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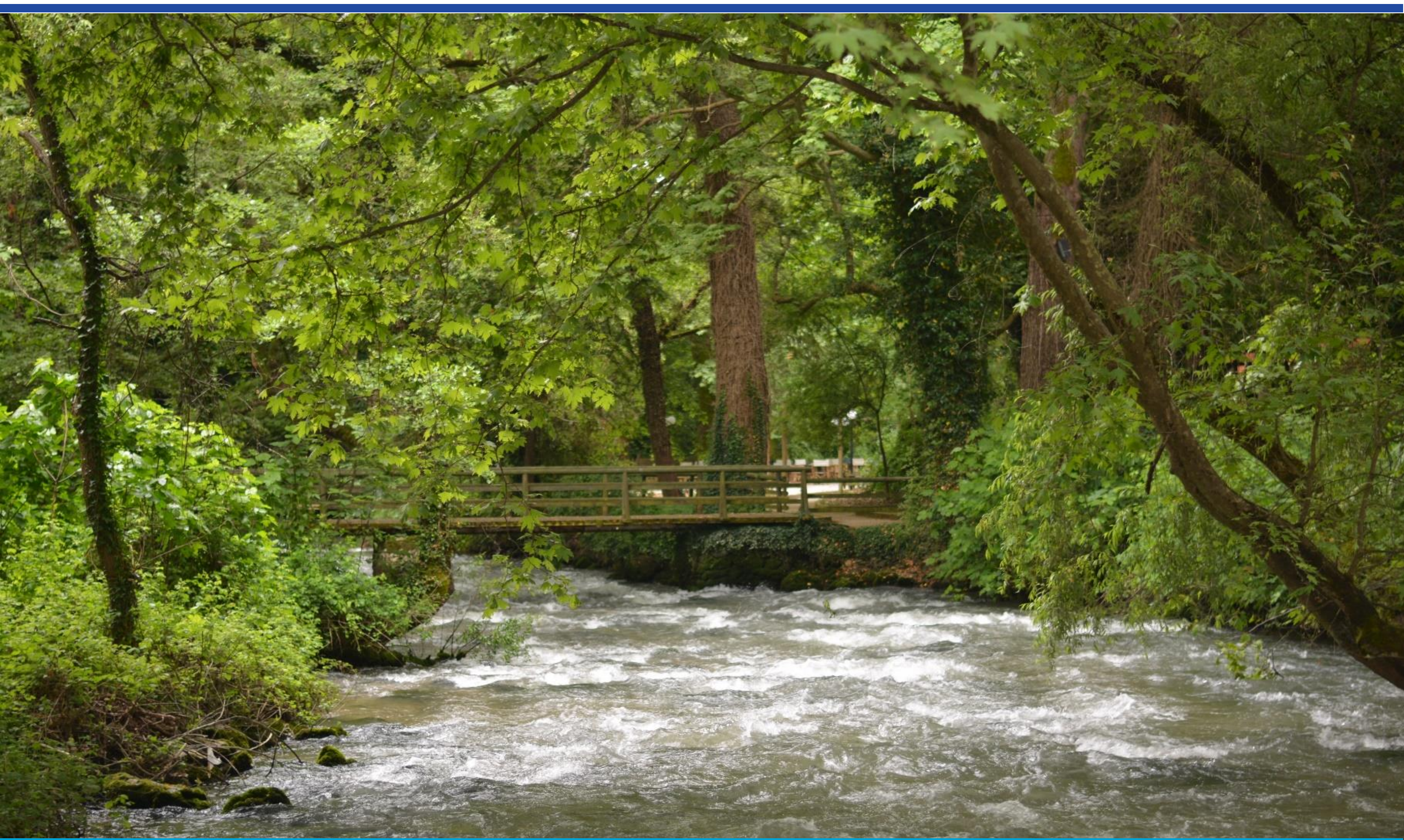

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PILOT AREAS REPORT

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Pilot Areas Report

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1. Aggitis-Drama Basin - GREECE

1.1. Geographical Characteristics - Administrative Division

The Aggitis-Drama basin is located between the latitude of 40°53'42.64"N, 41°14'48.02"N, 41°14'56.15"N, 40°56'46.76"N and the longitude of 23°48'41.80"E, 23°50'53.43"E, 24°27'49.83"E, 24°22'11.28"E (Figure 1.1). The basin has a perimeter of 243 km and an area of 2384 km2. Along with the sub-basin of K. Nevrokopi occupy an area of 2707 km^2. The sub-basin of K. Nevrokopi is a plateau north of Mount Menoikio and extends up to the border area with Bulgaria. The sub-basin of K. Nevrokopi drainages the water through karst sinkholes and creates an underground caved river which is visible at the Cave of Maara or Aggitis Cave and forms the homonym Aggitis River. The main basin of Aggitis-Drama is surrounded at east by the Mountains of Megalovouni, Lekani and the hill range of Kavala, at the south lies the Mountain Pangaio, west is the Menoikio Mountain and at north the Mount Falakro. The Aggitis-Drama basin administratively occupies the largest part of the Prefecture of Drama (Municipalities of Prosotsani, Doxato, Paranesti and Drama), a small part of the Prefecture of Kavala which is an area occupied by the Municipalities of Pangaio and Kavala; and finally a small part of the Prefecture of Serres which belongs to the administrative Municipalities of Amfipolis, Nea Zichni and Emmanouil Pappas (Figure 1.2).

Figure 1.1. The pilot area (pinned in yellow circle) located in North Greece.

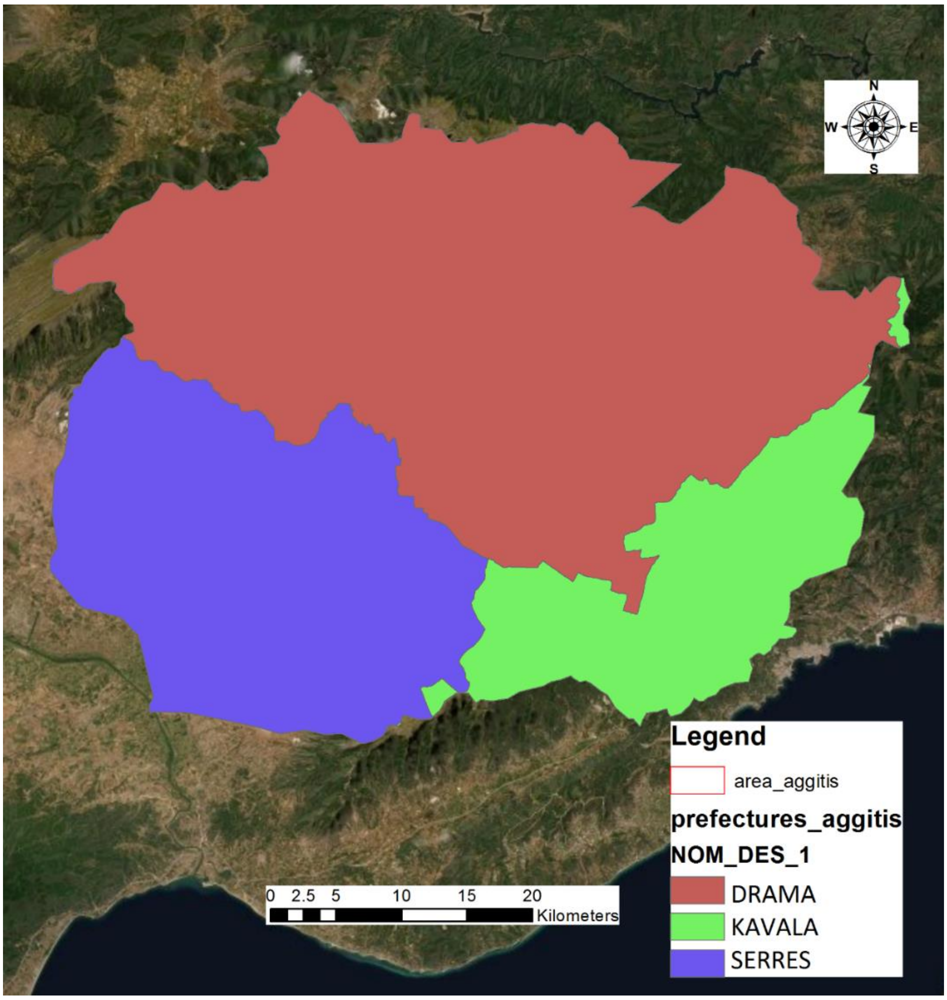

Figure 1.2. The prefectures of the pilot area: Drama (red), Kavala (green) and Serres (blue).

1.2. Towns - History - Population

The wider area of the basin is associated with human presence since the Paleolithic era. The first people to appear in the prefecture of Drama are nomadic hunters during the Middle Paleolithic Age (about 50,000 years from today) in the Upper Pleistocene and live in caves and rock roofs shelters. Since the mid-6th BC millennium (Neolithic period) the inhabitants of the area organize the first permanent residences - facilities next to water sources and in soils suitable for crops and livestock either in the plain of Drama or in low mountain ranges around it. The most important Neolithic settlements, among others, are those of Arkadikos (Drama) and Sitagroi. At the beginning of the 3rd BC Millennium (Bronze Age), life continues in Neolithic settlements while new types of settlements are created while cultural, social and economic changes are observed. There are findings of the processing of metals and the inhabitants produce copper and tin alloys. Populations are in a movement and trade is growing. The settlements of the Iron Age (1050-700 BC) continue as those of the Late Bronze Age. New settlements appear both in the lowlands and in mountain fortresses-acropolis. The excavation research so far has not yet reveal the life and character of the ancient settlements during the Archaic and Classical times. From the middle of the 4th BC and after the accession of the region to the Kingdom of Macedonia by Philip II (356 BC), the region flourished again under the influence of the settlements Philippoi and Amphipolis. The Worship of Bacchus - Dionysus stood out throughout ancient Thrace and Macedonia. The research has not progressed yet concerning the Hellenistic period. In Roman times, immediately after the famous battle of Philippi in 42 BC, Antonios organizes the installation of veteran soldiers of the 28th legion. The most important colonization, however, takes place from Octavian Augustus in 30 BC. Rewarding veterans, he grants them land in the prefecture of Drama. In Roman times, new highways were created and old ones were repaired, usually following natural passages. The largest highway, the Egnatia Odos (Via Egnatia) at the end of the 2nd BC, is a work of the Roman viceroy Gnaeus Egnatius that connected Rome with Byzantium (Constantinople), also passed through the pilot area. For the early Christian period (Byzantine times) the information drawn from the archaeological finds are few but valuable. Only a remarkable monument has survived from this Byzantine period, Agios Panteleimon a building of the Palaeologan era, at a distance of about 2.5 km west of Prosotsani. The Ottoman period in the region for almost 5 1/2 centuries (1383-1912) ensures, at least in theory, a stable power, putting an end to the frequent regime changes of the previous period. The movement of Christians to the mountains, due to colonization by Muslims, changes the population data, as the Orthodox element continues to shrink until the middle of the 16th century. Substantial change in the area is marked by the development of tobacco cultivation, gradually from the 1840s and rapidly in the late 19th century. This product will seal the entire recent history of the area. From the beginning of the 20th century. The Macedonian Struggle (1893–1908) is shocking in the north of the city, where the locals of Greek conscience are fighting hard with many victims. The region experienced its first Bulgarian occupation in October 1912, during the First Balkan War. The German invasion in Greece from the Bulgarian territory took place on April 6th 1941 and in the same month, the region passes to the administrative and military control of the Bulgarian authorities who try until the liberation of 1944 to systematically change the composition and consciousness of the population. After the World War II, the contraction of the rural economy was due to the wave of immigration since the 1960s. After the political changes in Eastern Europe and the improvement of the relations between the Balkan states, at the end of the 20th century, the population of the area aspires to participate in the great economic changes although it was badly hearted and affected by the economic crisis since 2009 and lately by the pandemic Covid-19. Figure 1.3 depicts the towns of the pilot area while Table

1.1 records the towns in Greek and English names, former and current Municipality, elevation and de facto population of 2011.

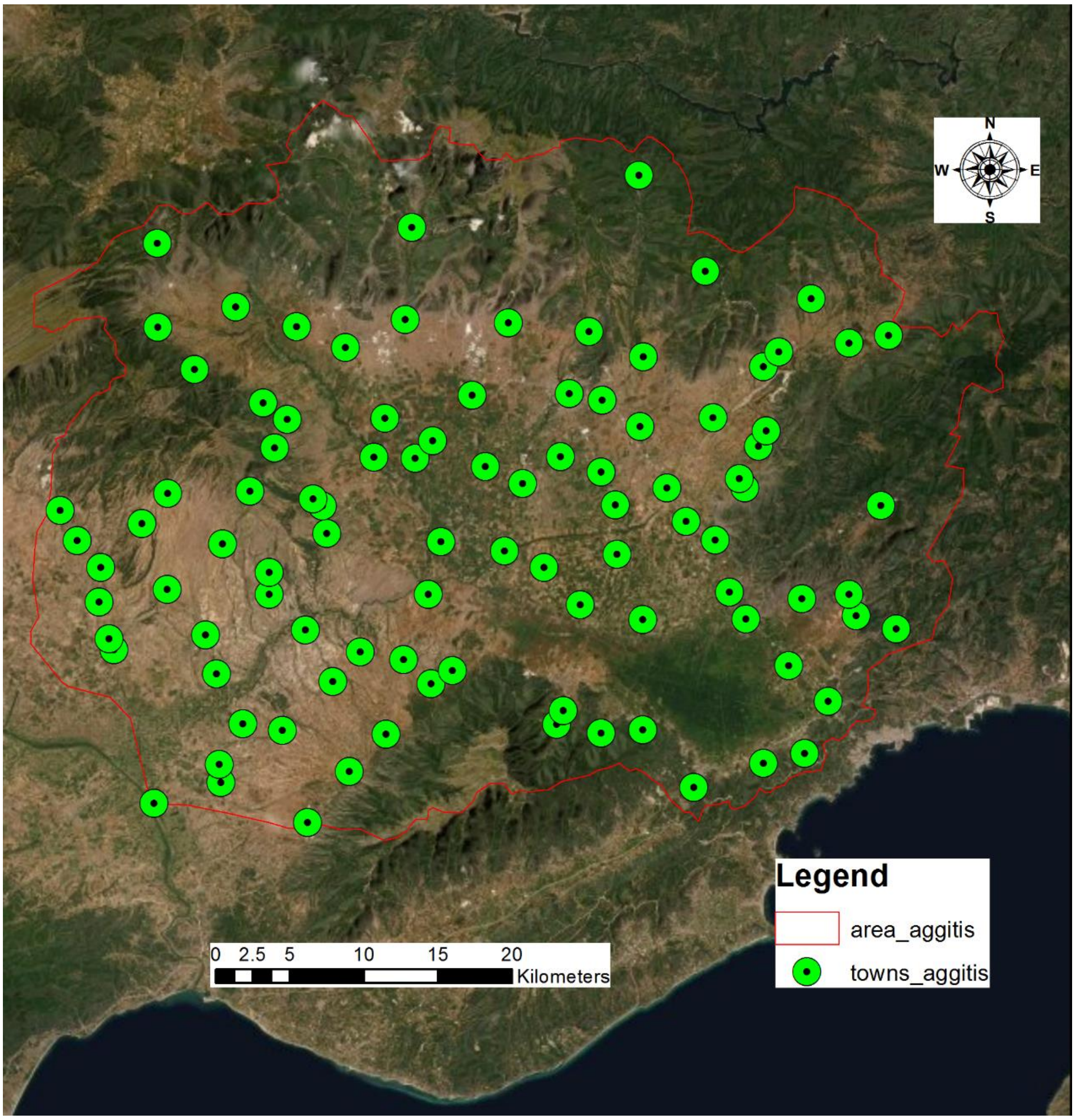

Figure 1.3. The towns of the pilot area.

Table 1.1. The towns of the pilot area including their names both in Greek and English, former and current Municipality, elevation and de facto population of 2011.

ID	GREEK NAME	ENGLISH NAME	FORMER MUNICIPALITIES (KAPODISTRIAS)	MUNICIPALITIES (KALLICRATES & KLEISTHENIS)	ELEVATION (meters)	POPULATION (de facto 2011)
1	Ροδολίβος	Rodolivos	Rodolivos	Amfipolis	344	2074

2	Δόμηρος	Domiros	Rodolivos	Amfipolis	220	155
3	Μικρό Σούλι	Mikro Souli	Rodolivos	Amfipolis	300	382
4	Πρώτη	Proti	Proti	Amfipolis	310	1204
5	Αγγίστα	Aggista	Proti	Amfipolis	170	293
6	Κρηνίδα	Krinida	Proti	Amfipolis	151	598
7	Κορμίστα	Kormista	Kormista	Amfipolis	400	589
8	Ηλιοκώμη	Iliokomi	Kormista	Amfipolis	250	338
9	Νέα Μπάφρα	Nea Bafra	Kormista	Amfipolis	210	716
10	Συμβολή	Simvoli	Kormista	Amfipolis	60	280
11	Δαφνούδι	Dafnoudi	Emmanouil Pappas	Emmanouil Pappas	157	432
12	Μέταλλα	Metalla	Emmanouil Pappas	Emmanouil Pappas	261	126
13	Μύρκινος	Myrkinos	Neas Zichni	Neas Zichni	10	198
14	Μαυρόλοφος	Mavrolofos	Neas Zichni	Neas Zichni	80	652
15	Δραβήσκος	Draviskos	Neas Zichni	Neas Zichni	90	1549
16	Μυρρίνη	Myrrini	Neas Zichni	Neas Zichni	90	233
17	Δήμητρα	Dimitra	Neas Zichni	Neas Zichni	90	373
18	Μεσορράχη	Mesorrachi	Neas Zichni	Neas Zichni	160	404
19	Νέα Ζίχνη	Nea Zichni	Neas Zichni	Neas Zichni	260	2499
20	Νέα Πέτρα	Nea Petra	Neas Zichni	Neas Zichni	65	280
21	Θολός	Tholos	Neas Zichni	Neas Zichni	70	782
22	Γάζωρος	Gazoros	Neas Zichni	Neas Zichni	62	1303
23	Άγιος Χριστόφορος	Agios Christoforos	Neas Zichni	Neas Zichni	150	215
24	Αναστασιά	Anastasia	Neas Zichni	Neas Zichni	450	257
25	Αγριανή	Agriani	Neas Zichni	Neas Zichni	620	295
26	Σφελινός	Sfelinos	Neas Zichni	Neas Zichni	430	303
27	Σκοπιά	Skopia	Alistratis	Neas Zichni	708	108

28	Σταθμός Αγγίστας	Stathmos Aggistas	Alistratis	Neas Zichni	36	169
29	Σταθμός Λευκοθέας	Stathmos Lefkotheas	Alistratis	Neas Zichni	30	296
30	Μανδήλι	Mandili	Alistrati	Neas Zichni	300	106
31	Αλιστράτη	Alistrati	Alistrati	Neas Zichni	283	2131
32	Αγιοχώρι	Agiochori	Alistrati	Neas Zichni	220	302
33	Περίχωρα	Perichora	Sitagroi	Prosotsani	190	186
34	Μεγαλόκαμπος	Megalokampos	Sitagroi	Prosotsani	73	311
35	Μικρόκαμπος	Mikrokampos	Sitagroi	Prosotsani	95	247
36	Σιταγροί	Sitagroi	Sitagroi	Prosotsani	75	770
37	Αργυρούπολη	Argyroupoli	Sitagroi	Prosotsani	97	663
38	Φωτολίβος	Fotolivos	Sitagroi	Prosotsani	63	1497
39	Μαυρολεύκη	Mavrolefki	Sitagroi	Prosotsani	59	419
40	Καλλιθέα	Kallithea	Prosotsani	Prosotsani	480	380
41	Ανθοχώρι	Anthochori	Prosotsani	Prosotsani	150	133
42	Καλή Βρύση	Kali Vrisi	Prosotsani	Prosotsani	278	722
43	Χαριτωμένη	Charitomeni	Prosotsani	Prosotsani	307	299
44	Μικρόπολη	Mikropoli	Prosotsani	Prosotsani	354	848
45	Πανόραμα	Panorama	Prosotsani	Prosotsani	560	42
46	Γραμμένη	Grammeni	Prosotsani	Prosotsani	120	320
47	Κοκκινόγεια	kokkinogia	Prosotsani	Prosotsani	143	548
48	Προσοτσάνη	Prosotsani	Prosotsani	Prosotsani	130	3520
49	Πετρούσσα	Petroussa	Prosotsani	Prosotsani	270	1732
50	Πύργοι	Pyrgoi	Prosotsani	Prosotsani	628	327
51	Καλός Αγρός	Kalos Agros	Drama	Drama	73	1203
52	Κουδούνια	Koudounia	Drama	Drama	68	995
53	Μαυρόβατος	Mavrovatos	Drama	Drama	80	734
54	Μικροχώρι	Mikrochori	Drama	Drama	83	631

55	Μυλοπόταμος	Mylopotamos	Drama	Drama	99	721
56	Ξηροπόταμος	Xiropotamos	Drama	Drama	255	2727
57	Μοναστηράκι	Monastiraki	Drama	Drama	330	881
58	Δράμα	Drama	Drama	Drama	110	45517
59	Καλλίφυτος	Kallifytos	Drama	Drama	206	1593
60	Χωριστή	Choristi	Drama	Drama	114	2717
61	Λιβαδερό	Livadero	Drama	Drama	626	18
62	Μακρυπλάγιο	Makryplagio	Drama	Drama	736	50
63	Νικοτσαράς	Nikotsaras	Drama	Drama	80	377
64	Αδριανή	Adriani	Nikiforos	Paranesti	162	1125
65	Νικηφόρος	Nikiforos	Nikiforos	Paranesti	246	311
66	Άνω Πυξαρίου	Ano Pyxariou	Nikiforos	Paranesti	277	144
67	Υψηλή Ράχη	Ypsili Rachi	Nikiforos	Paranesti	437	218
68	Πλατανόβρυση	Platanovrysi	Nikiforos	Paranesti	307	237
69	Πλατανιά	Platania	Nikiforos	Paranesti	338	633
70	Αγορά	Agora	Doxato	Doxato	251	128
71	Πηγάδια	Pigadia	Doxato	Doxato	211	177
72	Κύρια	Kyria	Doxato	Doxato	152	1713
73	Βαθύσπηλο	Bathyspilo	Doxato	Doxato	170	243
74	Δοξάτο	Doxato	Doxato	Doxato	100	2880
75	Άγιος Αθανάσιος	Agios Athanasios	Doxato	Doxato	90	3121
76	Κεφαλάρι	Kefalari	Doxato	Doxato	95	677
77	Φτελιά	Ftelia	Kalampaki	Doxato	78	906
78	Καλαμπάκι	Kalampaki	Kalampaki	Doxato	60	3087
79	Καλαμών	Kalamon	Kalampaki	Doxato	66	588
80	Αγία Παρασκευή	Agia Paraskeyi	Kalampaki	Doxato	58	447
81	Νεροφράκτης	Nerofraktis	Kalampaki	Doxato	60	578

82	Νικήσιανη	Nikisiani	Pangaiou	Pangaiou	350	2227
83	Γεωργιανή	Georgiani	Pangaiou	Pangaiou	250	619
84	Παλαιοχώρι	Paleochori	Pangaiou	Pangaiou	225	1372
85	Αντιφίλιπποι	Antifilippoi	Eleutheroupoli	Pangaiou	120	865
86	Ελευθερούπολη	Eleytheroupoli	Eleutheroupoli	Pangaiou	65	5456
87	Κοκκινόχωμα	Kokkinochoma	Eleutheroupoli	Pangaiou	100	1476
88	Αμισιανά	Amisiana	Eleutheroupoli	Pangaiou	150	928
89	Αμυγδαλεώνας	Amigdaleonas	Filippoi	Kavalas	71	2712
90	Πολύστυλο	Polystilo	Filippoi	Kavalas	60	827
91	Κρηνίδες	Krinides	Filippoi	Kavalas	140	3356
92	Λυδία	Lydia	Filippoi	Kavalas	80	807
93	Φίλιπποι	Filippoi	Filippoi	Kavalas	78	889
94	Κρυονέρι	Kryoneri	Filippoi	Kavalas	240	690
95	Ζυγός	Zygos	Filippoi	Kavalas	250	2044
96	Παλαιά Καβάλα	Palaia Kavala	Filippoi	Kavalas	360	107
97	Λιμνιά	Limnia	Filippoi	Kavalas	720	204

1.3. Topography - Geomorphology

The terrain of the basin is depicted by the Digital Elevation Model (DEM) and is characterized flat to hilly containing also semi-mountainous and mountainous zones (Figure 1.4). The lowland areas occupy mainly the central part of the basin as well as its exit to the Strymon basin, in the SW part. The hilly areas follow the lowlands and are surrounded by semi-mountainous areas. The semi-mountainous areas are surrounded by areas characterized as mountainous. In general, there is a uniformity in the distribution of altitudes within the boundaries of the basin that naturally follows the main bed of the hydrographic network. The highest altitude observed in the basin of the river Aggitis is at the top of Profitis Elias of Mount Falakro with an altitude close to 2200m. The lowest altitude is observed, as expected, at the exit of the basin, at the junction of the Aggitis River with the Strymon River and is equal to 3m. The relief is also depicted by the hill shade map that depicts the hypothetical illumination of the surface as a result it can greatly enhance the visualization of a surface for analysis or graphical display (Figure 1.5).

An important parameter of the relief of an area, is the slope map (Figure 1.6). The slope of the relief is a parameter that can provide insight about the degree of erosion that takes place in the specific area. Slope values from 0° to 5°, indicate an embossed to slightly sloping relief for sheet erosion and the beginning of rill erosion. In areas that show such slope values, the construction of buildings is favored again, while their cultivation should be done perpendicular to the slope they show. Slopes from 5° to 15°, indicate a strongly sloping relief, where mass movements and high sheet and rill erosion take place. In the slopes of this order there are significant difficulties in the construction of infrastructure as well as in the cultivation of soils. Slopes from 15° to 35° represent a steep to extremely steep terrain where intense stripping processes, soil creeps, mudflows as well as intense rill or gully erosion are observed. There are minimal human constructions on these slopes. Slopes from 35° to 55°, show a steep relief where a thin discontinuous layer of soil appears and intense stripping of the parent rock. Finally, slopes greater than 55°, reveal a vertical relief, absence of soil, bare rocks and rock collapse. Furthermore, the aspect map was produced in order to visualize the slope direction (Figure 1.7). This can help in various ways, e.g. to find all north-facing slopes on a mountain as the best slopes for ski runs or all southerly slopes in a mountainous region to identify locations where the snow is likely to melt first and identify those residential locations likely to be hit by runoff first.

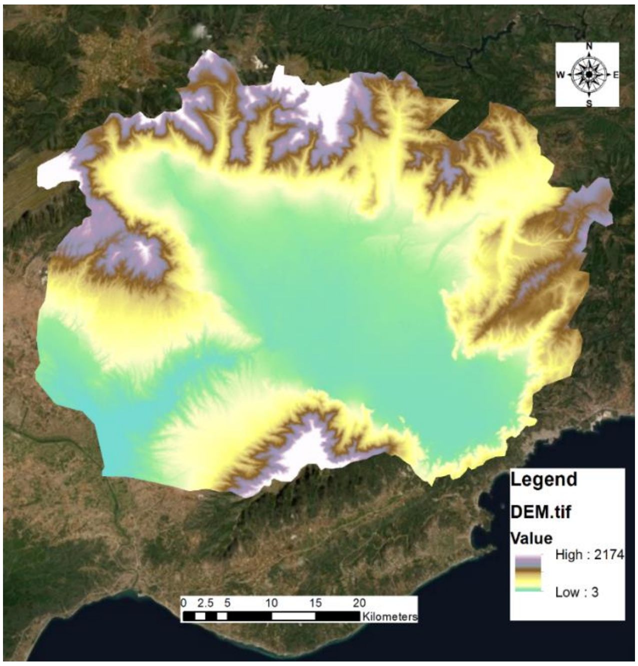

Figure 1.4. The digital elevation map (DEM) of the pilot area.

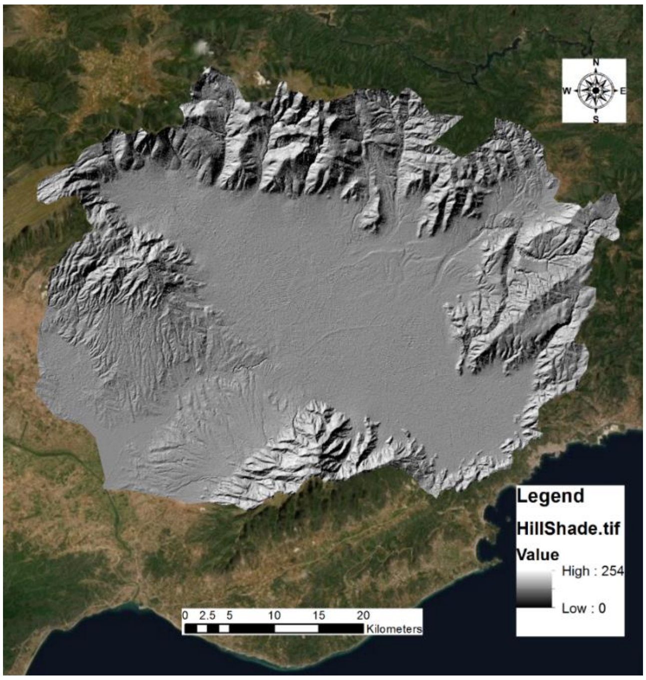

Figure 1.5. The hill shade / relief map of the pilot area.

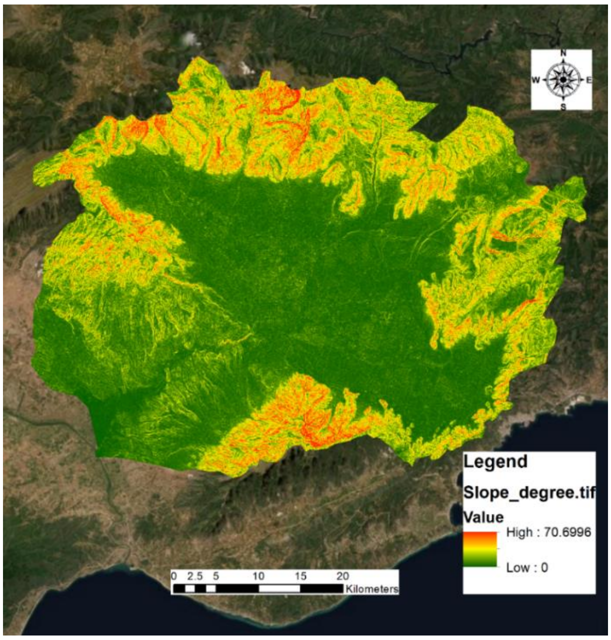

Figure 1.6. The slope map of the pilot area.

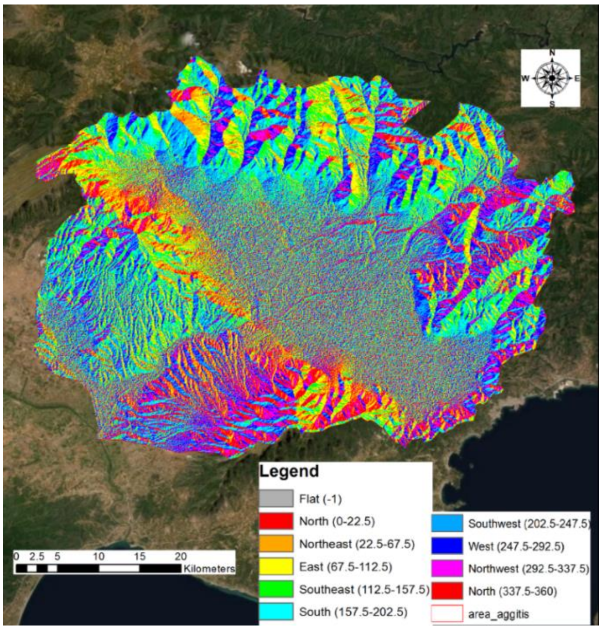

Figure 1.7. The aspect map of the pilot area.

1.4. Climate

There is a large altitude difference between the plains and the highest mountain peaks (Falakro Mountain peak is around 2,250 meters), which results in the creation of various climatic conditions with many different microclimates. The general climatic type for the Aggitis-Drama Basin has been determined as Mediterranean with a hot summer (Csa), based on the meteorological station in Drama (Data 1975-2001); a property of the Hellenic National Meteorological Service. This type resulted from the fact that the average rainfall of the driest month does not exceed 30 mm high (September, 22.50 mm high mean rainfall), while the average rainfall of the wettest month is at least three times that of the driest month (December, 56.60 mm). At the same time, the average temperature of the warmest month (July) is higher than 30 oC. The temperature in summer can reach up to 40 ° C while in winter it can drop to -15 ° C or even lower. The area receives high amount of precipitation (rainfall and snow) in winter. Thunderstorms are very common in the summer. Following the data from the meteorological station in Drama and specifically, the temperature (Figure 1.8), the rainfall (Figure 1.9), the relative humidity (Figure 1.10), wind direction (Figure 1.11) and wind velocity (Figure 1.12).

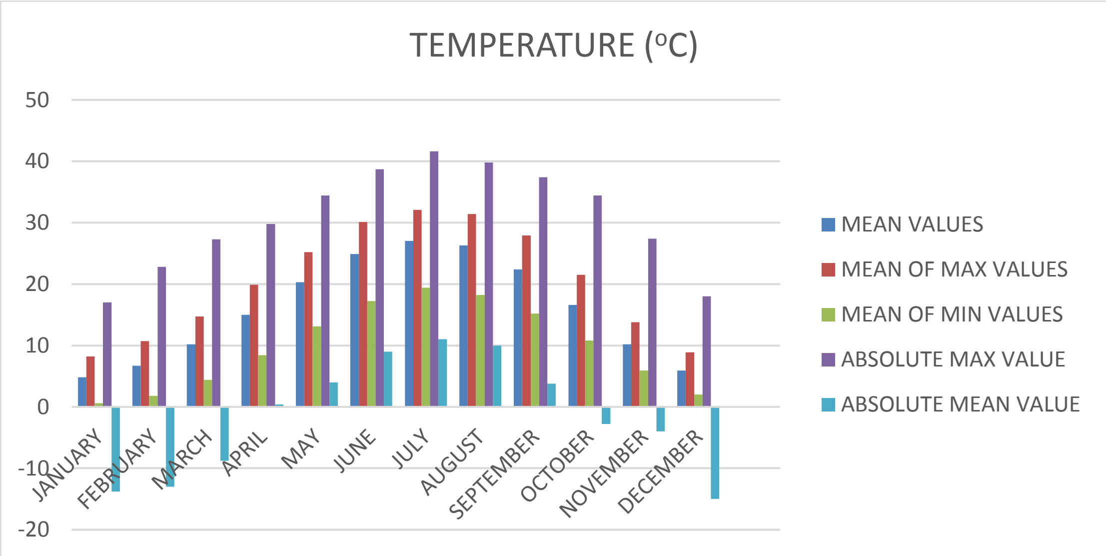

Figure 1.8. The temperature data per month recorded in Drama.

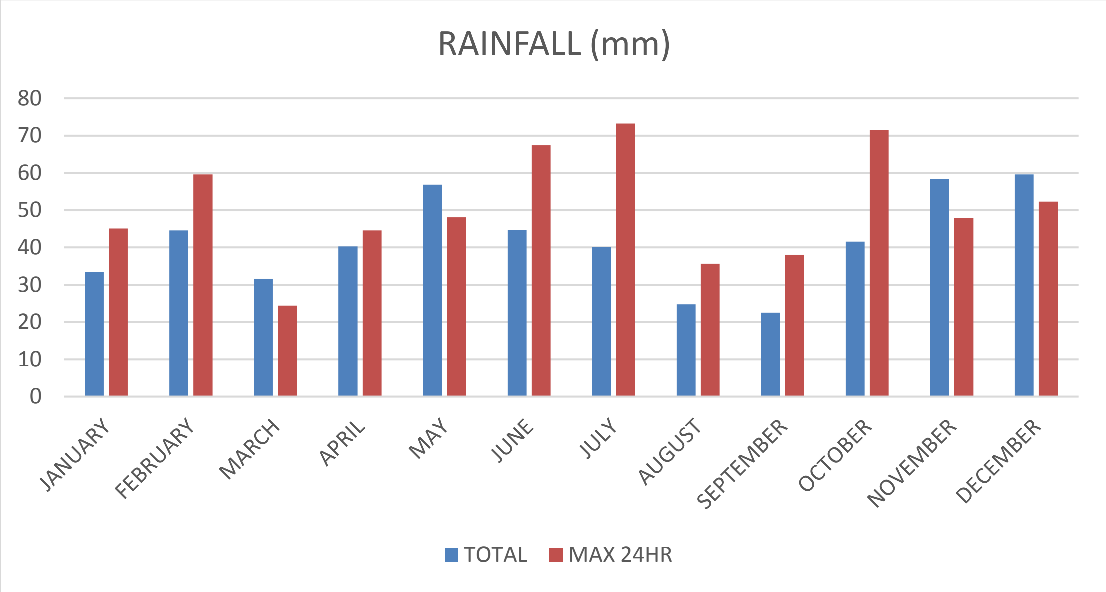

Figure 1.9. The rainfall data per month recorded in Drama.

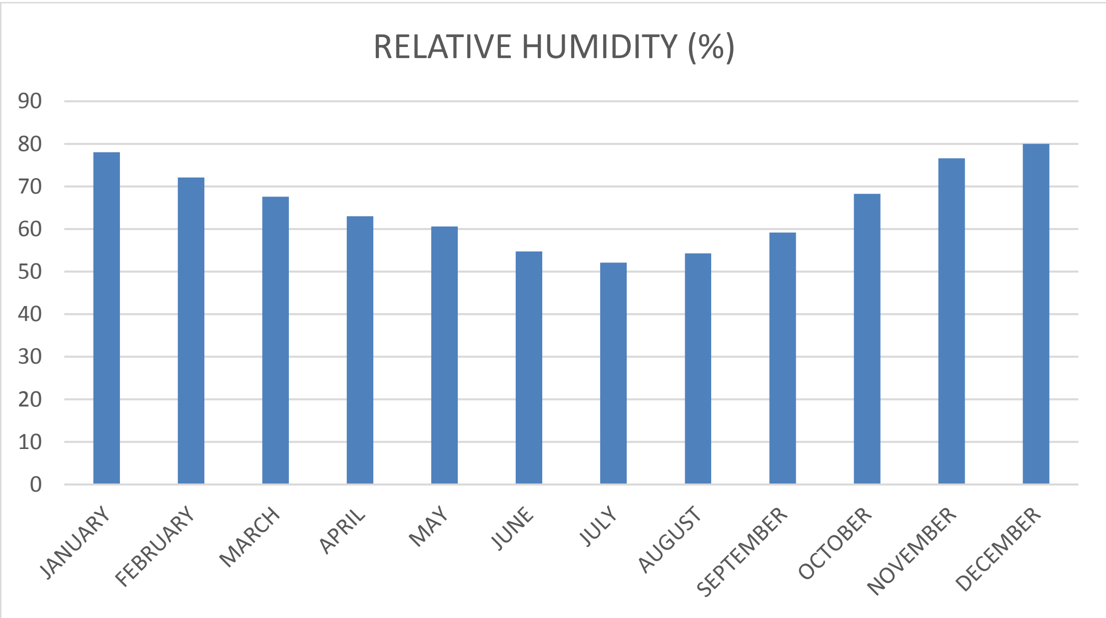

Figure 1.10. The relative humidity per month recorded in Drama.

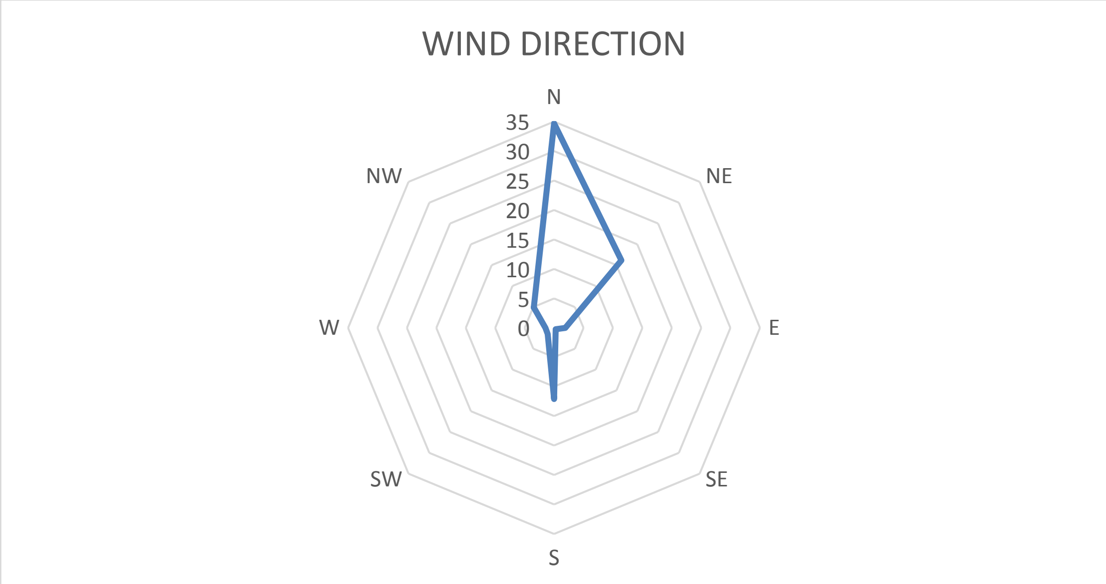

Figure 1.11. The dominant wind direction recorded in Drama.

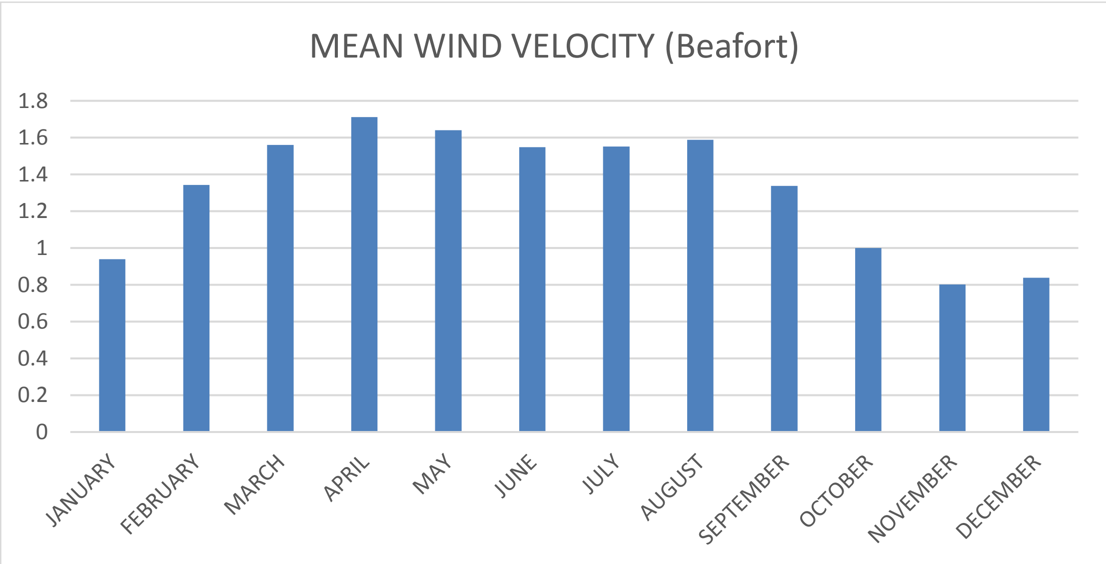

Figure 1.12. The mean wind velocity per month recorded in Drama.

1.5. Geology

Tenagi Philippon: A characteristic image for the plain of Drama is the large spread of the marshes formations, of the Holocene age. It is a surface peat spread (55 km^2) with interference of inorganic materials formed mainly by clay. This important part of the Aggitis-Drama basin is characterized as the Tenagi Philippon swampy area (Figure 1.13) occupying the south-eastern part of the basin, an area rich in organic matter but also peat. It is given to farmers for later cultivation from drainage of the swamp with the construction of the Great Drainage Channel that flows into the river Aggitis. Because of the elevation and the topography of the area with many drainage canals, many parts of the area are flooded during heavy rainfalls. The Tenagi Philippon is the area of the Aggitis-Drama basin in which the pre-eminent cultivation is the maize and secondarily fodder plants.

Figure 1.13. The Tenagi Philippon swampy area.

The wider area of the Aggitis-Drama basin is geologically located in the geotectonic zone of Rodopi mass which is characterized by a mountain zone of metamorphic rocks with minimal igneous penetrations. The pilot area is located in base gneisses that include Muscovites, gneisses, mica slates and amphibolite, mica gneisses, mica slates, marble series, marble series and slates series. Throughout the transformed system, plutonium bodies of granitic-granitic composition and sub-volcanic veins of andesitic-rhododendron composition have penetrated. The plutonites are mainly granites and granodiorites. Granodiorites are found in Falakro Mountain in the areas of Granitis, Panorama, Potamoi, as well as in the Pangaio Mountain. Granitic and granodiorite bodies of Oligocene age are found in the plain section of the basin. The hilly and semi-mountainous areas are composed exclusively of tertiary sediments which in their surface parts consist of cohesive cobblestones and sandstones and in depth of margarine materials. The plain part, which is a tectonic depression, has been filled with sediments of 370 m thickness. The surface (up to a depth of about 80 m) are the Quaternary sediments, characterized by alternating layers of clay, gravel, sand and sludge, which intertwine and sometimes show selective bands with permeable materials and sometimes not. In the deeper layers, clay materials and limestone sludge predominate and which are interrupted by lignite layers. The soils of the basin are classified as (Figure 1.14): a) Calcaric Fluvisol, b) Calcaric Leptosol, c) Calcaric Regosol, d) Chromic Luvisol, e) Dystric Cambisol, f) Dystric Leptosol, g) Eutric Cambisol, h) Eutric Histosol, i) Eutric Leptosol and k) Vertic Cambisol.

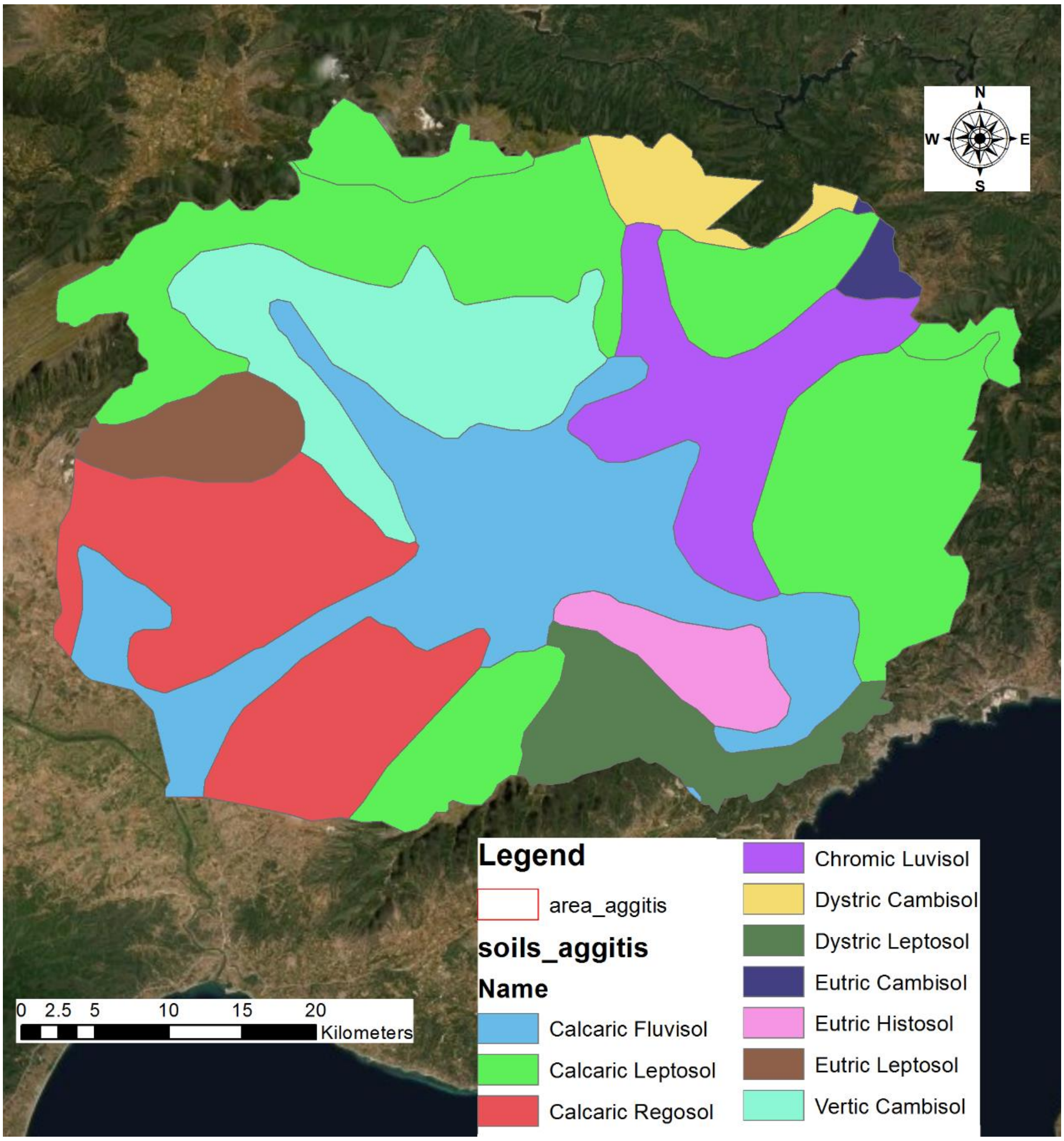

Figure 1.14. The soil map of the pilot area.

1.6. Hydrogeology – Caves

The groundwater systems included in the wider catchment area are associated with the surface waters are the following: GR110B030 (Falakro System) and GR1100050 (Drama System). Carbonate rocks, which form mountain massifs, grow beyond the boundaries of the hydrological basin of Drama, which prejudges possible transfusions of groundwater from the immediate vicinity of the wider area, such as the enclosed basin of Kato Nevrokopi and the basin of Nestos. Of particular importance for the karstic aquifer of Mount Falakro, is the aquifer of the Nevrokopi basin which supplies through sinks the water potential of the Aggitis-Drama basin and forms the Aggitis River. The marbles of the basin are one of the most important aquifers host huge amounts of groundwater. The groundwater of these aquifers in the carbonate formations, around the perimeter of the basin, is discharged on its curbs mountainous to the lowland zone, through a significant number of karst springs. Of particular importance for the karstic aquifer and especially of the Falakro Mountain, is the water supply of the Nevrokopi basin that plays an important role in its water potential basin of Aggitis-Drama. The aquifers in the quaternary deposits are hosted in the most granular formations (sands, etc.) and consist of alternating clays with sandstones and fine sands, in which a free well aquifer develops, which to the south it turns into superimposed aquifers under pressure. The aquifers in the central part of the plain consists of more fine-grained materials with clay layers. To the margins of the plain are observed more coarse materials, but also greater thickness sandy deposits. The contact of these formations in the upstream sections with the carbonates rocks creates favorable conditions for the enrichment of the underground aquifers through lateral transfusions. Worth mentioned are the qanats of the area; an ancient Persian system of water supply. A qanat or kariz is a gently sloping underground channel to transport water from an aquifer or water well to the surface for irrigation and drinking, acting as an underground aqueduct.

The springs of "Maara" is the origin of the Aggitis River, located next to the settlement Aggitis in Drama Prefecture and 25 km west of the city of Drama (Figure 1.15). The River Cave of Aggitis Springs (Maara) is described as a "Monument of Nature". It was discovered in 1978 by a team of French and Greek speleologists who explored it up to 4500 m. Its total length is considered to reach 21 km. Colorful and diverse stalactites and stalagmites coexist harmoniously with the groundwater of the river, adorn and compose rare representations of unprecedented beauty inside the cave. The temperature of the water is 13°C while the temperature of the cave is 17°C. The cave is inhabited by families of bats and transparent white fish. A biological study provided new evidence for the life of unique insects and bugs.

The cave of Alistrati is considered to be one of the largest and most beautiful ones in Greece and in Europe due to the rich stone decoration, which is distinguished for its beauty and the variety of cave deposits (Figure 1.16). The Hellenic Speleological Society was informed about its existence only in 1975 after Alistrati community sent relevant documentation. Its explored surface reaches 25.000 m^2 containing large cave chambers (e.g. width: 60 m., length: 100 m. and height: 20-30 m.) while there are also floors in the cave that are countless and not yet known. The cave temperatures are relatively high (15° -17°C) and maintained in winter while the relative humidity is also very high 95-105%. The cave has a fairly rich fauna of 36 species of microorganisms, such as Dolichopoda, Myriapoda and an unprecedented one named Alistratia Beron. Also seven species of bats, an endemic bug, a three-millimeter isopod, werewolves, two hummingbirds and a lepidoptera.

Figure 1.15. The Cave of Aggitis Springs (Maara).

Figure 1.16. The Alistrati Cave.

1.7. Protected Areas – Natura 2000 Network

The Natura 2000 is a network of protected areas covering Europe's most valuable and threatened species and habitats. The aim of the network is to ensure the long-term survival of Europe's most valuable and threatened species and habitats, listed under both the Birds Directive (Directive 2009/147/EC) and the Habitats Directive (Directive 92/43/EEC). The Greek pilot area includes 3 sites of the Natura 2000 Network that belong both to Habitats Directive Sites (pSCI, SCI or SAC) and Birds Directive Sites (SPA), specifically (Figure 1.17):

- KORYFES OROUS MENOIKION – OROS KOUSKOURAS - YPSOMA -SPILAIO PELADE (Site Code: GR1260004). Total Area: 23.604,22 ha (pSCI, SCI or SAC)

Mount Menoikio lies in a NW-SE direction. From a geological point of view Menoikio belongs to the Rodopi crystalline massif. According to Emberger climatic diagram the mountain lower altitudes belong to the humid or sub humid zones with cold or mild winter climate. The soil is sandy and is derived from metamorphic rocks (mainly limestones and gneisses). As one moves inland, away from the foot of the mountain, most Mediterranean species disappear. Hellenic beech forests with Abies borisii regis, Quercus frainetto and chestnut stands become more common. A mountain with rich forests of deciduous and coniferous trees. It has grasslands with rich flora. There are many rare species and species with districted distribution in the Balkan Peninsula. There is a monastery in mountain Kouskouras (Timios Prodromos). Although most commercial forests are publicity owned, they are have harvested by private associations under arrangements with Greek Forest Service. A lot of poor people work in logging and wood using industries, so the local unemployment decrease remarkable. Concerning the wild growing plants and the fauna species the quality of the site is indicated by the occurrence of many important and rare taxa.

- KOILADA TIMIOU PRODROMOU-MENOIKION (Site Code: GR1260009). Total Area: 29.211,86 ha (SPA)

Mount Menoikio lies in a NW-SE direction. From geological point of view Menoikio belongs to the Rodopi crystalline massif. According to Emberger climatic diagram the mountain lower altitudes belong to the humid or sub humid zones with cold or mild winter climate. The soil is sandy and is derived from metamorphic rocks (mainly limestones and gneisses). As one moves inland, away from the foot of the mountain most Mediterranean species disappear. This area is very important for birds of prey like the Long-legged Buzzard, the Golden Eagle, the Short-toed Eagle and the Lanner Falcon, for nesting and foraging. It is also very important for many other species, most notable the Roller, Stone Curlew, Syrian Woodpecker, White-backed Woodpecker, etc. This is a result of the habitat diversity and remoteness along with the reduction of human activities in the area. Concerning the wild growing plants and the fauna species the quality of the site is indicated by the occurrence of many important and rare taxa.

- KORYFES OROUS PANGAIO – PIGAIA NERA KEFALARIOU FILIPPON- SPILAIO ARKOUDOSPILIA (Site Code: GR1150005). Total Area: 11.879,01 ha (pSCI, SCI or SAC)

The site has a Mediterranean - middle European climate. Forests mainly consist of mixed stands of Fagus sp., Abies borisii-regis, Quercus sp. and Castanea sativa. There are also stands of Betula betula (Pangaio is the southern limit of this species in Balkan Peninsula). It is a large mountainous area with extensive beech and chestnut forests and pastures at higher altitude. In the rocky parts of the mountain there are cliffs with rare endemic plants or plants with restricted distribution in the Balkan Peninsula. Concerning the wild growing plants and the fauna species the quality of the site is indicated by the occurrence of many important and rare taxa.

- OROS PANGAIO KAI NOTIES YPOREIES TOU (Site Code: GR1150011). Total Area: 23.986,23 ha (SPA)

The area includes Mt Pangaio, part of Mt Symvolo and the plain between these two mountains. Young Beech forests, old Oak woodland, conifer plantations, mixed and broad-leaved woodland, alpine and sub-alpine meadows, along with rocky slopes form a unique environment. The plain has large areas of traditional cultivatios separated by hedges and tree stands, while there are also tracts of intensive cultivation and natural expanses that are not exploited. This area has remained in a great extent intact, despite the fact that Egnatia Highway passes through the plain of Pangaio and a number of forest roads provide access to many former remote areas. Birds of prey such as the Golden Eagle and the Booted Eagle thrive in the area, while rare birds associated with agricultural environments like the Roller and the Olive-tree Warbler are also common. Rock Partridges are still common in Mt Pangaio, while Semi-collared Flycatchers and other forest species nest in good numbers.

- KORYFES OROUS FALAKRO (Site Code: GR1140004). Total Area: 9.962,88 ha (pSCI, SCI or SAC)

The site consists mainly of crystalline-schist bed rock with igneous rocks (granites). This bed rock consists of metamorphic (crystalline) limestones of the marble series. The soil texture is sand-clay with adequate depth and fertility. In contrast, in the shrub lands derived from degraded forests, the soil is poor. On the rocky limestone areas the forest cover is sparse and soil occurs only in crevices. This mountain has a concentration of many rare plants for Greece with restricted distribution. The rare plant communities on the cliffs of the peaks of Mount Falakro and the grasslands of the area are of great importance. They also form a wide multi-color garden during May and June. There are rich forests of coniferous and broad leaved species on the lower altitudes. Concerning the fauna the quality of the site is indicated by the occurrence of the invertebrate Maculinea alcon which is referred to IUCN Conservation Monitoring Centre 1988.

- OROS FALAKRO (Site Code: GR1140009). Total Area: 24.649,17 ha (SPA)

Mount Falakro is a high mountain, with dense forest coverage in the northern slopes, while scrubland and phrygana cover most of the southern part. Conifer, mixed and broad-leaved woodland can be found in the forested area, while many cliffs are present. Mount Falakro still supports a very good Rock Partridge (Alectoris graeca) population, while is also very important for birds of prey like the Long-legged Buzzard (Buteo rufinus), the Golden Eagle

(Aquila chrysaetos) and the Booted Eagle (Hieraaetus pennatus). The southern part of the SPA is ideal for species like the Roller (Coracias garrulus) and the Stone Curlew (Burhinus oedicnemus).

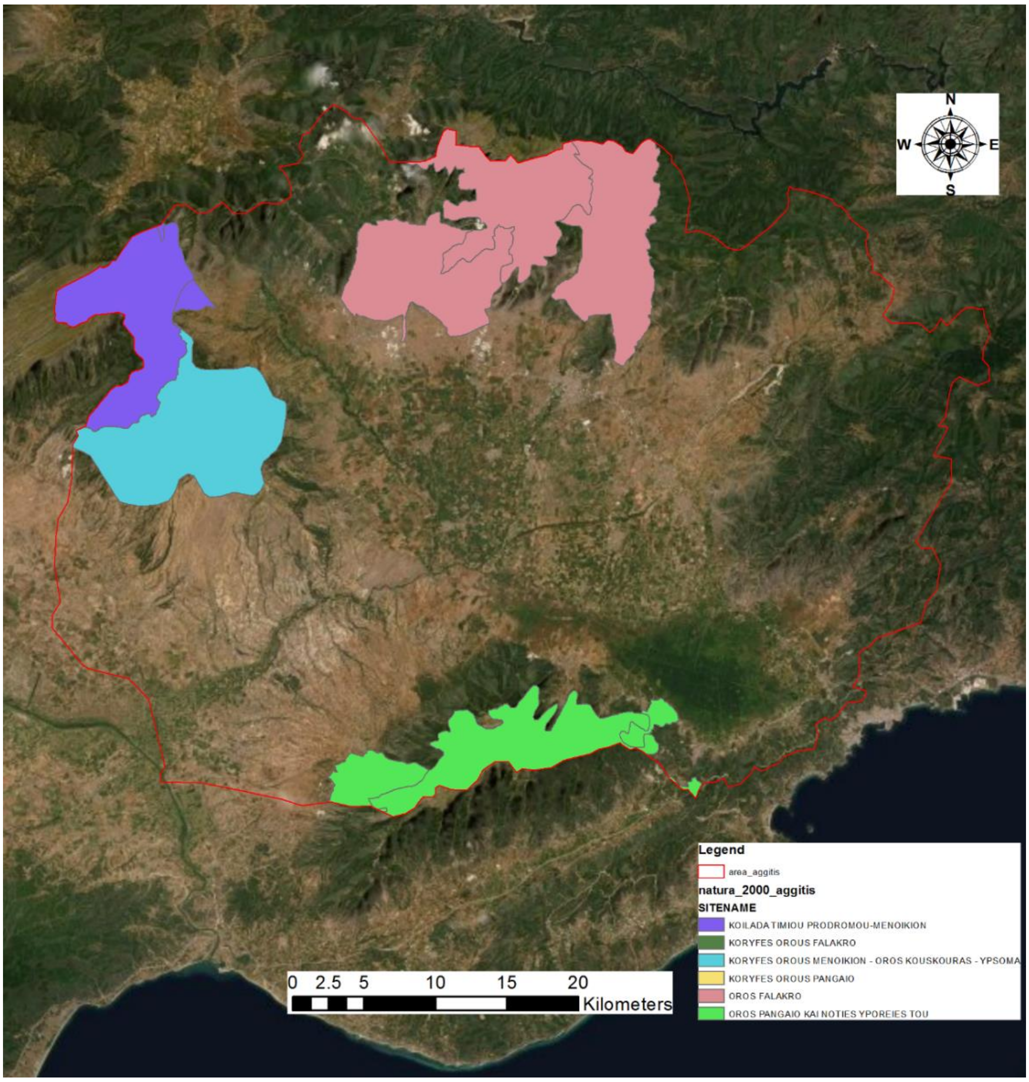

Figure 1.17. The NATURA 2000 Network map of the pilot area.

1.8. Riparian Area – Fauna and Flora Species

A dense riparian forest consisting of plane trees, alders, elms, willows, bitter chestnuts, poplars, rough pines, laurels, reeds, oaks, etc. Many and rare plants grow around the river, especially in the high places and in the gorge. The rare Haberlea rodopensis, Achillea chrysocoma, the lily Lilium martagon, the wild carnation Dianthus strymonis, the Arum maculatum, the iris Iris reichenbachii, the Stachys officinalis, the Alyssum saxatile and the Hesperis lacin stand out. Other species in the area are Colchicum Colchicum bivonae, Polygonum arenarium, Alium scorodoprasum, Anemone blanda, Erodium ciconium, Asphodeline lutea, Onobrychis viciifolia, Omithogirsum aractus and Cactus sambucina, Neottia nidus-avis and Orchis simia.

Both the riverbed and the surrounding fields gather many interesting species of birds. From the predators here live rare king eagles, serpent eagles, woodpeckers, wasps, hawks, meadows, meadows, hawks, hawks, peregrine falcons, golden eagles, kinkies, rock hawks, owls, owls and owls. In the surrounding fields live the rare lowland partridge and species such as hoofed bees, bee-eaters, coppersmiths, hawks, crows, carp, cuckoos, herons, katsoulierides, starlings, meadows, tricot fences, katsolakaathis In and near the river live gray egrets, crypto egrets, small egrets, night crows, white storks, black storks, kingfishers, nightingales, oystercatchers, coots, chewing gum, rope and watercress.

Amphibians are represented by common newts, salamanders, toads, green toads, tree frogs, gray frogs and pond frogs. The reptile fauna includes species such as river turtles, marsh turtles, Mediterranean turtles, green lizards, Taurus gusters, blinds, water snakes, pond snakes, house snakes, ephi, shuttles, rotters and vipers. Among mammals, the presence of the hare, a terrestrial species of squirrel, stands out, as well as the permanent presence of the otter throughout the river. Other species are wildcats, wild boars, hares, foxes, badgers, ferrets, weasels and woodpeckers.

The fish fauna of the river is rich and includes many rare, endemic species from which the Greek grouse (Caspiomyzon hellenicus), the strymonogast (Phoxinus strymonicus), the linear needle (Cobitis punctilineata), the sturgeon (Alburnus Strymon) of Strymon (Barbus strumicae). Other species of fish that live in Aggitis are the chondrostoma (Chondrostoma vardarense), the eels (Anguilla anguilla), the Bulgarian cob (Gobio bulgaricus), the small circus (Leucaspius delineatus), the lizard (Petroleuciscus borysthenicus), the pike (Esox lucius) and the Thracian river head (Squalius orpheus).

1.9. Vegetation – Land Cover

The land cover of the pilot area is mainly occupied by agricultural lands, broad-leaved forests natural grasslands and sclerophyllous vegetation based on the sites recorded in 2018 land cover (Figure 1.18). Table 1.2 provides the description of the Site Codes.

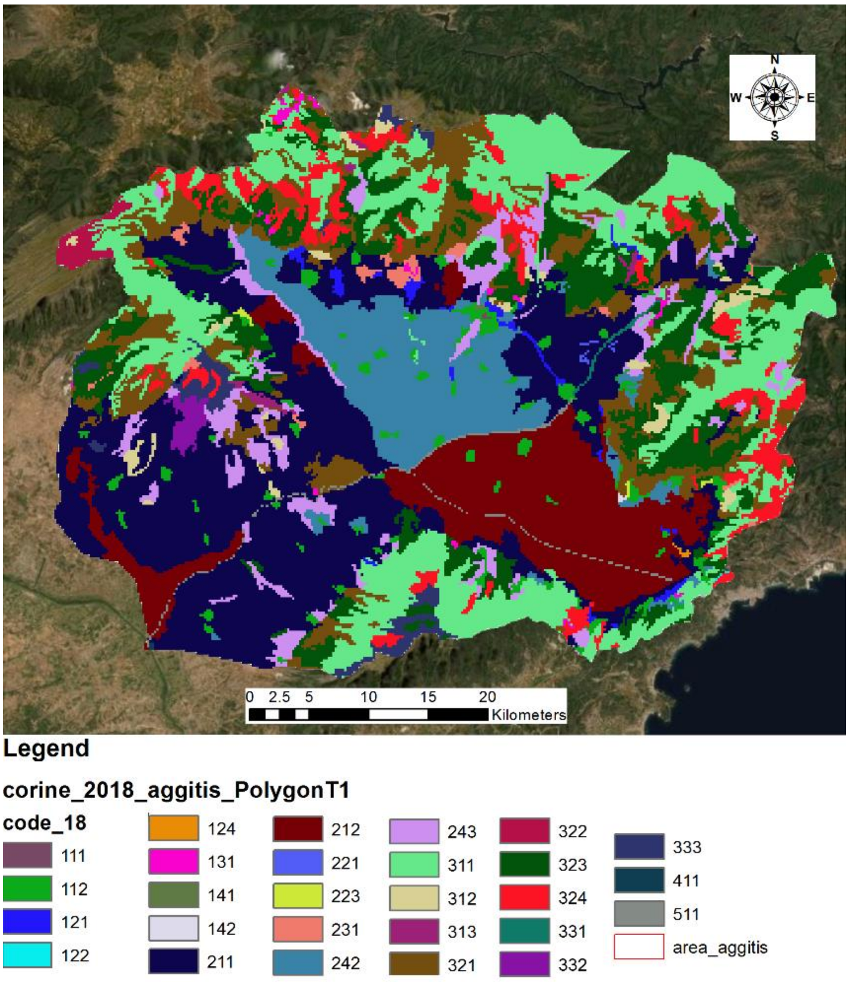

Figure 1.18. The Corine 2018 land cover map of the pilot area.

Table 1.2. The Corine Land Cover site codes and description concerning the pilot area.

Code	Description
1.1.1	Continuous urban fabric
1.1.2	Discontinuous urban fabric
1.2.1	Industrial or commercial units

1.2.2	Road and rail networks and associated land
1.2.4	Airports
1.3.1	Mineral extraction sites
1.4.1	Green urban areas
1.4.2	Sport and leisure facilities
2.1.1	Non-irrigated arable land
2.1.2	Permanently irrigated land
2.2.1	Vineyards
2.2.3	Olive groves
2.3.1	Pastures
2.4.2	Complex cultivation patterns
2.4.3	Land principally occupied by agriculture, with significant areas of natural vegetation
3.1.1	Broad-leaved forest
3.1.2	Coniferous forest
3.1.3	Mixed forest
3.2.1	Natural grassland
3.2.2	Moors and heathland
3.2.3	Sclerophyllous vegetation
3.2.4	Transitional woodland/shrub
3.3.1	Beaches, dunes, sands
3.3.2	Bare rock
3.3.3	Sparsely vegetated areas
4.1.1	Inland marshes
5.1.1	Water courses

In the Prefecture of Drama the main crop is cereals (174000 acres), maize (95000 acres), cotton (44,800 acres), potatoes (31,000 acres), livestock plants (48,000 acres) and in a much smaller number of acres. tobacco (1100 acres), beets (2200 acres), legumes (5000 acres), vineyards (5300 acres), trees (6500 acres) and vegetables (6500 acres). Examples of typical crops in the area are depicted in Figure 1.19.

Figure 1.19. Typical crop fields of the pilot area.

1.10. Hydrographic Network

Aggitis is the dominant water course of the pilot area. This is the largest tributary of Strymon River and one of the most beautiful rivers in Greece, as it forms landscapes of great aesthetic value. The hydrographic network of the basin, consists of sub-branches which end in a central branch (Aggitis River) that directs surface water to the river Strymon (Figure 1.20). It is also characteristic that the development of both the hydrographic network and the catchments is uneven. Characteristically, there is a greater development of the network in its Southwestern part (at the foot of Mount Menoikio) due to the different geology of the area. This area is characterized by the appearance of marlstones while all the mountains of regional basin dominated by marble background of the Rodopi mass.

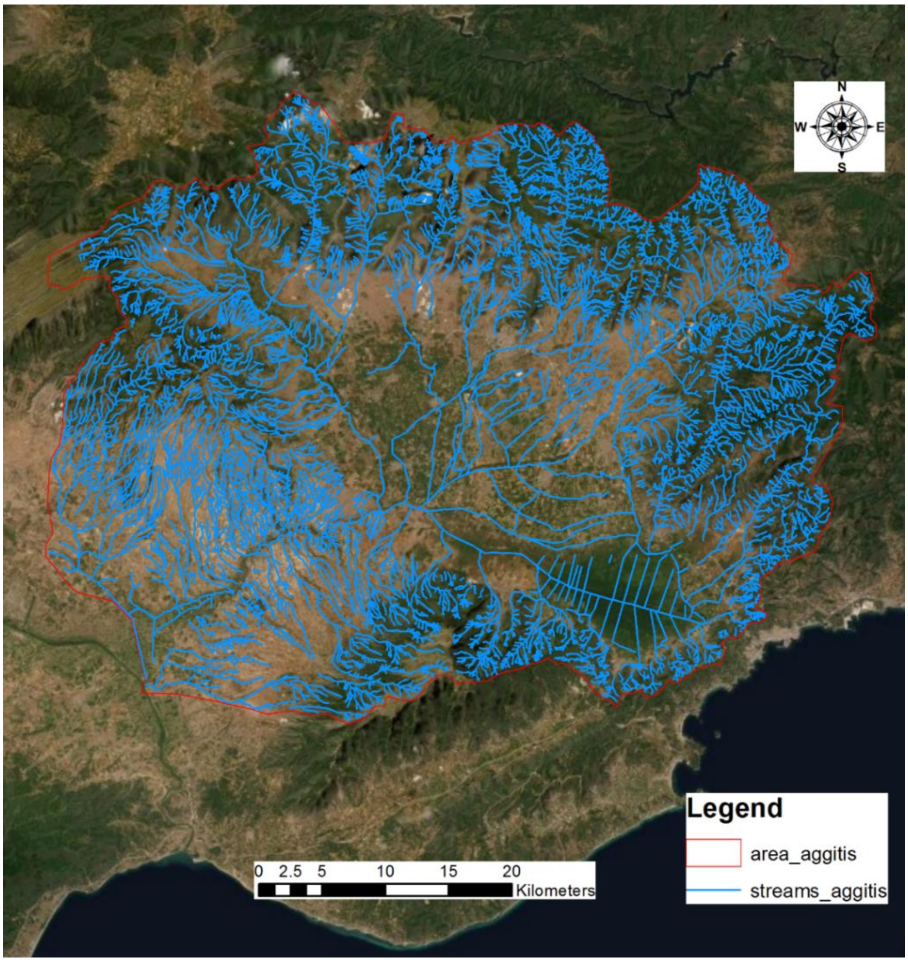

Figure 1.20. The hydrographic map (physical and irrigation network) of the pilot area.

The hydrographic network is mainly characterized as a dendritic hydrographic network and this form appear in homogeneous lithological areas of Aggitis-Drama Basin. In some areas the hydrographic network of the river can be characterized as a complex network. These areas are located in the southern part of Mount Menoikio where due to the gorge of 'Stena tis Petra' the network shows a dendritic and parallel form. The same form of the hydrographic network appears in branches of the Falakro Mountain, probably due to the large slopes (> 45°) and the lithological formations in the area.

Irrigation Network: In the whole plain area of the Aggitis-Drama basin there is an extensive surface drainage / irrigation network. But the most important land improvement project is construction of the drainage ditch of the Tenagi Philippon. The total drainage is done, with ditches and canals that drain the waters of Philippi but also the surface waters, coming from the springs of Kefalari, as well as from the springs of Portes, Nikisiani, Amisiana and Antiphilippoi which show a transient flow. The artificial waters drainage network discharges in the Aggitis River. Finally, certain seasons of the year this system of ditches works in reverse thus supplies the wells and vacuum underground horizons of the plain section.

1.11. Floods – Erosion – Water Pollution

Flood events are frequent, especially in the area of Tenagi-Philippoi, but also in floodplains of the local torrents which are dominant in the area. Figure 1.21. depicts the historic and significant flood events and the area which is vulnerable to floods. In addition, Aggitis discharge is high during spring period because of the high and intense rainfall events and snow melting. Both Aggitis and tributaries cause floods to the adjusted riparian areas and cause serious problems in agriculture and grey infrastructure (Figures 1.22 and 1.23). Furthermore, the high water discharge transports significant amounts of debris material that can be also serious and dangerous because of their dimensions (Figures 1.24 and 1.25). These materials contribute to erosion phenomena and their final deposition can have negative impacts and results to infrastructure and economic damages (Figures 1.26).

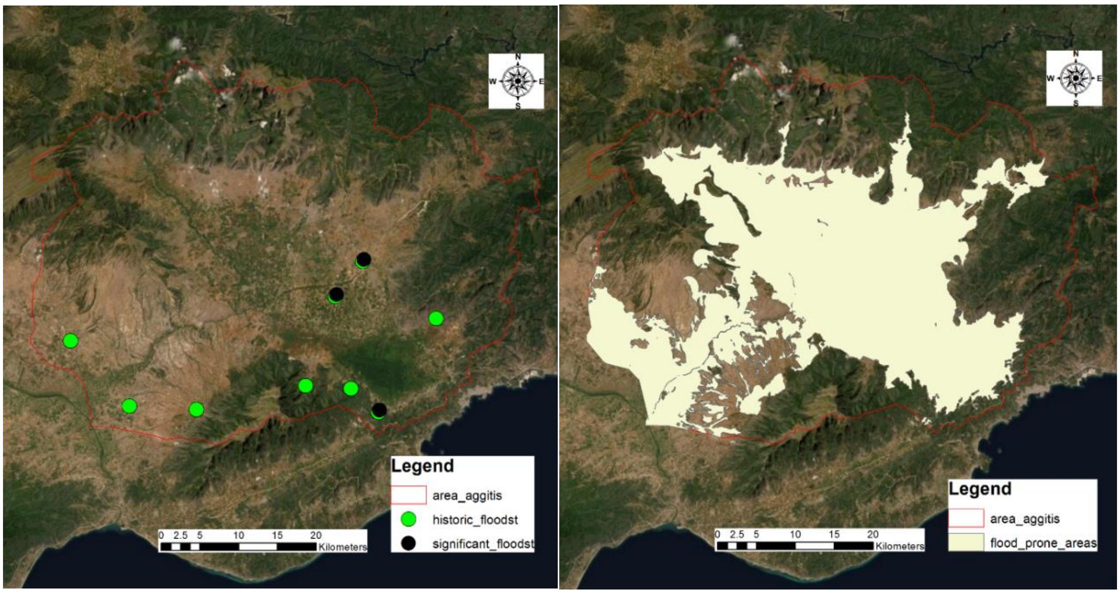

Figure 1.21. The historic and significant flood events and the flood prone map of the pilot area.

Figure 1.22. The Aggitis River flooded after heavy rainfall.

Figure 1.23. A typical sub-urban Greek torrent (ephemeral stream) flooded after heavy rainfall.

Figure 1.24. Floods' debris in Aggitis River after heavy rainfall. .

Figure 1.25. Severe erosion phenomena in Aggitis River after heavy rainfall.

Gravel excavations are riparian intakes of aggregates - transported materials of rivers for the construction of technical works or for other purposes. Gravel extraction, depending on the amount of aggregates obtained, can alter the geometric characteristics of the riverbed and cause hydromorphological alteration of the specific water systems. Such activities are present in many torrents (streams) of the pilot area such as Kallifytos torrent (Figure 1.26).

Figure 1.26. Floods' debris in a typical sub-urban Greek torrent (ephemeral stream) after heavy rainfall

The main sub-sources of non-point pollution originate from the agricultural activities, livestock (pastoral and stable), urban wastewater, charge of water from other sources (Figure 1.27). The area is vulnerable to nitrates, phosphorus and organic material. Stable livestock is divided as: pig farms, poultry farm, sheep farm, cattle farm. In addition, pollution comes from the sanitary landfill and dumps. A typical problem are the illegal garbage dumps of litter, plastics and dangerous pesticide that could end up in surface waters or aquifers (Figure 1.28). There are also mines such as "Bauxite Volaka Mines" which have been abandoned but are still a significant source of pollution for the Kalinas stream which ends at the Xiropotamos stream.

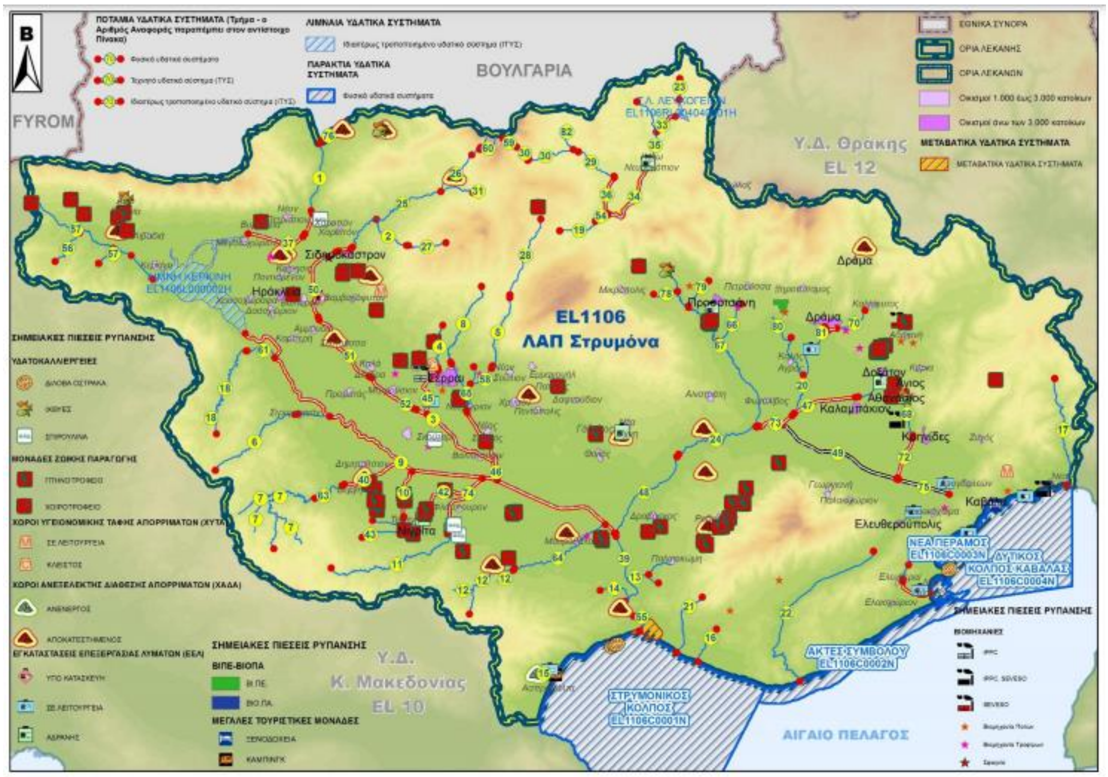

Figure 1.27. The main sources of pollution. Source: Special Secretariat for Water, Hellenic Ministry of Environment and Energy.

Figure 1.28. Typical point source pollutants - illegal garbage dumps of litter, plastics and dangerous pesticides.

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2. Buzau River Basin - Siriu Reservoir – ROMANIA

2.1. General aspects

The project *“Protecting streams for a clean Black Sea by reducing sediment and litter pollution with innovative joint monitoring and control tools and nature-based practices”* focuses on a common environmental monitoring of pollutants from diffuse pollution sources and waste that reaches Black Sea. This is a main and essential priority of the “Black Sea Basin” Program.

The general objective of the program is to contribute to the improvement of the well-being of the people of the Black Sea basin regions through sustainable growth and common protection of the environment, thus ensuring:

- The access of all the inhabitants of the Black Sea basin to an environment corresponding to their needs;
- Preventing the deterioration of the state of aquatic ecosystems, conservation and development of the biodiversity of their flora and fauna and of terrestrial ecosystems;
- Sustainable development of the water management system by long-term protection of available water resources;

2.2. Selection and presentation of the pilot area

In Romania, the eligible area of the “Black Sea Basin” programme 2014-2020 is the South-East Development Region which has the following counties: Brăila, Buzău, Constanța, Galați, Tulcea and Vrancea. A.B.A. Buzau-Ialomita, as a partner in the project, manages the surface and groundwater resources on the territory of Buzau and Braila counties located in the eligible area of the program.

For the purpose of the project, the eligible area of the project in Buzau County was selected. The pilot area of the project is represented by the main course of the Buzau River from the border with Covasna county and downstream by the Patarlagele locality, including the Siriu Reservoir.

The selection of the pilot area was made having as starting points the following aspects:

- the eligibility criteria of the programme has been met in terms of the project area;
- the Siriu reservoir has as main use the use of water for drinking purposes, thus ensuring drinking water for a series of localities downstream;

- identifying some problems regarding the accumulation in the Siriu dam area of a significant quantities of waste transported by the Buzau river, especially during periods of floods and their collection actions by ABA Buzau-Ialomita representatives hampered by the lack of high-performance equipment in this domain;
- the need for awareness-raising activities regarding the effects of lack of water or the use of water of inadequate quality, the importance of keeping surface water clean, following simple rules on waste collection and storage in a specially designed place, the consequences of storage waste on the banks of rivers and lakes for humans and the aquatic ecosystem in general and specifically in the pilot area of the project.

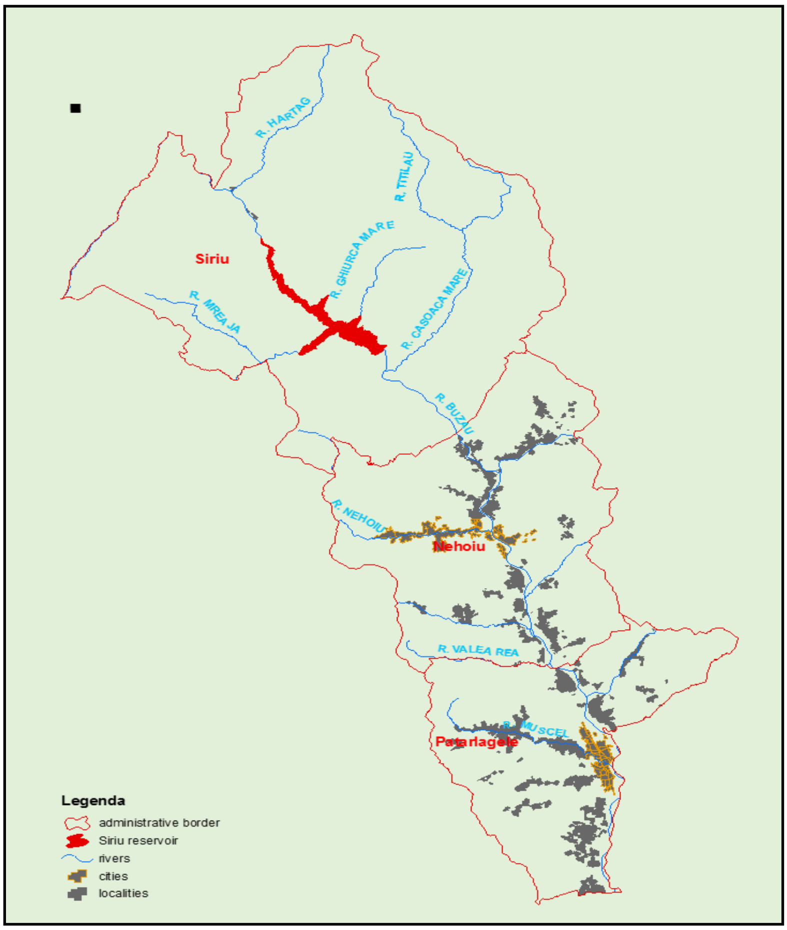


Figure 2.1. Project pilot area

Next, the pilot area is presented in terms of hydrography, relief, geology, precipitation variation, temperature variation, flora and fauna and activities that take place on its territory.

2.3. Hydrography

The first documentary mention of the river Buzau is from the 4th century: in a letter from 376, sent by Iunnius Soranus, the governor of Scythia Minor, to the archbishop of Caesarea Mazaca, tells about the martyrdom, on April 12, 372, of the Christian missionary Sava, drowned by non-Christian Goths in the waters of the Mousaios River (Buzau) by non-Christian

Goths led by Athanaric (the document "The Passion of Saint Sava", written in 376, is kept in children at the Vatican Library and the "San Marco" Library in Venice).

The Buzau river basin of the represents the basin of one of the most important tributaries of the Siret river, which brings a water contribution of about 14% of the flow. It is located in the southeastern part of the Eastern Carpathians, draining the area of the Ciucasului, Siriu, Podul Calului, Monteoru and Penteleu mountains, then the sub-Carpathian area with the two subdivisions and an area northeast of the Roman Plain. The total area of the Buzau river basin is 5264 km2, with a length of 1656 km.

The Buzau River has its origin in the Ciucas Mountains from an altitude of about 1800 m. From here, the river heads with great slopes to the corridor of the Buzau Turn, where it has a lazy and winding course. Among the tributaries of Buzau, until it enters the corridor, we mention on the left side Strambul river (S = 27 km2, L = 11 km) and Dalghiul river (S = 51 km2, L = 17 km), both coming from the Ciucas massif, and Acrisul river (S = 22 km2, L = 10 km), and on the right on Buzoel river (S = 54 km2, L = 16 km).

At Sita Buzaului it flows into Buzau river the Ladautiul river (S = 98 km2, L = 11 km), with its tributary Barcani. From here, downstream, the Buzau valley narrows, and from Crasna the Buzau corridor begins. The tributaries upstream of the gorge are Zabratau river (S = 54 km2, L = 12 km) on the left and Ciumernicul and Chichiraul rivers (S = 26 km2, L = 8 km) and Crasna river (S = 25 km2, L = 9 km) on the right. On the corridor sector it receives on the left Hartagul river (S = 36 km2, L = 9 km) and Siriul Mare river (S = 85 km2, L = 15 km). Downstream of Siriul Mare river comes Casoaca mare river (S = 57 km2, L = 16 km) at the mouth of which there is a widening of the Buzau valley (see the 2.16 River Basin Network of the Buzău River Basin below).

About 500 m upstream of the confluence of the Buzau River with its left tributary Casoaca Mare are located the dam and the Siriu Reservoir.The dam was approved for construction in January 1972 and was completed in December 1994. The purpose of building the dam was on the one hand to supply drinking water and industrial water to the downstream localities and to irrigate 50000 ha of agricultural land and, on the other hand, the production of electricity through the construction of the Nehoiașu hydroelectric power plant with an installed capacity of 42 MW, having an installed flow of 32 m^3/s and generating an average electricity production per year is 144 GWh. The reservoir is also used for flood protection, the Siriu Reservoir being provided with a flood mitigation tranche of 30 million m^3 up to 980 m^3/s.

Downstream of the dam, an important tributary of the Buzau river, the Basca river (S = 783 km2, L = 76 km) has approximately the same dimensions as the main collector and which is born from two main streams: Basca Mare river (S = 440 km2, L = 61 km) and Basca Mica river (S = 239 km2, L = 45 km).

The appearance of the Buzau river valley changes profoundly at its entrance in the sub-Carpathian area. In this region the solid transport of the rivers reaches maximum values, due to the massive deforestation. After the confluence with Basca river, the Buzaul river receives downstream from Patarlagele some smaller tributaries, such as Nehoiul river (S = 36 km2, L = 14 km), Catiasul Plescari river (S = 20 km2, L = 10 km) and Muscelul river from the right and Ciptorasu and Sibiciu rivers (S = 47 km2, L = 11 km).

Figure 2.2. Buzau River and its tributaries and Siriu Reservoir

2.4. Relief

The surface of the river basin of the Buzau River develops on three great relief steps: mountains, hills and plains, which descend from the high peaks of the Pentele to Baragan. Each of these steps is, in turn, very varied in shape, causing the differentiation of several subunits. The variety of relief forms and geological composition also imprinted the diversity of the other elements of the natural environment, influencing, at the same time, some aspects regarding the population and the economy of the basin.

The mountain area is part of the large unit of the Curvature Carpathians and includes two main subunits: the Buzau Mountains and the Vrancea Mountains.The Buzau Mountains are composed of five massifs: Penteleul, Podu Calului, Siriul, Monteorul and Ivanetul.

The Penteleu massif represents the main unit of the Buzau Mountains, being constituted by a central ridge that starts with Piciorul Caprei (1520 m) and continues with the peaks Penteleu (1772 m), Crucea Fetei (1578 m) and Ciulianos (1602 m). On either side of this alignment of peaks stretch plains at altitudes that reach up to 1400 m, but often descend to 1200 m.

The Podu Calului massif takes place between Basca Mare and Buzau rivers. It has lower heights compared to Penteleul or Siriul. It reaches 1440 m at the top of Podu Calului. It is strongly divided by valleys, so that it appears in the form of two or three massifs joined by wide saddles.

The Siriu massif, between Buzau, Crasna and Siriu, takes its name from the river that surrounds it to the south and southwest. Viewed from all sides, it appears as a well-individualized massif, surrounded by lower areas. It exceeds 1600 m in the Malaysian ridge (1663 m) and the Siriu peak (1659 m).

The peaks descend in steps developed at several levels. Some of them are very smooth and in some places have the character of structural surfaces. On the plateaus in western Malaya there are alpine meadows, water holes and sphagnum.

The sub-Carpathian area, also called the Buzau Subcarpathians, representing a combination of hilly peaks with depressions, basins and inundations. The altitudes of the peaks are between 400-800 m. The delimitation between the mountainous and the sub-Carpathian area is made by a difference in level of about 200 m, well-marked between Sibiciu and Lopatari.

The Siriu Reservoir is located in the mountain area, which is part of the large unit of the Curvature Carpathians and includes two main subunits: the Buzău Mountains and the Vrancea Mountains (see the map below).

2.5. Geology

From a geological point of view, the mountainous area consists of the so-called “flysch”, represented by an alternation of sandstones, marls, clays, shales and rarely conglomerates, all tightly folded, sometimes forming folds-scales, aligned in the north direction. East-southwest. The age of the rocks is mainly Paoleogenic. The area drained by the upper basin of Buzău corresponds from a geological point of view to the crystalline-Mesozoic area and to the area of the Cretaceous and Paleogene flysch.

In the Cretaceous and Paleogene, the thick sheets of flysch were formed, having the following stratigraphy: curbicortical series (albion), Sita-Tataru sandstone series (vraconiana), Teliu layers (vraconian-cenomaniana), fine sandstone series with inocerami (upper turonian).

The curbicortical series (albion) consists of fine sandstones, micaceous, gray, calcareous, curbicortical alternating with gray clays and marls (they appear in the Zabrataului valley at Crasna, on the Siriului Mic valley, etc.), which at the top has a thick conglomerate breccia of 600 m containing forms of inocerami and nechibolites.

The Lower Cretaceous is represented by black shales starting from Siriu, cutting the Buzău water at Crasna and heading north. Marls interspersed with volcanic tuffs and red felspat sandstones are placed over the black shales.

Figure 2.3. Geology around Siriu Reservoir

2.6. Average Annual Precipitations

In the mountain area, the precipitation regime, in terms of annual quantities, varies between 800-1200 mm.The wettest semester is April-September, and in the cold the amount of precipitation is lower, because the general atmospheric circulation is under the anticyclonal regime. Spatially, the precipitation regime presents a series of peculiarities related to the general circulation of air masses and the natural environment. Thus, the average annual precipitation decreases from north to south, as a result of the discharge of humid oceanic air masses in the mentioned direction and at the same time of the decrease of the relief altitudes. The average annual rainfall values in Nehoiu are 655.2 mm (see the map below).

2.7. Average Annual Temperature

The distribution and regime of air temperature bear the imprint of the influence of geographical position and relief. There is a steady increase in the average annual temperature in the north-south direction, from the high regions to those with lower altitudes. In the mountainous and hilly region, climatic differences can be noticed between the low depression areas and the high peaks. The depressions and basins developed in the mountain area and on the secondary hydrographic network in the sub-Carpathians, register lower average annual temperatures than the interfluvial areas, as a result of the very frequent temperature inversions. In the mountain area, temperatures exceeding the value of 0^0C are recorded eight months a year.

Freezing and thawing occurs when temperatures drop below 0^0C. The average date of the first day of frost is, in the mountain region, October 1, and in the sub-Carpathians October 20. The ice propagation wave is transmitted from north to south, as a result of both the relief steps and the direction of movement of the northern air masses.They enter through the Carpathian passes and through the valley corridor of Buzau, influencing the passage of time during their invasion. The thermal and freezing regime of rivers generally follows the development of air temperature.

Regarding the frost phenomena, the earliest date of their appearance is registered in the first decade of November, and the latest one in the last decade of March. Of these phenomena, the most common are ice bridges and cliffs. The average duration of the ice bridge is 25-60 days. The maximum duration of ice and shoreline retention is 20-50 days (see the map below).

2.8. Flora and Fauna

The Siriu massif is part of the subalpine floor that runs on all mountain gorges, from 1400-1500 m upwards. Documents from the 18th century indicate the existence on the peaks of Penteleu, Lăcătuș and Siriu of areas without forests.

The lowering of the subalpine floor boundary was linked to pastoral development and intensive logging. The low altitude and the low massiveness have reduced the number of species characteristic of the alpine floor. Of these, juniper (Pinus montana), emerald (Rhododendron kotschyi), dwarf willow (Salix reticulata) appear only in a few points. Instead, the juniper (Juniperus sibirica) is very widespread in Sirius and Penteleus.

Towards the forest floor, the meadows are combined with isolated shrubs and trees, which do not exceed 4m in height. The forested mountain area is the richest in fauna, because the living conditions are also particularly favorable.

The soil and foliage are particularly rich in insects, worms, mollusks, gastropods and myriapods. Numerous bird species can be found in the crown of the trees: the owl, the owl, the falcon, the barn owl, the jay, the pupa, the tit, the sitar, the cuckoo, the mottled woodpecker, the Romanian green woodpecker, less common in the rest of the country, the nightingale, the blackbird, the blackbird, heirs protected by law, the mountain rooster. There are also species of deer, wild pigs, squirrels, lynxes, martens, and on the forest paths the Carpathian brown bear (Ursus artos), which is the largest mammal in the area. In flowing waters and lakes there are many species of worms, mollusks, crustaceans, amphibians and fish (crucian carp, carp, perch, trout and grayling).

2.9. Drinking Water Source

The water from the Siriu reservoir is the main source of drinking water for the localities from Siriu commune and Nehoiu town and serves a number of 8589 equivalent inhabitants.

The water intake is located at a depth of about 40m. Water quality complies with the limit values from DIRECTIVE 98/83/ the quality of water intended for human consumption.

Figure 2.4. Siriu Dam

2.10. Tourism and Recreational Activities

In the pilot area of the project there are several tourist and recreational activities such as the dam and Siriu reservoir, Casoca waterfall, Vulturilor Lake, sulfurous mineral springs, poorly mineralized, thermal pensions and hotels. Also, on the Siriu Reservoir, sport fishing and canoeing activities, kayak rafting downstream of the reservoir to Patarlagele locality, etc.

Figure 2.5. Siriu Reservoir

Thus, the Siriu Reservoir is one of the most beautiful tourist destinations in Buzau County. Located in a wonderful area, surrounded by fairytale forests, the lake is crossed along the shore by a spectacular road, DN10 Buzau-Brasov. In 1975, when the construction of the dam began, the national road DN 10 Buzau-Nehoiu-Brasov had to be moved to another location, bypassing Siriu Reservoir on its contour line. In order to build this road, several viaducts had to be built. The most spectacular are: the Giurca viaduct, 276 m length, with 46 m high pillars and the Stanca Teharau viaduct, which crosses the rock of the slope of the same name.


Figure 2.6. Teherau and Giurca viaducts

During the summer, the area at the tail of Siriu Reservoir has the possibility of beach, rafting and sport fishing. You can fish broom, crucian, trout, carp and clean. On Siriu Reservoir you can practice various water sports, thus becoming one of the favorite destinations of people in the big cities nearby, especially during the summer, when temperatures are high.

Figure 2.7. Thermal Spring

On the left bank of the lake there are three mineral springs that come out of the ground, springs that have ferrous, thermal, slightly bicarbonate, chlorosodium and sulfurous waters. The thermal spring comes out in the sink of the Siriu Reservoir. Also, just 5 kilometers from Siriu Reservoir you have the opportunity to visit the beautiful Pruncea waterfall (Casoca).

Figure 2.8. Pruncea waterfall

Another picturesque lake is nearby. It is the Lake of the Eagles, of pre-glacial origin, which is located at an altitude of 1420 meters.

Figure 2.9. Eagle Lake

Being a mountainous area with many objectives, the tourism is practiced in various forms such as traffic, stay, weekend, rural, ecological and cultural, ecumenical, mountain having the possibility to practice sport fishing, kayaking rafting, etc.

Figure 2.10. The recreational activities - rafting

2.11. Characterization of surface waters in the pilot area

2.11.1. Typology of surface water courses

In the pilot area of the project, the Buzau river and its tributaries fall into the category of watercourses located in the mountain area, with a slope between 20-200%, altitudes higher than 500 m, rainfall between 600-1400 mm/year, temperature between -2 + 9 degrees C and a specific fish fauna (trout and chub).

2.11.2. Typology of reservoirs

In the pilot area of the project is the Siriu Reservoir which falls into the category of accumulation lakes located in the hill and plateau area, with great depth (approx. 80 m), siliceous geology, altitude between 200-800 m, surface of 370 ha being included in the site of community importance site "Siriu" (ROSCI0229) from Natura 2000 Network.

It has a surface of 2.34 km^2 and a length of 9.5 km. The reservoir has several uses such as use of water for drinking purposes, irrigation, hydropower and flood protection (see subchapter *2.2.1.Hydrography)*.

2.12. Anthropic Activities

Within the pilot area of the project, several anthropic activities are carried out, such as: human settlements, agricultural activities, industrial activities, schools, hospitals, etc. Below are presented these activities which in accordance with the provisions of the Water Framework Directive 2000/60/EEC are considered pressures and can cause a potentially significant impact on the state of water quality.

2.12.1. Human Agglomeration - Sources of Punctiform and Diffuse Pollution

On the Buzau River, upstream of the pilot area there are several human agglomerations such as the city of Intorsura Buzaului, Sita Buzaului, Vama Buzaului which will be taken into account in the activity of identification of the hotpoints in the pilot area of the project.

Within pilot area there are several localities, the first being located on the Buzău river valley in the Siriu Massif, close to the border with Covasna County, upstream of the tail of Siriu reservoir, namely the village of Gura Siriului which is part of Siriu commune with only 24 inhabitants. The locality does not have a wastewater collection and treatment network.

Downstream of the Siriu Reservoir are the villages of Lunca Jaristei, Casoca, Muscelusa and Coltu Pietrii from Siriu commune with a population of about 3187 inhabitants. The locality does not have a wastewater collection and treatment network. From the point of view of waste, these localities represent diffuse sources of pollution.

Downstream of these localities are located another localities that are part of the Nehoiu City: Bîsca Rozilei, Chirlești, Curmătura, Lunca Priporului, Mlăjet, Nehoiu, Păltineni, Stănila, Valea Nehoiului and Vineţişu. Only Nehoiu locality has a centralized network for wastewater collection and treatment, the other localities are not yet connected to it (representing diffuse pollution sources in terms of human agglomerations).

Following the Buzau River downstream, there are other localities belonging to the Patarlagele City with a population of 7304 inhabitants: Muscel, Pătârlagele (residence), Poienile, Sibiciu de Sus, Stroești, Valea Lupului, Valea Sibiciului and Valea Viei, Calea Chiojdurile, Gornet, Lunca, Mănăstirea and Mărunțișu. Only Patarlagele locality has a centralized network for wastewater collection and treatment, the other localities are not yet connected to it (representing diffuse pollution sources in terms of human agglomerations).

Figure 2.11. View of Nehoiu and Lunca Jaristei localities

Also, inadequate storage of household and industrial waste and residues on undeveloped land/spaces (for example on the banks of watercourses) is a significant source of water and soil pollution in the area of these localities. The largest share is biodegradable waste - about 51% (results from individual households, public institutions, parks, gardens, greenhouses, solariums, etc.), paper and cardboard about 11%, plastic 10 %, glass, metals and textiles around 5% each.

Εικόνα 2.12. Waste transported by the Buzau River

2.12.2. Agriculture - Diffuse Pollution Sources - Agricultural Crops and Animal Breeding

The natural conditions of the area are not the most favorable for large-scale agriculture, which is why until the nineteenth century and in the first decades of the twentieth century, the main occupation of the locals was pastoralism, favored by the existence of large areas of pastures, meadows and plantations with fruit trees, in the mountainous area the arable land being restricted to small areas (in the area of the villages only around 18% of the agricultural land in the form of arable lots can be capitalized). Regarding animal husbandry, sheep have the most important share being achieved in individual households.

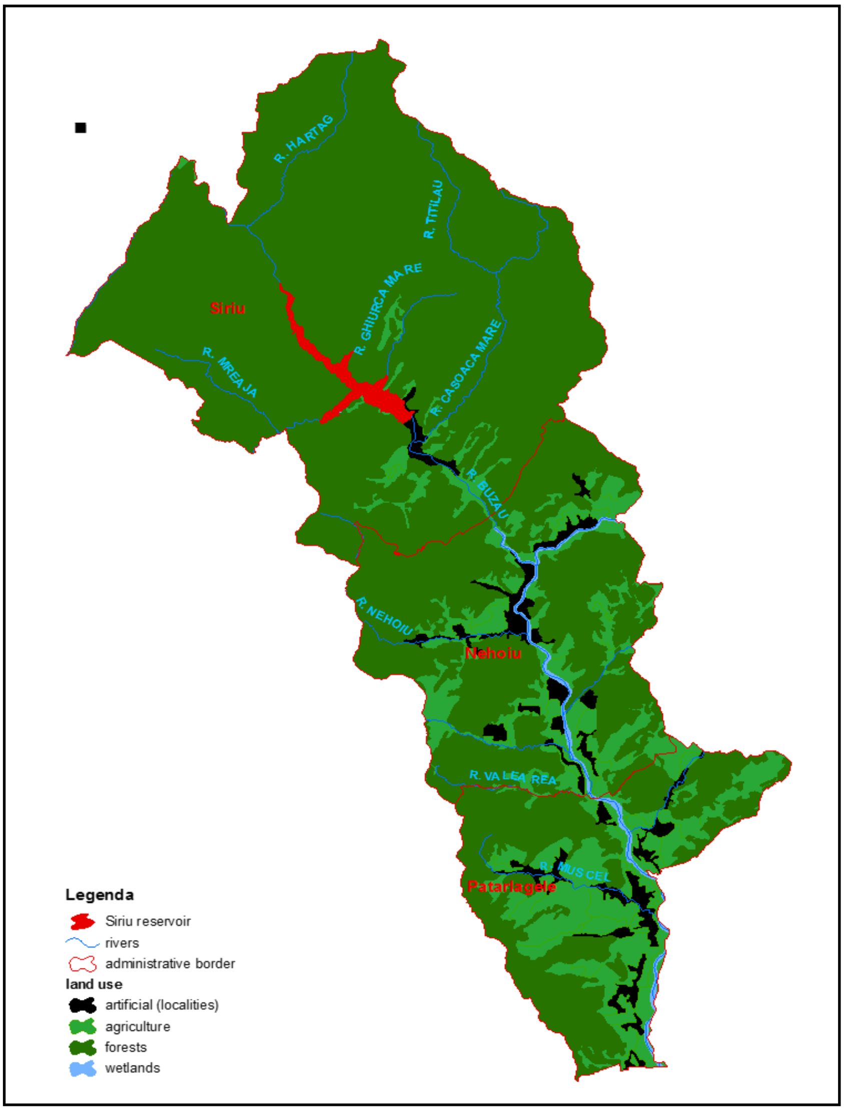


Figure 2.13. The land use map

2.12.3. Tourism and Recreational Activities - Diffuse Pollution Sources

The tourist development of the area has led to an increase in the amount of plastic waste that often ends up in the Siriu Reservoir or along the Buzau River. In the pilot area of the project there are several guesthouses and hotels that can generate different types of waste (plastic, paper, glass, etc).

Figure 2.14. The Spring Joy pension

Figure 2.15. Gueshouses and waste generated by them

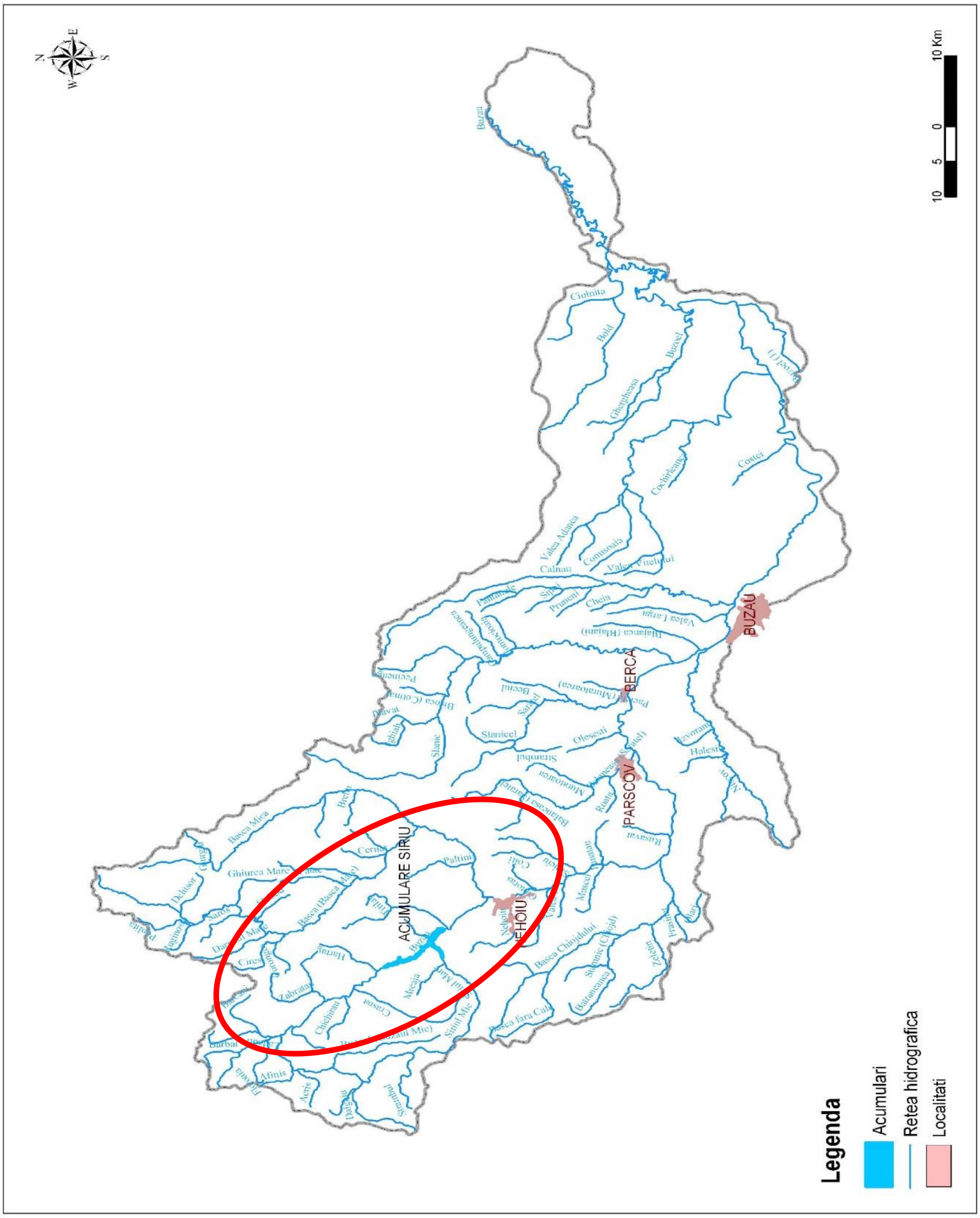
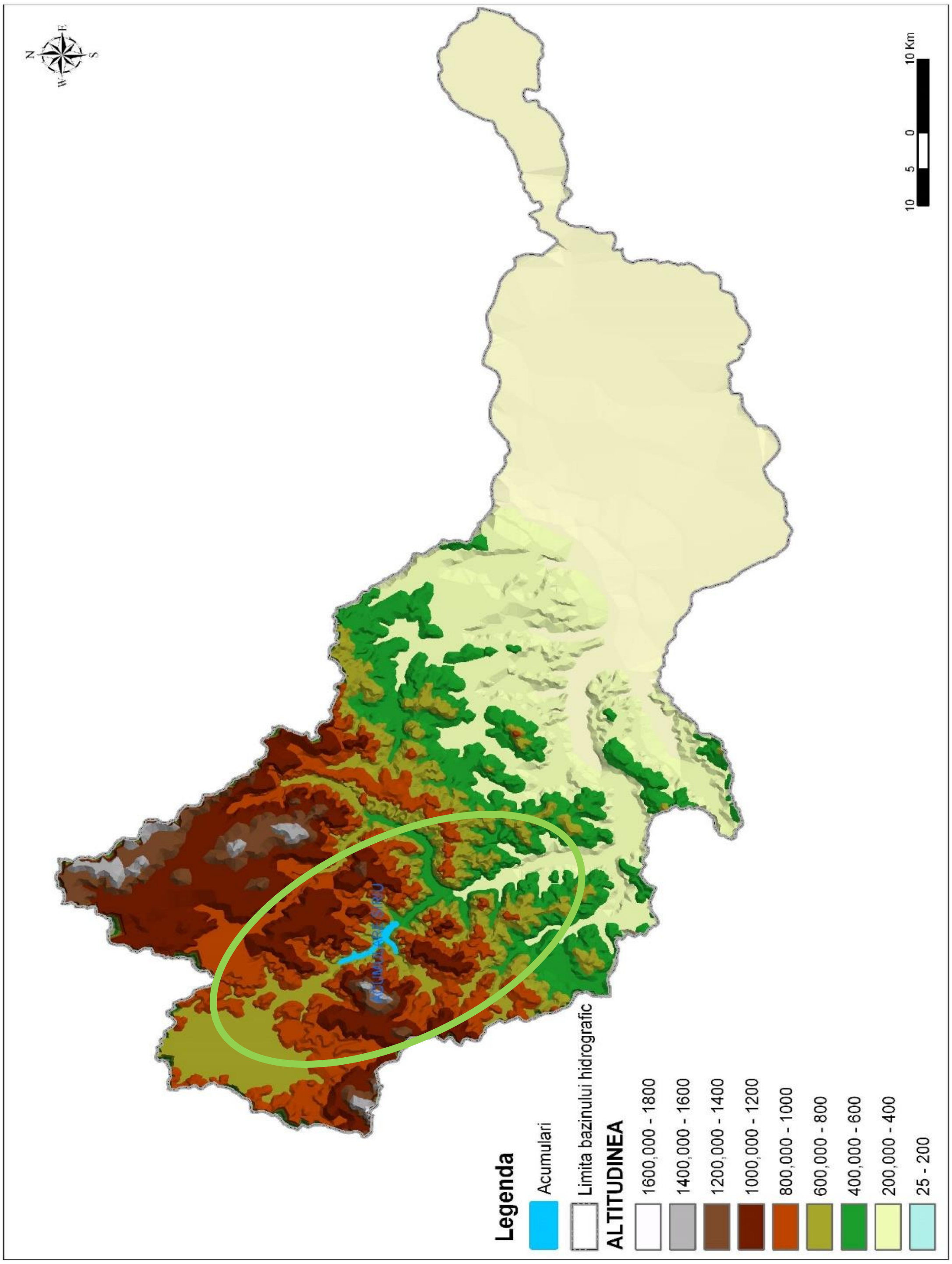


Figure 2.16. River Basin Network of the Buzău River Basin



2.17. Relief units in Buzău River Basin

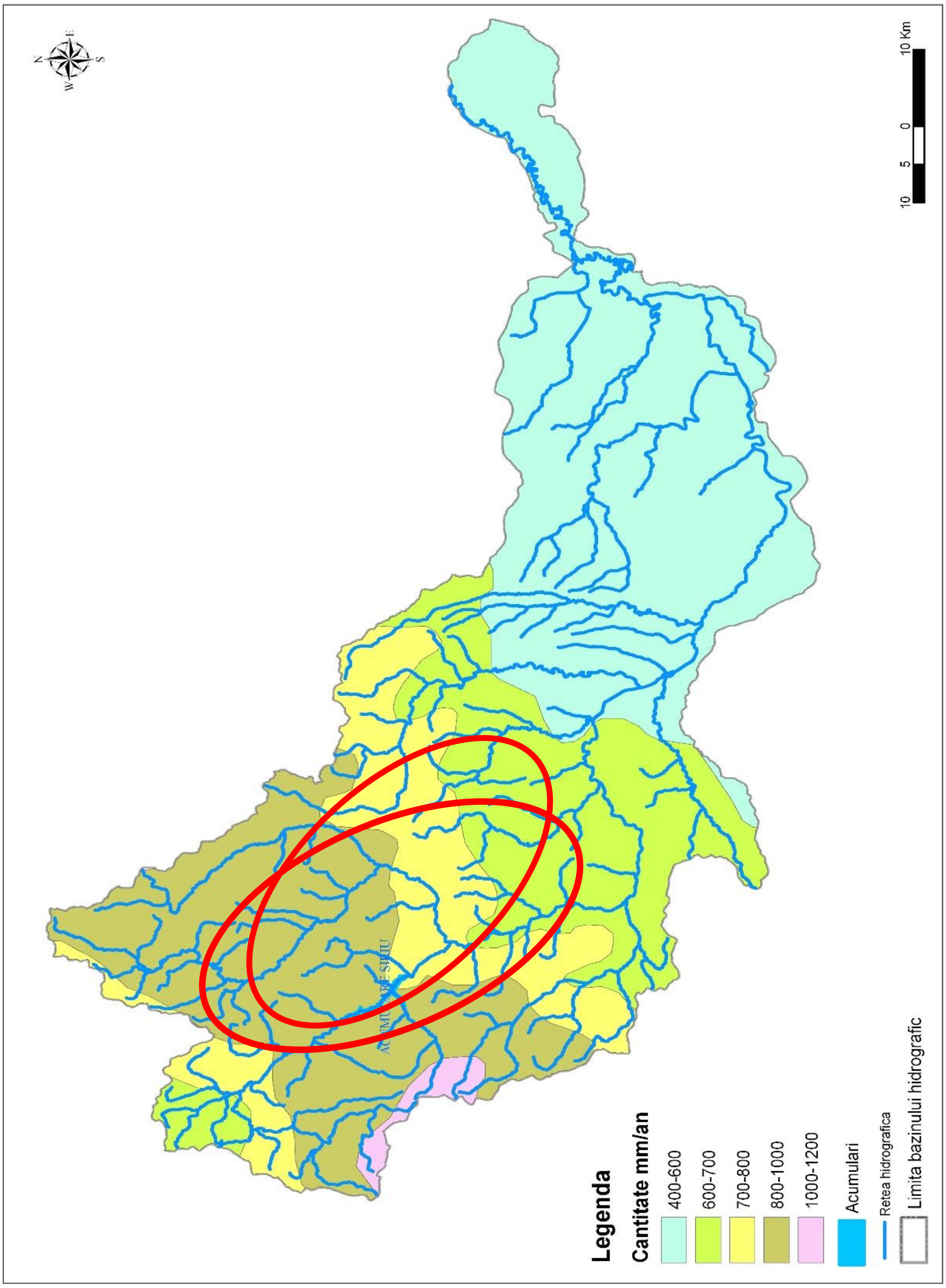


Figure 2.18. Average annual rainfall in the Buzau River Basin

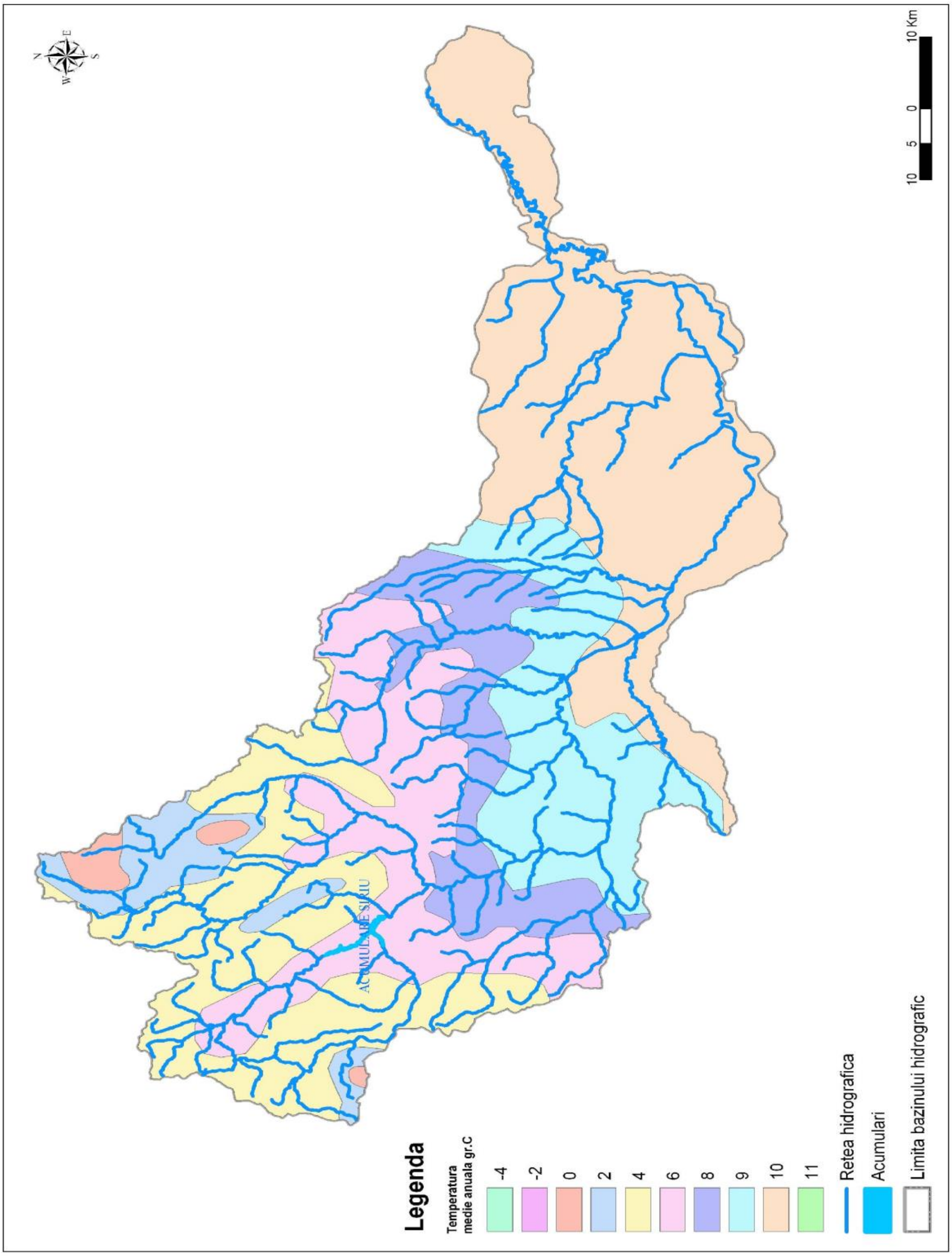


Figure 2.19. Average annual temperature in the Buzau River Basin

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***Buzau-Ialomita River Basin Management Plan, 2016-2020, chapter 2, pag.9-10, chapter 3, pag.17-18, 26

***http://www.primaria-nehoiu.ro/wp-content/uploads/Strategia-de-dezvoltare-durabila-a-orasului-Nehoiu-in-perioada-2011-2018.pdf, pag.65, 66, 97-98

*** https://turistprinromania.com/2019/07/21/rafting-club-nehoiu/

3. Debed River Basin - ARMENIA

3.1. General Description of the Armenian partner's pilot area

The depth of the river valley reaches 350m near the town of Tumanyan.

Debed River Basin (Figure 3.1) area extends in the northern part of Armenia, bordering with Georgia and serving as a natural boundary between the two countries. It borders with Akhuryan river basin in the west, Kasakh and Hrazdan river basins in the south, as well as Aghstev and Kura basin tributaries in the east (Figure 3.2). The map shows the location of the Debed basin in the territory of the Republic of Armenia.

Figure 3.1: Debed River Valley

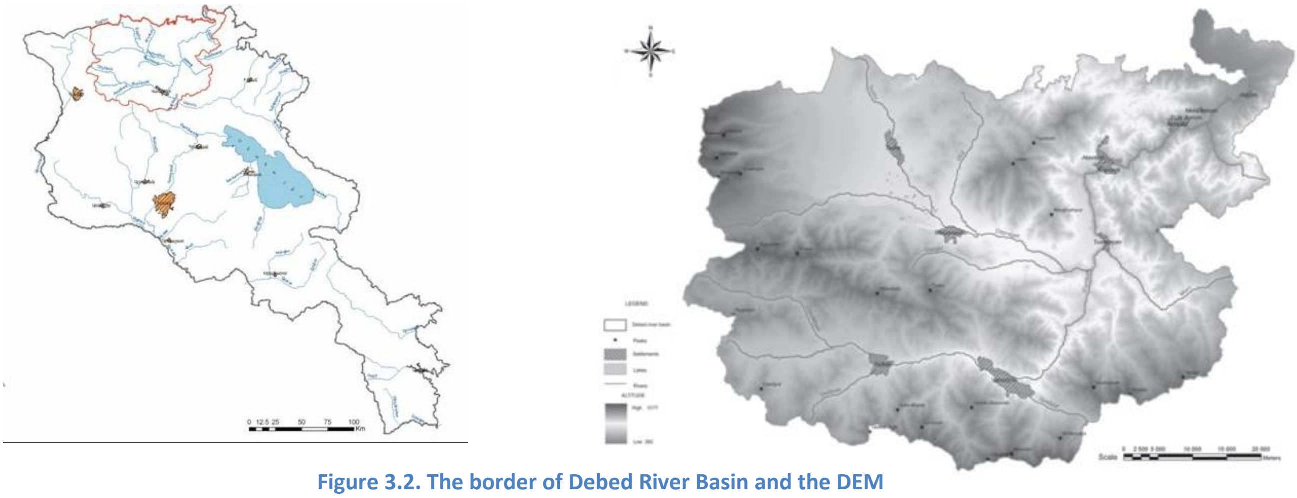


Figure 3.2. The border of Debed River Basin and the DEM

The basin area is 3,790km^2. The highest point in the basin is located at 3,196 m above the sea level, the Achqasar Mountain peak of the Javakhq Mountain range. The lowest point in the basin is also the lowest in in the basin is also the lowest in Armenia and is located at 375m above the sea level in the valley of Debedavan Village.

3.12. Settlements

The settlements here have a linear distribution and are located in river valleys, most often in the immediate vicinity of rivers. Both highways and railways run mainly through the lower reaches of river valleys.

Figure 3.3. Riverside roads and settlements

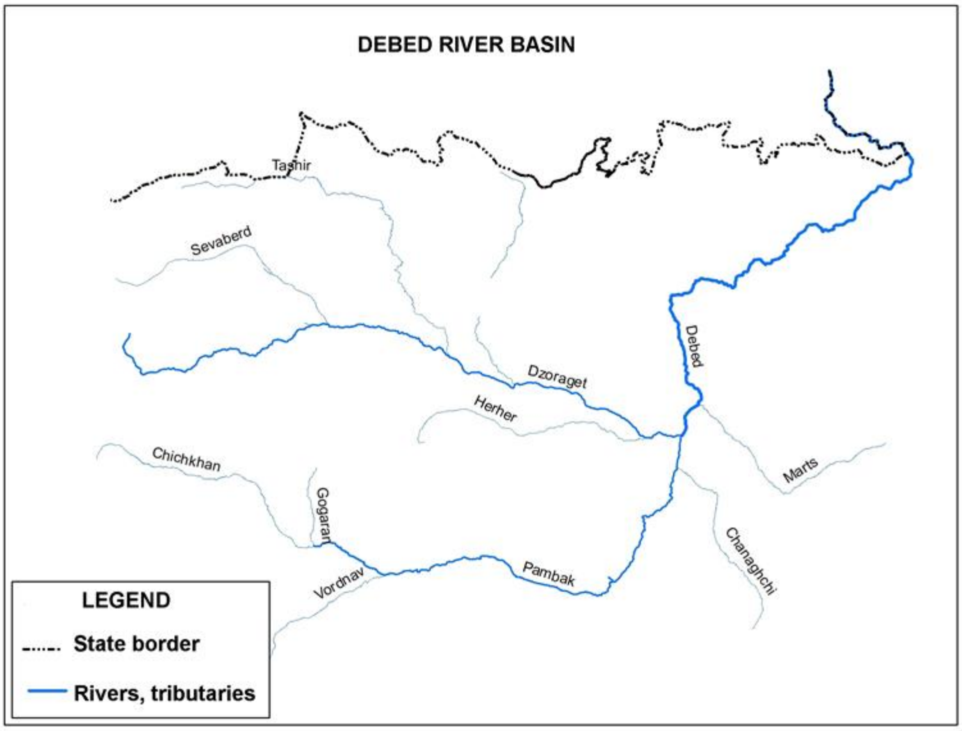


Figure 3.4. The Debed River, its tributaries and the state border

The river basin includes 133 rural and 9 urban settlements of Lori, Shirak and Tavush regions of Armenia.

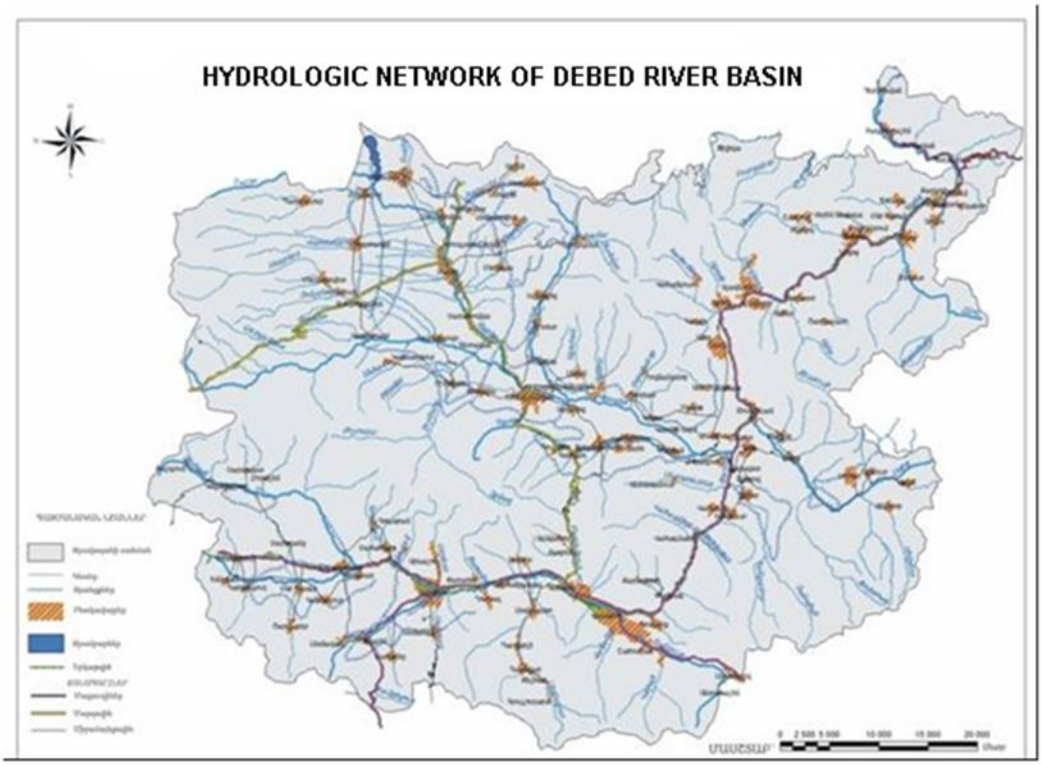


Figure 3.5. Hydrologic network of Debed River Basin

Yerevan-Tbilisi railway and Yerevan-Vanadzor-Alaverdi-Tbilisi, Vanadzor-Gyumri, Vanadzor-Tashir-Tbilisi, Vanadzor-Dilijan-Ijevan interstate highways pass through the basin of the river Debed.

Landscape diversity in the basin is presented by sub-alpine and alpine meadows and grasslands, forests and dry steppes. More than 24% of the basin area is forested, with the most of it situated on the altitudes between 2,000-2, 200m ASL.

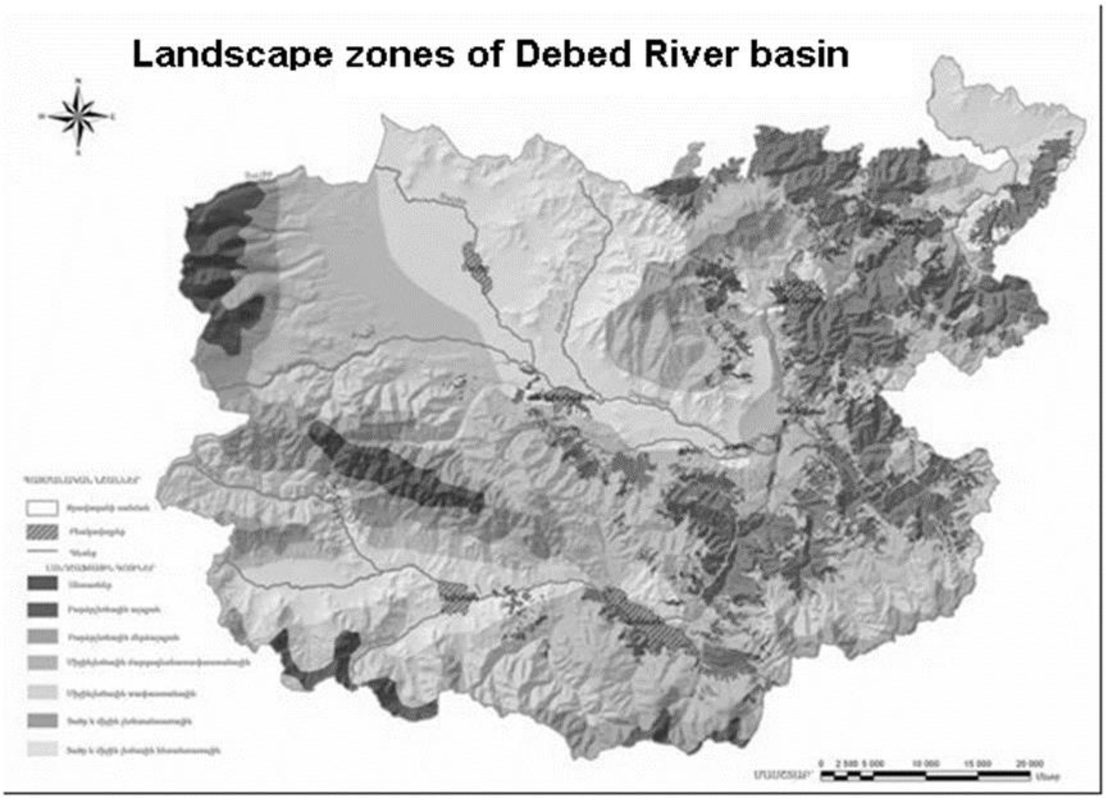


Figure 3.6. Landscape zones

3.13. Flora

Beech, Oriental and Georgian oak tree species are predominating among the others. The accompanying species include hornbeam, Eastern hornbeam, linden, ash, maple, etc., as well as wild pear, apple and etc. Juniper and blackberry are widespread in the Debed gorge, in the section extending from Alaverdi to Ayrum. Pine Island are also found in the forests. On the northern slopes of Bazum and Pambak, at altitudes of 2000-2400 m, relict Rhododendron can be found.

Cereal high-grasses reaching up to 1.0-1.5m in height can be found everywhere in the subalpine zone, and above that, alpine vegetation, which sometimes appears in the form of alpine carpets.

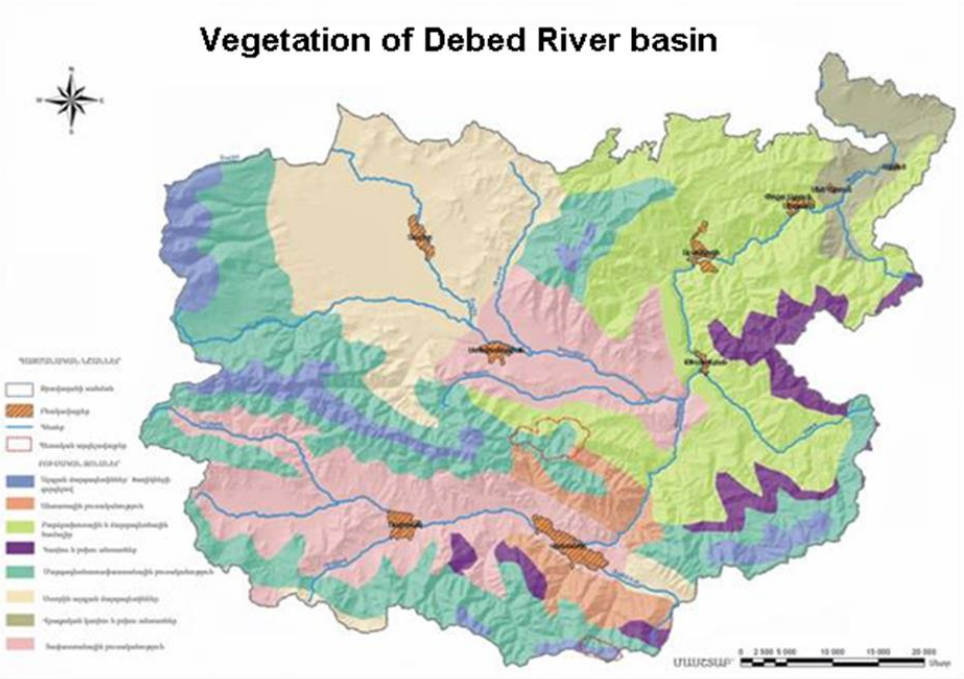


Figure 3.7. Vegetation

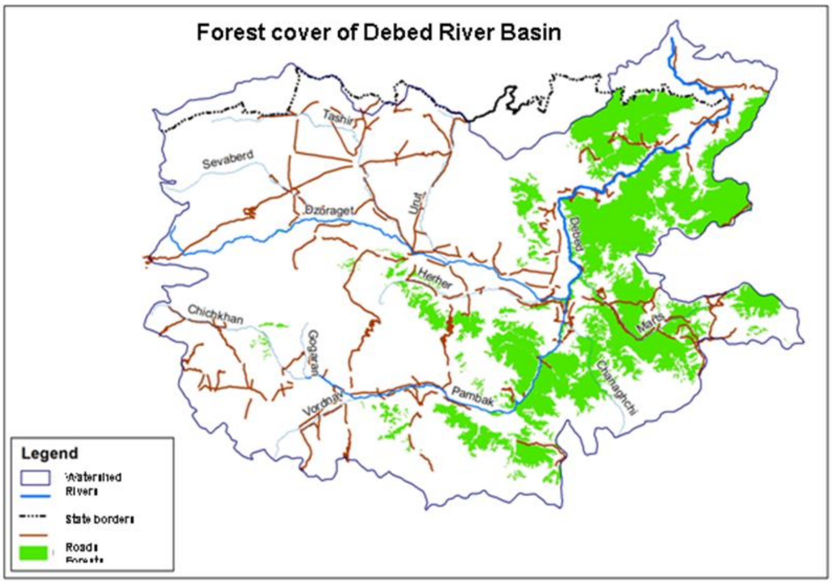


Figure 3.8. Forest cover

Figure 3.9. Riverside forest

Figure 3.10. Forest

3.14. Fauna

The area of the basin hosts a vast diversity of flora and fauna species. Specifically the local fauna is represented by brown bears, deer, boars, vultures, different types of birds, such as partridge, mosquito, woodpecker, etc. There are a number of fauna species including wolves, foxes, rabbits and rodents. Amphibians are represented by various species of snakes and lizards. Brown trout is found in the upper reaches of the tributaries of the Debed River basin, and in the middle and lower reaches of the tributaries Barbus and other fish species.

Most of the lakes in the area (Svetli Lima, Krugloe, Kuibish, etc.) are used for spawning of carp.

Figure 3.11. Fauna

In order to preserve these endangered and rare flora and fauna species, Specially protected areas of nature have been established in the Debed River basin, including - Gyulakarak sanctuary, which occupies an area of 2586 hectares, was established in 1958 and Rhododendron Caucasicum Sanctuary. Rhododendron Caucasicum is found in Armenia on humid, foggy slopes of the Javakhk, Bazum and Pambak mountain ranges at altitudes of 1900-2200 m.

3.15. Relief and Geologic characteristics of Debed River Basin

Although the area of the basin is relatively small, its complex topography includes folded mountain ranges with significant inclines of 150-200m, volcanic ranges with smaller incline, high mountains, wide inter-mountain depressions and river valleys.

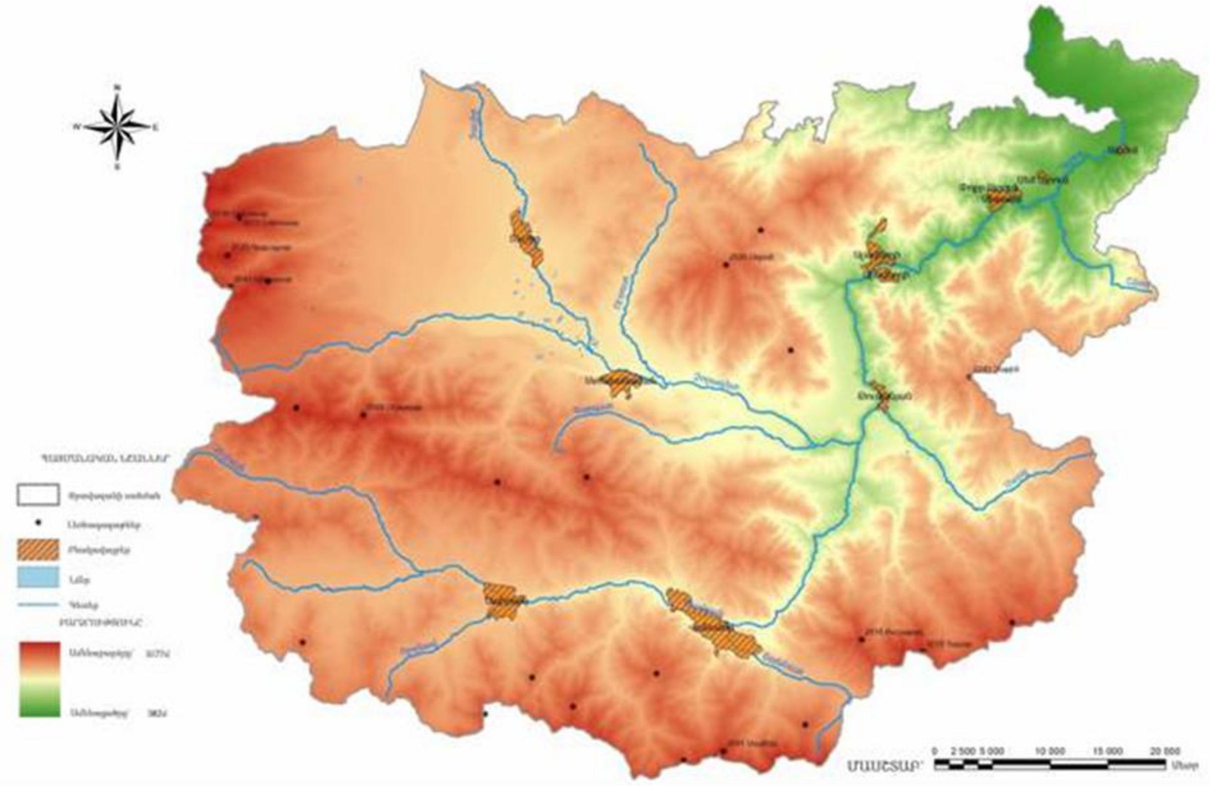


Figure 3.12. Digital elevation model

From the point of view of the topography, two mountain zones are clearly distinguished in the study area including folded mountain ranges of the Lesser Caucasus and volcanic massifs. The Bazum mountain range stretches south-east almost from the center of the river basin. Pambak mountain range, which starts from Jajur Mountain pass in the west, reaches its maximum height in the central part. The Lori plateau, which has an average height of 1400-1500 m, spreads between Bazum and Virahayots mountain ranges which is an intermountain gorge depression, reach with Neogene-Quaternary lavas and fluvial sediments. Dzoraget and Gargar rivers created deep gorges here. The area has a complex geological structure. As a result of repeated tectonic movements in different geological periods, the earth crust was bent and fractured. Two geotectonic rock complexes can be distinguished in the basin area: Precambrian-Lower Jurassic and Jurassic-Quaternary period.

3.16. Climate

Climatic conditions in the basin are also very diverse, varying from dry sub-tropical to high-mountainous zones which due to sharp height fluctuations and relief features. Precipitation across the basin is unequally distributed. In general, the basin area is under the influence of the western air movements specific to the subtropical zone and has the characteristics of a continental climate.

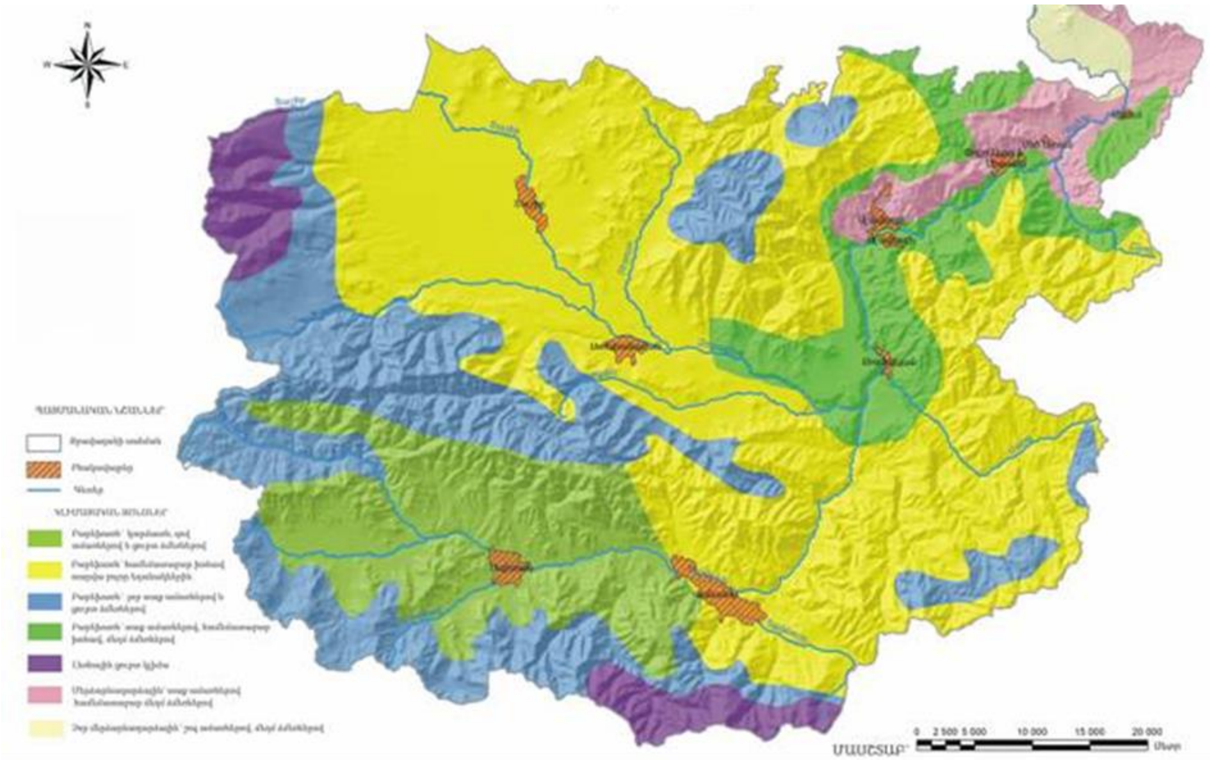


Figure 3.13. Climate zones

There were about 30 meteorological stations and observation points in the Debed basin in different years, 10 of which are operating today. The altitude of meteorological stations varies from 453 (Debedashen) to 2061 m (Pushkin mountain pass).

Cloudy weather has a significant effect on the inflow of radiant energy. Thus, in the lower reaches of the Debed River, where the annual precipitation is relatively low (450-550 mm) and the number of clear days is large, the radial balance is relatively high at 55-60 kcal / cm 2, while in the rest of the area it is 48-55 kcal/cm 2: In general, the region receives a large amount of radiant energy, the intensity of which increases with altitude. The average annual rainfall here ranges from 2000 to 2350 hours.

One of the main climatic factors in the process of flow formation of the area is the role of air temperature, the increase of which causes the evaporation to increase and the flow to decrease.

The cumulative evaporation is one of the important hydrological indicators of the area. Using the formula developed by VP Valesyan, the values of evaporation were calculated. More than 57% of the study area has an evaporation rate of 300–400 mm, which is a result of the impact of mountainous terrain. The total evaporation varies with altitude; the maximum evaporation is observed in the north-eastern foothills of the study area - 500–550 mm, and in the high mountainous areas the evaporation is 200–250 mm.

Table 3.1. Estimation of cumulative evaporation in Debed basin for the period 1960-2008, mm

Meteorological observation point	Absolute height, m	Months												Year
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Shnogh	656	14	17	28	42	65	80	69	59	49	39	24	15	501
Odzun	1127	8	14	24	37	59	74	66	55	45	33	22	12	449
Vanadzor	1350	10	14	21	34	55	70	66	57	45	32	19	12	435
Stepanavan	1397	12	16	19	34	57	71	64	57	43	32	18	14	437
Tashir	1507	12	17	18	31	52	57	64	55	43	30	18	16	413
White	1552	12	15	17	33	50	61	55	50	40	31	18	16	398
Lermontovo	1797	10	11	16	29	56	63	59	56	39	29	17	11	396

The role of atmospheric precipitation is especially important among climatic factors. Atmospheric precipitation is unevenly distributed in the Debed River basin, which is due not only to the general circulation of the atmosphere, but also to the complex mountainous terrain of the area, under the influence of which the infiltrating air masses are subject to certain changes. In general, precipitation is higher in the western and southern regions of the area than in the northeast.

Table 3.2. Intra-year distribution of atmospheric precipitation in the Debed basin for the period of 1960-2008, mm

Meteorological observation point	Absolute height, m	Months												Year
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Debedashen	456	17	18	36	44	67	75	44	35	32	36	27	13	444
Akhtala	570	13	17	29	43	69	72	47	37	29	36	26	13	431
Alaverdi	721	15	21	36	52	83	88	57	41	36	41	31	15	516
Gargar	987	17	23	35	58	93	110	64	46	41	41	35	17	580
Tumanyan avan	1200	18	24	36	60	95	113	66	48	42	41	36	18	597
Vanadzor	1350	16	22	37	88	97	125	66	73	40	43	35	19	660
Stepanavan	1397	18	19	39	90	97	157	77	85	41	40	29	20	712
Tashir	1507	24	20	42	109	141	213	96	105	50	54	40	26	920
Urasar	1547	24	31	47	78	126	133	94	63	63	55	47	24	785
Spitak	1552	14	16	26	48	72	73	47	34	30	38	27	14	439
Metsavan	1573	20	26	41	66	107	112	73	59	53	46	40	20	663

Meteorological observation point	Absolute height, m	Months												Year
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Katnarat	1602	26	33	55	89	145	145	95	75	52	54	42	24	835
Shirakamut	1681	19	26	38	80	108	108	64	51	38	51	39	26	648
Pushkin mountain pass	2061	25	25	57	114	109	137	75	82	53	60	44	25	806
Odzun	1127	19	28	33	70	91	141	60	76	40	37	20	11	625

3.17. Hydrology

The hydrographic network of the area is characterized by a very uneven distribution. The length of the Debed River, including the source of Pambak, is 176 km. Pambak originates from the eastern foothills of Jajur, at an altitude of 2090 m. There are more than 1356 rivers 55 of which are 10 km and longer in the Debed system, which is formed from the confluence of the Pambak and Dzoraget rivers. Tashir, Chknagh, Urut, Gargar are relatively large tributaries of Dzoraget. Among the tributaries of Pambak are Lernapat, Tandzut, Alarex, and among the tributaries of Debed are Marts and Shnogh.

Table 3.3. Tributaries of Debed river

h/h	Name of the river	Flows to	Distance to the estuary, km	Length, km Basin area, km2	Length, km Basin area, km^2
1	Debed	Khram	15	176	4080
2	Tsaghkashen	Pambak	145	11	45.3
3	Chichkan	Pambak	136	29	192
4	Gogaran	Pambak	135	10	25.5
5	Shenavan	Pambak	132	10	14.2
6	Odzidzor	Pambak	128	12	19.0
7	Vordnav	Pambak	127	18	92.0
8	Pamb	Vordnav	9.5	11	25.0
9	Lernanck	Pambak	124	10	30.0
10	Karadzor	Pambak	123	11	23.0
11	Lernapat	Pambak	117	18	126
12	Karachoba	Lernapat	6.2	11	33.0

h/h	Name of the river	Flows to	Distance to the estuary, km	Length, km Basin area, km2	Length, km Basin area, km^2
13	Bazum	Pambak	113	17	47.2
14	Tandzut	Pambak	100	23	141
15	Garpi	Tandzut	6.0	11	43.0
16	Vanadzor	Tandzut	1.7	14	40.0
17	Vahagn	Pambak	94	12	39.0
18	Alarex	Pambak	87	24	115
19	Antaramut	Pambak	86	12	30.0
20	Dzoraget	Debed	84	67	1460
21	Sarzan	Dzoraget	46	18	28.9
22	Pokh	Dzoraget	42	10	24.0
23	Lori	Dzoraget	40	29	110
24	Chomcha	Lori	7.0	10	22.2
25	Metsaru	Dzoraget	36	12	37.3
26	Tashir	Dzoraget	28	50	470
27	Sarnaghbyur	Tashir	27	17	48.0
28	Karanikh	Tashir	26	23	58.0
29	Irgan	Քարանիխ	1.6	19	26.5
30	Metsavan	Tashir	22	11	25.5
31	Norashen	Tashir	18	12	43.5
32	Vardaghbyur	Tashir	15	20	50.0
33	Ananun	Tashir	12	12	22.0
34	Medovka	Tashir	11	15	40.1
35	Chknagh	Dzoraget	26	28	163
36	Deghin	Chknagh	14	12	35.4
37	Spitak	Chknagh	9.0	12	19.0
38	Urut	Dzoraget	21	29	156
39	Cheremsha	Urut	20	10	31.4
40	Lejan	Dzoraget	19	11	20.3
41	Mendzor	Dzoraget	17	10	31.5

h/h	Name of the river	Flows to	Distance to the estuary, km	Length, km Basin area, km2	Length, km Basin area, km^2
42	Hovnanadzor	Dzoraget	14	15	40.8
43	Koghes	Dzoraget	9.0	4	4.5
44	Gargar	Dzoraget	4.0	26	129
45	Marts	Debed	80	29	252
46	Ahnidzor	Marts	19	14	61.0
47	Geghatar Gomer	Ahnidzor	1.4	12	30.7
48	Sarnaghbyur	Marts	12	17	55.2
49	Kachachkut	Debed	70	11	55.0
50	Alaverdi	Debed	65	10	36.0
51	Ajir	Debed	60	15	66.0
52	Kistum	Ajir	5.5	10	21.8
53	Akhtala	Debed	49	14	48.4
54	Shnogh	Debed	44	19	153
55	Gulyab	Shnogh	13	11	33.4

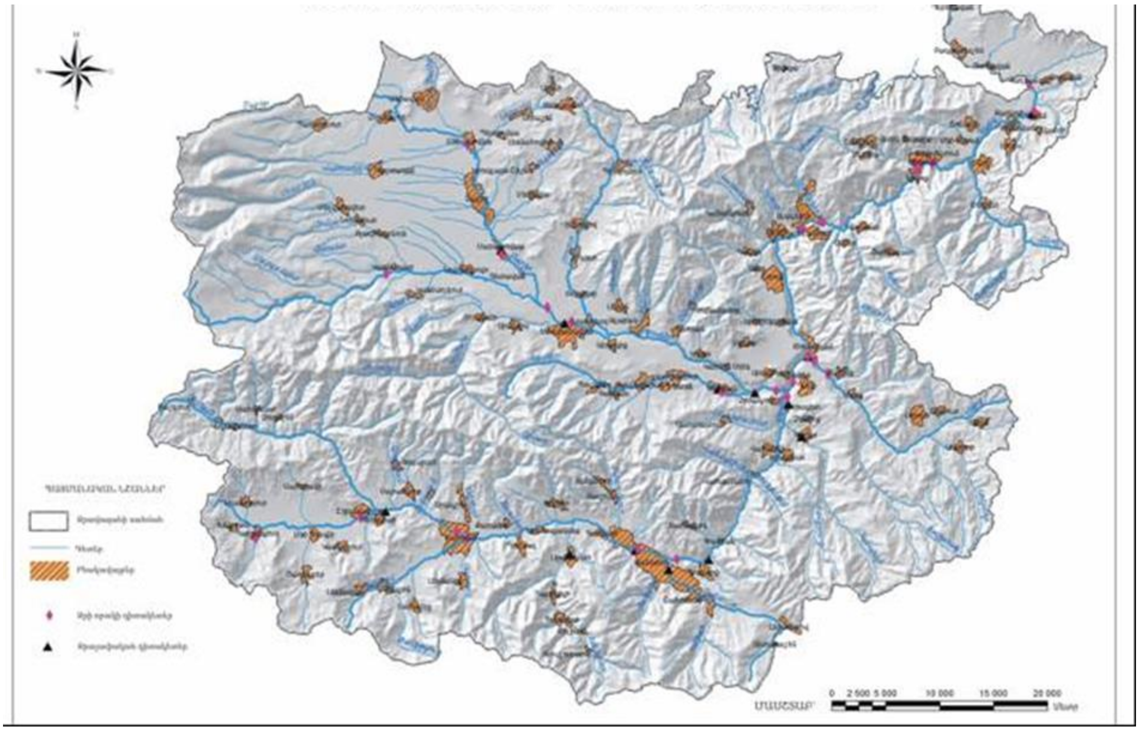


Figure 3.14. Monitoring network of the river basin

Table 3.4. The main dimensional characteristics of large tributaries of the Debed River

h/h	Name of the river	Mark at the source, m	Mark at the river mouth, m	Length, km	Average slope, ‰	Basin area, km^2
1	Pambak	2100	870	92	13.0	1370
2	Chichkhan	2250	1608	29	22.0	192
3	Dzoraget	2320	870	67	22.0	1460
4	Tashir	2900	1355	54	31.0	470
5	Chknagh	2420	1320	28	39.0	163
6	Gargar	2300	981	26	51.0	129
7	Marts	1980	829	29	40.0	252

Only 11 rivers in the Debed Basin are 20 km and longer. The average density of the river network is 0.84 km / km2, but it increases with the height of the area. In total, there have been established about 50 water metering points, 13 of which are currently operational. One of the important features of the rivers in the study area is that their feeding is mixed. The rivers feed on rainwater, snowmelt and partly groundwater and due to mixed feeding conditions almost all the rivers in the study area have an unstable regime, with consequent large fluctuations in water flow rate.

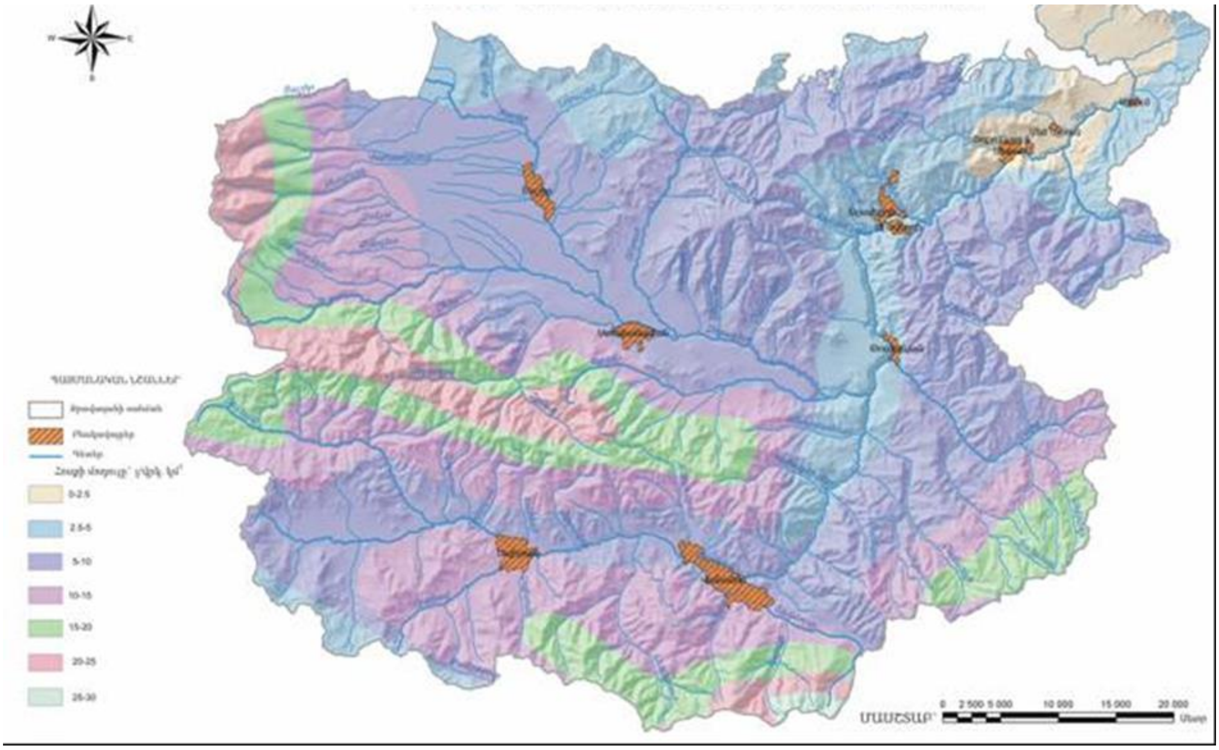
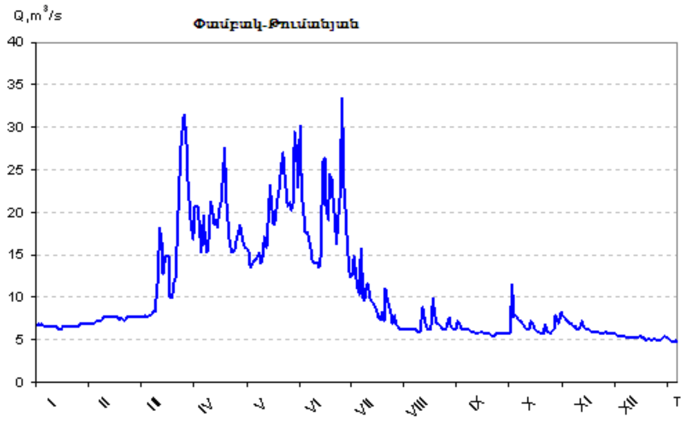


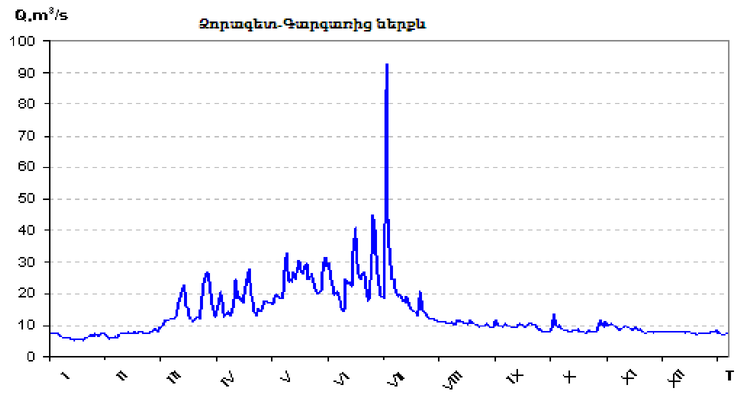
Figure 3.15. Flow module of Debed River Basin

The flow module in the Debed River basin changes from 0.5-2.5 to 25-30 l / s. km2 and at one point, reaching the highest value near the peaks of the high mountains. River flooding occurs from mid-March to mid-July, peaking in May. The second, weakest phase of the flood is observed in September-October. Thus, about 70% of the annual flow of Debed is observed in spring and early summer. This is due to the spring snowmelt and the maximum precipitations observed during this season. Due to the large differences in altitude in the river basin, the snowmelt is gradual, due to which the flood season is extended until mid-summer. Daily average discharge graphs with different water regime of Debed river basin.

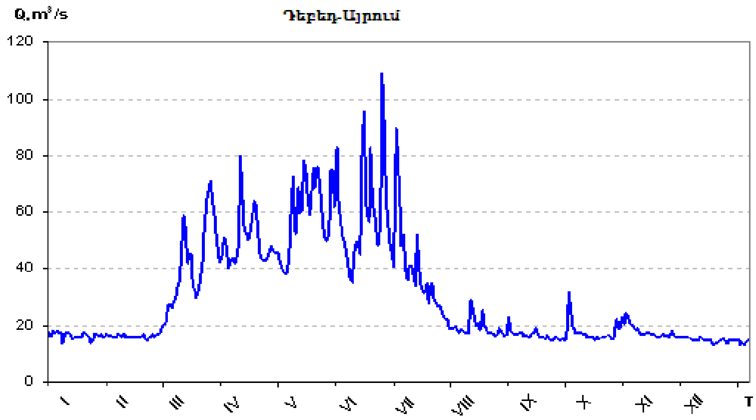
Pambak-Tumanyan



Dzoraget-downstream Gargar



Debed-Ayrum



3.18. Anthropogenic pressures and impacts

Main sources of anthropogenic pressures in the Debed River Basin are: water abstraction, domestic and mining wastewater, agriculture, food and non-food industry, hydropower plants, solid waste and transport. As of January 1, 2010, population in the basin was 289,500 of which 58.4% is urban, 41.6% is rural population. However, difficult socioeconomic situation, political and other factors led to large scale emigration, which also continues today. There is some internal migration from previously active industrial urban settlements to rural where the main occupation is agriculture.

The pressures on river water quality from agricultural activities are due to Nitrogen and Phosphorus penetrating groundwater and rivers due to washing of manure through snowmelt or rainwater. Application of fertilizers in the basin is insignificant due to high prices which are not affordable for farmers.

Transport is considered as one of the significant pollution sources in the Debed Basin, because the interstate roads, as well as the railroad from Armenia to Georgia (Yerevan-Vanadzor-Alaverdi-Georgia) which is intensively used for transportation of goods, pass through the basin. Significant section of these roads goes immediately near and along the river and affects water quality through road runoff, oil spills, atmospheric pollution, which are the sources of Nickel, Copper, Zink, Cadmium, Lead and fuel combustion by-products.

Mining industry presents significant risks for several water bodies within the Debed system due to wastewater discharge into the surface waters. Mining wastewater contains heavy metals (Copper, Zink, and Cadmium), sulphates and ammonium which pollute the rivers Alaverdi, Akhtala and Debed. The largest mining industries in the basin are Alaverdi Copper smelter and Akhtala Ore Mining Enterprise. Armanis and Akhtala poly-metallic mines produce gold and copper. Sulphur dioxide emissions by Alaverdi Copper Mining Factory are the source of sulphuric acid which eventually ends up in the river through precipitation.

Existing tailing dams do not fulfil their environmental functions. Chochkan tailing dam previously serving for Akhtala Ore Mine is full and in-operational, and pollutants are washed off the surface with precipitation into the Debed River. Armanis tailing dam is currently under construction. In addition, mining industry is one of the largest water users in the basin. There are solid waste open landfills for each of the main cities in the basin: Vanadzor, Spitak, Tashir, Stepanavan, Tumanyan and Alaverdi.

However, they do not comply with the sanitary requirements, and were constructed without environmental impact assessment. In terms of source of pressure on local water bodies the most significant is Vanadzor landfill, since it contains also industrial solid waste and is located downstream of the city near the road. Thus, the most affected by solid waste is the section of Pambak River from Vanadzor to confluence with Dzoraget.

3.19. Pressure-impact analysis

Based on the basin characterization information and pressure-impact analysis, new EU WFD compliant monitoring program for the Debed Basin has been proposed and tested during the 2012 with support from the EU Kura Project. One station was proposed for each water body and included the existing stations, where possible, to ensure long data series.

Location of sampling sites considered their representativeness in terms of anthropogenic pressures, hydromorphology and accessibility of the given water body. Based on the results of the three rounds of sampling and analysis, water bodies within the Debed River Basin have been classified according to the five EU WFD classes: high, good, moderate, poor, bad.

Sampling was conducted in 23 sampling sites according to the proposed monitoring plan according to the following schedule: 1) May -early June 2012 (higher river flow, beginning of vegetation season); 2) August - early September 2012 (lower river flow, peak of vegetation season); 3) October 2012 (low river flow, end of vegetation season).

Laboratory analysis was conducted using standardized methods for the physico-chemical quality elements and parameters. According to the obtained results the water quality risks associated with anthropogenic pressures in the Debed Basin can be divided into two main groups: caused by biogenic elements (Nitrogen and Phosphorus) and by heavy metals (such as Copper, Cadmium, Lead, and Zink). In the 15 out of the 23 sampling sites water quality fell below the Armenian quality class II, corresponding to the EU WFD “good” status, and were defined as Water Bodies at Risk.

In order to better understand human impacts on surface water quality in the rivers, monitoring programs need to be revised periodically based on the outcomes of the analysis of the most recent monitoring data. Updated monitoring will help to evaluate measures targeted at improved ecological status of water bodies. In order to meet the EU WFD requirements it is absolutely necessary to establish Biological Monitoring Laboratory and include biological monitoring (which, in fact, costs less than chemical monitoring) in the state monitoring program. State budget allocations should be made for implementation of the program of measures for improved water quality in the basin. The water quality of the river basin for the 2017 and 2018 are given below. Source: Statistical Committee of the Republic of Armenia

Table 3.5. The main dimensional characteristics of large tributaries of the Debed River

observation points	pollutants	2017	2018
point N5	BOD5, Number of samples, times	11.000	10.000
point N5	BOD5, Maximum annual concentration, mg of O2 /liter	4.490	4.140
point N5	NH4, Number of samples, times	11.000	10.000
point N5	NH4, Maximum annual concentration, mg of N /liter	0.311	0.210
point N5	Total phosphorus, Number of samples, times	11.000	10.000
point N5	Total phosphorus, Maximum annual concentration, mg of P/liter	0.133	0.110
point N5	Nitrates, Number of samples, times	11.000	10.000
point N5	Nitrates, Maximum annual concentration, mg of NO3/liter	3.052	2.930
point N5	Phosphates, Number of samples, times	11.000	10.000

observation points	pollutants	2017	2018
point N5	Phosphates, Maximum annual concentration, mg of P/liter	0.289	0.260
point N6	BOD5, Number of samples, times	11.000	10.000
point N6	BOD5, Maximum annual concentration, mg of O2 /liter	4.890	5.180
point N6	NH4, Number of samples, times	11.000	10.000
point N6	NH4, Maximum annual concentration, mg of N /liter	0.587	0.200
point N6	Total phosphorus, Number of samples, times	11.000	10.000
point N6	Total phosphorus, Maximum annual concentration, mg of P/liter	0.134	0.140
point N6	Nitrates, Number of samples, times	11.000	10.000
point N6	Nitrates, Maximum annual concentration, mg of NO3/liter	3.256	2.930
point N6	Phosphates, Number of samples, times	11.000	10.000
point N6	Phosphates, Maximum annual concentration, mg of P/liter	0.304	0.360
point N7	BOD5, Number of samples, times	11.000	10.000
point N7	BOD5, Maximum annual concentration, mg of O2 /liter	5.020	4.690
point N7	NH4, Number of samples, times	11.000	10.000
point N7	NH4, Maximum annual concentration, mg of N /liter	0.276	0.200
point N7	Total phosphorus, Number of samples, times	11.000	10.000
point N7	Total phosphorus, Maximum annual concentration, mg of P/liter	0.134	0.120
point N7	Nitrates, Number of samples, times	11.000	10.000
point N7	Nitrates, Maximum annual concentration, mg of NO3/liter	3.300	3.000
point N7	Phosphates, Number of samples, times	11.000	10.000
point N7	Phosphates, Maximum annual concentration, mg of P/liter	0.319	0.270

3.20. Soils

The land cover of the Debed River Basin is remarkably diverse. This is due to many land-forming factors: mountainous terrain, lithologic composition of various rocks on the earth's surface, different hydrothermal conditions, diverse flora and fauna, etc. This process was greatly facilitated by the land use, the use of various agricultural systems, especially irrigation. The upward zonal distribution of the main factors of land formation, in turn, contributed to the development of the genetic land types. As the river basin is characterized by a mild, humid climate, there are a few soil types that are typical of the Araks Basin, which has a dry and hot climate. For example, there are no semi-desert gray soils, mountainous soils. The most common soil types in the basin are mountain soils, forest gray-brown soils, as well as mountain-meadow-steppe and mountainous-forest soils.

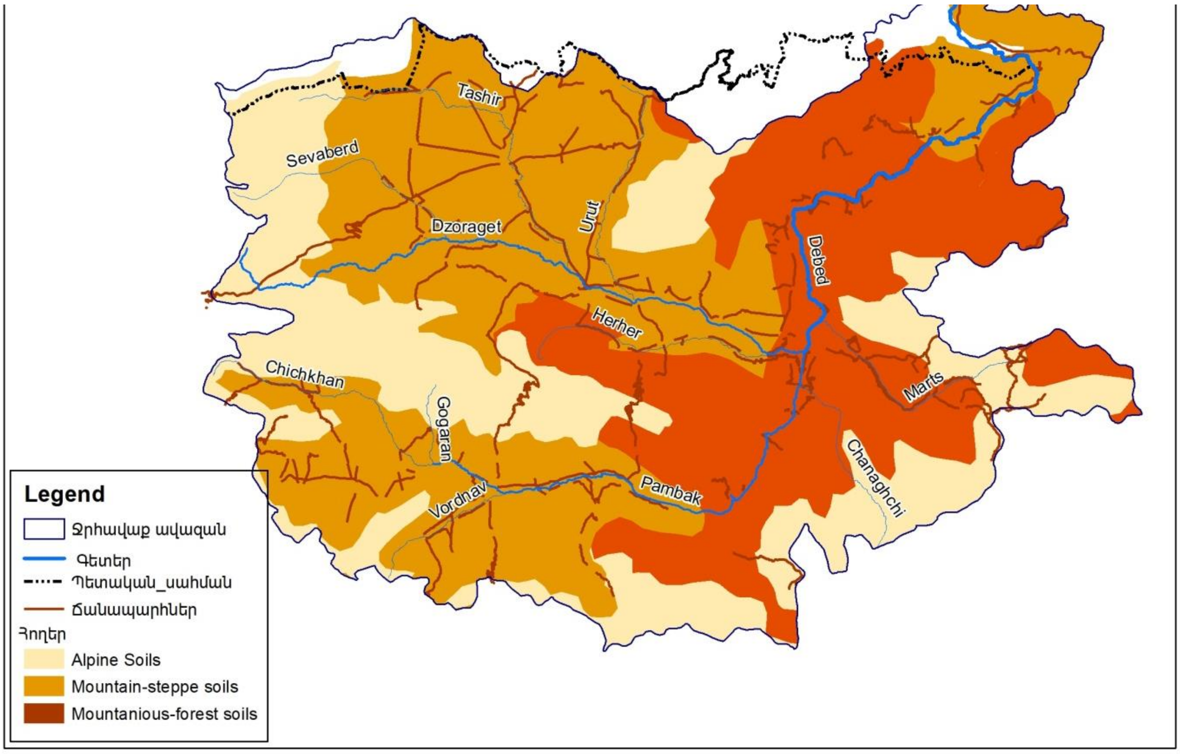


Figure 3.16. Main soil types in the river basin

3.21. <u>Erosion & Climate Change</u>

Due to the economic crisis in the Debed river basin, about 15% of the entire forest, which is about 14,000 hectares, has been deforested. Deforestation has had an impact on the amount of water quantity and regime, which has resulted in intensification of erosion processes like in Tandzut River, where erosion was intensified due to deforestation, which has led to an increase in the amount of alluvial sedimentation in the river and a changed the entire flow regime. However, this pressure is not considered significant because the amount of water has not decreased.

Climate change is inevitably occurring in the world and in Armenia particularly. The increasing trends in the mean annual temperature, the mean daily minimum temperature, and mean daily maximum temperature over the last century are vivid markers of already happening reality, although there are no trends observed in mean annual precipitation, or the number of wet days per year. All the climate models forecast a significant increase of the mean annual temperature by the end of the century by 4 °C to 5.1 °C in Armenia.

3.22. Cultural values and tales

There are numerous historical monuments in the coastal area of Debed: Haghpat, Sanahin, Akhtala, Kobayr, Karsnits Mankanc Monastery, Bardzrakash St. Gregory Church and etc.

Figure 3.17. Sanahin and Haghpat Monastic complexes

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4. Baltata River Basin - MOLDOVA

4.1. Introduction

Small rivers, or rivers with a channel length from 10 to 100 km, play a significant role in the formation of water resources. Being mainly tributaries of higher order rivers they contribute to the formation of both local and large river flows. Moldova's hydrographic network has 126 small rivers. However, a situation on these rivers remains unfavorable, and not only because of their low water content (Trombitsky, 2018). Most of them are dirty, strongly transformed and dried out, sometimes being on the verge of complete disappearance. The main reason for such situation is creation of illegal artificial reservoirs in their catchment and a large number of pollution sources. In particular, most nearby settlements dump their household waste both into permanent and temporary watercourses in the conditions of poor performance of existing treatment facilities and unsustainable land use.

The problem is aggravated by a fact that in many cases a water abstraction from small rivers is carried out by land tenants for personal needs or for illegal creation of artificial ponds, without appropriate permission and availability of project documentation. As a result, the small river channels change, they lose their sources and tributaries, and a surface runoff either evaporates or seeps underground. The prevalence of evaporation over precipitation, especially in conditions of the warming climate, in combination with intense pollution and the absence of water protection zones, leads to small rivers drying up. This seriously affects the general state of water and riparian ecosystems. Day by day, most small Moldova' rivers become more and more polluted and unsuitable for any type of water consumption. Some examples are presented in photos below (Fig. 4.1).

Figure 4.1. Some examples of Moldova's small rivers pollution as of 2020

For addressing the *BSB963* Project's tasks and correct understanding the nature and consequences of small rivers pollution for general sediments and pollution of the Black Sea, as well as for the development of adequate responses to emerging problems and challenges, and the adoption of informed decisions, the Baltata River — a fairly typical small river of Moldova — was selected as the Pilot area of PP4's activities.

4.2. Study area: general characteristics

The Baltata River is a right tributary of the Dniester River – one of main Moldavian rivers that flows into the Black Sea (Fig. 4.2). Thus, the surface pollution and litter entering its mainstream are directly transported to the Black Sea. Namely this factor has based choosing this river basin as a pilot area. Moreover, this river as one of Moldova' small rivers presents current situation in other analogous basins of the country.

The pilot area has 153.9 km^2; its length from northwest to southeast is 27.47 km, the width – 7.74 km. It is located within three administrative units: Chisinau municipality, Criuleni and Anenii Noi rural rayons, occupying respectively 35%, 64.9% and less 0.1% of the pilot area. In total, the basin includes 19 communities (Table 4.1), but practically completely – only three of them. The largest part, lying in the basin, has Balabanesti (3,233 ha), the smallest – Cobusca Veche (73 ha) (Kuharuk e.a., 2020a,b). The basin includes 13 rural settlements and a very small part of Chisinau. *The total population leaving in the pilot area, as of January 2020, is about 44,760.*

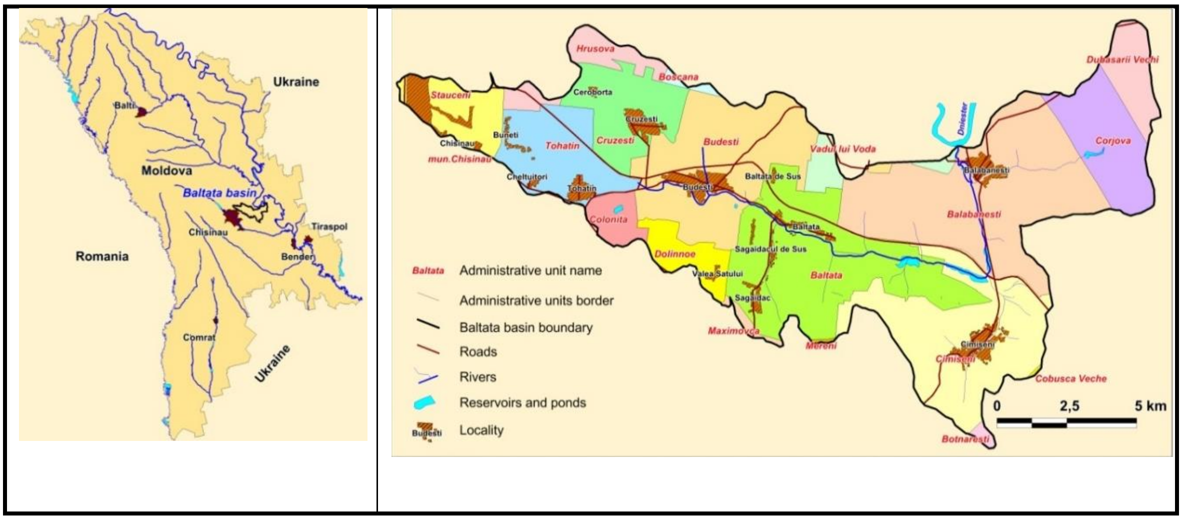


Figure 4.2. Baltata basin on the map of Moldova (left) and its administrative division (right)

4.12. Initial material and methods

The description of the pilot area - the Baltata river basin - was mainly carried out, using the available literature and statistical information on this region. In part, the available information was supplemented by a visit to the study area, with conducting the field surveys and the selection of sites for further research. The climatic and hydrological information was kindly provided by the Hydrometeorological Service of the Republic of Moldova.

Table 4.1. Distribution of the pilot area by administrative units

№	Administrative unit	Area			
		Total, sq.km^2	Part in the basin, sq. km^2	Part in the basin. %	Part of the unit, %
1	Balabanesti	46.11	32.33	70.11	19.42

2	Baltata	27.88	27.28	97.84	16.38
3	Boscana	30.61	0.55	1.80	0.33
4	Botnaresti	16.22	0.44	2.74	0.27
5	Budesti	28.79	23.43	81.39	14.07
6	Cimiseni	29.94	23.11	77.17	13.88
7	Cobusca Veche	39.53	0.07	0.18	0.04
8	Colonita	26.36	3.01	11.43	1.81
9	Corjova	24.47	10.51	42.96	6.31
10	Cruzesti	10.76	10.37	96.33	6.23
11	Dolinnoe	15.60	4.34	27.81	2.61
12	Dubasarii Vechi	65.97	5.01	7.59	3.01
13	Hrusova	32.33	4.40	13.61	2.64
14	Maximovca	11.18	0.68	6.09	0.41
15	Mereni	65.97	0.11	0.16	0.06
16	Chişinau	122.20	0.07	0.06	0.04
17	Stauceni	28.26	6.84	24.20	4.11
18	Tohatin	15.93	11.35	71.28	6.82
19	Vadul lui Vodă	14.77	2.593	17.55	1.56
	Baltata basin	**652.87**	**166.49**	**25.5**	**5.26**

The methods to perform a research were determined by the nature of the problem being solved. In particular, along with the study, analysis and description of the available literary sources, a certain statistical processing of long-term observation series was also required. First of all, such an approach was required for describing the Baltata River flow and historical climate in its basin. In more detail, the concrete methods and approaches, which were used, are described when presenting the results obtained.

4.4. Relief and land use

Most of the Baltata basin is located within the steppe zone; a smaller northwestern part – in the forest-steppe zone (e.g., Fig. 4.3).The relief of the basin is predominantly flat; in the lower reaches of the river it is low, in the upper reaches and in the watershed part – an elevated plain. The absolute marks of heights vary from 16 m to 219 m, averaging 120 m. The slopes of the territory vary from sub-horizontal to steep (about 17°), on average being 40°28´ (Fig. 4.4). Slopes from 2° to 5° are most common, and horizontal surfaces are less than 0.1%. The western rhumbs predominate (30%), the eastern and southern ones are slightly less (by 26% each); the even more rare rhumbs are northern and northeastern (18%).

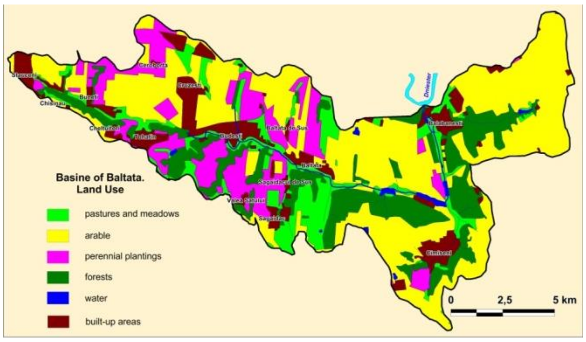
Figure 4.3. The Baltata catchment space image (left), its typical landscape (center) and steppe zone (right)

The principal land uses in the pilot area are agriculture, forests, pastures, meadows, perennial plantations and built-up plots. 46.2% of the land is occupied by agricultural crops, which cause a large load on soils. Perennial plantations and pastures occupy 13.8% and 11.4%, respectively. Only 17.4% of the basin's territory is covered by forests (Fig. 4.5: Table 4.2 and 4.3). The landscape of the region contains also forest-steppe and purely steppe elements. As a result of intensive farming and its low culture, the Baltata basin's soils are degraded above 29% (Kuharuk et al., 2020 a,b).

Figure 4.4. Slope in the Baltata basin, degrees

Table 4.2 Distribution of lands in the Baltata basin by types of using and individual administrative units

Name Admin. unit	Area in basin, km2	Area under and land use, km2					
		Build-up	Arable	Perennial	Forest	Pasture	Water
Balabanești	32,33	2,26	19,41	0,73	7,53	2,15	0,25
Balțata	27,28	2,35	4,62	3,82	8,50	7,77	0,21
Boșcana	0,55	0,19	0,24			0,12	
Botnarești	0,44		0,42			0,02	
Budesti	23,43	3,02	8,63	6,49	2,83	2,45	0,01
Cimișeni	23,11	2,70	14,24	0,88	3,85	1,00	0,43
Cobusca	0,07		0,07				
Colonița	3,01	0,04		1,22	1,10	0,59	0,07
Corjova	10,51	0,29	9,62	0,05	0,25	0,21	0,09
Cruzești	10,37	1,93	5,24	2,17	0,01	1,03	
Dolinnoe	4,34	0,23	0,05	2,55	1,03	0,48	
Dubăsarii Vechi	5,01	0,09	4,92				
Hrușova	4,40	0,71	0,86	2,48	0,21	0,14	
Maximovca	0,68	0,00	0,51		0,00	0,17	
Mereni	0,11		0,10		0,00	0,00	
Chișinău	0,07	0,03	0,01		0,00	0,03	
Stauceni	6,84	1,62	3,11	0,57	0,89	0,65	
Tohatin	11,35	2,12	4,87	1,51	1,84	1,01	
Vadul lui V.	2,59	0,01	0,07	0,48	0,86	1,17	
Total	**166,5**	**17.6**	**77.0**	**22.9**	**28.9**	**19.0**	**1.1**



Landuse type	Area	
	km2	%
Pastures and meadows	19.0	11.4
Arable	77.0	46.2
Perennial plantings	22.9	13.8
Forests	28.9	17.4
Surface water	1.1	0.66
Built-up areas	17.6	10.6
Total	166.5	100

Fig. 4.5. Map of land-use in the Baltata basin

Table 4.3. Land-use distribution in the Baltata basin

4.5. Soil types and erosion processes

The most important feature of Moldova'a soils is their diversity: more than 700 types (Krupennikov, 1985). For example, only Tohatin village in the Baltata basin has more than 40 types of soils. Thanks to such soils diversity, there is an opportunity to grow grapes, fruit, tobacco, grain and industrial crops. A second important feature of Moldova soils is the large percentage (about 70%) of chernozem (*black soil)* that has different subtypes: typical, ordinary, podzolic, carbonate, leached, etc. Typical chernozem contains more than 6% of humus down to 1.20 m depth with a maximum (100) soil bonitet score (Fig. 4.6).

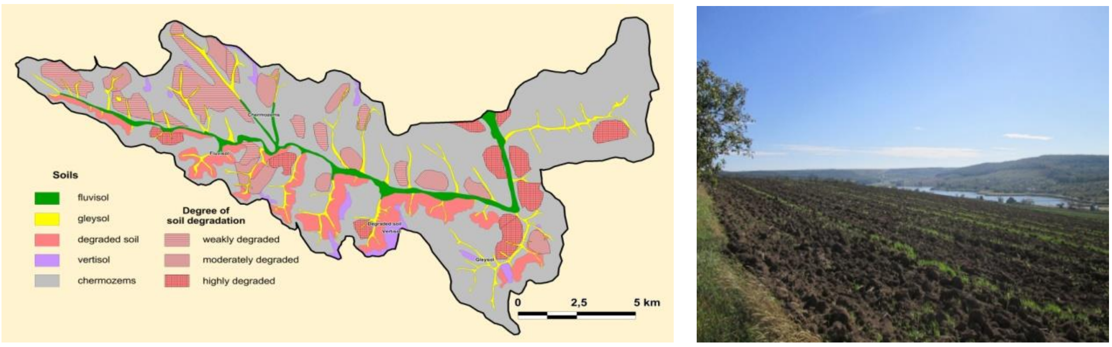


Figure 4.6. A soil map of the Baltata catchment (leftt) and an ordinary chernosem area (right)

Usually, main relief characteristics, along with a degree of fragmentation, slopes lengths and shape, significantly steep slopes, etc., include local erosions' depth and base levels. Since these and other morphometric parameters form a very complex system, it becomes impossible to give a single relief characteristic. Therefore, based on individual features, the differentiated approaches to each river catchment and even slope are required.

The Baltata basin belongs to the soil region of leached chernozems of the eastern and southern spurs of the Codru forest-steppe, with a clear manifestation of the altitudinal differentiation of landscapes and soils. However, in general, the soil cover of the basin is complex and heterogeneous; it is presented not only by all subtypes of chernozems, but also by forest and alluvial soils of river floodplains. Watersheds and floodplains account for a third of the territory. Mostly, they are presented by gentle slopes (40% of the area) and low gradient slopes (more 10%), which is half as much as in the higher Codru Mountains. Here there are many ravines where erosion and land slide processes are especially manifested. Light clays and heavy loams predominate. In general, the soil-forming rocks are heavier in granulometric compositions than in any other area of the Central Moldavian soil province.

The intensity of the *soil erosion* manifestation is also largely determined by the relief of an area, the main indicators of which are usually degree of surface dissection, depth of local bases of erosion, length and shape of slopes. In Moldova, depending on the relief morphometric characteristics, the degree of soil erosion manifestation is estimated by five degrees (Table 4.4).

Table 4.4 Dependence of the soil erosion intensity on relief morphometric characteristics in Moldova

Degree of erosion	Hydrographic network	Average slope length, m	Erosion base depth, m	Part of area (%) of slopes different steepness (degree)	
				More 20°	*More 60°*
Insignificant	0,3	<300	>50	20	5
Weak	0,3-0,5	300-500	50-70	20-40	5-10
Medium	0,5-0,6	500-700	100-100	40-50	10-20
Strong	0,6-0,7	700-1,000	100-150	50-70	20-25
Very strong	>0,7	>1,000	<150	>70	>25

Source: Ursu (2000)

The Baltata basin soils are affected by erosion processes. About 60% of its carbonate and ordinary chernozems are subject to various types of erosion, which require anti-erosion measures. Without such measures the slightly eroded soils pass usually into the category of moderately eroded ones. The situation with eroded lands, assessed in the pilot are according to Moldavian classification, is shown in Table 4.5 and Figure 4.7.

Table 4.5 Area of eroded lands in the Baltata basin, ha

Locality	Area of eroded lands			Total
	Weak	Medium	Strong	
Мэлэешть	55	149	122	326
Balabaneşti	350	73	14	437
Baltata	541	119	77	737
Будешть	452	296	86	834
Крузешты	225	53	17	295
Тогатин	138	92	39	269
Ставчены	648	194	143	985
Total	2,409	976	498	3,880
Percent	18.2	7.4	3.8	29.3

Figure 4.7. Erosion processes on arable land and reclaimed soils

Due to predominantly hilly landscapes, the landslides are very characteristic for Moldova's landscapes, provoking erosion (Figure 4.8) This is also linked with the deforestation processes and intensive pasturing, especially goats and sheeps.

Figure 4.8. Landslide near Balabanesti village, not far from the Baltata River mouse

4.6. Historical flow of the Baltsata River

At present, due to an intensive anthropogenic load, the Baltata River and its tributaries are completely transformed; its natural flow has significantly changed and practically all accumulates in four artificial ponds: three – directly in the riverbed and one – in its right tributary near Balabanesti village. As a result, the river channel has turned actually into a shallow watercourse, including at the mouth where it ends into the Dniester (Figure 4.8). Today a water intake for serious practical needs can really be carried out only from these artificial reservoirs.

			
Pond 2 km southeast of Baltata village	Pond 1.3 km northwest of Cimişeni village.	Pond 2 km southward Balabaneşti village	Устье реки при впадении в р. Днестр

Photo 4.8. Condition of the Baltata main riverbed on its individual reaches

Regular instrumental observation of the Baltata streamflow were carried out at the hydrological post located near of the same name village between 1954 and 2012, after which the post was closed, with a three-year break in 1958-1960 and a six-year break in 1978-1983 (Figure 4.9). In addition, the data from the first years of observations, as well as some of the data after the resumption of observations in 1983, cannot be considered reliable. Based on this circumstances, to analyze the Baltata flow, two approximately equal time intervals were selected at the beginning and end of qualitative observations: from 1961 to 1976, and from 1996 to 2012. Such choice has made possible to compare changes, which has occurred during the period under study, both in the total water discharge and in its annual dynamics and trends

Figure 4.9. Remains of Baltata hydrological post

It should also take into account a fact that Baltata hydrological post was located in the middle course of the river and therefore the presented below results describe only that part of its catchment runoff that was formed in the upper part of the basin. On the other hand, this part of the runoff is least of all subject to anthropogenic transformations. For example, here there are no artificial dams directly in the riverbed, and we can suggest the registered changes in Baltata flow are mainly due to changes in natural factors, e.g. in regional climate in the period under study.

Comparison of the seasonal and annual water discharge in the two periods under consideration (Table 4.6) clearly demonstrates its decrease in all seasons, except in autumn months when some increase is observed. In particular, in 1996-2012 the spring flow has decreased vs. 1961-1976 by more than 40%; similarly, in winter and summer it decreased by 15-20%. This decrease has not been compensated by an autumn increase (~17%), and as a result the annual flow decreased by above 20%.

Table 4.6 The Baltata flow in two observation periods

Season	Period		Flow change	
	1961-1976	1996-2012	Abs., l/sec	Related %
Winter	49.0	41.7	-7.3	-15.0
Spring	77.9	46.4	-31.5	-40.4
Summer	49.3	38.7	-10.6	-21.4
Autumn	35.6	41.8	6.2	17.4
Year	***53.0***	***42.2***	***-10.8***	***-20.5***

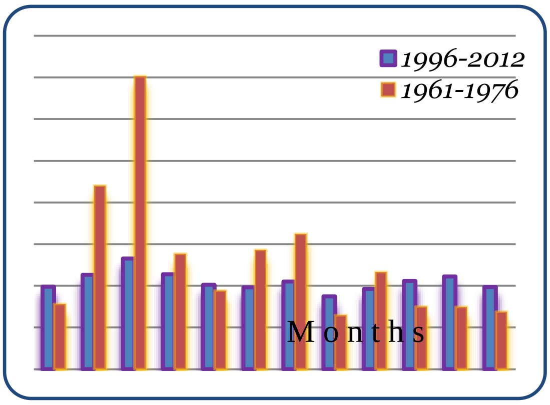
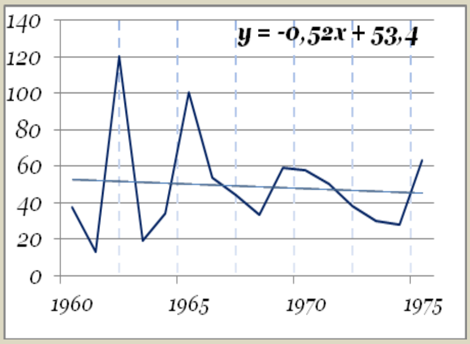
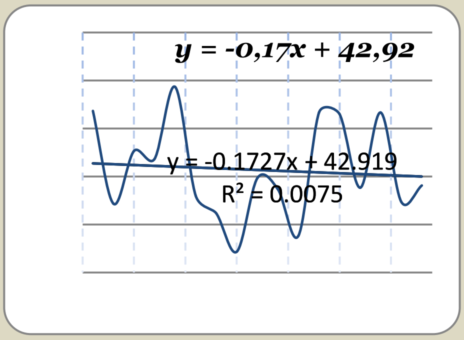


Fig. 4.10. The annual dynamic of Baltata flow (l/sec) in two observation periods

On a monthly basis, the maximum flow occurs in March and February that is especially clearly visible in the first period of its registration (Fig. 4.10). In those years, the second, much smaller flow peak was observed in June-July. However, in recent years, the February-March peak of the Baltata flow has significantly decreased, as well as the summer maximum. Against the general background of flattening the monthly mean values, the share of autumn runoff has increased.

Fig. 4.11 demonstrates long-term trends and interannual variability in the Baltata flow. As can be seen from the graphs, in some seasons the direction of change in water discharge, outlined in the second half of the last century, has been preserved in the 2010s; in other seasons, the trends changed their sign to opposite. In particular, the discharge decrease in the winter-spring period continues, while its previously observed increase in summer and autumn was replaced by a decrease in early 1996-2012. This reduction led to an overall decrease in annual flow on average by *3.5* m^3/sec. It can be assumed the observed changes are associated with a new temperature and humidity regime in the region.

	Observation period	
	1961 – 1976	1996 - 2012
Winter		

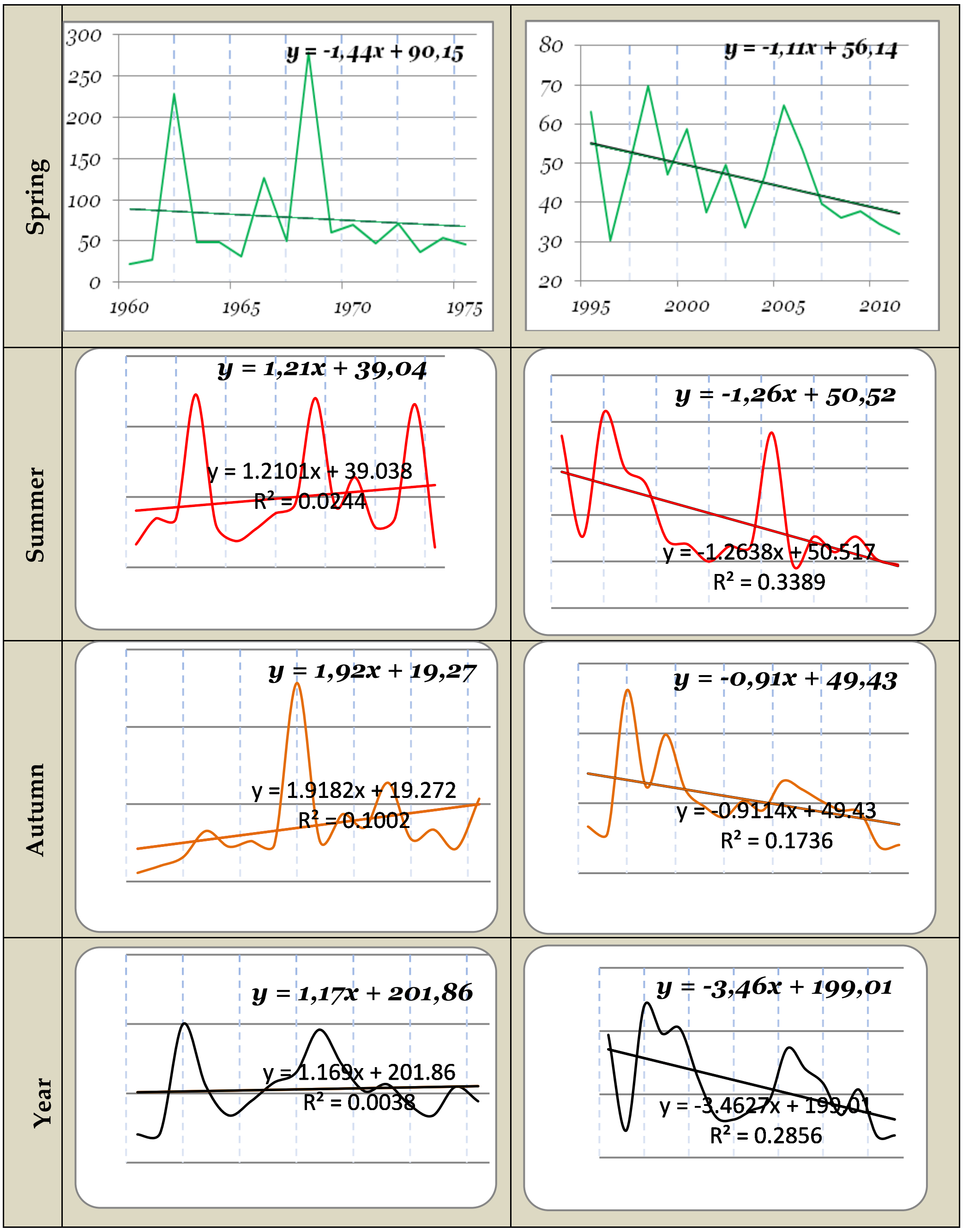


Fig 4.11. Linear trends of the Baltata River in two observation periods, l / sec

Note: The coefficients at x in trend equations show the annual average change in river flow in a period under consideration; x - ordinal number of a year in observation series

Really, the analysis of changes in temperature and humidity conditions in the basin (see below) showed a universally observed positive trend in air temperature change in 1981-2010 for all its indicators and seasons, although with different intensities. The most pronounced increase in air temperature was observed in the warm period, especially in summer, when the mean air temperature increased by more than 0.8°C per decade. Unlike air temperature, changes in precipitation regime were not so significant.

This is a very important point, which is often not taken into account in various kinds of applied research, when to describe a 'current' climate the data from the last century middle or even earlier observation periods are used. The new, warmer climate has already become a reality to which one must adapt.

In particular, since the air temperature increase is not compensated by a proportional increase in precipitation, an adequate increase in climate aridity took place and, consequently, — a decrease in surface runoff and river flow. To test this hypothesis, the regression dependence of the annual Baltata river discharge on air temperature and precipitation was estimated (Fig. 4.12).

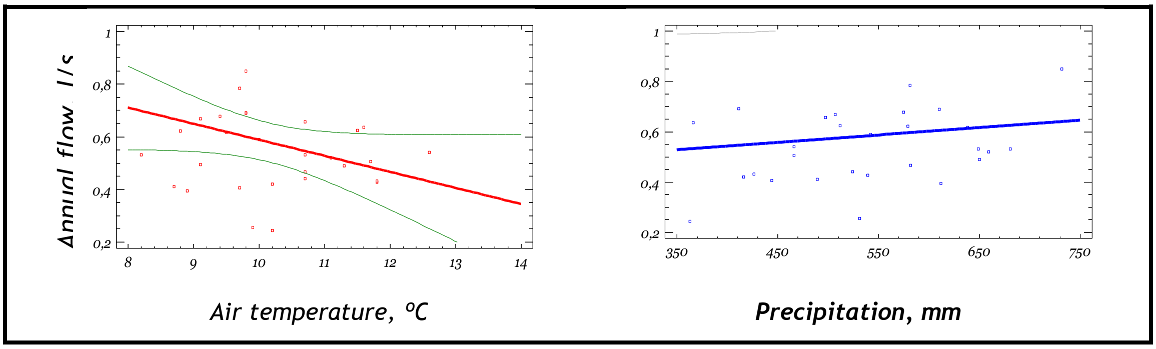


Figure 4.12. Graphs of a simple linear regression of the Baltata annual flow on average annual air temperature and precipitation

As expected, there is an inverse correlation between air temperature and volume of the Baltata annual flow, i.e. the higher air temperature, the lower the later. This is due to a fact that an increase in air temperature is inevitably accompanied by an increase in evaporation from the earth's surface and, as a consequence, a smaller proportion of precipitation falls into the riverbed. Although this relationship is rather moderate (simple pair correlation coefficient r = 0.332 (Table 4.7), it is statistically significant at a confidence level more than 90% (p-value = 0.07). Based on the value of regression coefficients, we can also conclude that an increase in the mean air annual temperature by 1°C leads to a decrease in the Baltata annual discharge by about 0.6 m^3/sec.

Table 4.7 Parameters of linear regression dependences of the Baltata annual discharge (Q, m3/s) on mean annual temperature (T) and precipitation (P)

Regression	Air temperature	Total precipitation
Simple regression	Q = 1,196 - 0,061T *r = -0,332; p = 0,068*	Q = 0,424 + 0,294*10^{-3}P *r = 0,140; p = 0,452*
Multiple regression	Q = 1,063 - 0,059T + 0,208*10^{-3}P; *R = 3,465; p = 0,167*	

The obtained dependences made it necessary to further study temperature and precipitation regimes and tendencies of their changes in the Baltata basin.

4.7. Current and future climate of the pilot area

4.7.1 Approach to the assessment and initial material

A climate and climate change load on any natural system, in our case – on the Baltata river basin, is usually represented by long-term observed series of key climatic variables (air temperature and precipitation). Such load determines the exposure of a system to climate variability and change. The exposure is one of the most important factors determining the system's vulnerability to these impact factors.

The direct assessment of climate is based on its definition adopted by the Intergovernmental Panel on Climate Change (IPCC): "Climate is average weather, or more strictly, its statistical description in terms of average values and variability of the corresponding indicators over times ranging from months to millions of years. The classical averaging period established by the World Meteorological Organization is 30 years" (IPCC, 2012, p. 557).

Over past decades, in the scientific research and development of future climate changes scenarios, as a so-called "baseline" or "reference" climate, the 30-year period from 1961 to 1990 has been used. However, in a number of studies, including for Moldova and the Dniester basin (Corobov et al., 2010; 2014), due to global anthropogenic warming, the climate in general and, above all, its temperature regime has changed significantly. In fact, already we are living in a new climate. It was reliably shown (IPCC, 2013) that in each of last decades the Earth's surface has been consistently warmer than in any previous decade, starting in 1850. On this basis, to transit to using the most modern climate indicators for applied purposes becomes an urgent task. In this regard, in 2018 the description of current and likely future climate in the Dniester basin, which has been carried out somewhat earlier (Corobov et al., 2014), was detailed in relation to the studied basin of the Baltata river (Corobov and Trombitsky, 2018). Some results of this work are used in this description.

In present research two different sources of initial information and two approaches for its processing were used:

1. Observations at the Baltata weather station (Figure 4.13), representatively describing the historical climate of the pilot area in the last full climatic thirty years (1981-2010).

2. Climatic indicators of a likely future climate, obtained in its modeling in the nodes of the Regional Climate Models (RCM), served as initial (base) values for calculating the projections of expected future climate in the pilot area in the current century. For the development of future climate scenarios, other thirty-years (1971-2000) were taken as the baseline climatic period.

Figure 4.13. Baltata weather station

4.7.2. Current climate of the pilot area

Evidently, there is no sense to talk about exposure to climatic stresses in an annual context since different seasons subject to their own specific threats. Therefore, the assessment of both current and expected future climate in the Baltata river basin was carried out separately for the warm (April-October) and cold (November-March) seasons. Special attention was paid to maximum and minimum temperatures because an increase in frequency and amplitudes of extreme events is considered as a main climate change danger (IPCC, 2012). It is also well known the population vital activity is in a different degree adapted to a current local climate, and various kinds of threatening situations are mainly caused by climatic anomalies and extremes.

As was noted above, the assessment of key parameters of the pilot area's current climate was carried out on the basis of observation data at the Baltata weather station in 1981-2010. The chosen period is also interesting because it describes years of distinct manifestations of global warming. The early 1980s are usually considered as a kind of "turning point" in the long-term curve of air temperature, starting from which the anthropogenic influence on the atmosphere is most pronounced. In the Northern Hemisphere as a whole, 1983–2012 was the warmest period for 14 last centuries (IPCC, 2013). In Moldova, this fact was statistically confirmed by national studies (Corobov et al., 2010).

The climatic variables, considered under this study, were ***air temperature*** (mean — *Tmean*, maximum — *Tmax* and minimum — *Tmin*) as well as ***precipitation*** sums *(P);* all variables were expressed by their seasonal and annual values. In parallel, the time trends and interannual variability of these variables and air humidity were assessed. All statistical analyzes were performed, using appropriate tools provided by the *Microsoft Excel* and *Statgraphics* (2014) soft.

The annual course of monthly mean air temperature, with its maximum in July and minimum in January, as well as precipitation sum, with maximum in June and minimum in February, are shown in Fig. 4.14. Their exact numerical values by seasons are shown in Table 4.8.

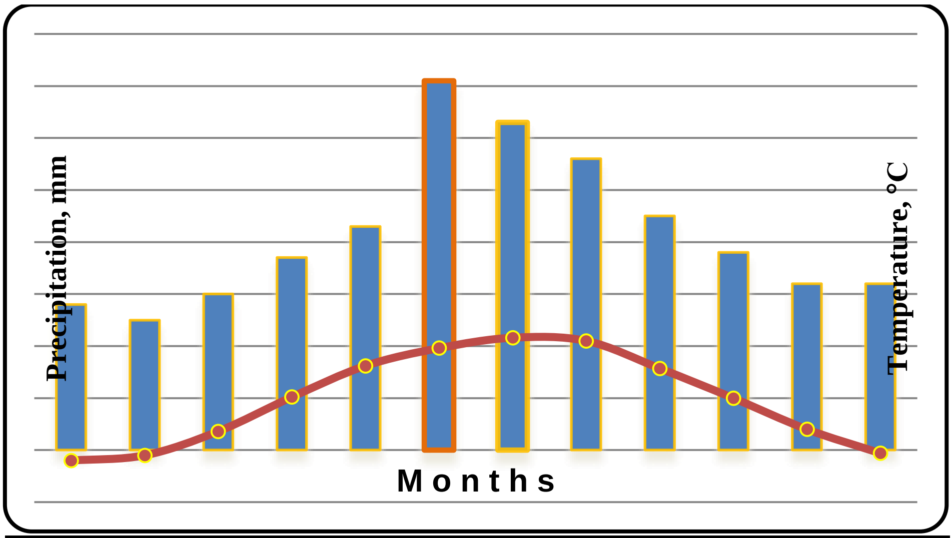


Fig. 4.14. Diagram of mean monthly precipitation (columns) with the superimposed curve of mean monthly air temperatures at the Baltata weather station in 1981-2010.

However, as follows from the above definition of climate, it is described not only by mean values, but also by their variability, which is usually characterized by the amplitude *(Range)* of changes, measured as a difference between observed maximum and minimum values of estimated climatic variables, and their standard deviations *(Sd)*. The ratio of *Sd* to the average climate variable ($\overline{x}$), expressed in percents (the so-called coefficient of variation *CV*), gives an easily interpretable value of the average (Table 4.8).

Table 4.8 Average values of air temperature and precipitation (x) in 1981-2010 at Baltata weather station and their interannual variability, expressed by the amplitude of changes (Amp) and Coefficient of variation (CV)

Season	Air temperature, °C									Precipitation, mm		
	Mean			Maximum			Minimum					
	$\overline{x}$	Range	CV, %	$\overline{x}$	Range	CV, %	$\overline{x}$	Range	CV, %	$\overline{x}$	Range	CV, %
Winter	-1,2	8,4	11,8	2,3	8,3	23,8	-4,5	8,6	32,5	86	174	49,0
Spring	10,0	5,6	12,1	15,9	7,2	10,9	4,4	4,0	17,8	109	188	41,9
Simmer	20,7	5,3	5,3	27,2	6,2	5,2	14,3	3,6	5,7	191	250	35,9
Autumn	9,9	4,4	10,7	15,3	4,9	8,2	5,1	4,1	21,6	115	210	48,8
Year	10,2	4,1	11,9	15,2	4,4	7,7	4,8	3,1	14,8	501	377	64,9

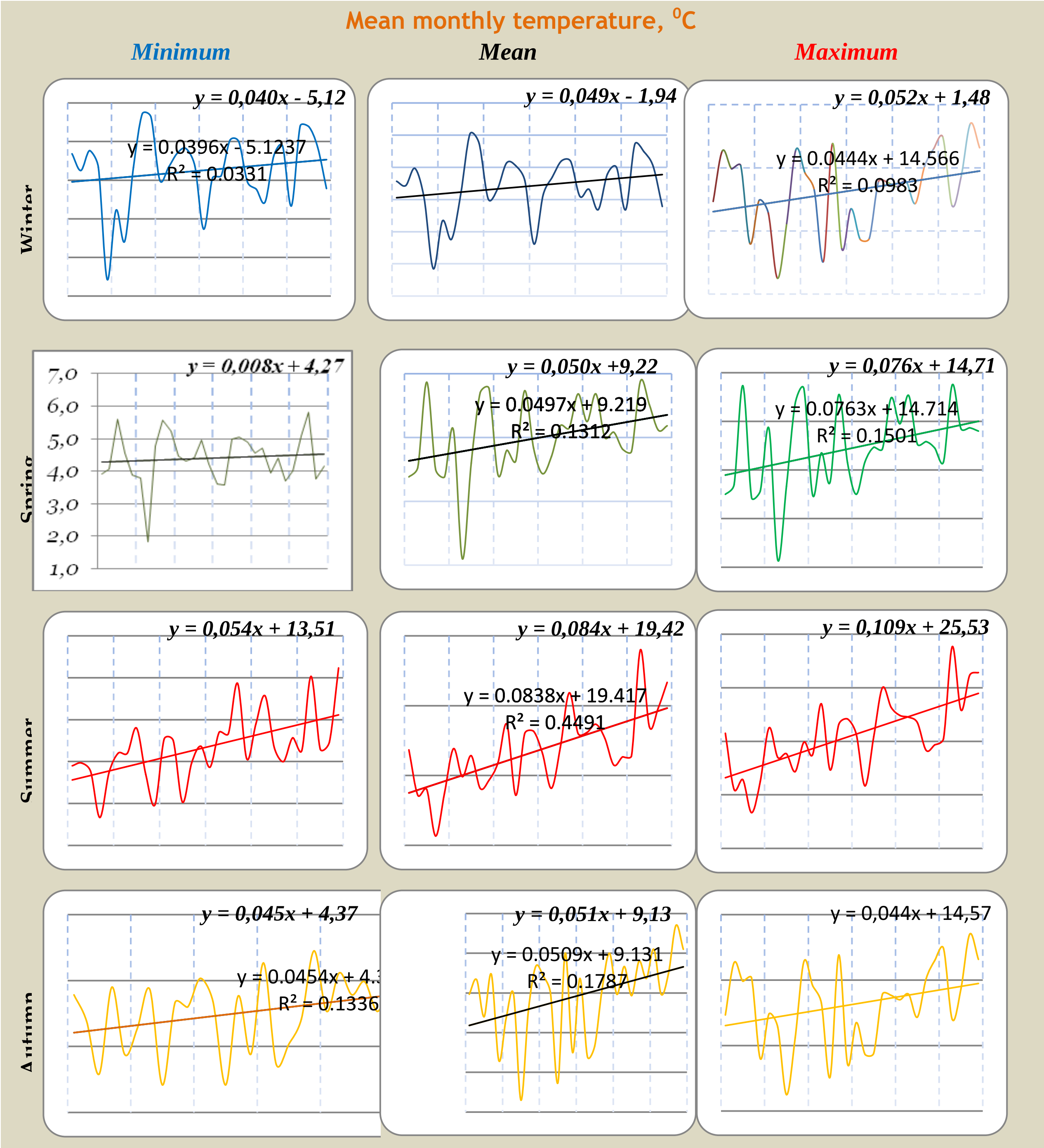
As can be seen from this table, the temperature and humidity regime of the pilot area is most variable in winter, reaching about 25-30% for maximum and minimum temperatures. Mean monthly temperatures are less volatile (from 5.3% in summer to 11.8% in winter). Seasonally, the temperature regime is most stable in summer when for all temperature variables CV is within 5-6%. As for an interannual variation in mean annual temperatures, they range from 4.1% for mean temperatures to about 8% and 15% for their maximum and minimum values, respectively.

The amplitude of changes, although it is a more easily interpreted statistics, is less indicative because it directly depends on the parameter being measured. Nevertheless, in absolute terms the interannual fluctuations in mean annual air temperature in 1981-2010 were in the range of about 3-4ºC. The interannual amplitudes of the seasonal values are much larger.

The interannual variability of ***precipitation*** is much higher: CVs = 35-50% in the seasonal context (higher in the autumn-winter period and the lowest in summer) and the highest – in the interannual context (up to 65%). This result confirms the typical for Moldova alternation of wet and dry years in Moldova. For example, here in the extremely dry 1994 only 282 mm of precipitation fell against 659 mm in the wettest 2001.

In addition to extreme seasons and years, it is necessary to take into account the possibility of extreme weather events, the frequency and intensity of which are increasing along with the observed climate change. So, on June 28, 2014 when a heavy downpour passed throughout Moldova, which turned streets into rivers, flooded many houses and paralyzed public transport, the most powerful rainfall occurred in Baltata village. Here, according to the meteorological service data, 104 liters of precipitation fell per square meter, while the monthly norm is about 70 liters.

4.7.3. Trends of temperature and precipitation
Along with the variability of air temperature and precipitation, the tendencies in their changes are of great interest (Fig. 4.15 and 4.16).


Mean monthly temperature, °C
Minimum
Mean
Maximum
Winter
y = 0,040x - 5,12
y = 0.0396x - 5.1237
R² = 0.0331
y = 0,049x - 1,94
y = 0,052x + 1,48
y = 0.0444x + 14.566
R² = 0.0983
Spring
y = 0,008x + 4,27
7,0
6,0
5,0
4,0
3,0
2,0
1,0
y = 0,050x +9,22
y = 0.0497x + 9.219
R² = 0.1312
y = 0,076x + 14,71
y = 0.0763x + 14.714
R² = 0.1501
Summer
y = 0,054x + 13,51
y = 0,084x + 19,42
y = 0.0838x + 19.417
R² = 0.4491
y = 0,109x + 25,53
Autumn
y = 0,045x + 4,37
y = 0.0454x + 4.3
R² = 0.1336
y = 0,051x + 9,13
y = 0.0509x + 9.131
R² = 0.1787
y = 0,044x + 14,57

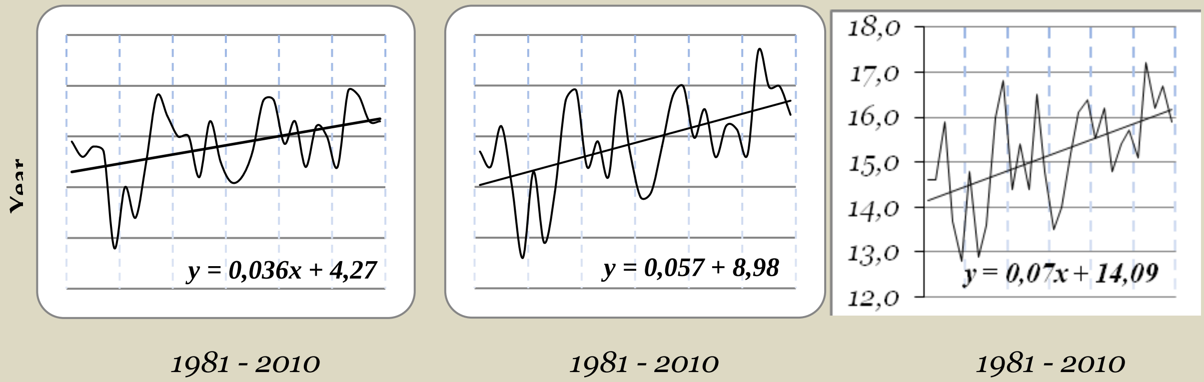


Fig. 4.15 Trends of monthly air temperatures in the Baltata basin in 1981-2010

Note: The coefficient at x in the trend equation shows the average change in air temperature per year in the period under consideration; x - ordinal number of a year in the observation series

So, the everywhere observed positive trends of air temperature change indicate an increase in all its parameters and all seasons in 1981-2010, albeit with different intensities. The most pronounced increase in temperature was observed during the warm period, especially in summer when a mean temperature increased by more than 0.8 °C per decade. Its decadal growth in other seasons was about 0.5 °C. The mean annual temperature increased by 0.57 °C per decade. In particular, if in 1981-1990 the increase was 9.4 °C then in 1991-2000 it was 9.8 °C and in 2001-2010 – already 10.4 °C, i.e. in 30 years it has grown by a whole Celsius degree.

This is a very important point, often not taken into account in various kinds of applied research, when describing the "current" climate there are used data from the middle of the last century or even earlier observation periods. A new, warmer climate has already become a reality, to which one must adapt.

Similarly to the mean air temperature, its maximum and minimum values also are changing. The annual increase in Tmax reaches 0.11 °C in summer, 0.08 °C in spring, and 0.04-0.05 °C in autumn and winter. For Tmin a somewhat opposite picture is observed: with its maximum increase in summer (0.054 °C) and 0.040-0.045 °C – in winter and autumn, the spring growth is extremely insignificant (less than 0.01 °C per year). This fact needs further analysis by the methods of synoptic climatology. In relative terms, the increase in minimum temperatures exceeds the increase in maximum, which is also noted in most of the available studies (e.g., IPCC 2013) and means that general warming occurs primarily due to the increase of night temperatures.

Unlike air temperature, changes in precipitation regime are not so significant (Fig. 4.16). Their increase of 0.5-1.5 mm/year is observed only in the autumn-winter period and in spring that, with a slight decrease in summer precipitation (0.7 mm/year), leads to less than 2 mm precipitation increase per year.

Since an increase in air temperature is not compensated by a proportional increase in precipitation, a priori an increase in climate aridity could be assumed.

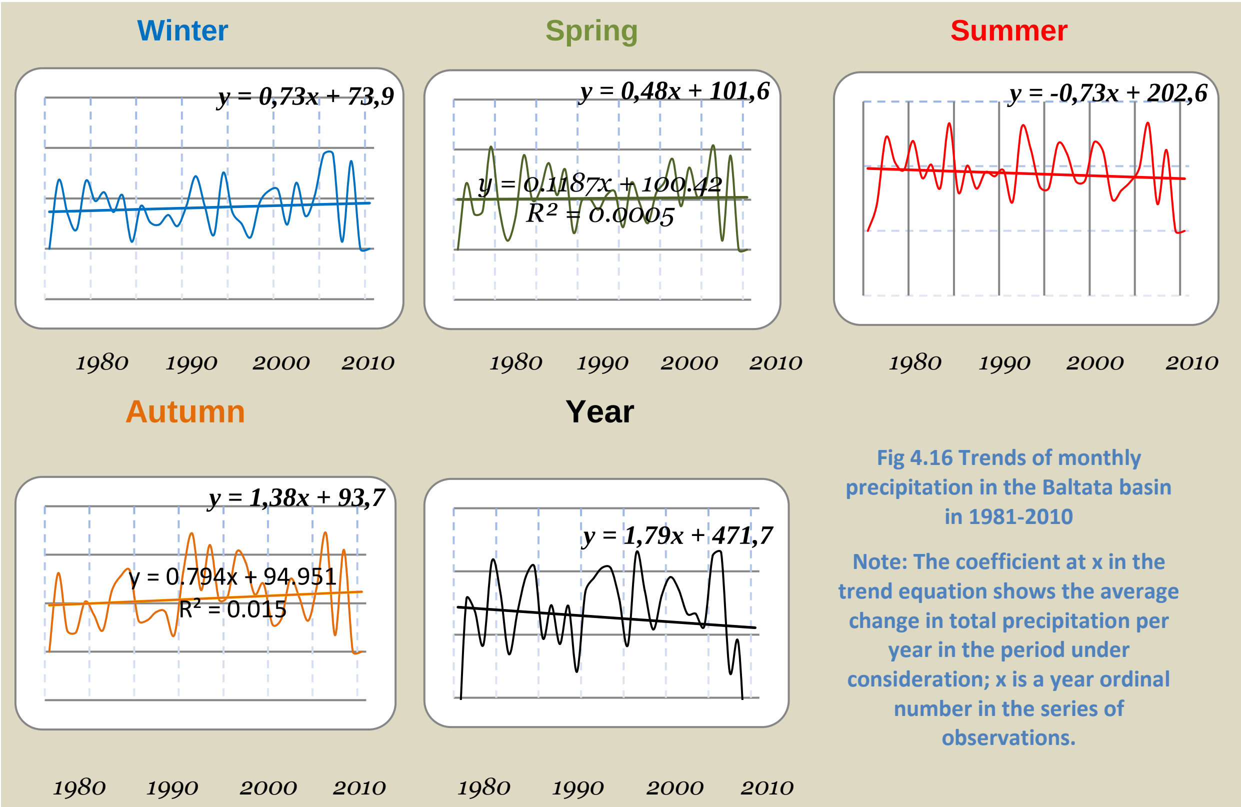


Fig 4.16 Trends of monthly precipitation in the Baltata basin in 1981-2010

Note: The coefficient at x in the trend equation shows the average change in total precipitation per year in the period under consideration; x is a year ordinal number in the series of observations.

As an indicator of the pilot area aridity, the Coefficient of humidity *(CH)* was chosen, calculated as the ratio of precipitation to potential evaporation, or evaporability. For its calculation, the statistical dependences of *CH* on the mean monthly air temperature and precipitation, obtained in (Corobov and Nikolenko, 2004) for 1961-1990, was used. Of course, these estimations are made under an assumption that at present above mentioned dependences have not changed fundamentally. *CH* values calculated for the warm period of a year for the two thirty years are shown in Table 4.9.

Table 4.9 Coefficients of air humidity in the pilot area in the two periods

Observation period	Months						
	April	*May*	*June*	*July*	*August*	*September*	*October*
1961-1990	0,63	0,43	0,64	0,65	0,40	0,62	0,59
1981-2010	0,53	0,35	0,57	0,50	0,46	0,62	0,85

It is easy to see the first four months of the warm season, which are especially important for plant development, undoubtedly become more arid. Humidity slightly increases only in August and especially in October. Nevertheless, according to the generally accepted classification, the studied basin is still in a humid sub-humid zone, with the exception of July and August, which are already becoming semi-arid (CH is in the range 0.20-0.50).

4.8. Conclusion

The basin of the Baltsata River, selected as a pilot area for solving the project's aims in Moldova, reflects fully the current state of the country's small rivers. Over the past decades, as a result of intensive land use, often in violation of agrotechnical requirements and norms, a complete transformation of the river bed, flood plain and its flow took played. At present, most of the river flow is accumulated in a series of artificial ponds, some of which are created directly in the main channel. Blocking the river bed by dams prevents the normal passage of water and promotes the accumulation of garbage and various kinds of industrial waste in its catchment. This seriously impairs the quality of river water, and in the case of a dam breakthrough (a fairly frequent event in Moldova), all accumulated sediments are carried into the Dniester River. Given the proximity of the confluence of the Baltata River to the Dniester mouth, all these sediments inevitably end up in the Black Sea.

In the Baltata catchment there are many ravines where erosion and land slide processes are usually especially manifested. About 60% of Its soils are carbonate and ordinary chernozems that are subject to various types of erosion requiring anti-erosion measures, and under different forms of soil erosion above 29% soil are now. Without anti-erosion measures the slightly eroded soils pass usually into the category of moderately eroded ones. The erosion processes are also provoked by landslides that are very characteristic for Moldova due to predominantly hilly landscapes. The landslides are also linked with the deforestation processes and intensive pasturing, especially goats and sheeps.

The above mentioned negative processes are strengthened by climate change. Positive air temperature trends indicate an increase in all its parameters and all seasons in 1981-2010, especially in summer when an average temperature increased by more than 0.8 °C per decade. In this period the average annual temperature increased by 0.57 °C per decade. The increase in temperature that was not accompanied by a corresponding increase in precipitation has resulted in the decrease of the Baltata annual flow by above 20%.

And, at last, the transition of the Baltata basin climate to a new dry state is accompanied by intensive droughts (Photo 4.8); this fact requires a further deep and comprehensive study.

Figure 4.17 Drought in Moldova in 2020

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5. Arhavi River Basin - TURKEY

5.1. Location and Topography

Located in Artvin Province in northeastern Turkey, the Arhavi River Watershed lies between the latitude of 41° 07′55′′N and 41° 21′ 35′′ N and the longitude of 41° 15′35′′ E and 41° 30′ 05′′ E. The size of the watershed (pilot area) is 29901 ha. The Arhavi city center lies on the delta of the Arhavi River next to Black Sea shorelines (Figure 5.1). The villages and small hamlets are located along the flat sides of the Arhavi River and its tributaries (Figure 5.1). The study site was surrounded by Findikli Prefecture on the west site, Yusufeli Prefecture on the south side, Hopa Prefecture and Black Sea on the south side and Murgul Prefecture on the east side (Figure 5.2).

Figure 5.1. The Arhavi City and Arhavi River merging with the Black Sea (URL-01, 2020).

The terrain is mountainous and the elevation ranges between 20 m and 3343 m from MSL (Figure 5.2). The majority of the area has a steep slope class. A very small part of the area has flat and medium slope class (Figure 5.3).

There is no single aspect on the watershed but 41.4% of the watershed faces to the westerly aspect (20.6 South West; 5.7% West and 15.1% North West). 16.6% of the watershed faces North aspect while 15% of the area faces to North East and 10.2% of the area faces to East. South and South East aspects are to be 8.1% and 7.9%, respectively (Figure 5.4).

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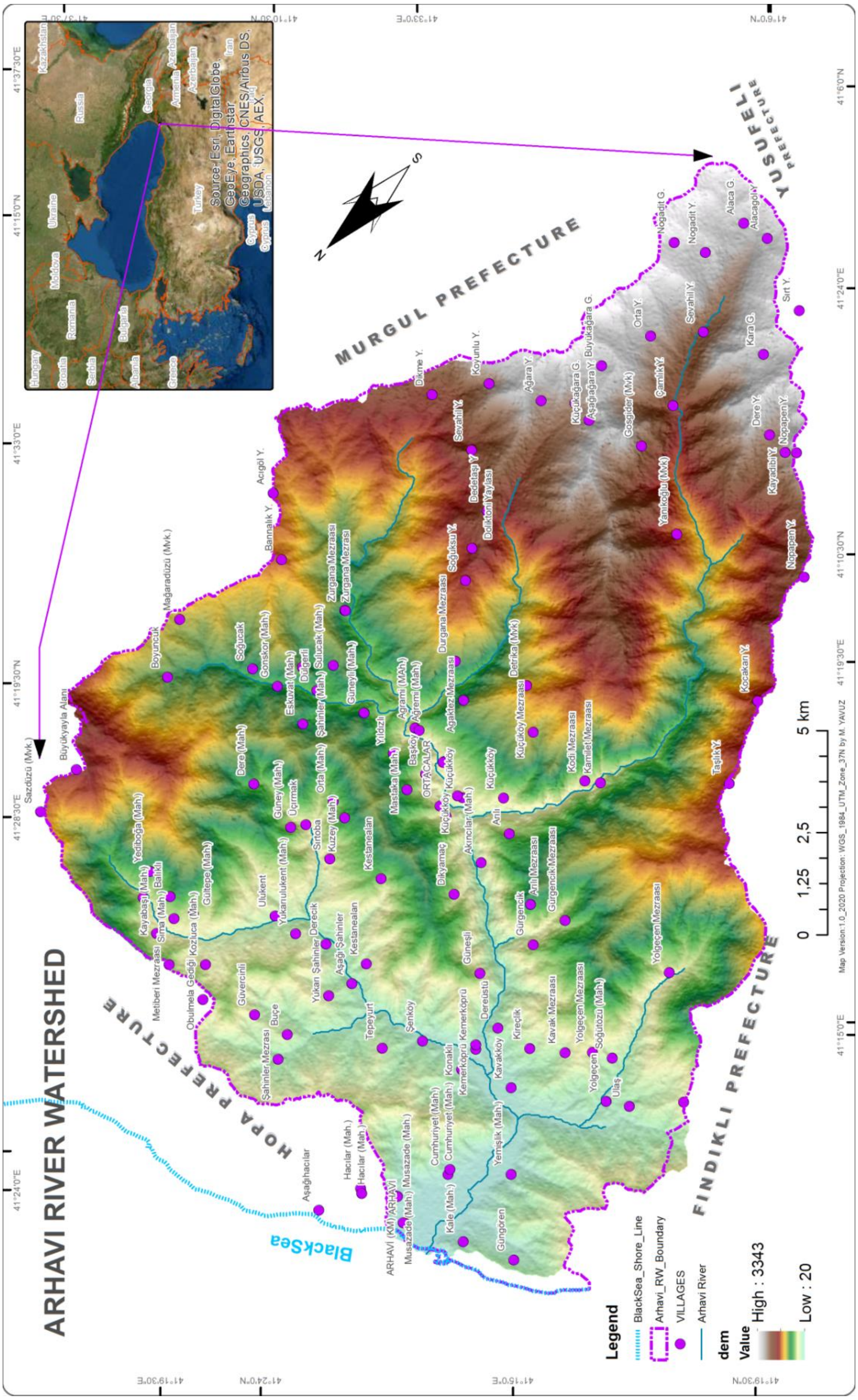

Figure 5.2. Location map of Arhavi River Watershed, Northeastern, Turkey

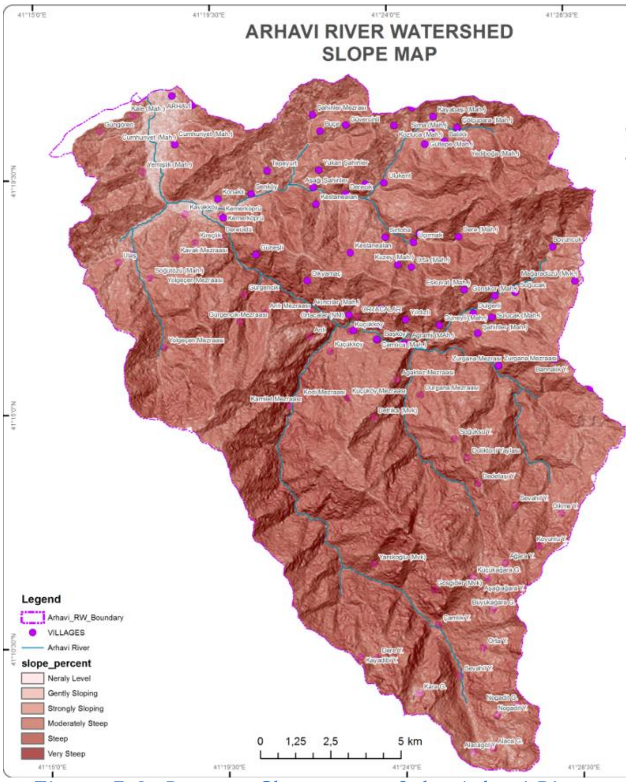

Figure 5.3. Percent Slope map of the Arhavi River Watershed

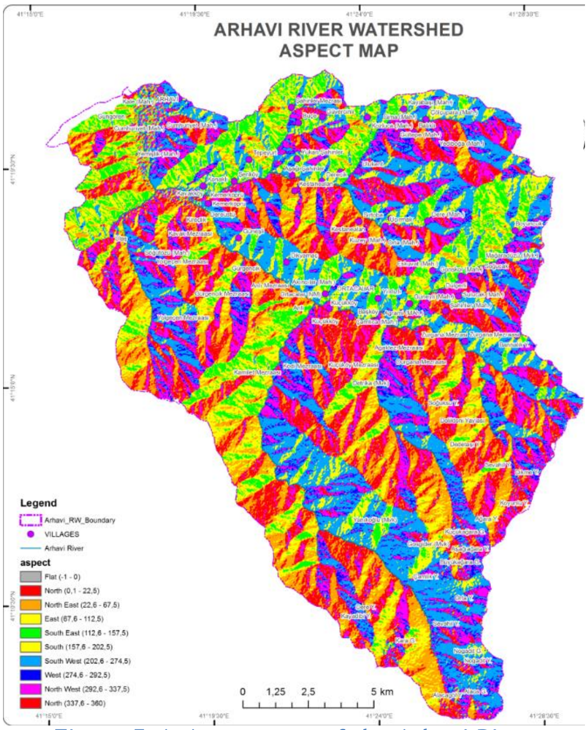

Figure 5.4. Aspect map of the Arhavi River Watershed

5.2. Stream Network

The measured total channel network of the watershed is 263.77 km (Table 5.1). Of the total, 1st, 2nd, 3rd and gully lengths were measured as 43.21, 29.48, 13.32 and 177.75, respectively (Table 5.1; Figure 5.5; Figure 5.6).

Table 5.1. The measured total stream (1st, 2nd, 3rd) and gully lengths by Strahler (1957) classification

Stream Order	Count	Length (m)	Length (km)	Max (m)	Min (m)	Mean (m)
1st	13	43219	43.21	7598	701	3324.53
2nd	4	29484	29.48	11665	4151	7371
3rd	1	13324	13.32	13324	13324	13324
Gully	153	177752	177.75	4523	60	1161.77
Total	*171*	*263779*	*263.77*	*13324*	*60*	*1542.56*

Figure 5.5. A photo from Arhavi River (main channel) right next to the city of Arhavi (photo by M. Tufekcioglu)

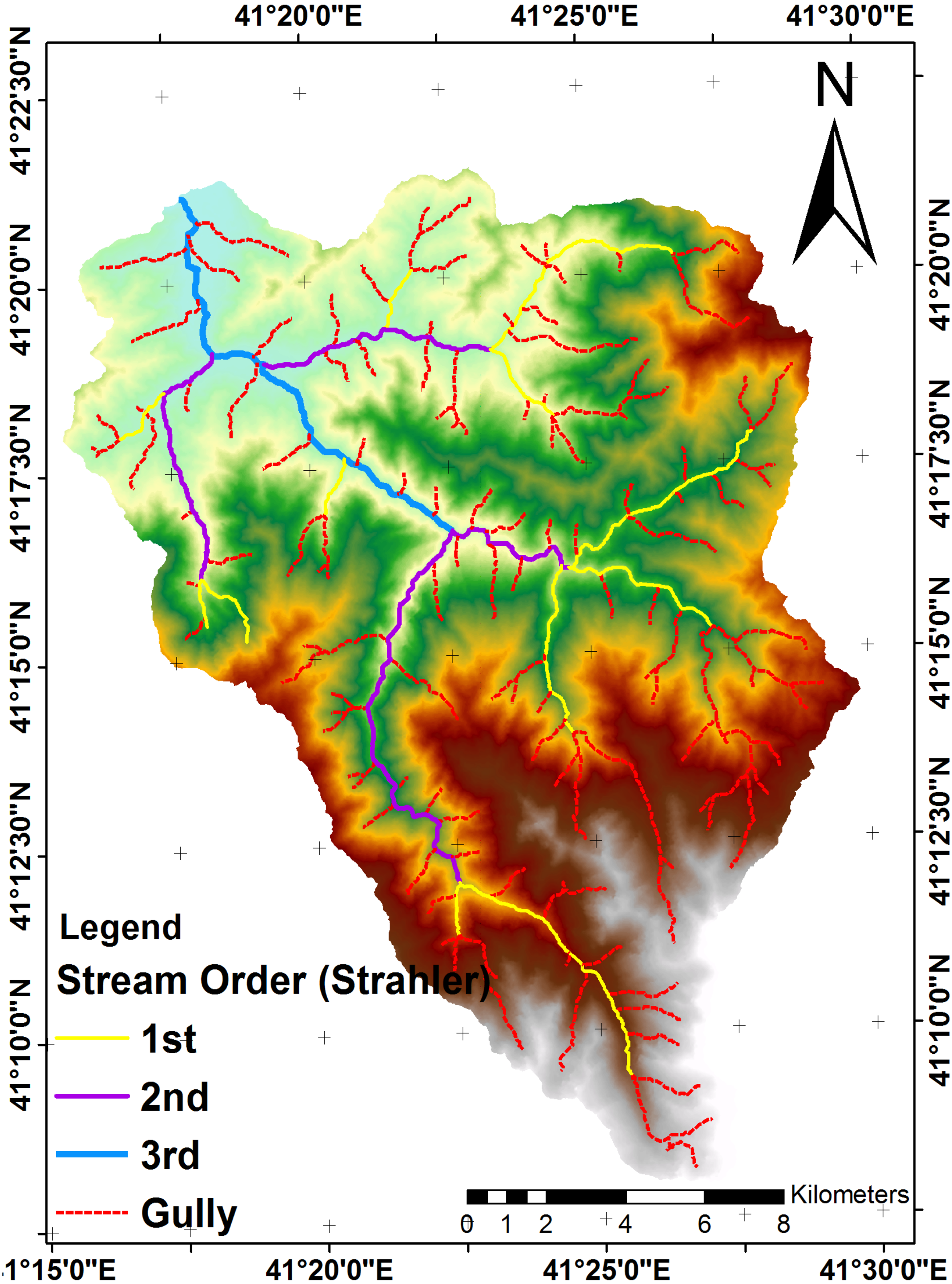

Figure 5.6. Stream network and Strahler stream order of the Arhavi River Watershed

5.3. Land Cover / Land Use and Slope Classes

The forest covers 56.6 % of the total watershed areas followed by grassland and highland areas (26.5%), agriculture and residential areas (16.7 %) (**Error! Reference source not found.**;Table 5.2Table).

The arable agricultural land is approximately 5000 hectares (Table 5.2,Table 5.3). Of this area 3000 hectares are for tea, 900 hectares for hazelnuts, 700 hectares for corn and the remaining part are used for various fruit and vegetable areas.

Table 5.2. Landuse and elevation zones of the study area

Elevation Zone (m)	Forest Areas (Ha)	Grasland &Rocky Areas (Ha)	Agriculture & Residential Areas (Ha)	Other Areas (Ha)	Grand Total (Ha)	Percentage distribution of the areas
0-1000	9606	48	4944	15	14663	**49.0%**
1000-2000	7173	3316	57	0	10585	**35.4%**
>2000	79	4553	0	13	4652	**15.6%**
Total (Ha)	**16857**	**7917**	**5001**	**28**	**29901**	
Total (%)	**56.6%**	**26.5%**	**16.7%**	**0,19%**		**100%**

79.4 % of the total area is in the steep and very steep slope class range while 13.1 % of the total area is in the middle slope class. The flat slope class covers 7.5 % of the total study area (Table 5.3).

Table 5.3. Landuse and slope distribution of the study area

Slope (%)	Forest Areas (Ha)	Grasland &Rocky Areas (Ha)	Agriculture & Residential Areas (Ha)	Other Areas (Ha)	Grand Total	Percentage distribution of the areas
0-20	699	360	1112	10	2233	**7.5%**
20-33	1947	796	1159	4	3930	**13.1%**
>33	14211	6761	2730	14	23738	**79.4%**
Grand Total	**16857**	**7917**	**5001**	**28**	**29901**	**100%**

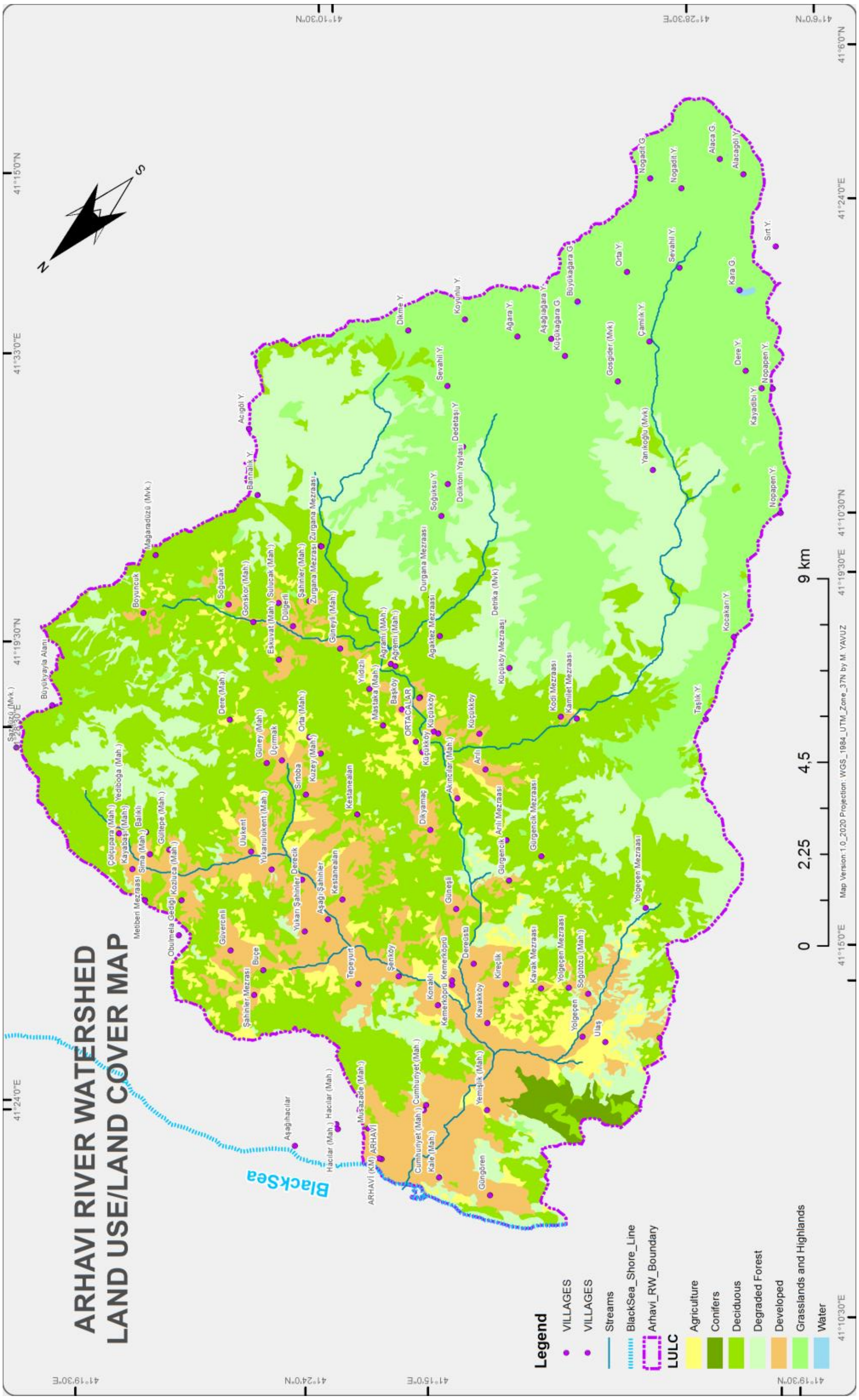

Figure 5.7. Land use and Land cover map of Arhavi River Watershed

5.4. Climate

The area has a typical very humid black sea climate and is highly affected by seaborne air masses from the Black Sea. According to the Köppen-Geiger climate classification, Arhavi is in the climate class with Cfa (warm summer and rainy season in all seasons) (Figure 5.7) (TSMS, 2016).

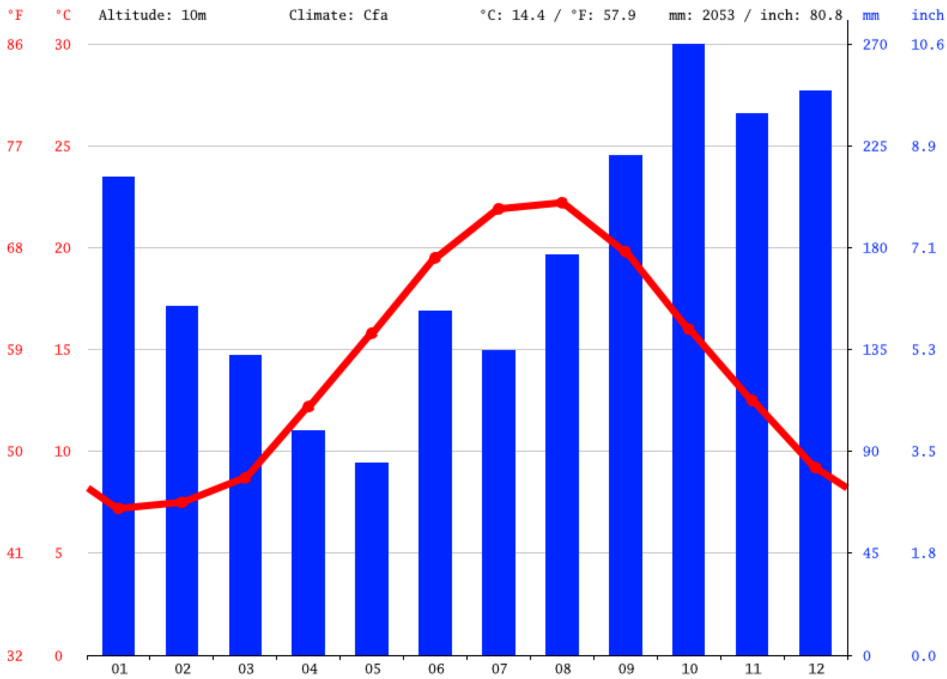

Figure 5.7. Climate Properties in Arhavi River Watershed (URL-02,2020)

According to

Table 5.4, the mean annual temperature is 14.4 ^{0}C, the hottest month is August (22.2 °C) and the coldest month is January (7.2 °C). The average annual precipitation for the site is 2053 mm, the wettest month is October (261 mm) and the driest month is May (82 mm).

Table 5.4. Climate Parameters (URL-03, 2020)

Parameters	**January**	**February**	**Marc**	**April**	**May**	**June**	**July**	**August**	**Semptember**	**October**	**November**	**December**	**Mean**
Mean Temp. (°C)	**7,2**	7,5	8,7	12,2	15,8	19,5	21,9	**22,2**	19,8	16,0	12,5	9,2	**14,4**
Min. Temp. (°C)	3,8	4,0	4,7	8,1	11,9	15,4	18,4	18,6	15,7	11,7	8,5	5,5	10,5
Max. Temp. (°C)	10,6	11,1	12,7	16,4	19,7	23,7	25,5	25,9	23,9	20,3	16,5	13,0	18,3
Precip. (mm)	204,0	149,0	128,0	96,0	82,0	147,0	130,0	171,0	213,0	261,0	231,0	241,0	**2053,0**

5.5. Vegetation

Elevation differences caused by the unique topographic structure exhibit a rich floristic composition of different habitats. Arhavi Watershed is rich in the species representing the Colchic Sector of Euro-Siberian plant geography. Vegetation of Arhavi River Watershed is typical Black Sea vegetation. The major species in the forest site include Oriental beech (*Fagus orientalis* Lipsky.), bearded alder (*Alnus glutinosa subsp. barbata* (C.A. Mey.) Yalt.), Oriental spruce (*Picea orientalis* (L.) Link.), Anatolian Chestnut (*Cestanea sativa* Mill.), Scots pine (*Pinus Silvestris* L.), hornbeam (*Carpinus orientalis* L.), and sycamore (*Platanus orientalis*) (Figure 5.8).

Although bearded alder and wild blackberry reach the upper limit of the forest, starting from 1600 meters coniferous species are dominant. Grasslands are dominant above 2000 meters. The dominant tree species is bearded alder in the area up to altitude of 700-750 m from the shore. Beech communities are found in between 600-1200 meters. Anatolian Chestnut communities are mostly found in between 500-600 meters. Hornbeam infrequently is seen up to 1800-1900 meters. Scots pine is found individually or in small groups up to 1200 meters from the shore. Rhododendron species, bearberry, blackberry species, ferns species, wild vine, vine, ivy, nettle and similar aquatic plants are found in the under-forest vegetation of coastal forests.

The major crop species in the agricultural areas include tea (*Camellia sinensis* (L.) Kuntz.), hazelnut (*Corylus avellana* L.), pear (*Pyrus* ssp.), apple (*Malus* ssp.), kiwi (*Actinidia* ssp.) and grape (*Vitis* ssp.). The most important cultivated plants of the area are tea and hazelnuts.

Although tea plant usually can be seen from the shore up to 500 meters high, it can also be seen in areas with altitudes of 800-900 meters. On the other hand, hazelnut is seen on the steep slope lands up to 400 m above the sea level (URL-04, 2018).

Figure 5.8. A photo from beech and chestnut mixed forest from study area (photo by A. Tufekcioglu)

Figure 5.9. Goats grazing in high plateau of the study area (Photo by Oznur Bulbul)

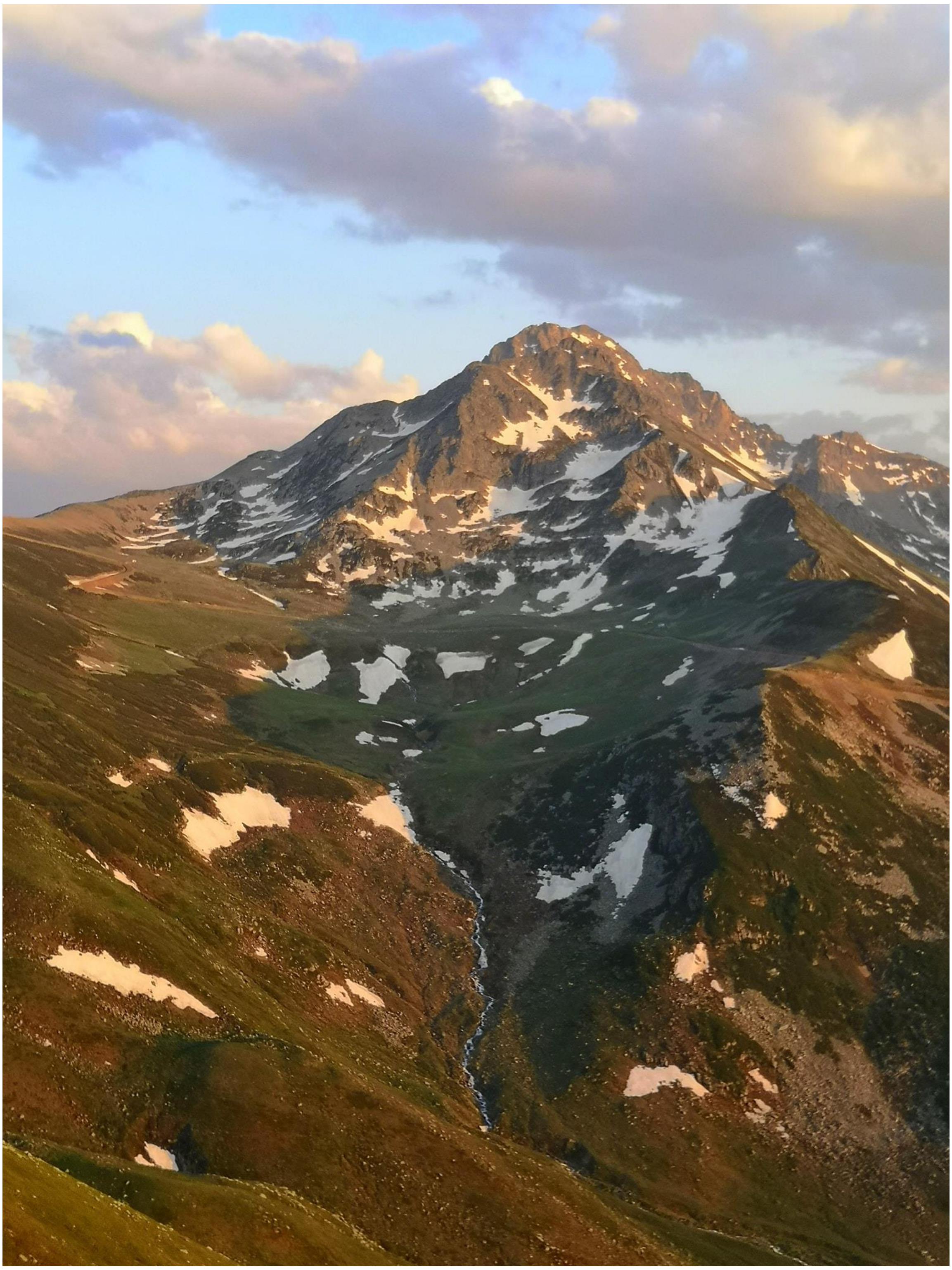

Figure 5.10. A picture from high plateau of the study area (Photo by Oznur Bulbul)

Figure 5.11. A photo from tea and hazelnut cultivation areas in the study area

5.6. Geology

The majority of the area forms volcanic facies in the eocene and upper cretase period. The remaining areas consist of granite, granodiorite, quartz and diorite belonging to the tertiary age and the Holocene belonging to the last years (Figure 5.12).

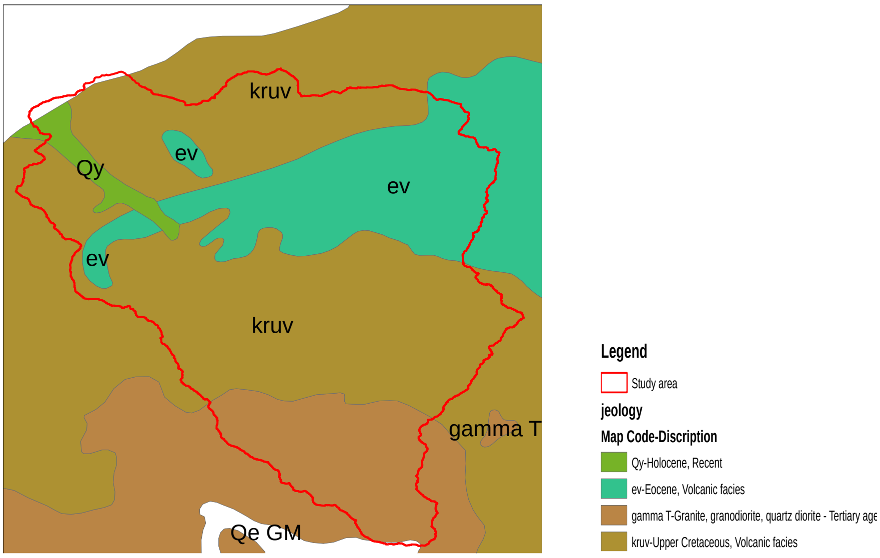

Figure 5.12. Geological map of the study area

5.7. Soils

The dominant soil types of the area are Agrisol soils (Figure 5.13).

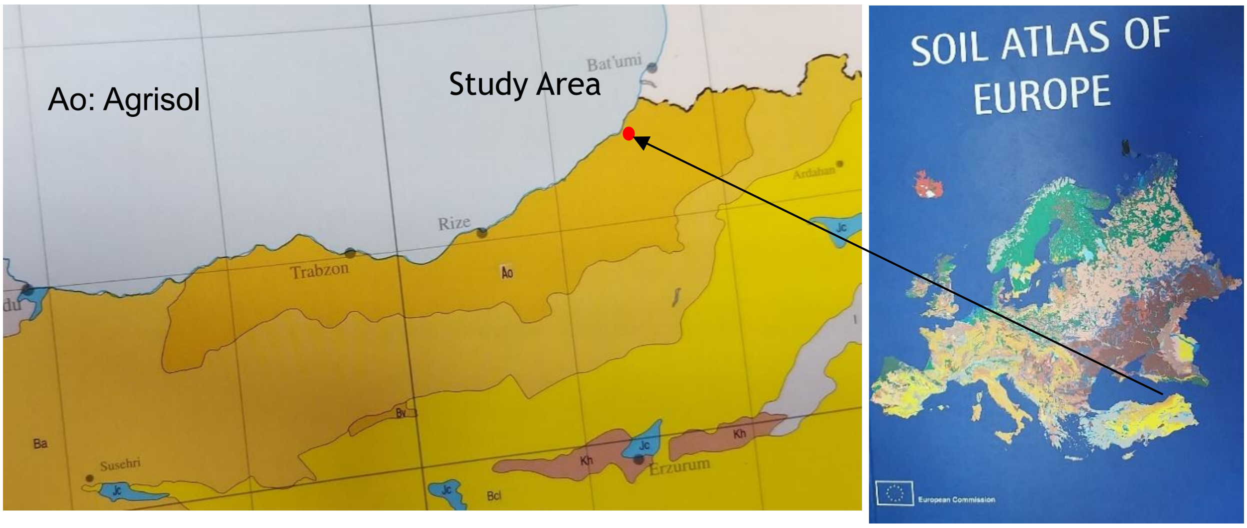

Figure 5.13. Soil Type map of Study Area

5.8. Water Resources

The area has a very good water potential; Mencuna, Kavak, Sahinkaya, Agara, Balikli, Cifteköprü and Kapisre streams are important water resources in the watershed and flow year-around. When climping up higher elevation in the area, water sources are getting scarce, especially during the late summer time. There are many large and small lakes in this part where the erosion is effective. The main ones are; Gadit, Sarıgöl, Alacal, Büyükagara, Küçükagara and Karagöl.

5.9. Demographics

The total population is 18380. The distribution of these by gender and villages is given in the Table 5.5.

Table 5.5. Population of villages of the study area

District	Village	Male	Female	Total
Arhavi	*Merkez*	*7910*	*8225*	*16125*
Arhavi	Balikli	68	60	128
Arhavi	Baskoy	60	61	121
Arhavi	Derecik	71	55	126

Arhavi	Dereustu	67	64	131
Arhavi	Dikyamac	39	35	74
Arhavi	Dulgerli	61	56	117
Arhavi	Gurgencik	19	20	39
Arhavi	*Kavak*	*228*	*230*	*458*
Arhavi	Kireclik	61	47	108
Arhavi	Konakli	121	123	244
Arhavi	Sırtoba	55	65	120
Arhavi	Ulas	58	55	113
Arhavi	Yolgecen	191	180	371
Arhavi	Guvercinli	52	53	105
Total		**9061**	**9329**	**18380**

16125 of the total population live in the city center and 2255 live in the countryside. The distribution of these by gender is given in the

Table 5.6.

Table 5.6. Distribution of population in the study area

District	Village	Male	Female	Total
Arhavi	City Center	7910	8225	**16125**
Arhavi	Rural Area	1151	1104	**2255**
Toplam		**9061**	**9329**	**18380**

5.10. Education

In the district with a literacy rate of 96%, there is a Vocational School, four high schools, seven primary schools, a kindergarten and a public education center under Artvin Coruh University. In addition, two private tutoring centers and one private driving school center continue to serve (Figure 5.14).

Figure 5.14. Photo of Arhavi Campus Artvin Coruh University
(https://stf.artvin.edu.tr/tr/fotohaber/arhavi-yerleskesi-7)

5.11. Economy

Arhavi economy is based on agriculture. Tea, hazelnuts and kiwi are cultivated by local people. There are tea factories belonging to different companies. Most of the forest areas belongs to the State.

5.12. Historical and touristic places to visit

Double Belt Bridge: It is a bridge built in the 18th century. It was built of rubble stone and cut stones. It is a bridge built on very precise balances by calculating entirely with centrifugal force. The stones are knitted with lime and egg whites. The lower part is calculated on the full circle and there are cornice projections on the side surfaces (Figure 5.16).

Figure 5.15. The historic Double Belt Bridge (Photo by A. Tufekcioglu)

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Project acronym: Protect-Streams-4-Sea

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Joint Operational Programme Black Sea Basin 2014-2020

"Protecting streams for a clean Black Sea by reducing sediment and litter pollution with joint innovative monitoring and control tools and nature-based practices"

Protect-Streams-4-Sea Management Team
November 18th 2020

Joint Technical Secretariat of Joint Operational Programme Black Sea Basin 2014-2020

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