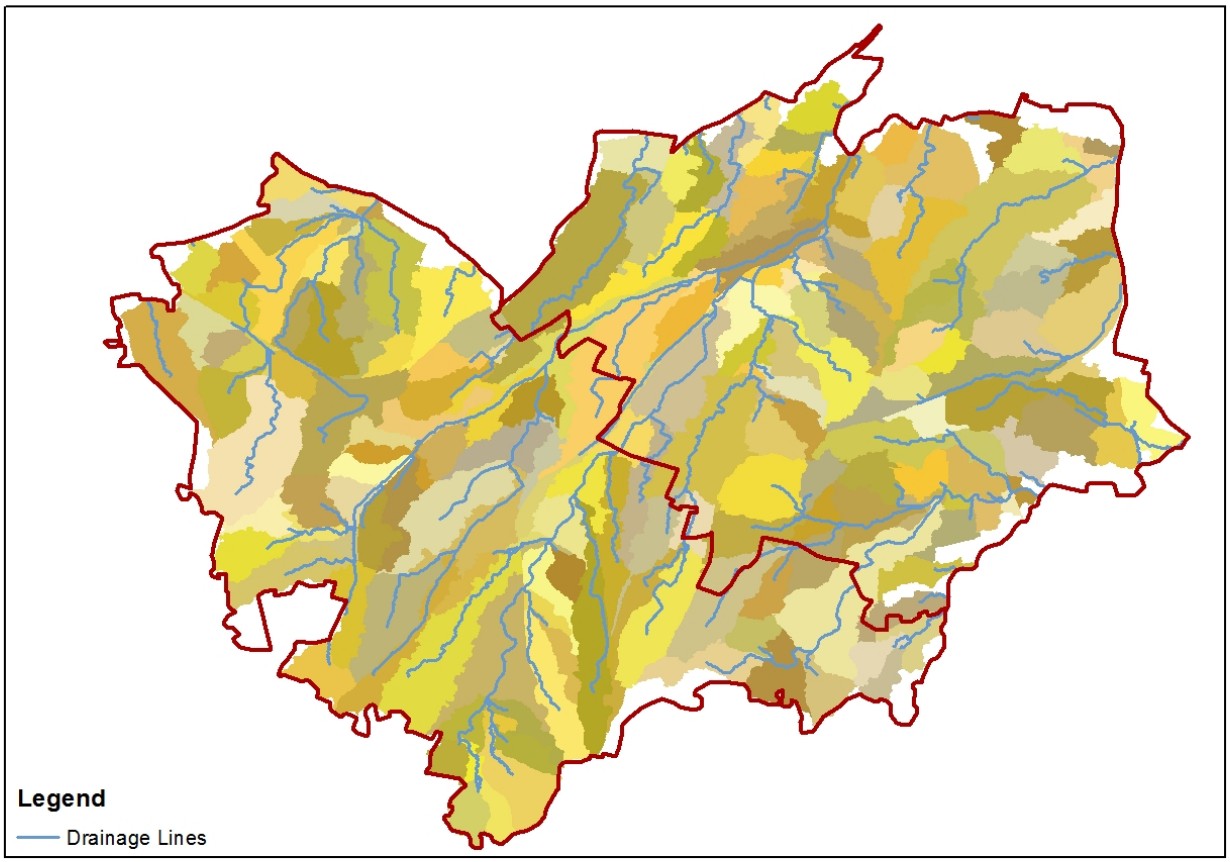


2.1.3.6 Urban Streams and Sub-catchments

Storm-water flow for both municipalities, derived from the DTM model, has been calculated through GIS processes. Then, the territory has been divided in sub-catchments following the morphological profile, and defined the path of the drainage streams. Streams are tracked once they drain a minimum of 0,125km². Data near the boundaries may not be exact due to incomplete input data.

Deliverable – Layer name: **C_Stream** and **C_Subcatchment**

Figure 2-12: Streams and Sub-catchments

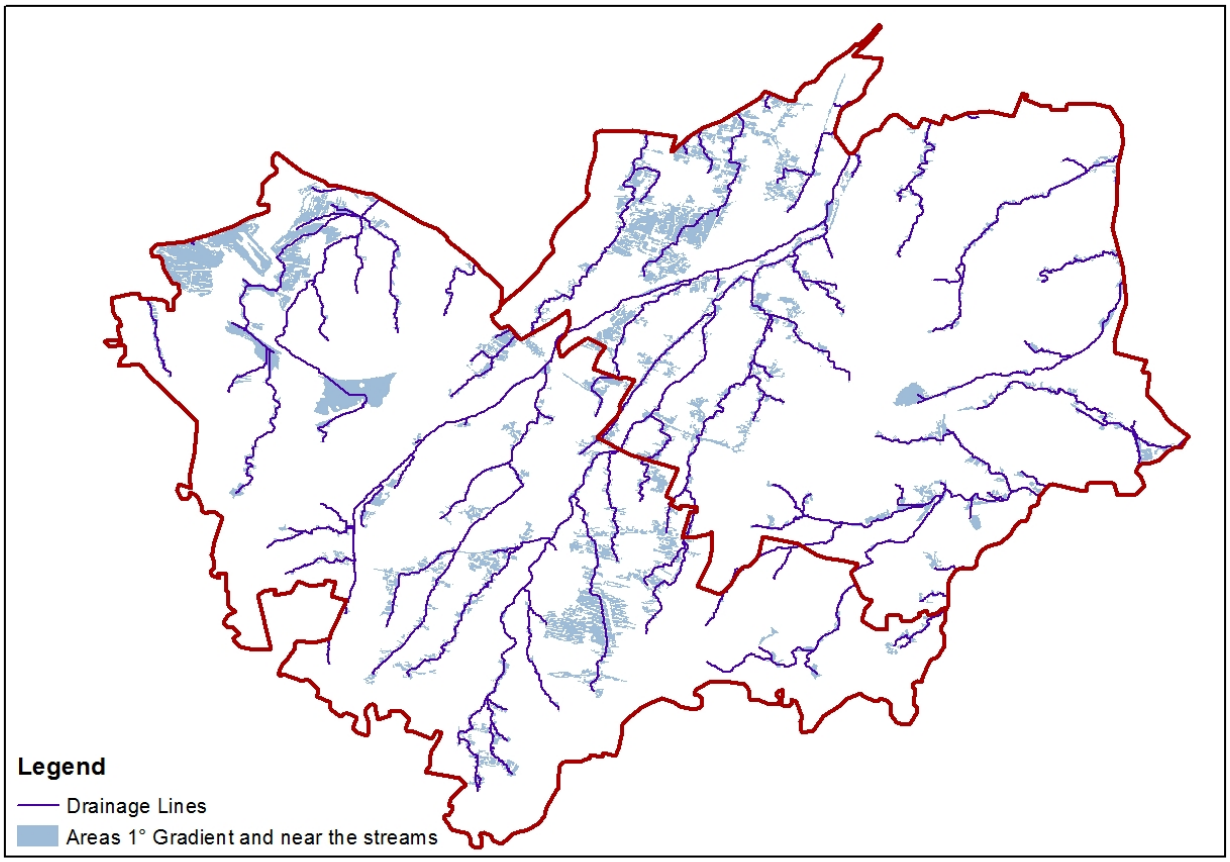


2.1.3.7 Low-lying areas next to water flow

Once the path of urban streams is defined, it is interesting to highlight the areas that are crossed by the streams and that have a gradient lower than 1°. This layer represents the areas that are most likely to host the expansion of water when the streams intensify their flow (e.g. an extreme precipitation event). So the dataset of this layer is made of horizontal areas (<1°), connected to urban streams that drain areas bigger than 0,125km².

Deliverable – Layer name: **C_Lowandnear**

Figure 2-13: Potentially Floodable Areas

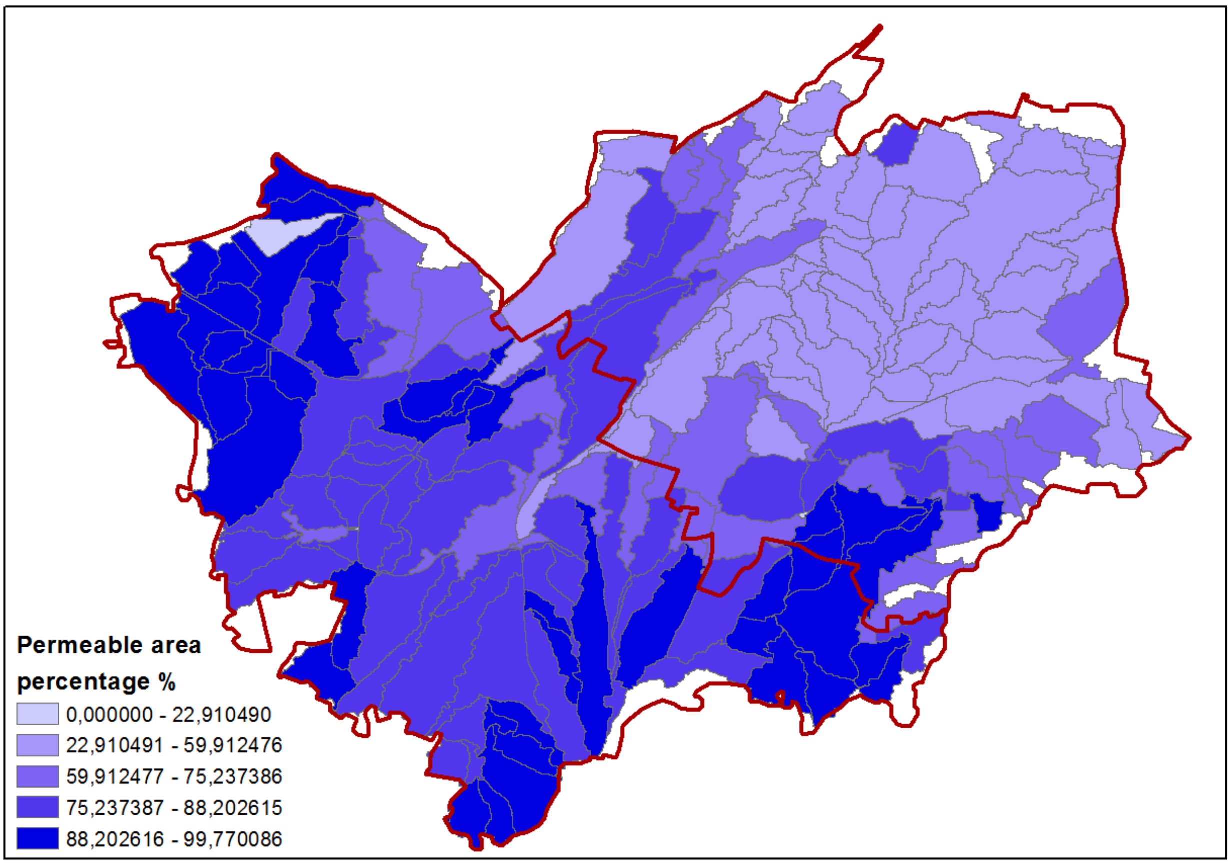


2.1.3.8 Pervious sub-catchments

Based on hydrographic sub-catchments (2.1.3.6) and impervious surfaces (2.1.3.1) defined in previous steps, the goal of this analysis is to identify the most impervious sub-catchments. Data shows in percentage the amount of permeable surfaces in each basin. The catchments with more intense color have a greater amount of permeable areas. Data near the boundaries may not be exact due to incomplete input data.

Deliverable – Layer name: **C_perc**

Figure 2-14:Pervious Sub-catchment



2.2 Heat-related Data Collect

The heat-related data collection has the aim to investigate the natural and urban morphology and surface structure that can influence heat gain, night dissipation and storage. The resulting layers can serve as inputs for activity C.4.2: High temperatures and energy demand.

2.2.1 Input Data

To carry-out the analysis, these initial data have been used:

- Shape files from the Inspire GeoPortal of Cyprus.
- Ortho images from the Inspire GeoPortal of Cyprus.
- DTM and DSM models – Courtesy of the Department of Lands and Surveys of Cyprus.

2.2.2 Method

Firstly, through the proceedings of the digital terrain model it has been isolated the urban surface to highlight the elements above the surface, where the barriers are and how the built environment it's composed.

Then, of this urban structure it has been highlighted the urban canyons through the sky view factor index.

Also urban green surfaces have been mapped.

2.2.3 Results

2.2.3.1 Normalized Urban Surface

This elaboration, made subtracting the DSM to the DTM, highlights the urban roughness, showing the height of urban elements.

Deliverable – Layer name: **C_dsm_n**

Figure 2-15: Normalized Urban Surfaces

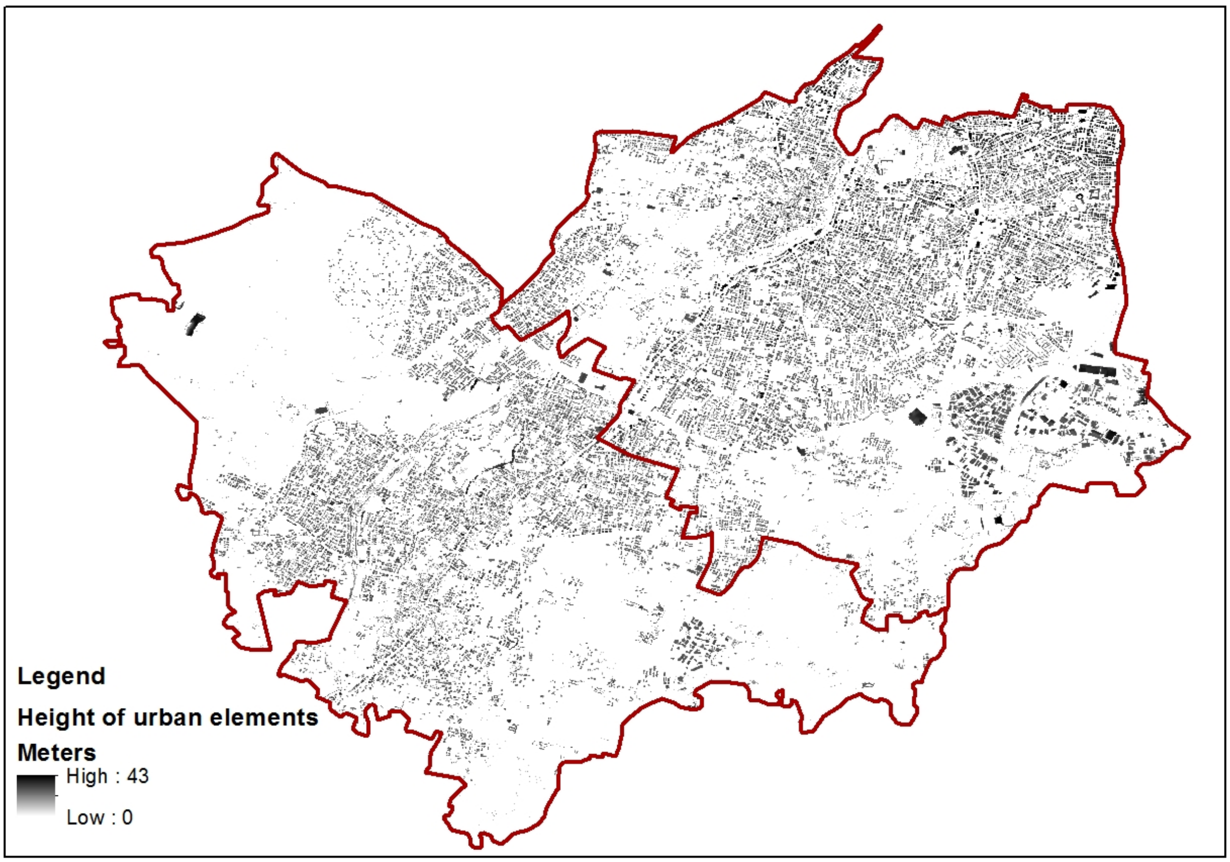
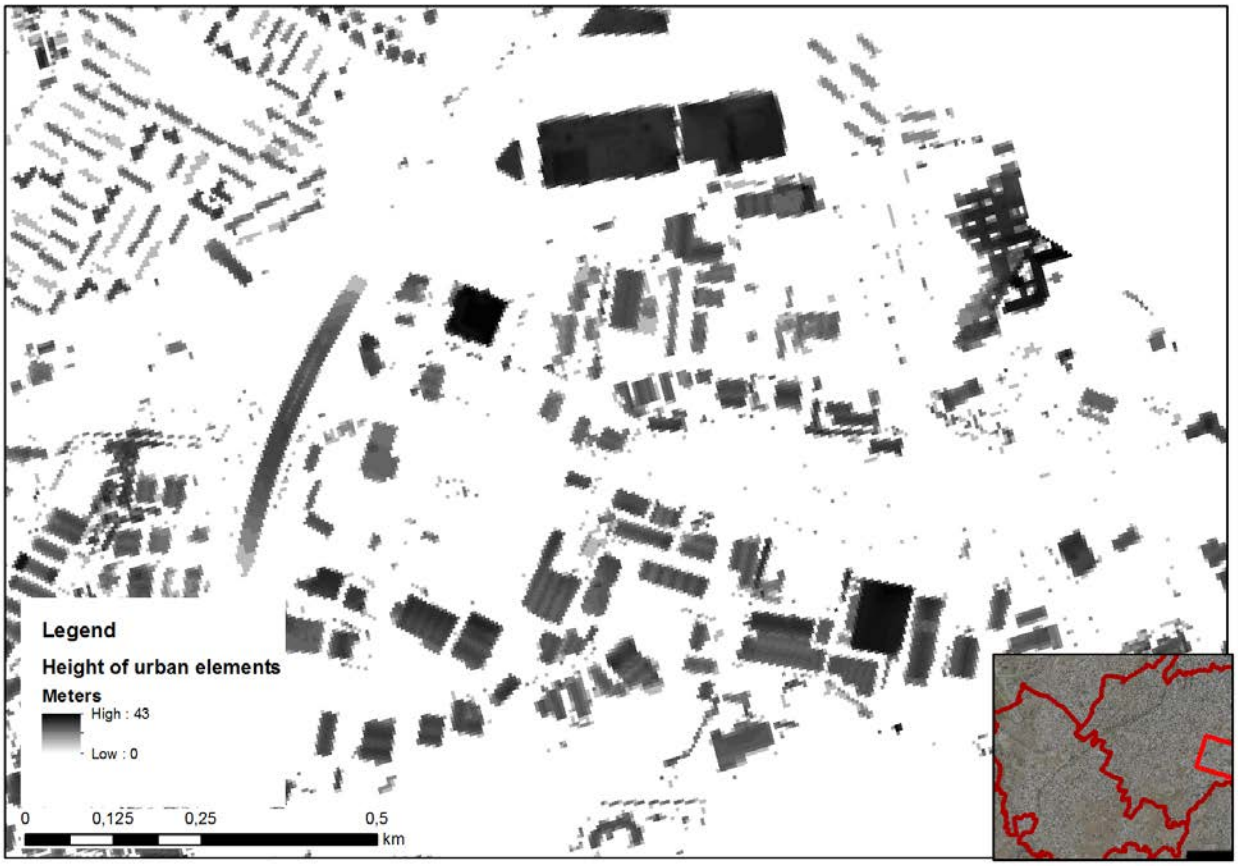


Figure 2-16: Normalized Urban Surfaces

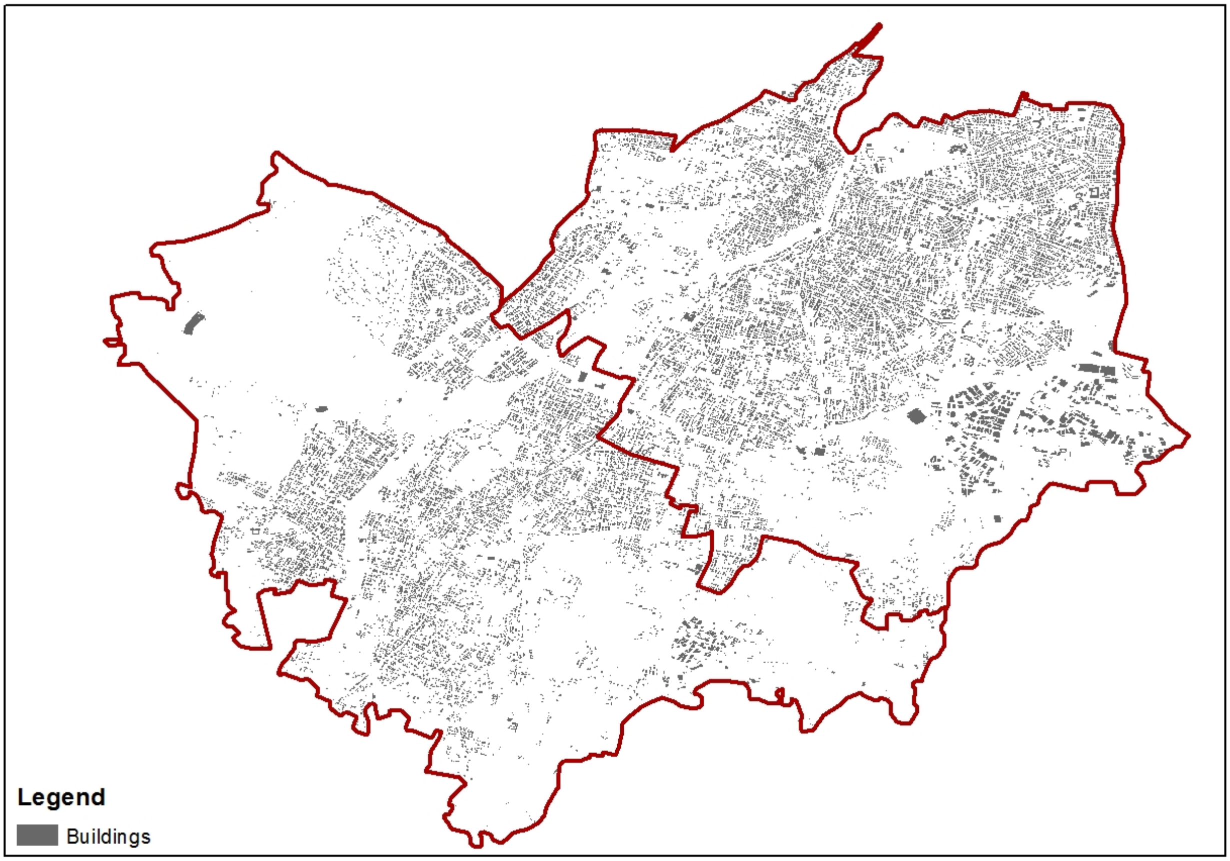


2.2.3.2 Building's Shape

Shape files from the Inspire GeoPortal of Cyprus.

Deliverable – Layer name: **C_buildings**

Figure 2-17: Building's Shape



2.2.3.3 Building's Height

This elaboration shows the mean height of buildings. The height in meters is proceeded through GIS technologies, the number of floor is assumed to better represent the results.

Deliverable – Layer name: **C_h_build**

Figure 2-18: Building's Height

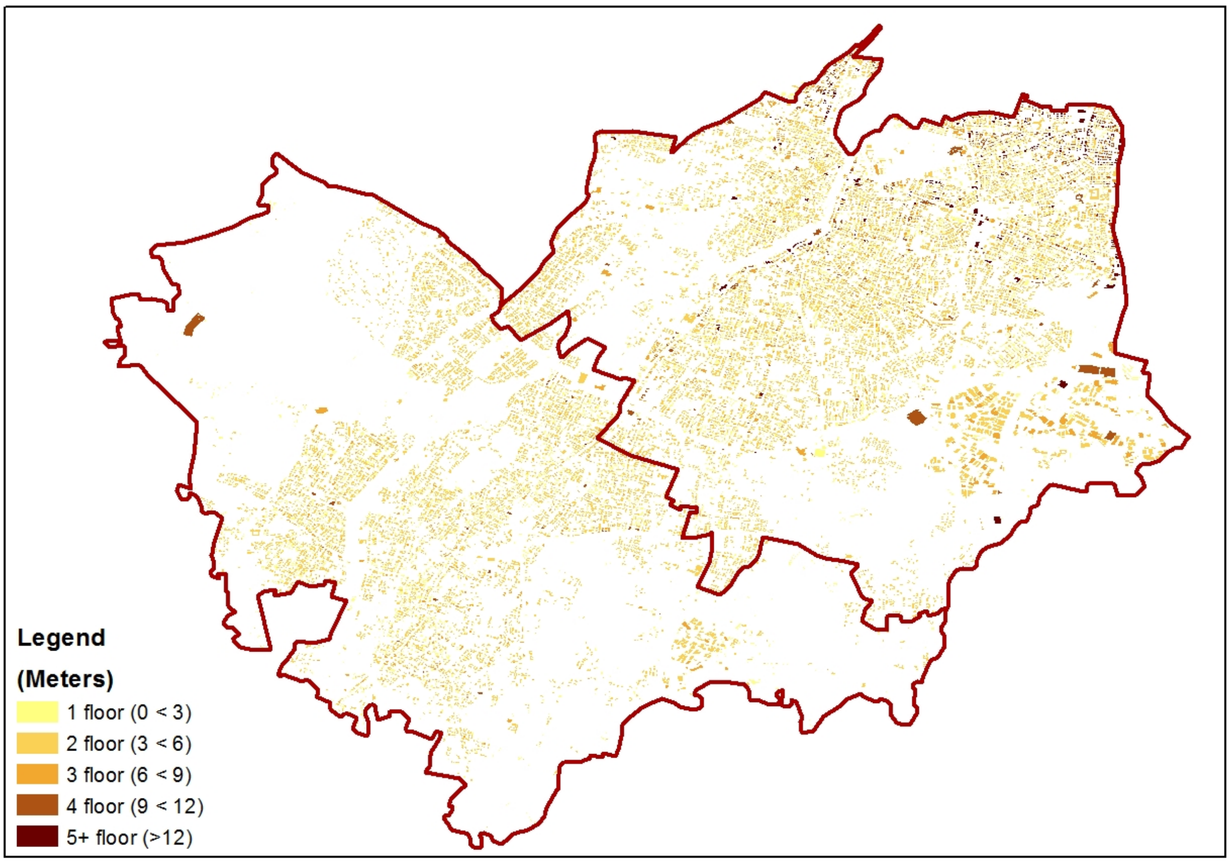
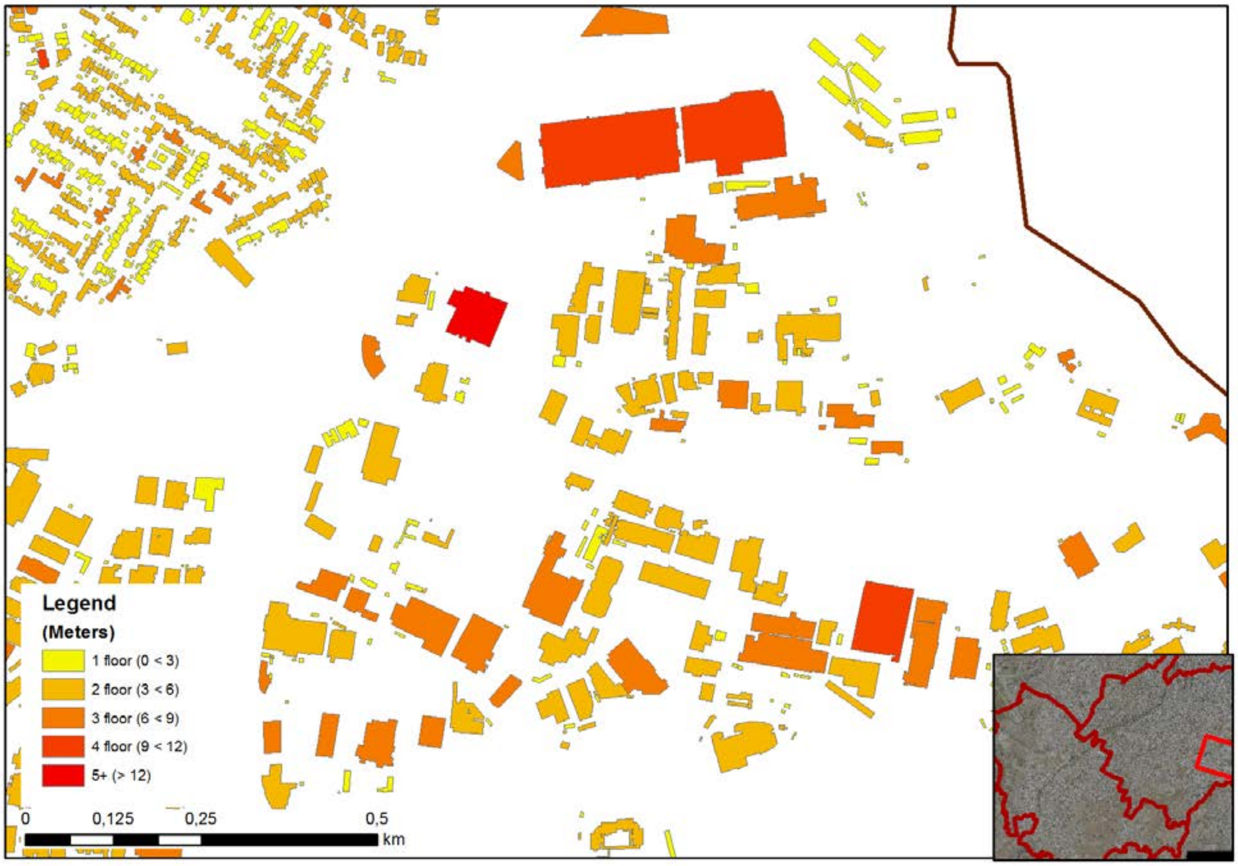


Figure 2-19: Building's Height



2.2.3.4 Sky-View Factor

The calculation of visible sky, sky view factor (SVF), is based on the normalized urban structure and has been processed through GIS tools. This index represents the extent of sky observed from a point as a proportion of the total possible sky hemisphere. This index varies between 0 and 1, respectively closed and full open, and it is useful to understand which urban morphology is more inclined to store heat during the day and night.

Deliverable – Layer name: **C_skv**

Figure 2-20: Sky View Factor

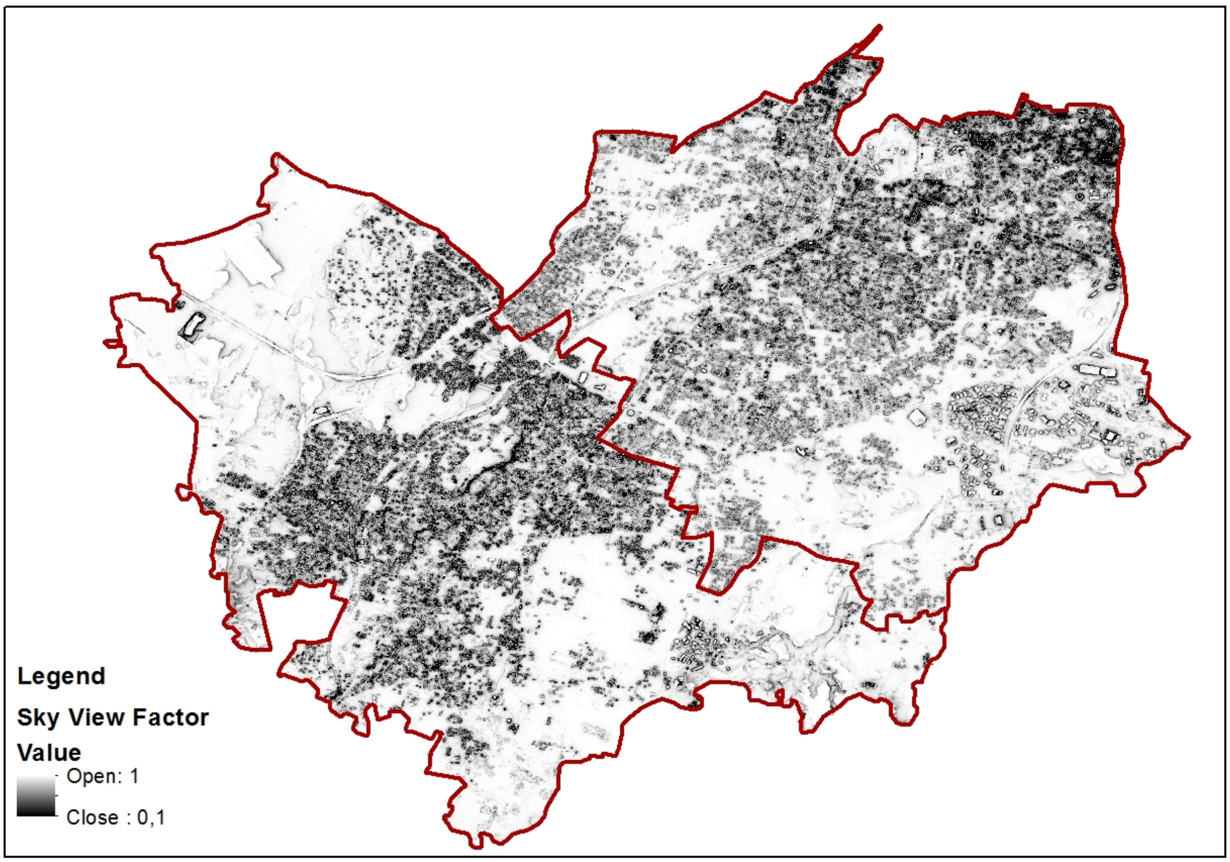


Figure 2-21: Sky View Factor – Detail of Strovolos

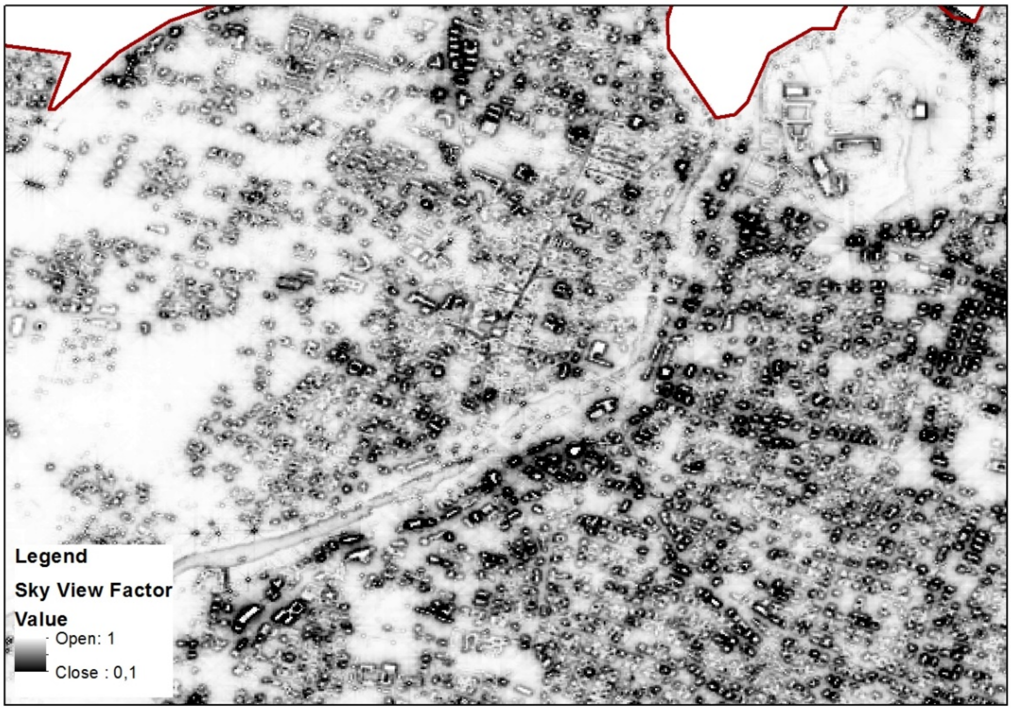
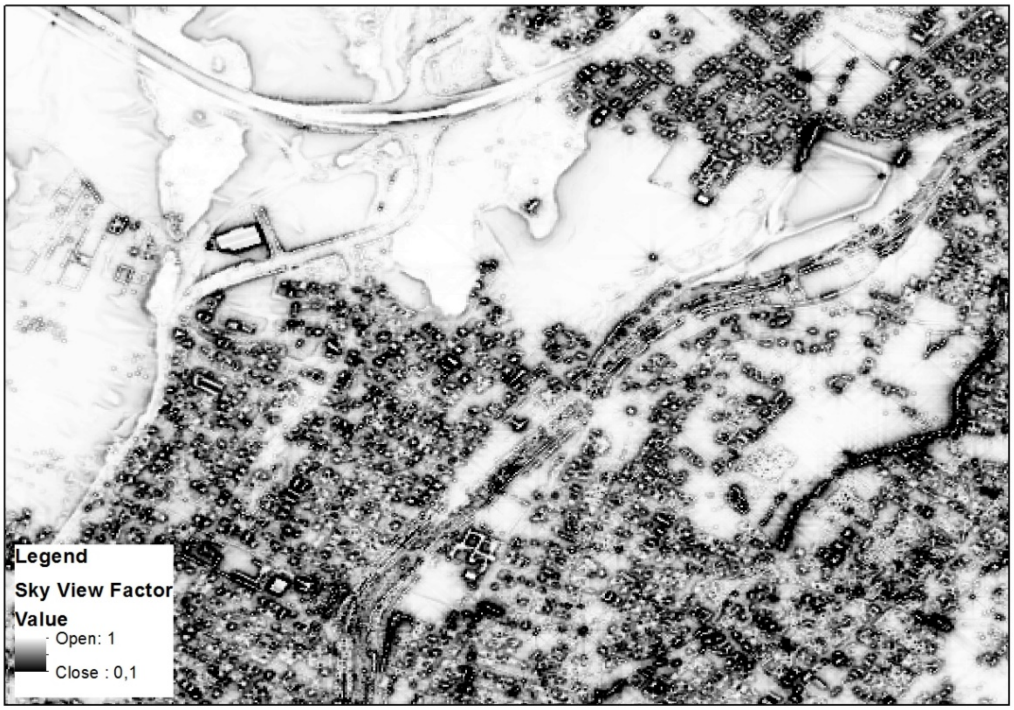


Figure 2-22: Sky View Factor – Detail of Lakatamia



2.2.3.5 Urban Green Location

This layer represents all the permeable surface classified through different processes. For Strovolos and Lakatamia partner municipalities, the permeable surface was extracted analogously as the impervious process through a land cover mapping software (eCognition). The first raw data contains information on all permeable surfaces identified, then it sums up with the agricultural fields (filtering the features of anthropic land use) and then subtract the buildings came from official cartographic sources (Cyprus Geoportal, Corine Land Cover). In order to recognize the existing land cover at a local scale, we set four different classes: permeable, impermeable, buildings and roadways. Permeable class includes plant communities, green ground cover, cultivable surfaces, green surfaces for private and public property.

Deliverable – Layer name: **C_perm**

Figure 2-23: Urban Green Location

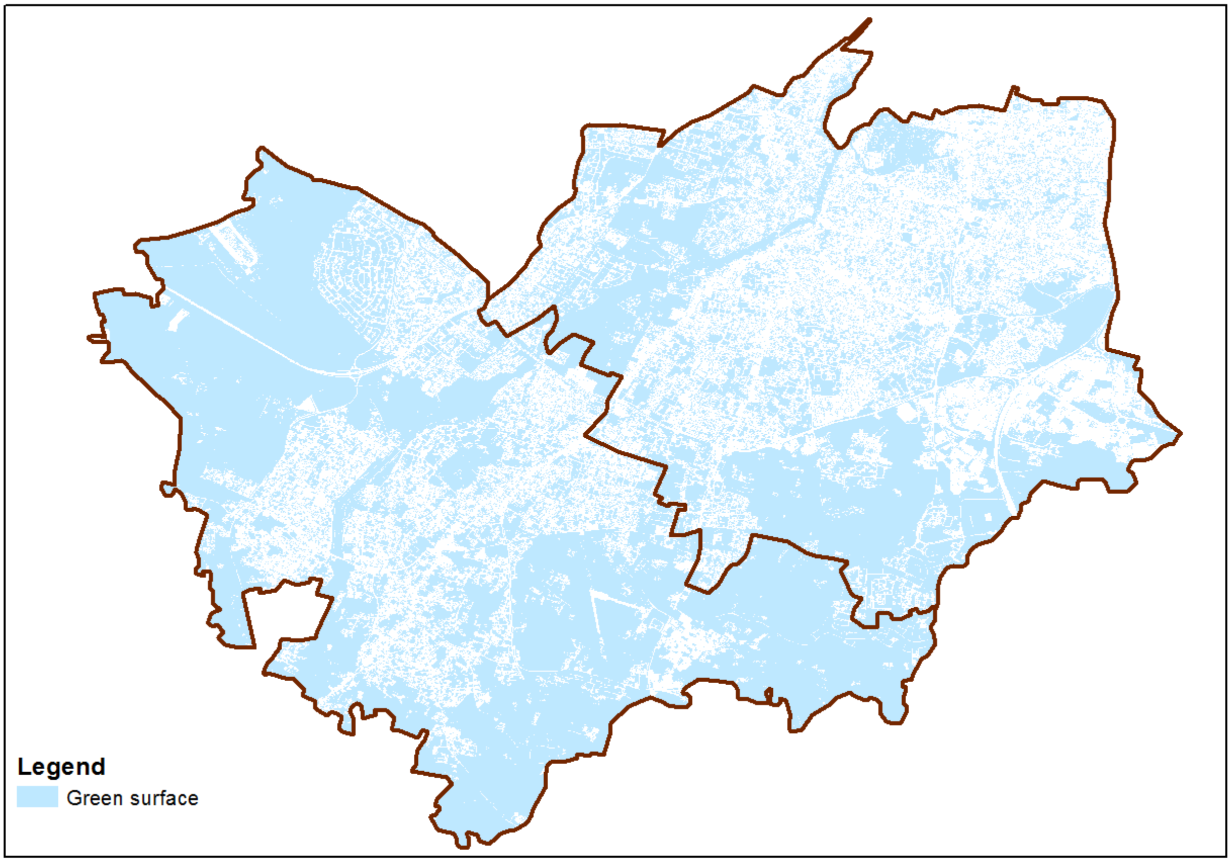

Legend
Green surface

Figure 2-24: Urban Green Location

Figure 2-25: Urban Green Location

Figure 2-26: Urban Green Location

Figure 2-27: Urban Green Location

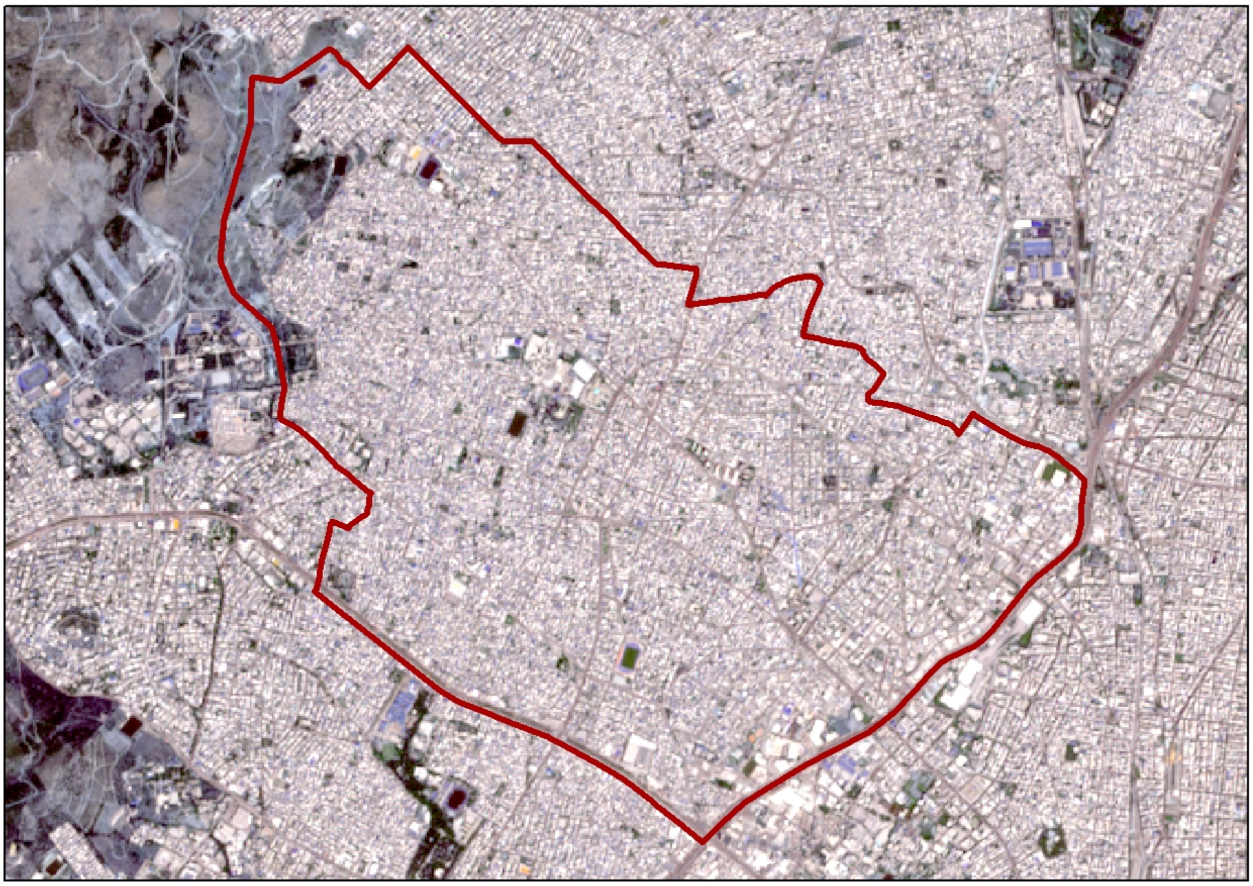

Legend
Green surface

Figure 2-28: Urban Green Location

3 PERISTERI

Peristeri partner municipality in Greece.

Figure 3-1:Administrative Boundaries of Peristeri



3.1 Water-related Data Collect

The water-related analysis has the aim to investigate the surface composition, identifying barriers, gradient and path that can influence the water flow. The resulting layers can serve as inputs for activity C.3.2 Floods.

3.1.1 Input Data

Mayor problems have been experienced since the Greek Municipality of Peristeri had almost no data of its own territory or built environment.

To carry-out the analysis, it has been widely used open-data retrieved from online resources such as:

- Dwg file from Peristeri Municipality, then manually improved and converted
- Satellite images from Sentinel 1 Copernicus
- DTM model – Open data from Alaska Satellite Facility. Resolution 12.5m

3.1.2 Method

First, an analysis to understand the composition of the surface was carried on.

Then, a static analysis of the morphological composition of the area was run through GIS technologies and the Arc Hydro Tool based on the 12meters' resolution Digital Terrain Model. This led to understand the flow of water, where the streams and their related catchment basins are where the slopes are. These analyses are based on the methodology of "*Watershed and Stream Network Delineation using ArcHydro Tools" Prepared by Venkatesh Merwade School of Civil Engineering, Purdue University.*

Finally, through a cross analysis of these two previous steps, the most impervious catchments basins were identified and their streams were analyzed identifying the most vulnerable and low-lying floodable areas.

3.1.3 Results

3.1.3.1 Impervious Surfaces

For the partner municipality of Peristeri, the analysis of impervious surfaces is based on open-source four-band satellite images. This allows to analize the surface through the Normalize Difference Vegetation Index (NDVI) index. This index allows to distinguish the vegetation through the recognizable spectral signature of the plants. Once vegetation and permeable surfaces have been detected, the impervious surfaces were mapped.

Deliverable – Layer name: **At_impe**

Figure 3-2:Impervious surfaces

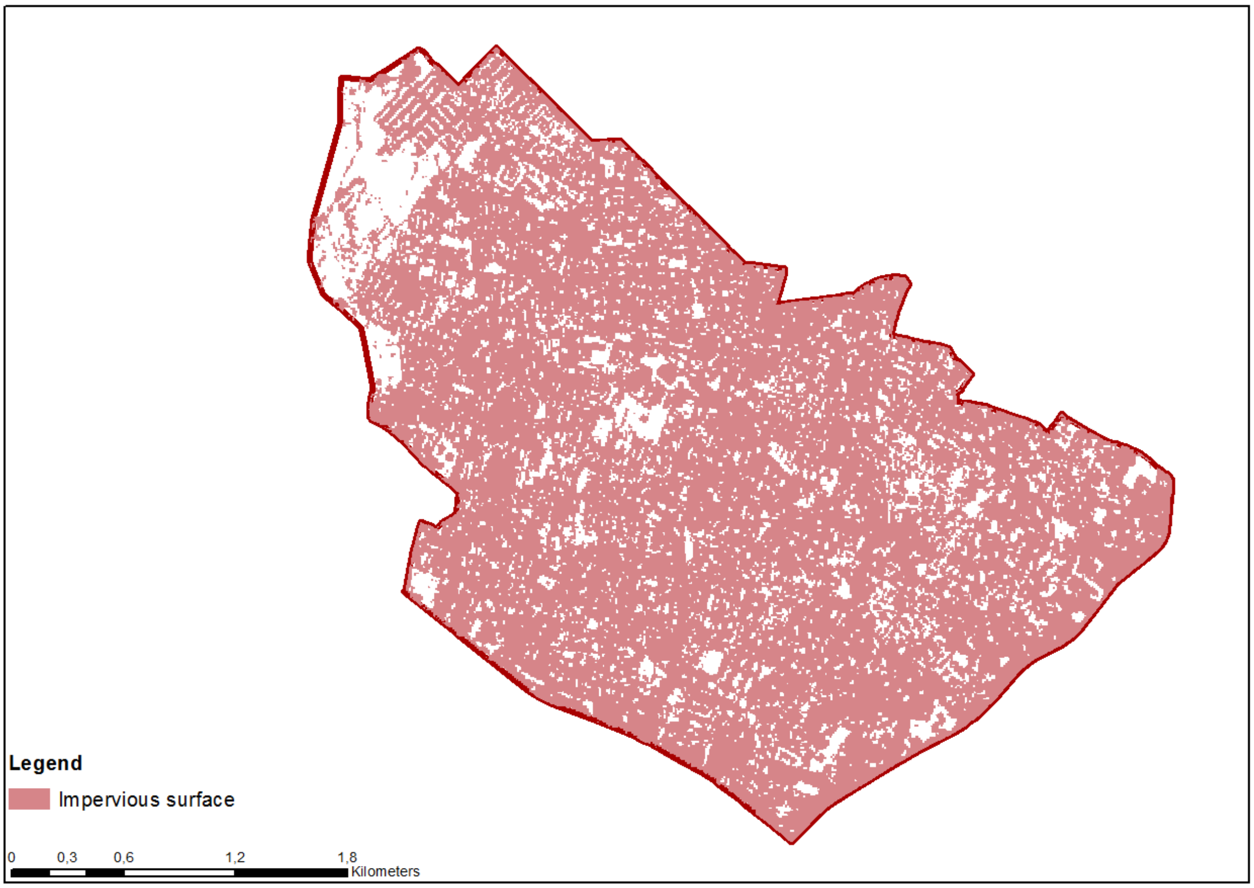
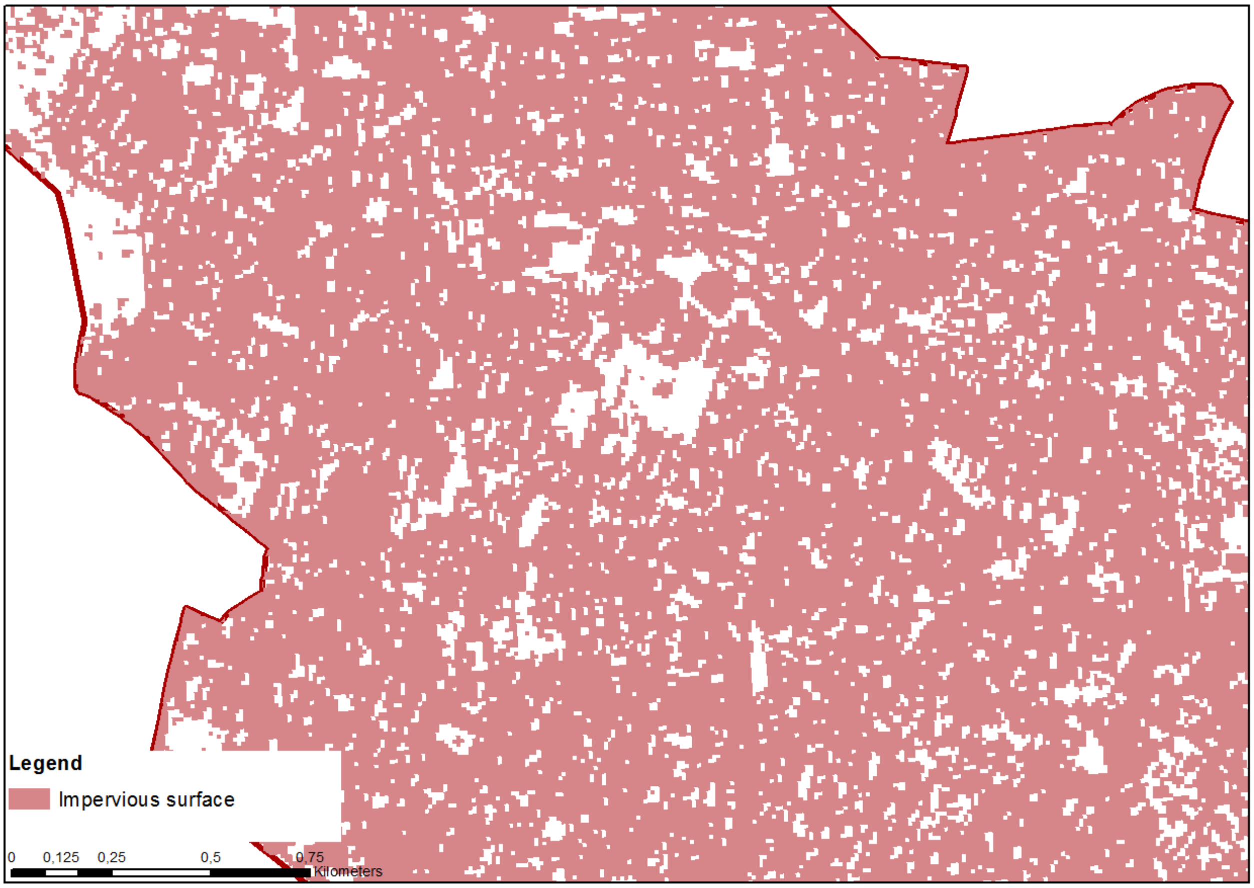


Figure 3-3:Impervious surfaces

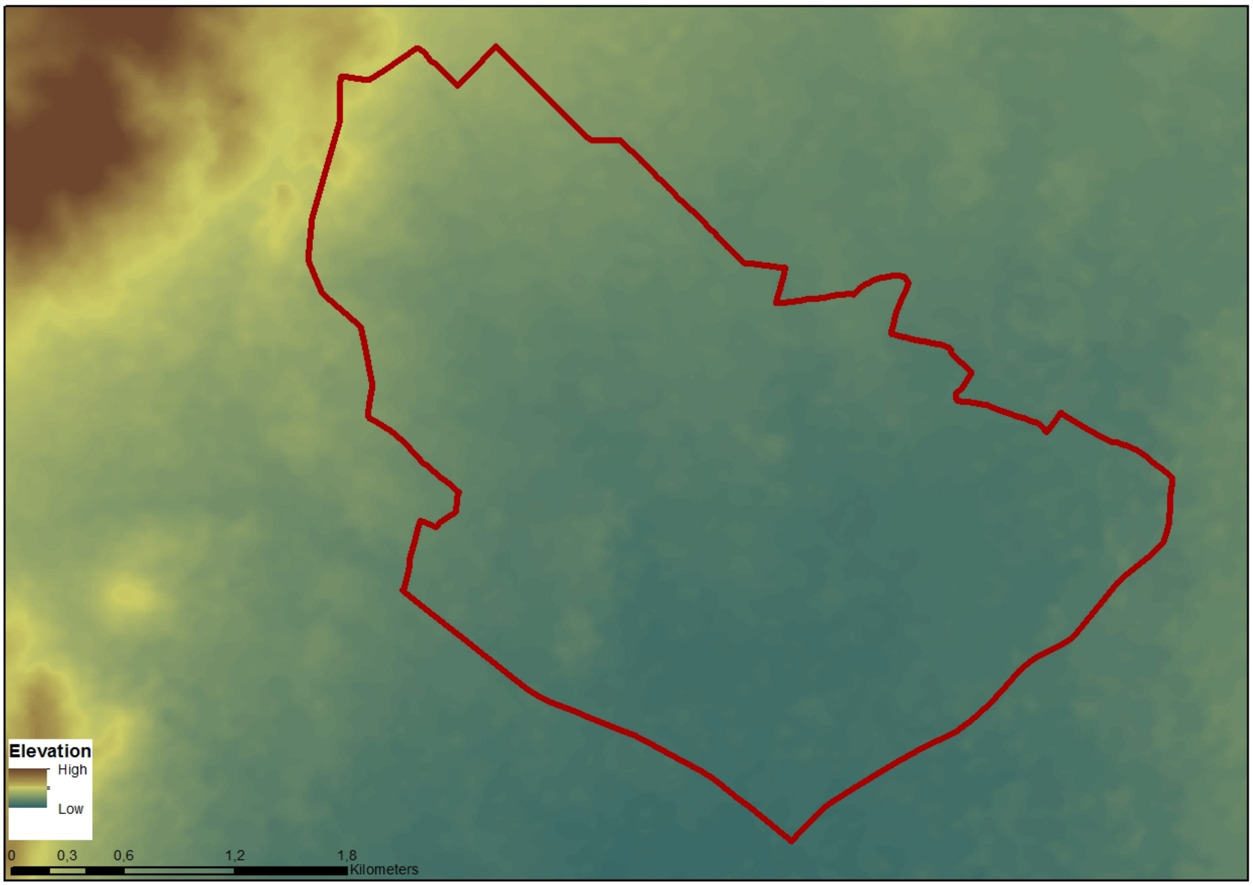


3.1.3.2 Elevation

Elevation for both municipalities, derived from the DTM model, is the initial framework to understand the flow of water.

Deliverable – Layer name: **At_Elevation**

Figure 3-4:Elevation

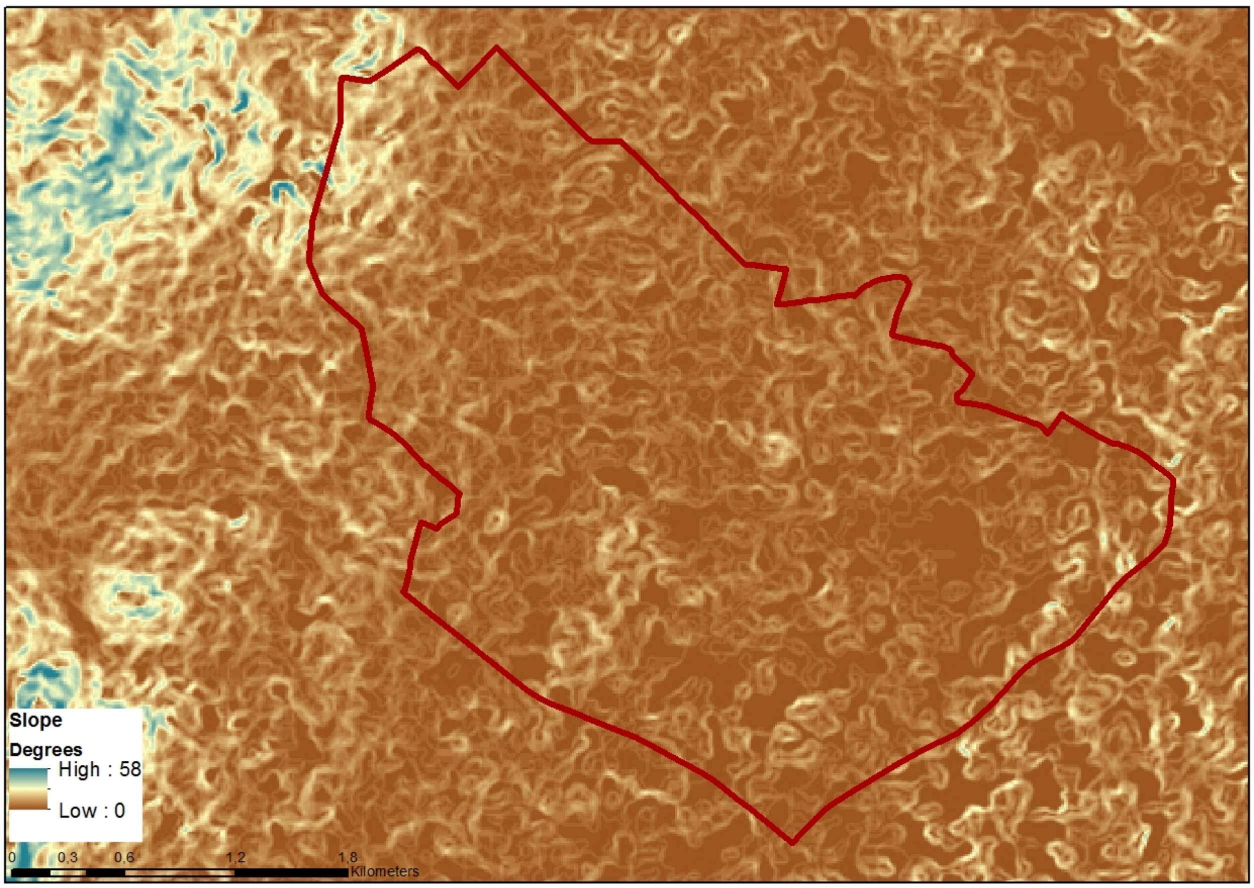


3.1.3.3 Slope

Slope in degrees for Peristeri municipalities, derived from the DTM model and GIS processing. Helps to point out which are the natural and artificial barriers for water flow. Identifies low-lying zones and horizontal gradient zones.

Deliverable – Layer name: **At_Slope**

Figure 3-5: Slope in degrees



3.1.3.4 Flow Direction

Flow direction for Peristeri municipality, derived from the DTM model, has been calculated through GIS processes. Through chromatic classes, this layer represents in which direction the water flow from each cell. This dataset is the base to calculate the following paths.

Deliverable – Layer name: **At_Flow_Direction**

In the layer, each number refers to a direction:

1=E;

2=S-E;

4=S;

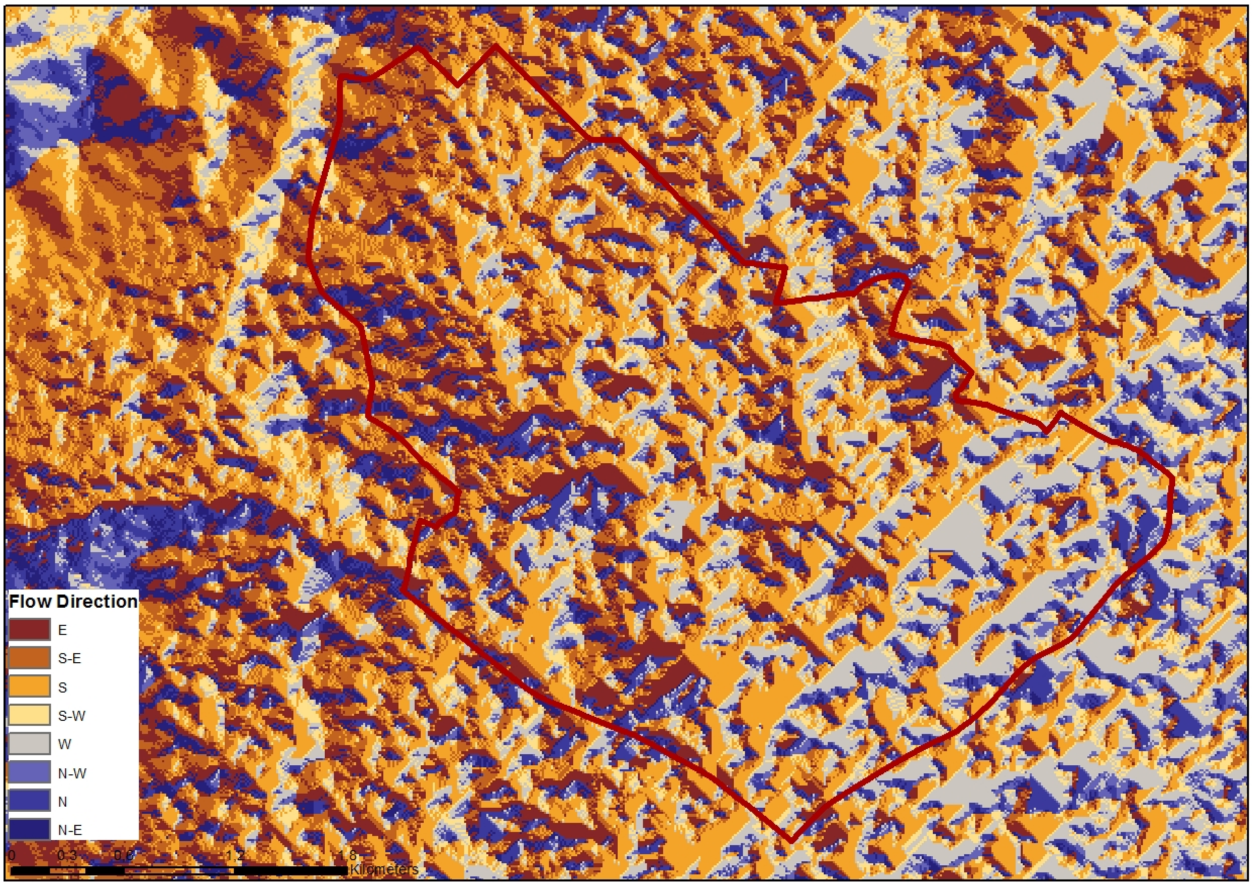
8=S-W; 16=W;

32=N-W;

64=N

128=N-E

Figure 3-6: Flow Direction



3.1.3.5 Flow accumulation

Flow direction for Peristeri highlights the hierarchy of the flow streams, classifying them by the dimension of the area they drain. The classes in the layer are:

1= Stream with drainage area smaller the 0,025 Km^2

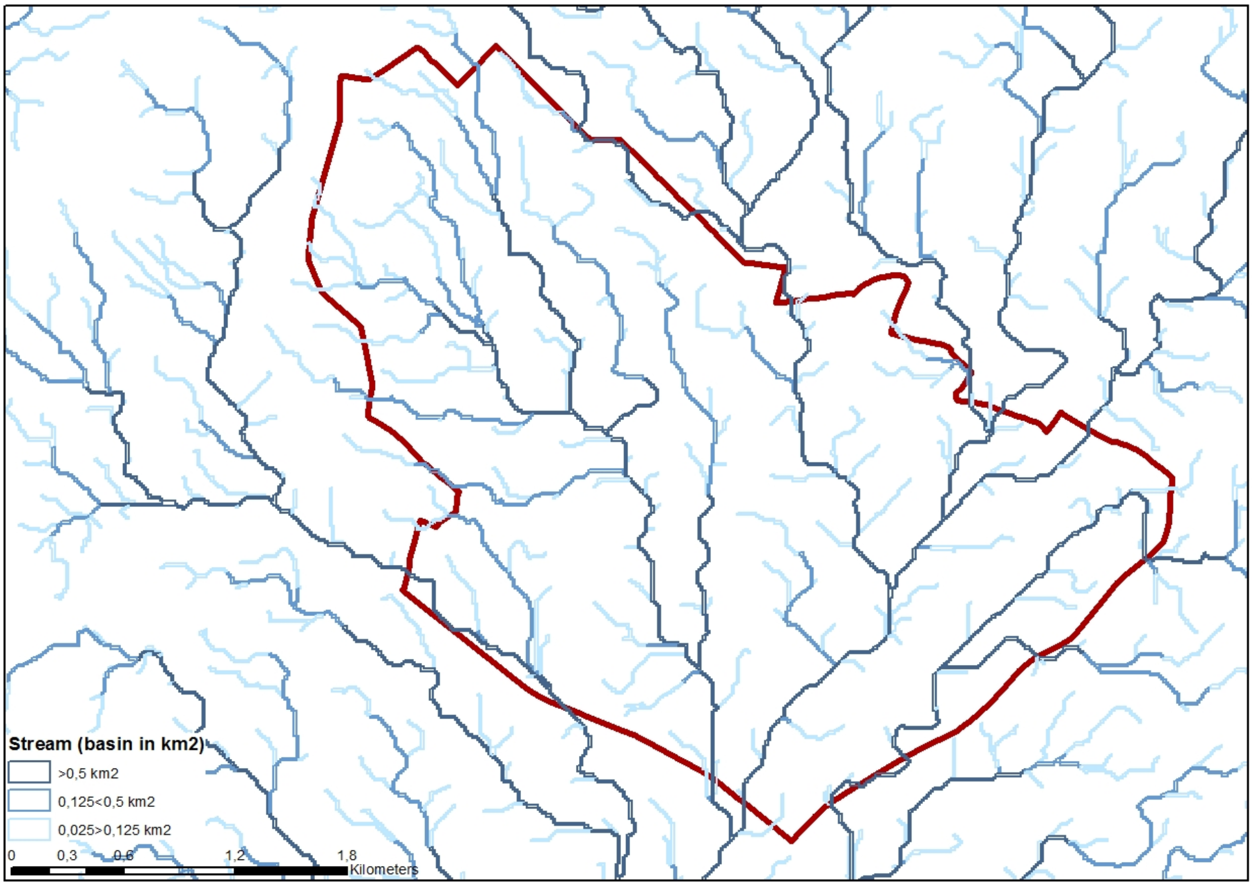
2= Stream with drainage area between 0,025 Km^2 and 0,125 Km^2

3= Stream with drainage area between 0,125 Km^2 and 0,5 Km^2

4= Stream with drainage area bigger than 0,5 Km^2

Deliverable – Layer name: **At_Flow_Accumulation**

Figure 3-7: Flow Accumulation


Stream (basin in km2)
>0,5 km2
0,125<0,5 km2
0,025>0,125 km2
0
0,3
0,6
1,2
1,8
Kilometers

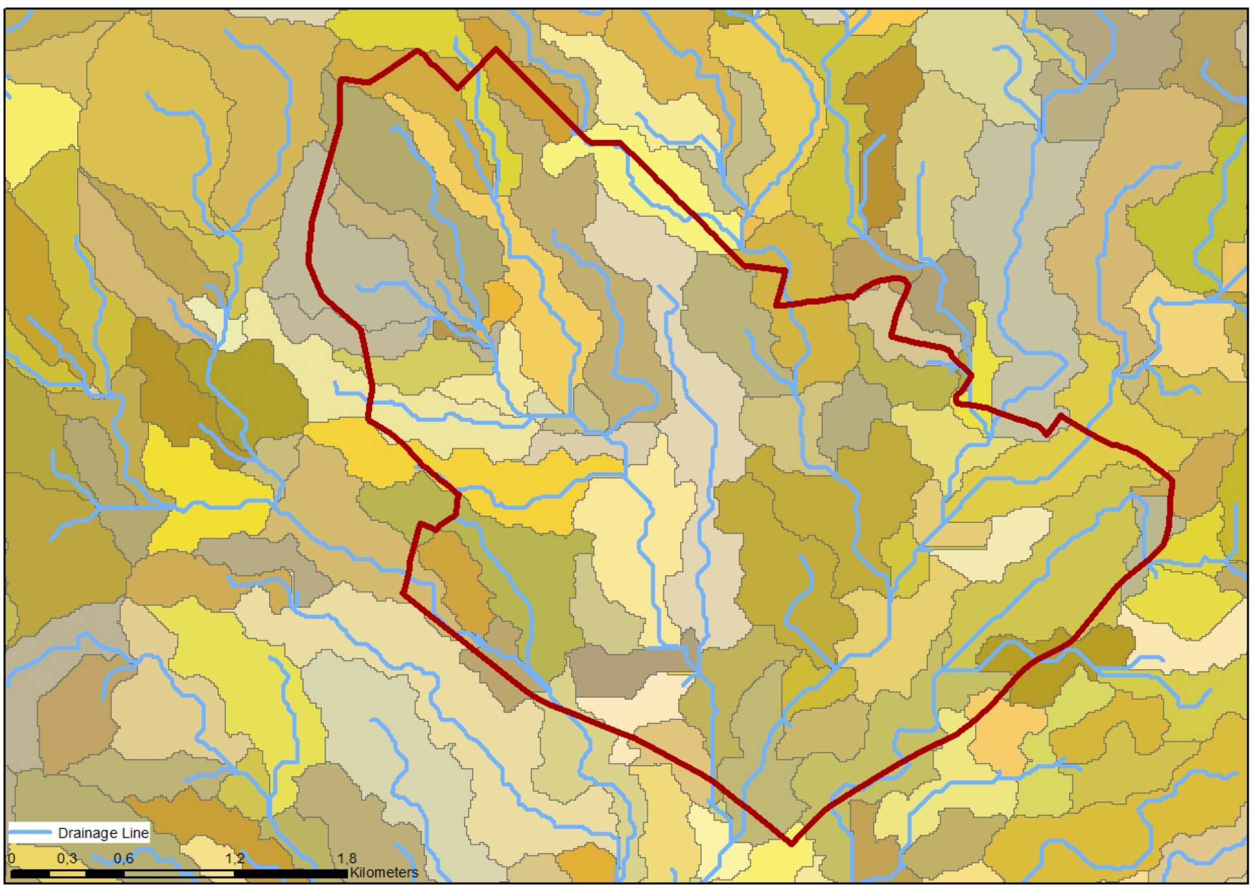
3.1.3.6 Urban Streams and Sub-catchments

Data, derived from the DTM model. It divides the territory in subcatchments following the morphological profile, and defines the path of the drainage streams. Streams are tracked once they drain a minimum of 0,125km².

Storm-water flow for Peristeri municipality, derived from the DTM model, has been calculated through GIS processes. Then the territory has been divided in sub-catchments following the morphological profile, and defined the path of the drainage streams. Streams are tracked once they drain a minimum of 0,125km².

Deliverable – Layer name: **At_Stream** and **At_Subcatchment**

Figure 3-8: Streams and Subcatchments

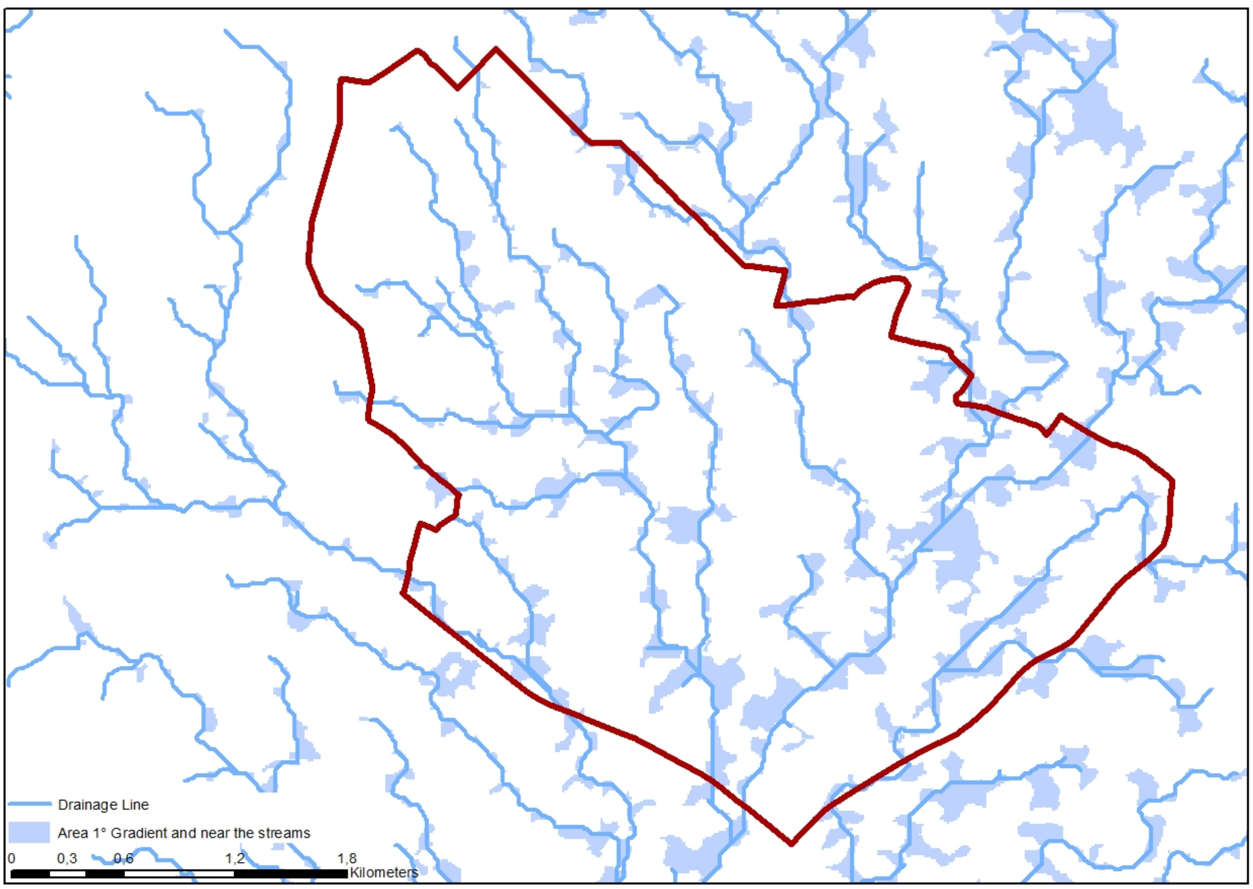


3.1.3.7 Low-lying areas next to water flow

Once the path of urban streams is defined, it is interesting to highlight the areas that are crossed by the streams and that have a gradient lower than 1°. This layer represents the areas that are most likely to host the expansion of water when the streams intensify their flow (e.g. an extreme precipitation event). So the dataset of this layer is made of horizontal areas (<1°), connected to urban streams that drain areas bigger than 0,125km².

Deliverable – Layer name: **At_Lowandnear**

Figure 3-9: Low-lying areas next to water flow

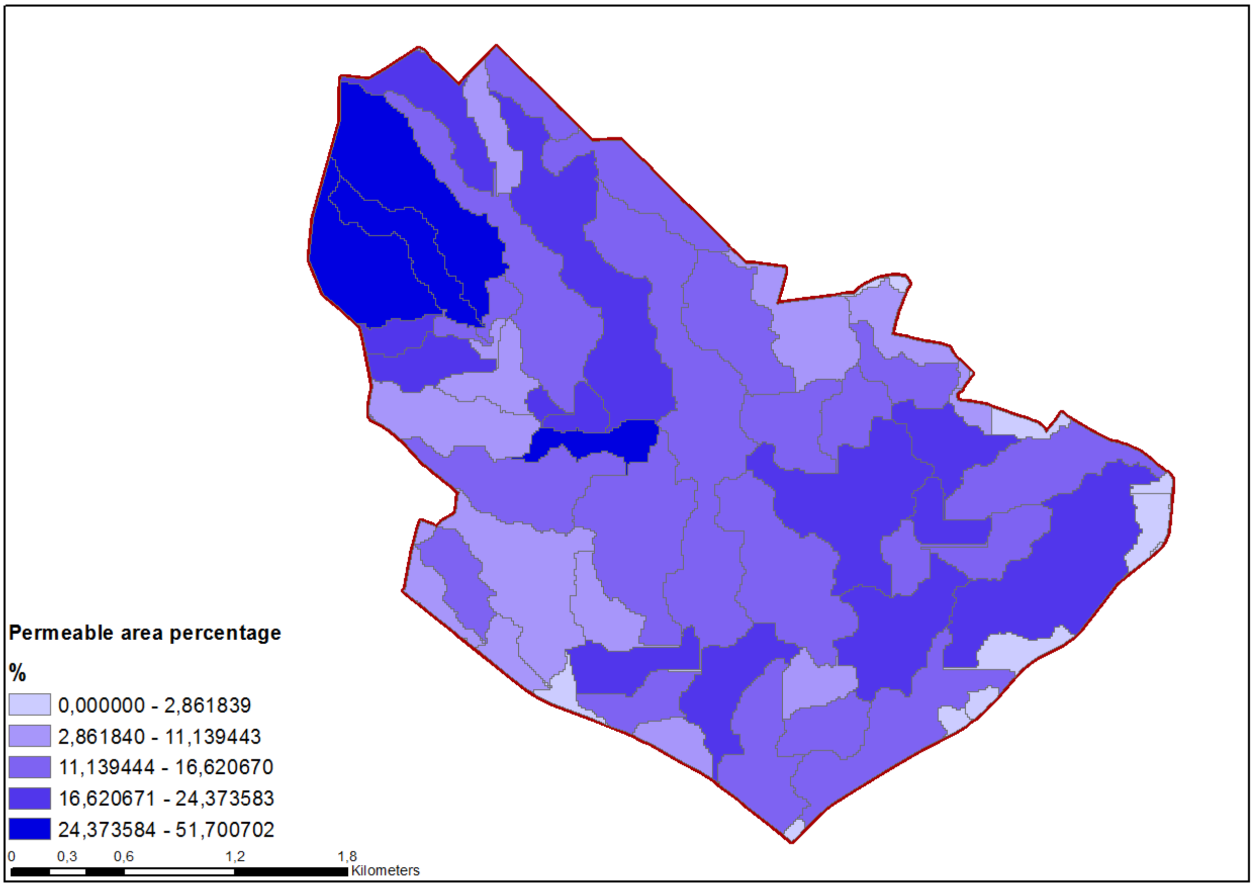


3.1.3.8 Pervious sub-catchments

Based on hydrographic sub-catchments and impervious surfaces defined in previous steps, the goal of this analysis is to identify the most impervious sub-catchments. Data shows in percentage the amount of permeable surfaces in each basin. The catchments with more intense color have a greater amount of permeable areas.

Deliverable – Layer name: **At_perc**

Figure 3-10:Pervious Sub-catchment



3.2 Heat-related Data Collect

The heat-related data collection has the aim to investigate the natural and urban surface. The resulting layers can serve as inputs for activity C.4.2: High temperatures and energy demand.

3.2.1 Input Data

Mayor problems have been experienced since the Greek Municipality of Peristeri had almost no data of its own territory or built environment.

To carry-out the analysis, it has been widely used open-data retrieved from online resources such as:

- Dwg file from Peristeri Municipality, then manually improved and converted
- Satellite images from Sentinel 1 Copernicus
- DTM model – Open data from Alaska Satellite Facility. Resolution 12.5m

3.2.2 Method

Since no data was available for the height of urban elements, building or vegetation, most of the elaboration carried out for Cyprus are not replicable in Peristeri.

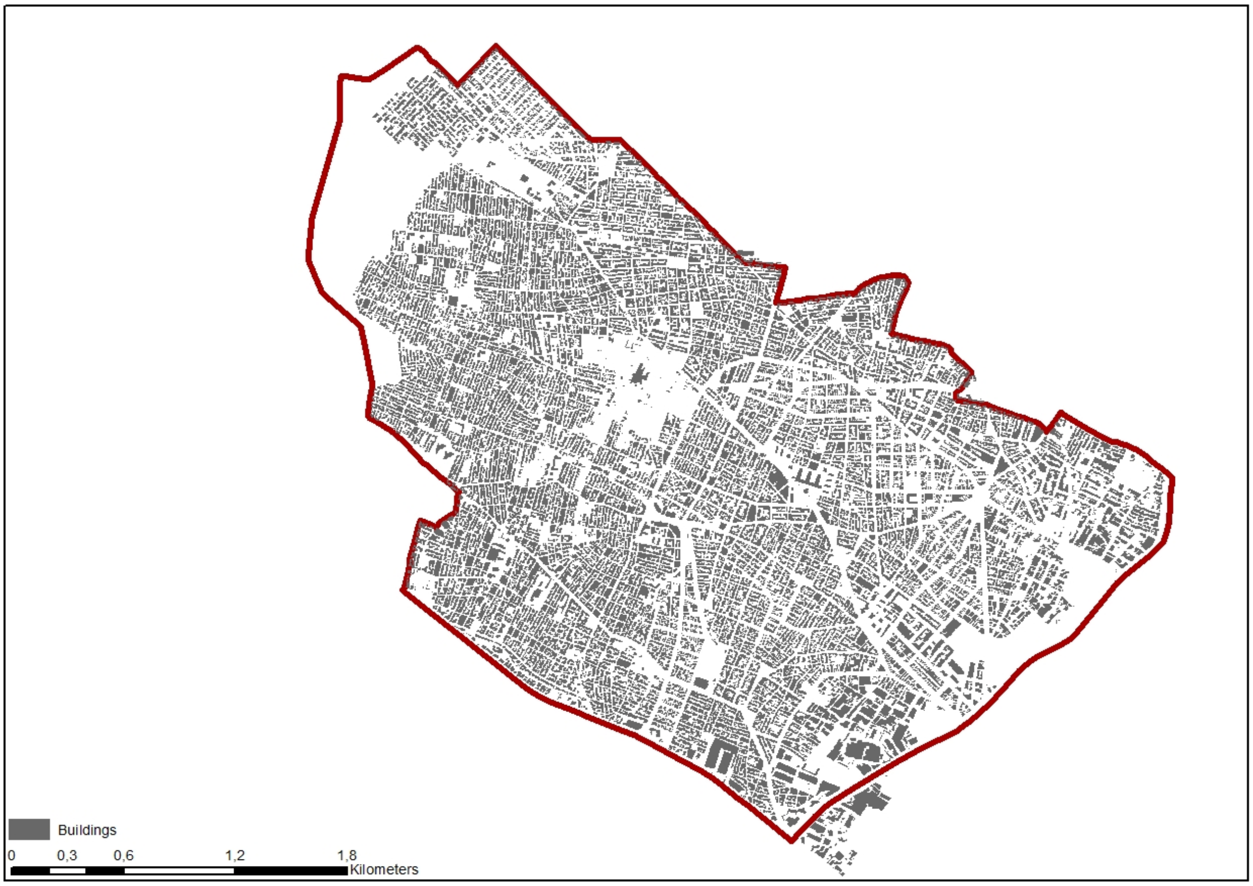
3.2.3 Results

3.2.3.1 Building's Shape

This deliverable is based on the dwg sent by the partner Municipality of Peristeri, it has been manually improved, translated in GIS language and georeferenced.

Deliverable – Layer name: **At_buildings**

Figure 3-11: Building's Shape



3.2.3.2 Urban Green Location

This layer represents all the permeable surface classified through different processes. In order to recognize the existing land cover at a local scale, we set four different classes: permeable, impermeable, buildings and roadways. Permeable class includes plant communities, green ground cover, cultivable surfaces, green surfaces for private and public property.

For the Peristeri municipal area, crossing information between NDVI index and known cartographic base it is possible to discern green from the non-green areas. All green surfaces can be assumed to be permeable

Deliverable – Layer name: **At_perm**

Figure 3-12: Urban Green Location

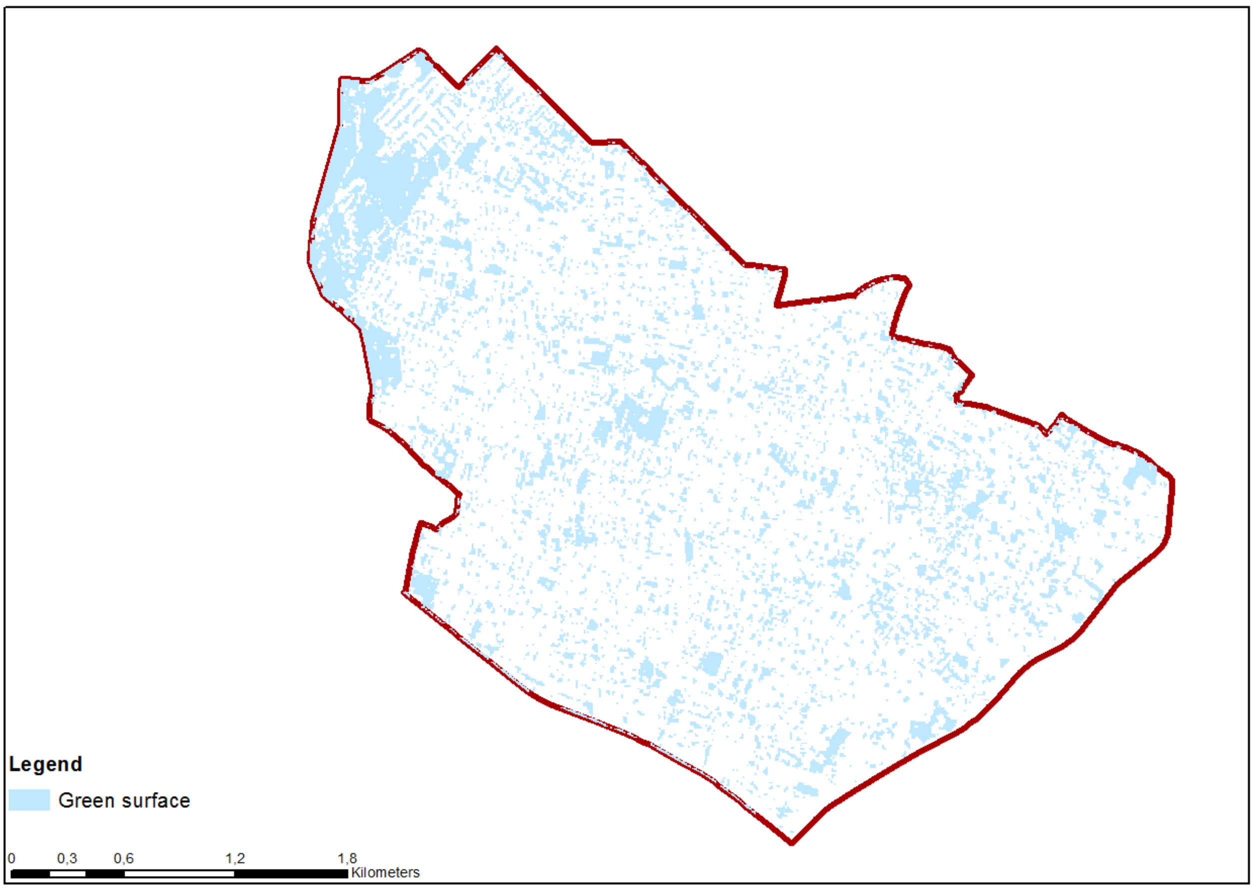
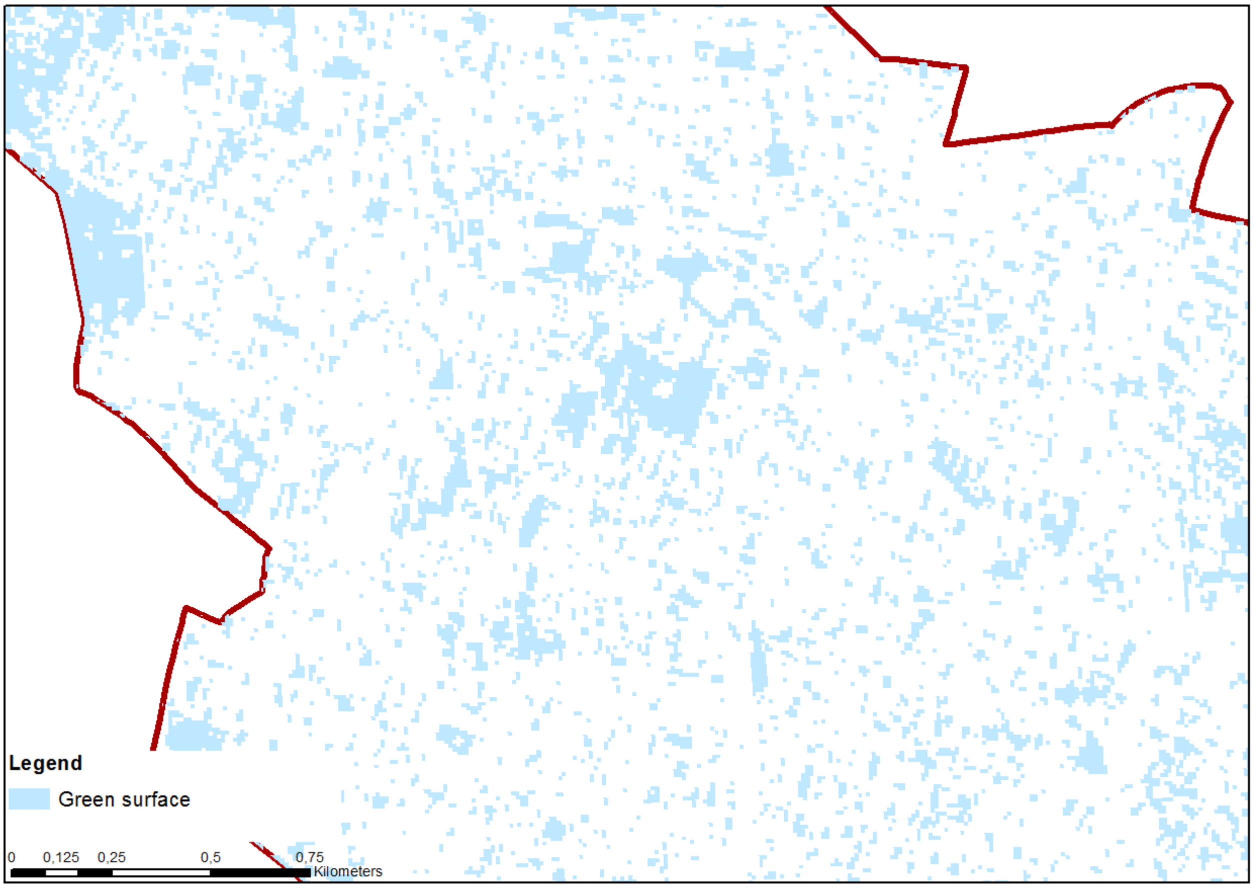


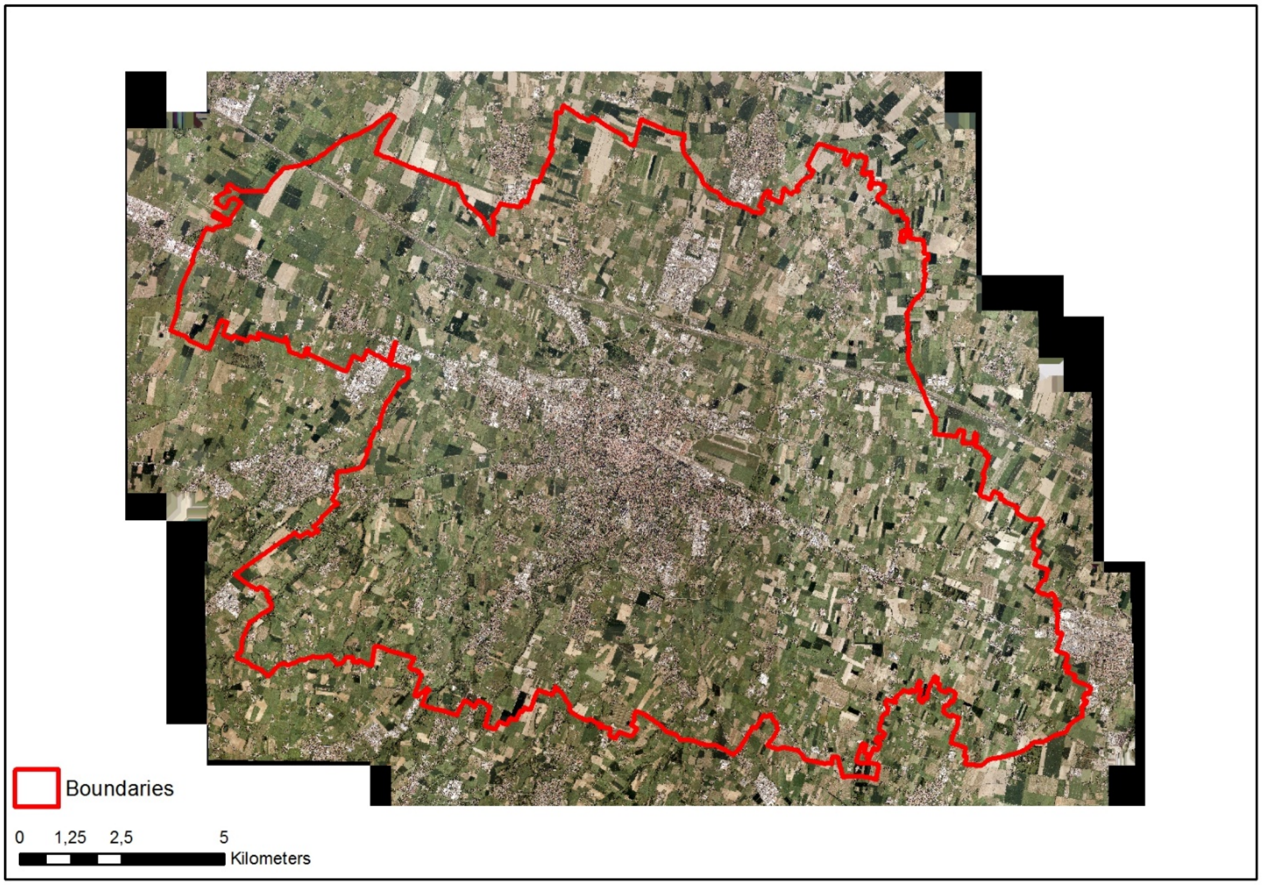
Figure 3-13: Urban Green Location



4 REGGIO EMILIA

Reggio Emilia patner municipality in Italy

Figure 4-1:Administrative Boundaries of Reggio Emilia



4.1 Water-related Data Collect

The water-related analysis has the aim to investigate the surface composition, identifying barriers, gradient and path that can influence the water flow. The resulting layers can serve as inputs for activity C.4.2 Floods

4.1.1 Input data

To carry-out the analysis, these initial data have been used:

- Aerial photography obtained by UAV (unmanned aerial vehicle)
- DSM model from Lidar survey
- Building, Roadways, Idrography, Land Use information from Emilia-Romagna regional Geoportal

4.1.2 Method

First, an analysis to understand the composition of the surface was carried on. This led to identify wherever the surfaces were permeable or not, mapping all the green areas (public and private) and the urban elements (buildings, roads. etc..).

Then, a static analysis of the morphological composition of the area was run through GIS technologies and the Arc Hydro Tool. This led to understand the flow of water, where the streams and their related catchment basins are and where the slopes are. These analyses are based on the methodology of "*Watershed and Stream Network Delineation using ArcHydro Tools" Prepared by Venkatesh Merwade School of Civil Engineering, Purdue University.*

4.1.3 Results

4.1.3.1 Impervious Surfaces

The analysis of impervious surfaces is based on aerial photography catch by UAV (unmanned aerial vehicle). Impervious surfaces include all areas that do not absorb water as cemented, asphalted and built surfaces. For Reggio Emilia Municipal area, the impervious surface was extracted through a series of operations.

Deliverable – Layer name: **Re_imp**

Figure 4-2: Impervious surfaces

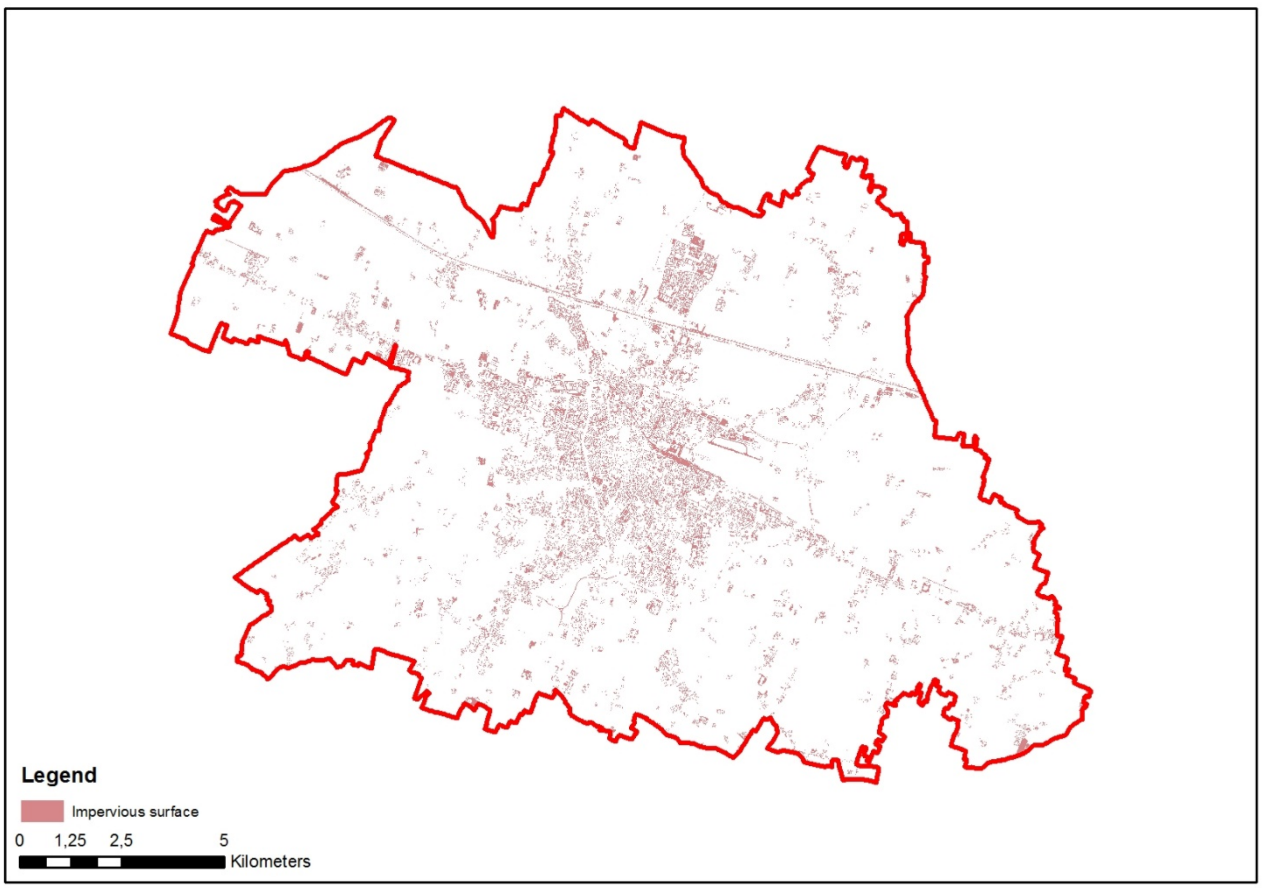


Figure 4-3: Impervious surfaces - Detail at neighborhood scale

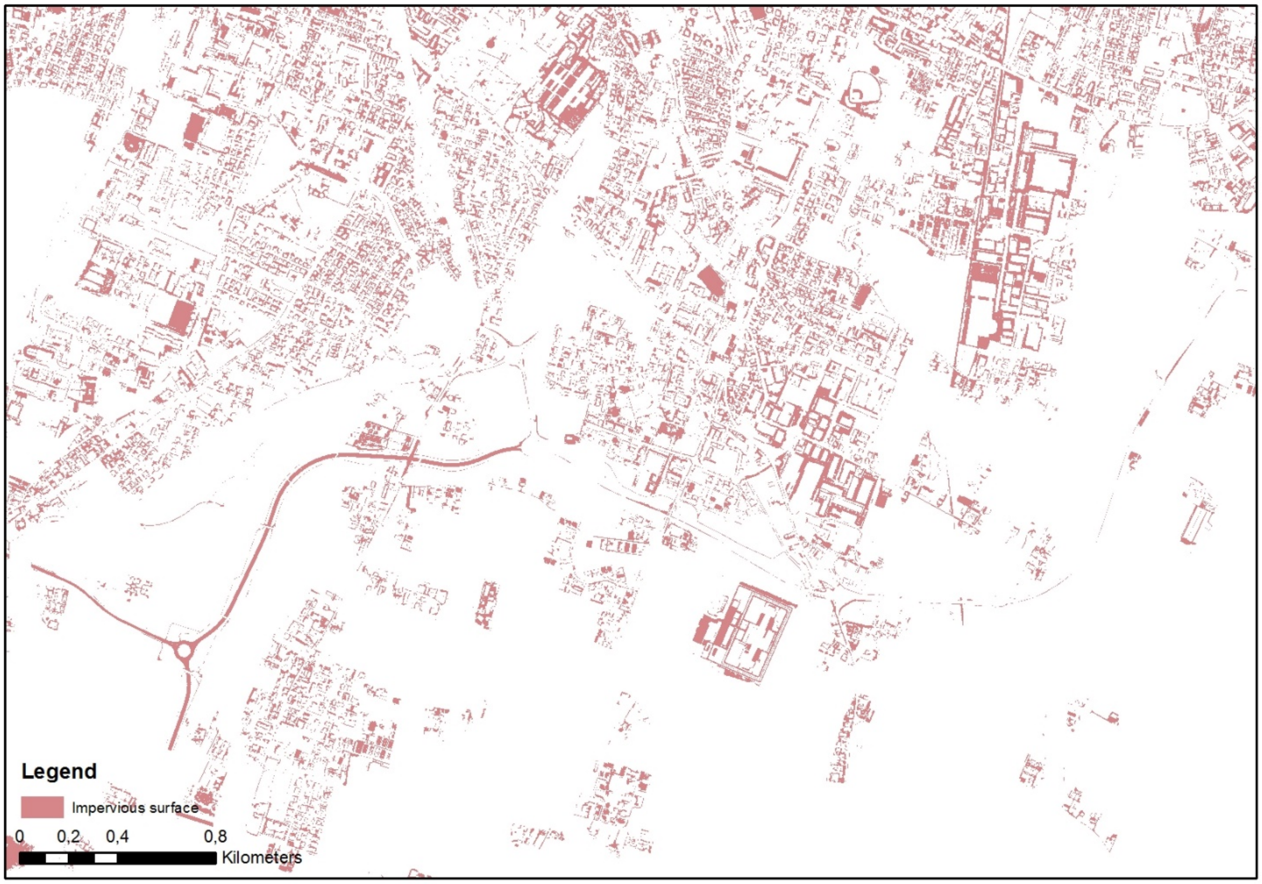
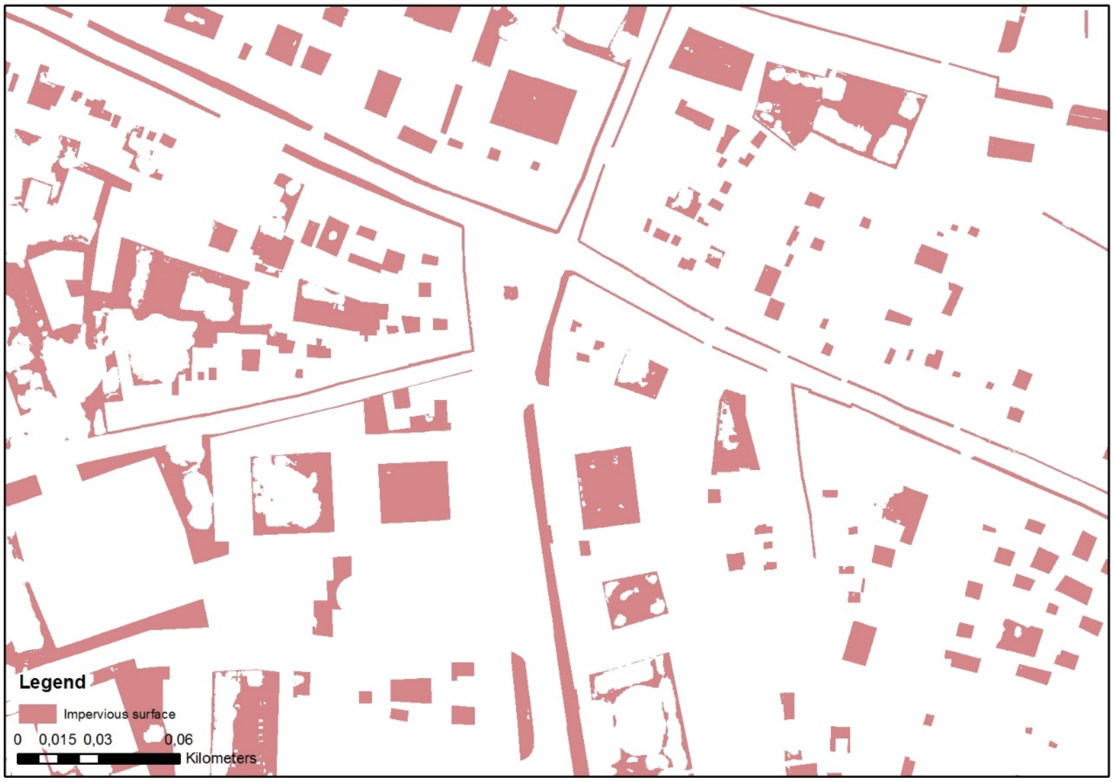


Figure 4-4: Impervious surfaces - Detail at building scale

Figure 4-5: Impervious surfaces - Detail at building scale

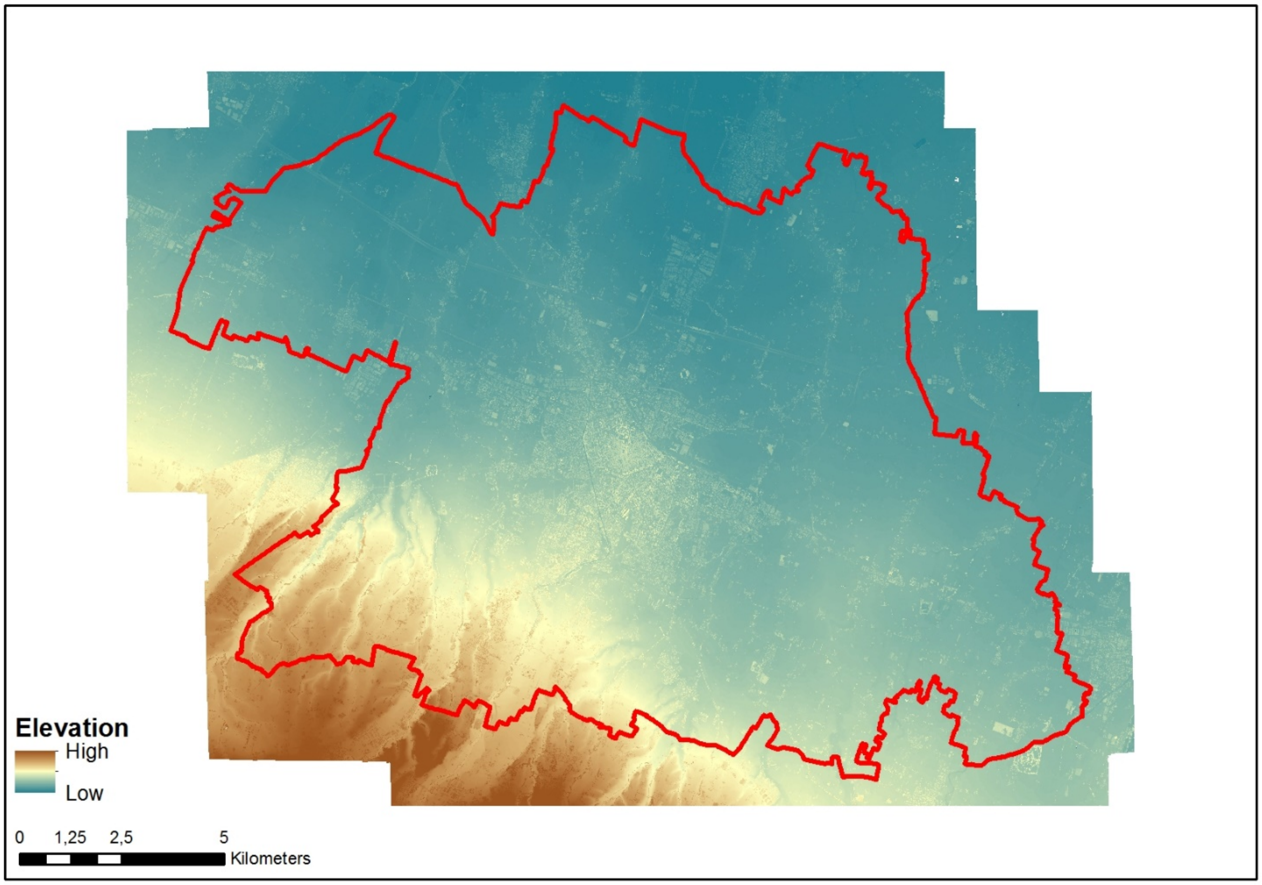


4.1.1.1 4.1.3.2 Elevation

Elevation for Reggio Emilia municipality, derived from the DSM model, is the initial framework to understand the flow of water.

Deliverable – Layer name: **Re_Elevation**

Figure 4-6 Elevation

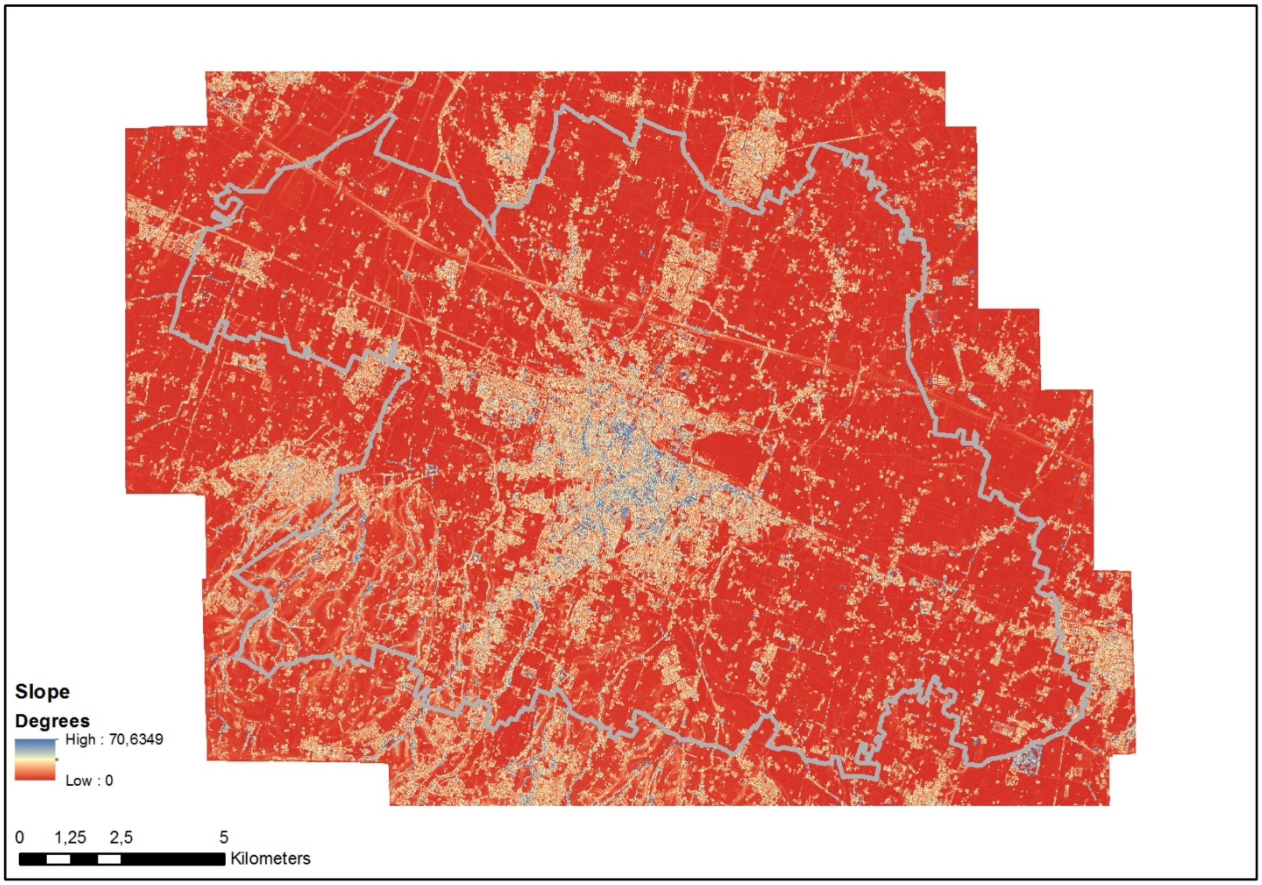


4.1.3.3 Slope

Slope in degrees for Reggio Emilia municipality, derived from the DSM model and GIS processing. Helps to point out which are the natural and artificial barriers for water flow. Identifies low-lying zones and horizontal gradient zones.

Deliverable – Layer name: **Re_Slope**

Figure 4-7 Slope



4.1.3.4 Flow Direction

Flow direction for Reggio Emilia municipality, derived from the DSM model, has been calculated through GIS processes. Through chromatic classes, this layer represents in which direction the water flow from each cell. This dataset is the base to calculate the following paths.

Deliverable – Layer name: **Re_Flow_Direction**

In the layer, each number refers to a direction:

1=E;

2=S-E;

4=S;

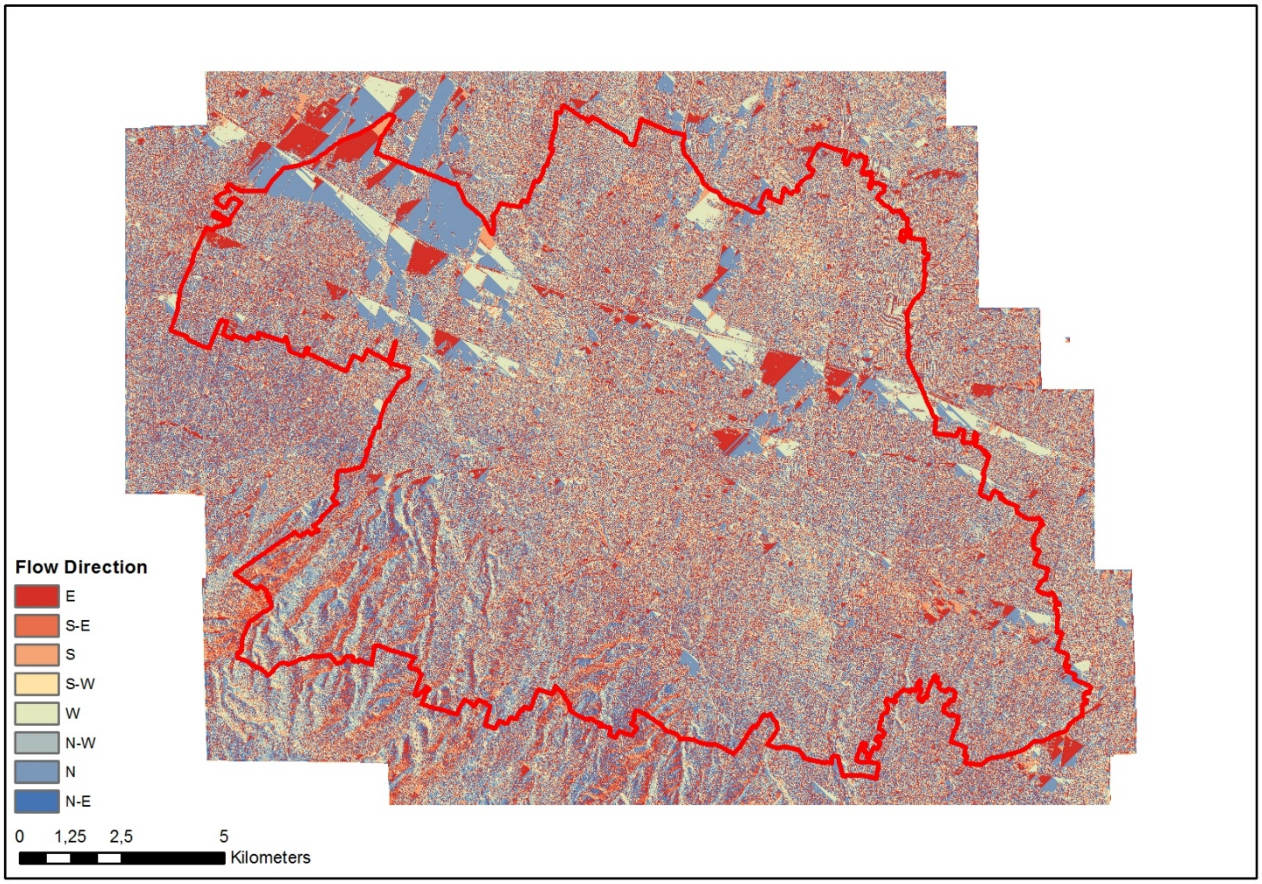
8=S-W; 16=W;

32=N-W;

64=N

128=N-E

Figure 4-8: Flow Direction


Flow Direction
E
S-E
S
S-W
W
N-W
N
N-E
0 1,25 2,5 5
Kilometers

4.1.3.5 Flow accumulation

Flow direction for Reggio Emilia highlights the hierarchy of the flow streams, classifying them by the dimension of the area they drain. The classes in the layer are:

1= Stream with drainage area smaller the 0,025 Km^2

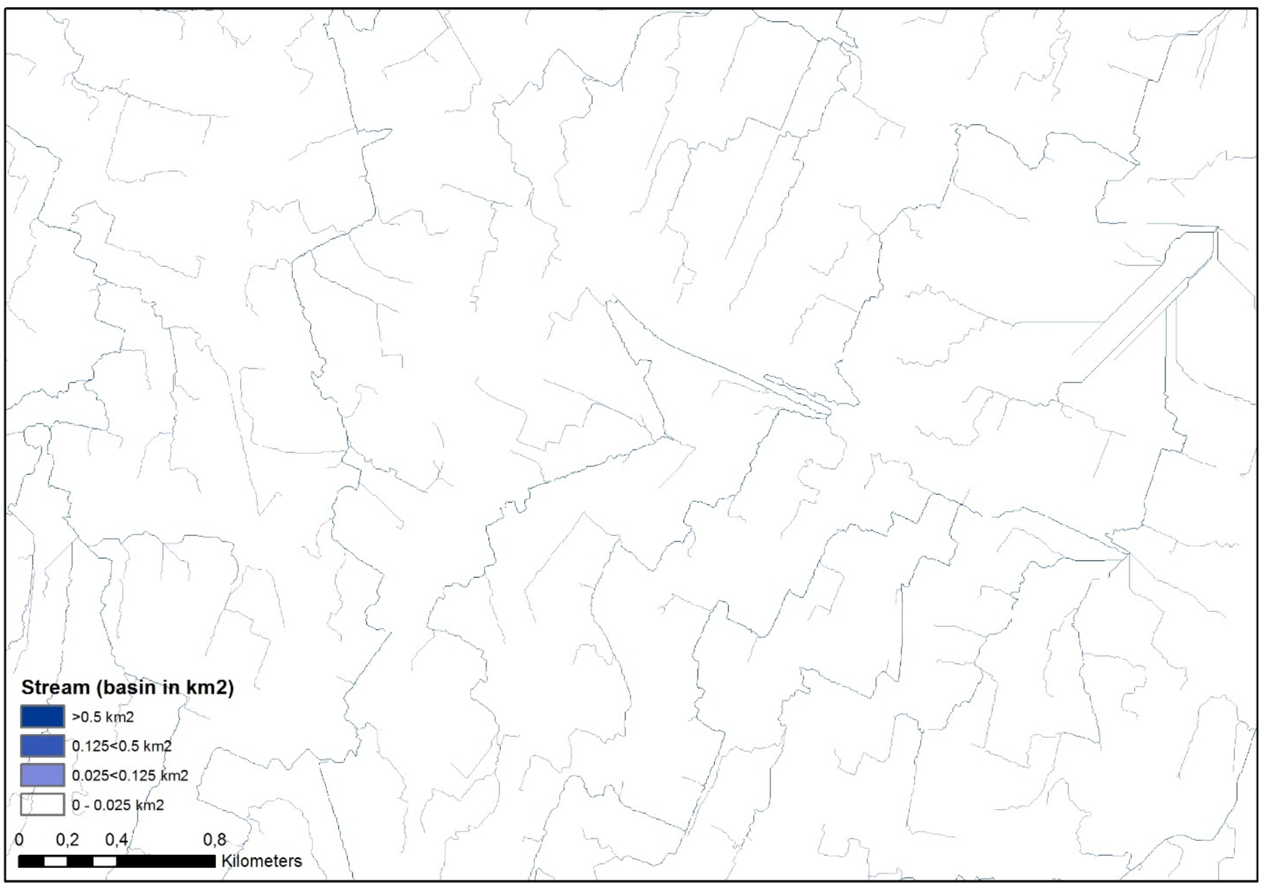
2= Stream with drainage area between 0,025 Km^2 and 0,125 Km^2

3= Stream with drainage area between 0,125 Km^2 and 0,5 Km^2

4= Stream with drainage area bigger than 0,5 Km^2

Deliverable – Layer name: **Re_Flow_Accumulation**

Figure 4-9: Flow Accumulation



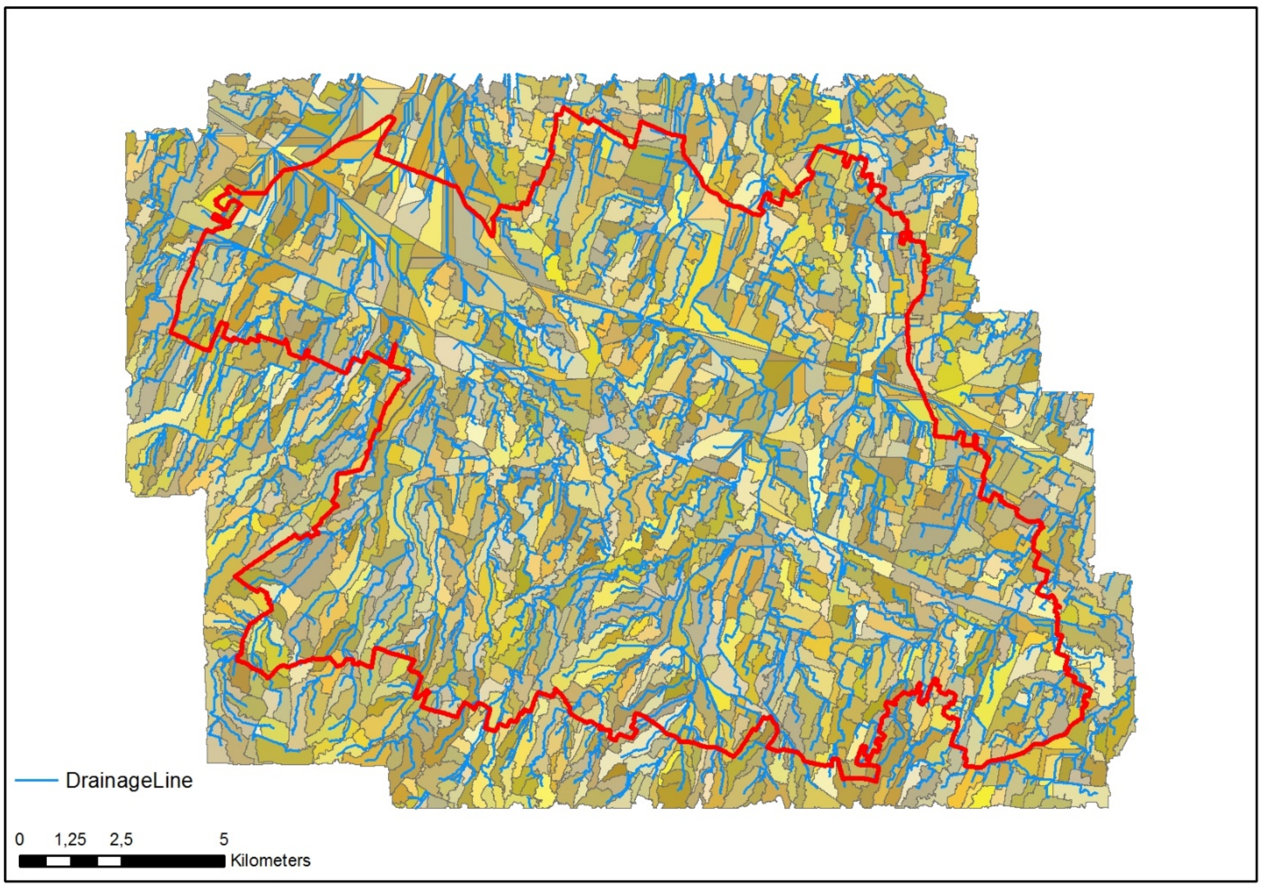
4.1.3.6 Urban Streams and Sub-catchments

Data, derived from the DTM model. It divides the territory in subcatchments following the morphological profile, and defines the path of the drainage streams. Streams are tracked once they drain a minimum of 0,125km².

Storm-water flow for Reggio Emilia municipality, derived from the DTM model, has been calculated through GIS processes. Then the territory has been divided in sub-catchments following the morphological profile, and defined the path of the drainage streams. Streams are tracked once they drain a minimum of 0,125km².

Deliverable – Layer name: **Re_Stream** and **Re_Subcatchment**

Figure 4-10: Streams and Subcatchments

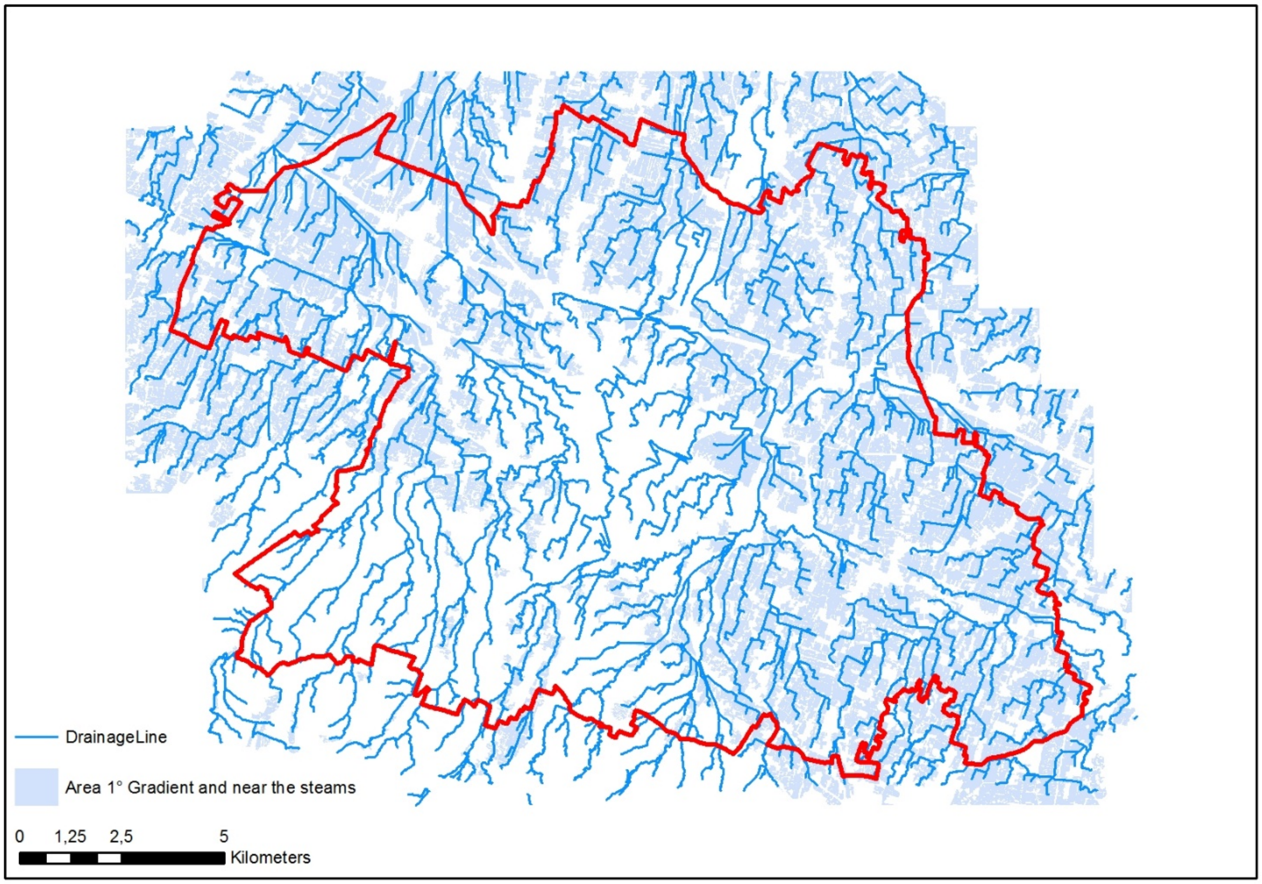


4.1.3.7 Low-lying areas next to water flow

Once the path of urban streams is defined, it is interesting to highlight the areas that are crossed by the streams and that have a gradient lower than 1°. This layer represents the areas that are most likely to host the expansion of water when the streams intensify their flow (e.g. an extreme precipitation event). So the dataset of this layer is made of horizontal areas (<1°), connected to urban streams that drain areas bigger than 0,125km².

Deliverable – Layer name: **Re_Lowandnear**

Figure 4-11: Low-lying areas next to water flow



4.1.3.8 Pervious sub-catchments

Based on hydrographic sub-catchments and impervious surfaces defined in previous steps, the goal of this analysis is to identify the most impervious sub-catchments. Data shows in percentage the amount of permeable surfaces in each basin. The catchments with more intense color have a greater amount of permeable areas.

Deliverable – Layer name: **Re_perc**

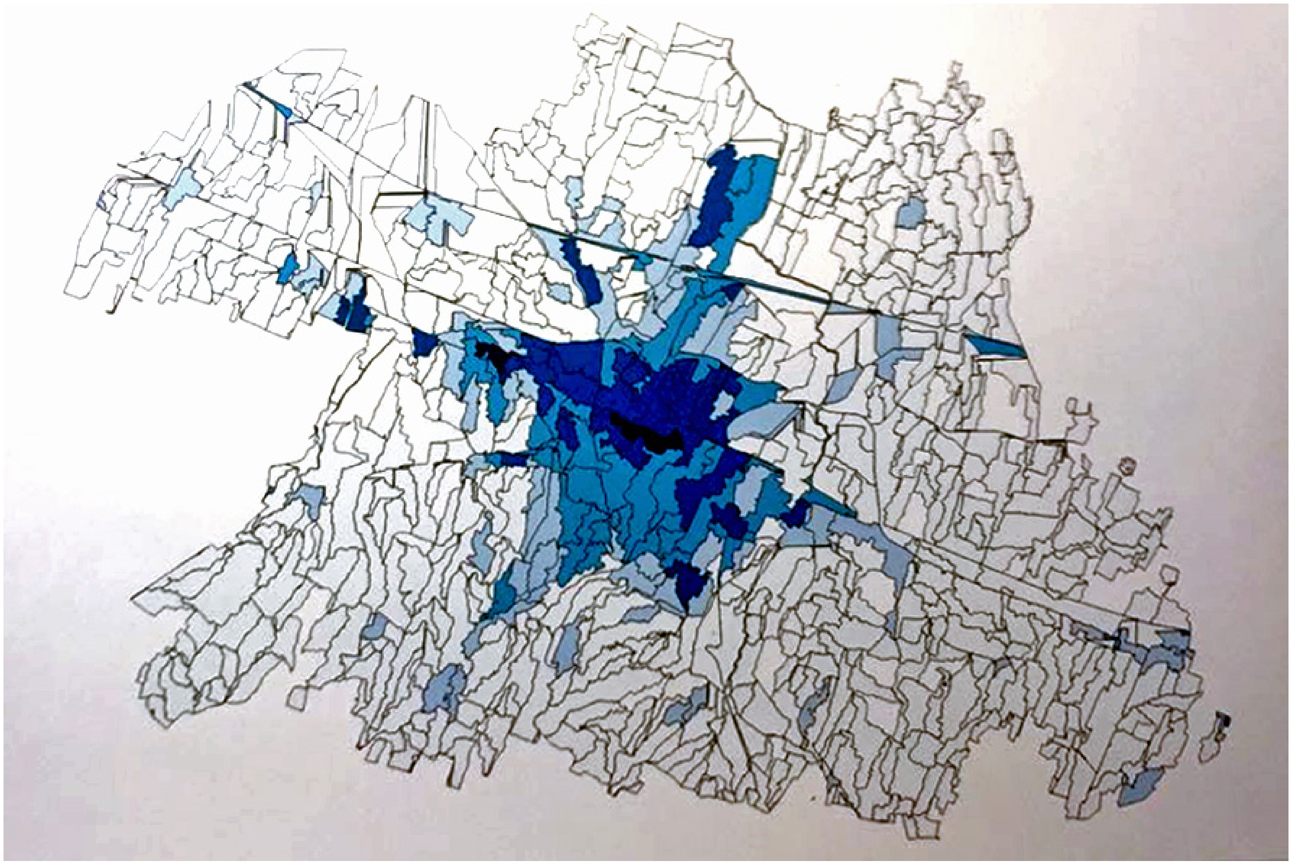


Figure 4-12:Pervious Sub-catchment

4.2 Heat-related Data Collect

The heat-related data collection has the aim to investigate the natural and urban surface. The resulting layers can serve as inputs for activity C.4.2: High temperatures and energy demand.

4.2.1 Input Data

To carry-out the analysis, it has been widely used open-data retrieved from online resources such as:

- Aerial photography obtained by UAV (unmanned aerial vehicle)
- DSM model from Lidar survey
- Building, Roadways, Idrography, Land Use information from Emilia-Romagna regional Geoportal

4.2.2 Method

Firstly, through the proceedings of the digital terrain model it has been isolated the urban surface to highlight the elements above the surface, where the barriers are and how the built environment it's composed.

Then, of this urban structure it has been highlighted the urban canyons through the sky view factor index.

Also urban green surfaces have been mapped.

4.2.3 Results

4.2.3.1 Building's Shape

This deliverable is based on the…

Deliverable – Layer name: **Re_buildings**

Figure 4-12: Building's Shape

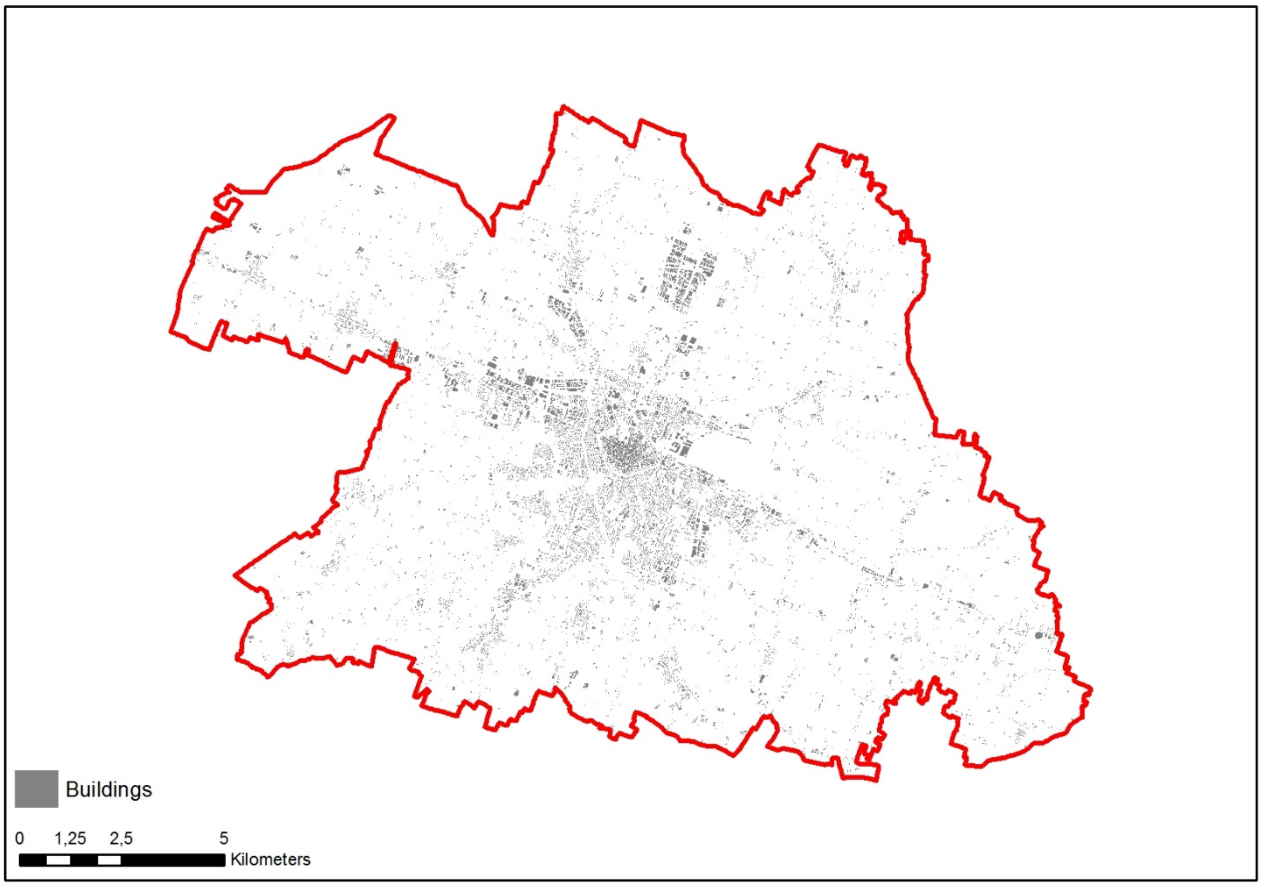


Figure 4-13: Building's Shape (neighborhood scale))

4.2.3.2 Sky-View Factor

The calculation of visible sky, sky view factor (SVF), is based on the normalized urban structure and has been processed through GIS tools. This index represents the extent of sky observed from a point as a proportion of the total possible sky hemisphere. This index varies between 0 and 1, respectively closed and full open, and it is useful to understand which urban morphology is more inclined to store heat during the day and night.

Deliverable – Layer name: **Re_svf**

Figure 4-14 Sky View Factor

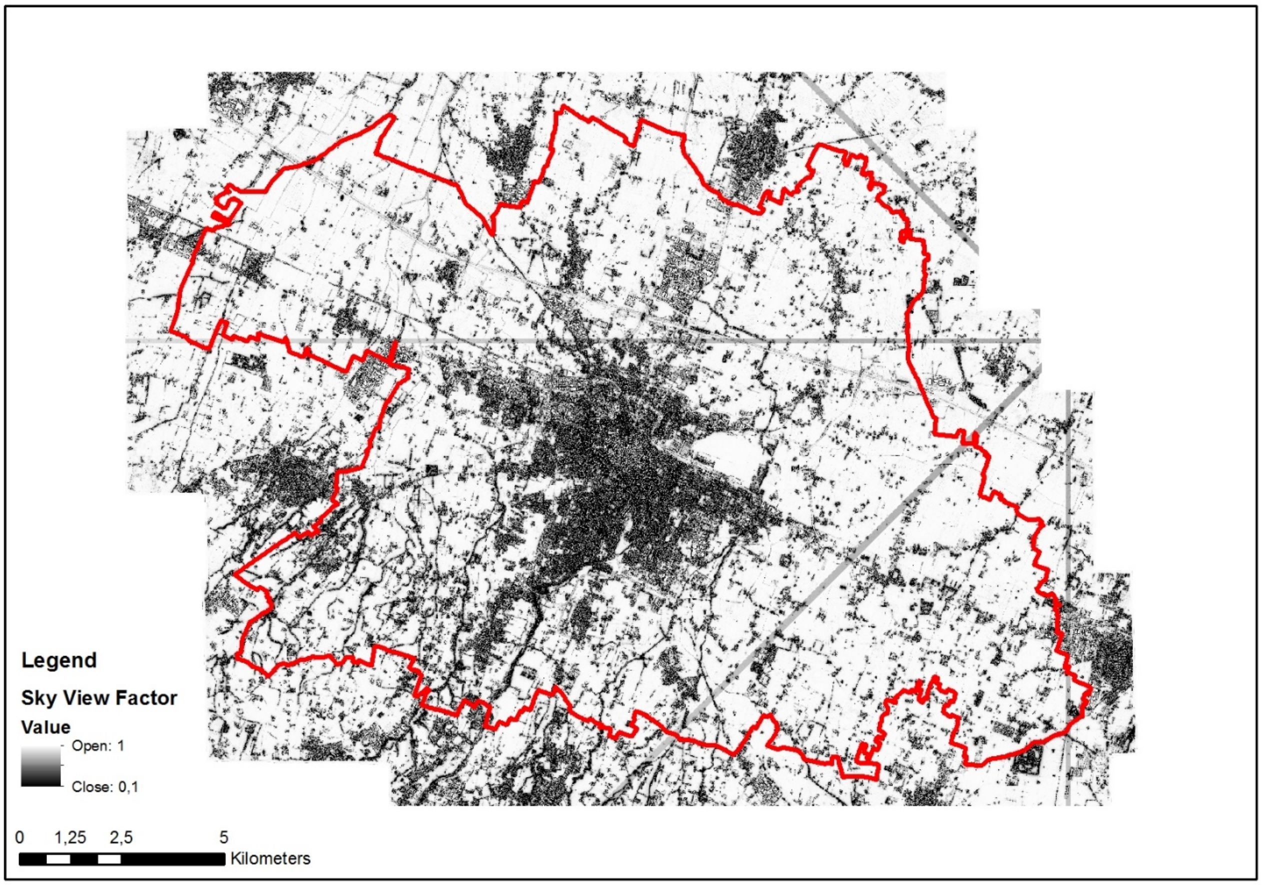
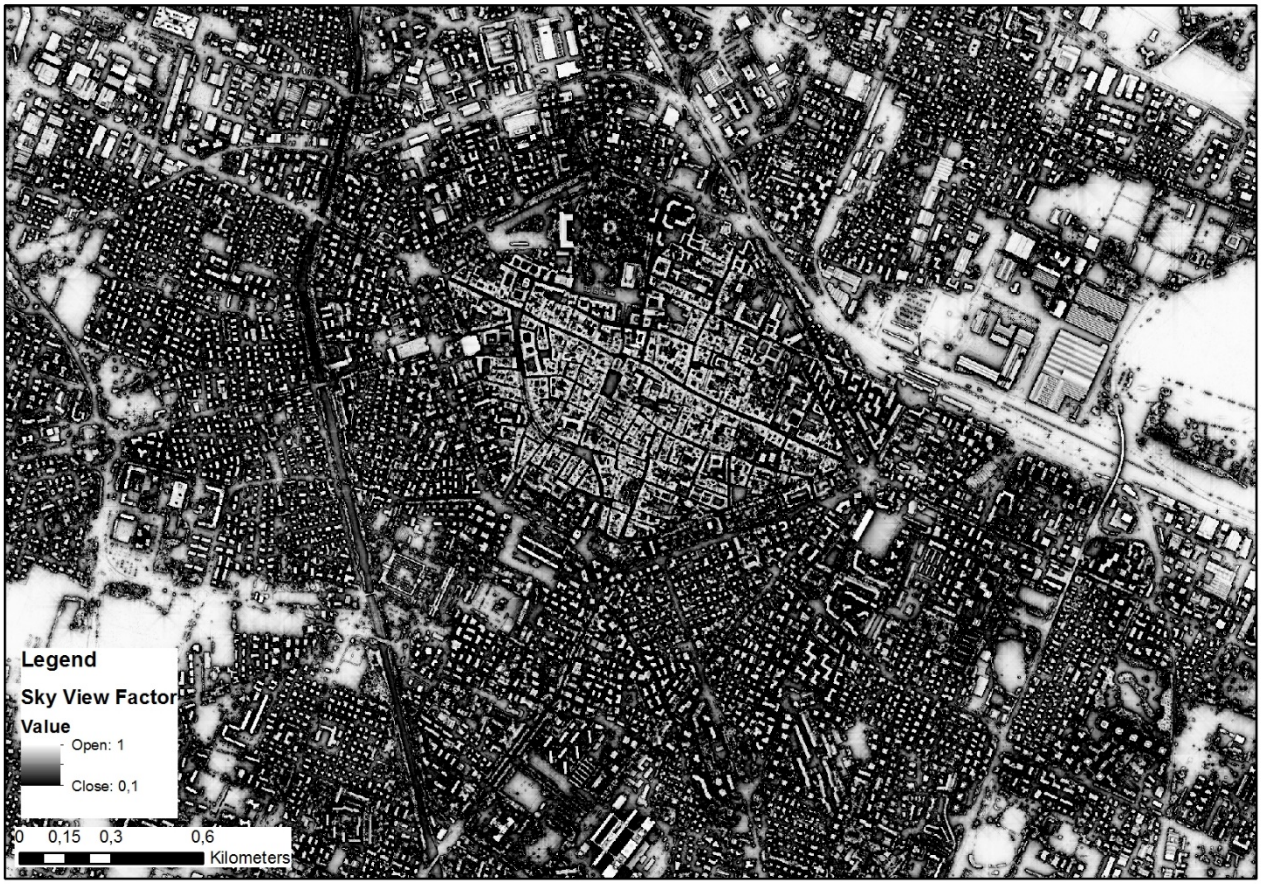


Figure 4-15 Sky View Factor - Detail



4.2.3.3 Urban Green Location

This layer represents all the permeable surface classified through different processes. In order to recognize the existing land cover at a local scale, we set four different classes: permeable, impermeable, buildings and roadways. Permeable class includes plant communities, green ground cover, cultivable surfaces, green surfaces for private and public property.

For the Reggio Emilia municipal area, crossing information between NDVI index and known cartographic base it is possible to discern green from the non-green areas. All green surfaces can be assumed to be permeable

Deliverable – Layer name: **Re_perm**