



TRANSNATIONAL INTEGRATED MANAGEMENT OF WATER RESOURCES IN AGRICULTURE FOR EUROPEAN WATER EMERGENCY CONTROL (EU.WATER)

Priority Axis: Protection and Improvement of the Environment

Area of Intervention: A.O.L. 1.2 Improve integrated water management and flood risk prevention

Project Duration: 36 months

WP3: Knowledge capitalization and sensitive area maps

Action 3.2: regional report

Regional report

Pilot area: Arges-Vedea watershed (Romania)

Partner: ICPA



1.1. Location and topography of the studied area

The studied area covers three counties (Arges, Giurgiu, Teleorman) located in the Arges-Vedea watersheds, South Romania (Figure 1). The total surface is 16,183 km² (Arges county: 5,800 km², Giurgiu: 3,549 km², Teleorman: 6,834 km²) representing 75% of the Arges-Vedea watersheds (21,548 km²).

The area lies between Carpathian mountains in the north (up to 2,500 m altitude) and Danube river in the South. Therefore, all the major relief forms (mountain, hill, plane) are included in the area (Arges: mountain, hill, plain; Giurgiu and Teleorman: plain only). Figure 2 shows the distribution of altitudes and slopes in the area.

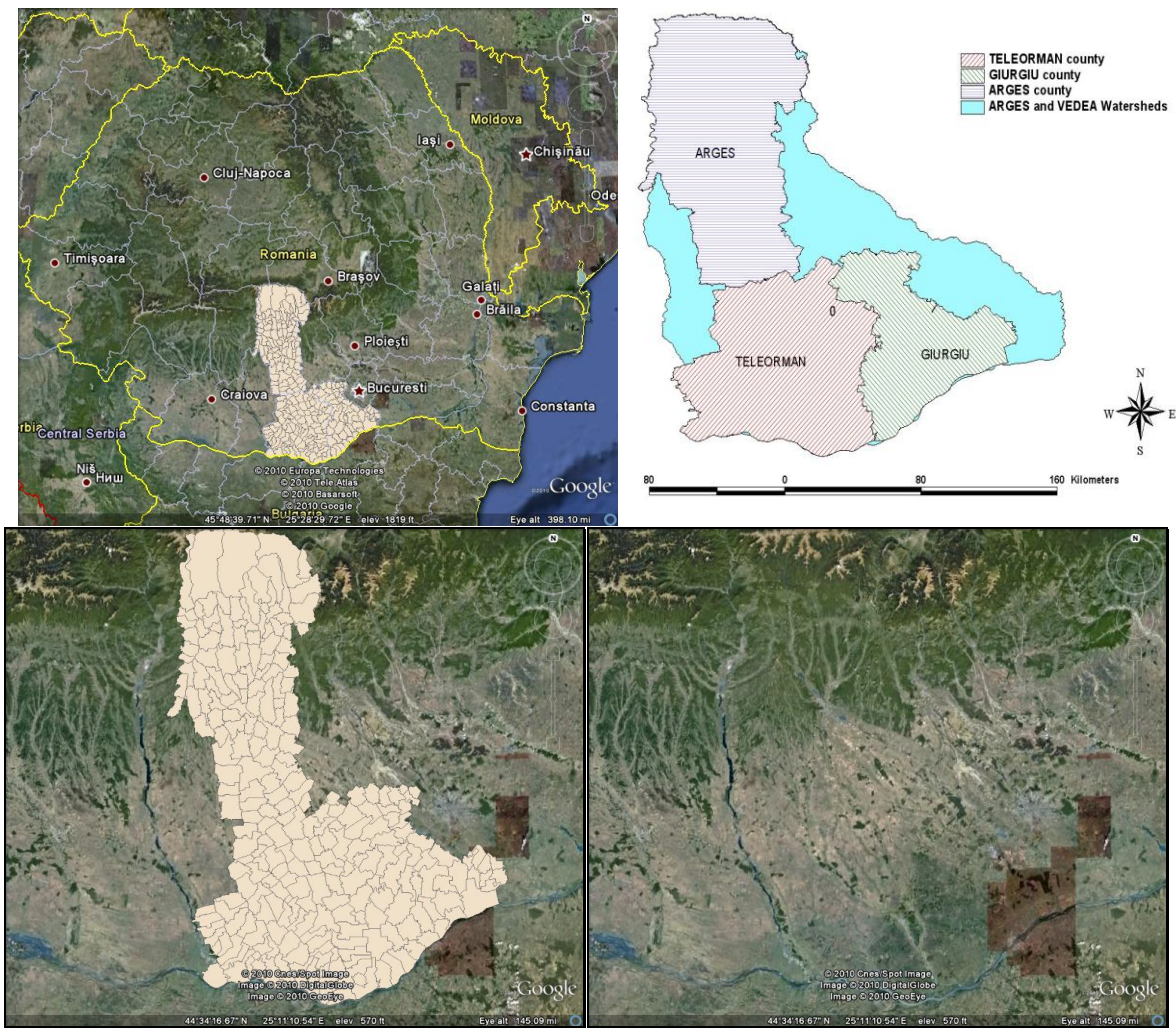


Figure 1. Location of the EU WATER case study area in Romania

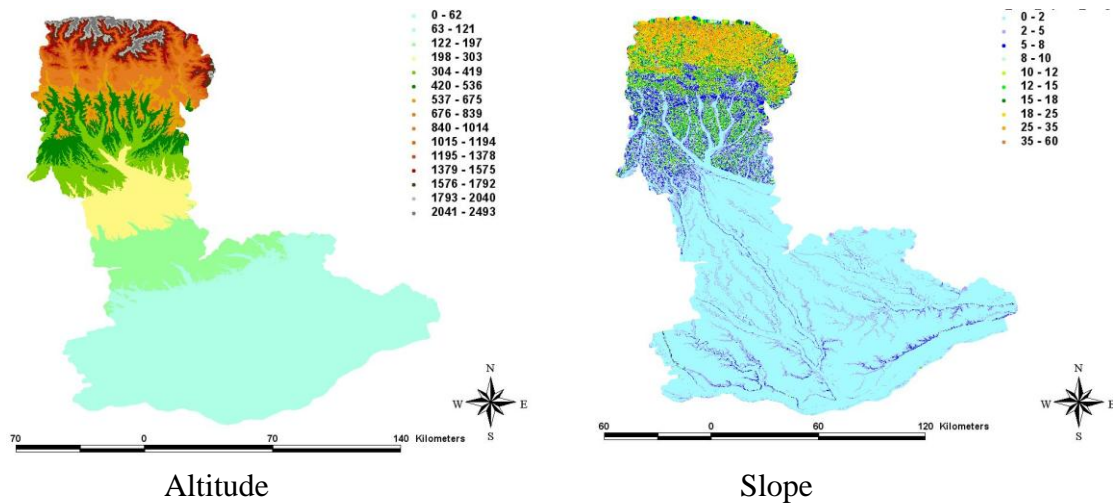


Figure 2. Altitude and slopes in the EU.WATER case study for Romania

Due to its relief the area shows a disistribution of climate from mountain specific climate (low temperature, excedent of water) to the dry climate of the plain next to Danube river. Figure 3 shows the distribution of the cumulated rainfall and potential evapotranspiration based on the downscaling to a 10' x 10' grid (longitude x latitude) of the instrumental data measured in the reference meteorological stations in the region for the time period 1961-2000.

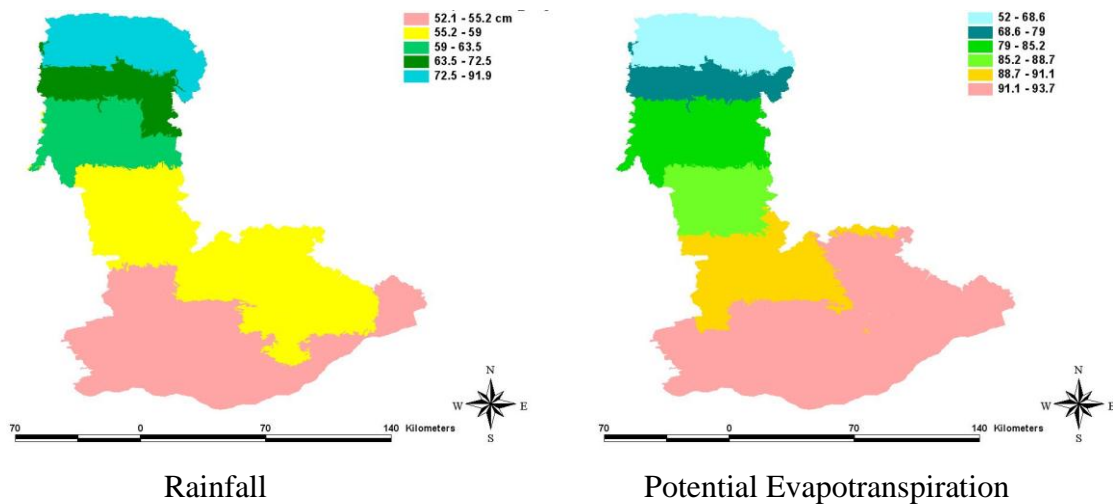


Figure 3. Spatial distribution of the cumulated rainfall and potential evapotranspiration in the EU-WATER case study area in Romania. Average for 1961-2000 time period

Figure 4 shows the spatial distribution of the reference meteorological stations in the are: Rucar- mountain area, Cimpulung and Curtea de Arges – hilly area, Pitesti – transition between hilly and plain area, Alexandria – plain area, Giurgiu and Turnu Magurele – plain in the Danube lowland area.

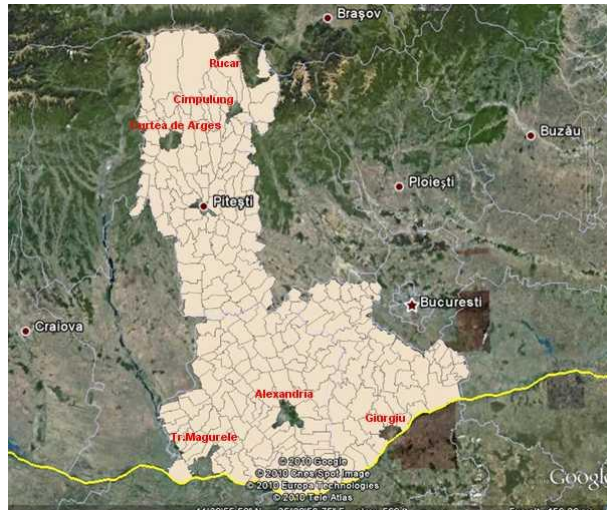


Figure 4. Spatial distribution of the reference meteorological stations in the area

Figures 5- show the distribution during the year as monthly average values for rainfall, potential evapotranspiration, actual evapotranspiration and air temperature in each of the reference meteorological stations in the area.

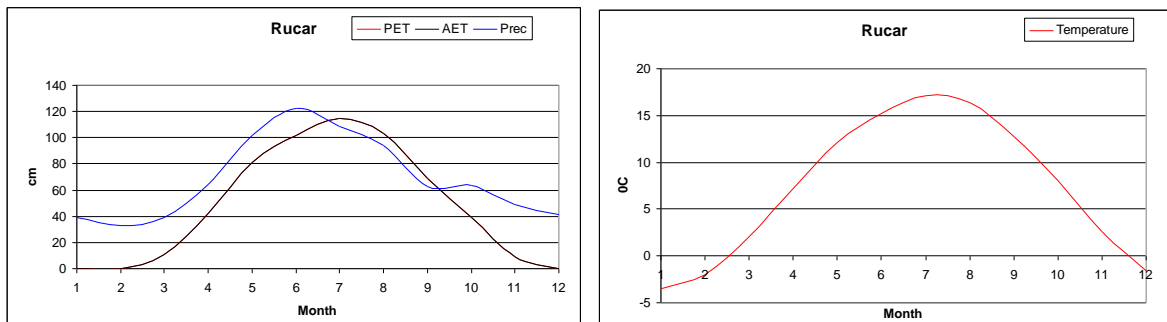


Figure 5. Monthly average values for the potential evapotranspiration (PET), actual evapotranspiration (AET), Precipitation (Prec) and Temperature for Rucar reference weather station (Longitude: 25.167 Latitude: 45.383 Altitude: 679 m)

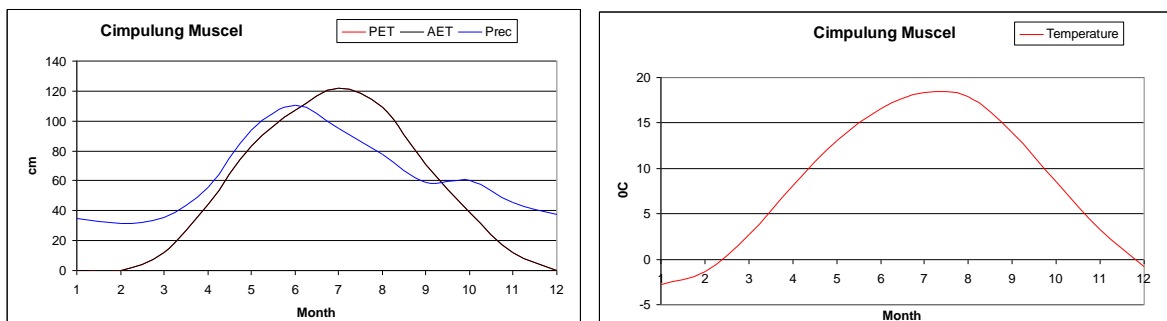


Figure 6. Monthly average values for the potential evapotranspiration (PET), actual evapotranspiration (AET), Precipitation (Prec) and Temperature for Cimpulung – Longitude: 25.033 Latitude: 45.283 Altitude: 639 m

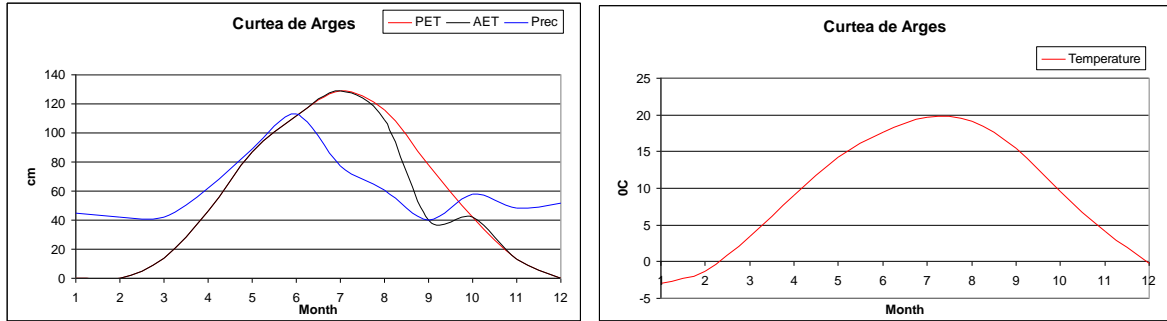


Figure 7. Monthly average values for the potential evapotranspiration (PET), actual evapotranspiration (AET), Precipitation (Prec) and Temperature for Curtea de Arges - Longitude: 24.667 Latitude: 45.133 Altitude: 437 m

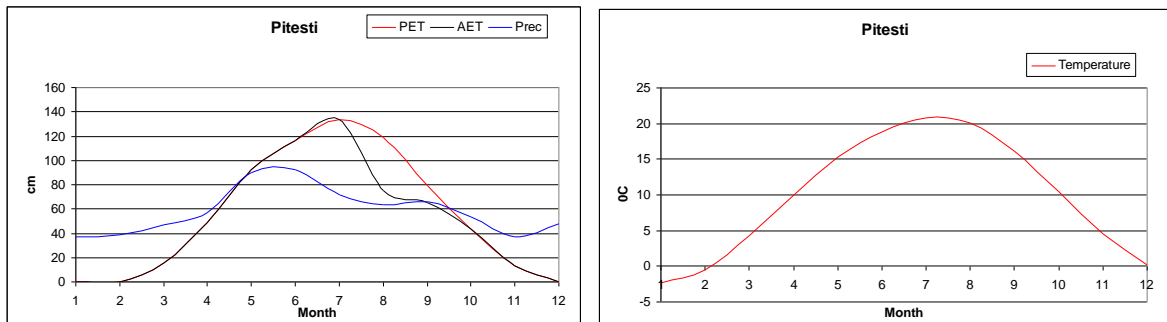


Figure 8. Monthly average values for the potential evapotranspiration (PET), actual evapotranspiration (AET), Precipitation (Prec) and Temperature for Pitesti - Longitude: 24.867 Latitude: 44.867 Altitude: 307 m

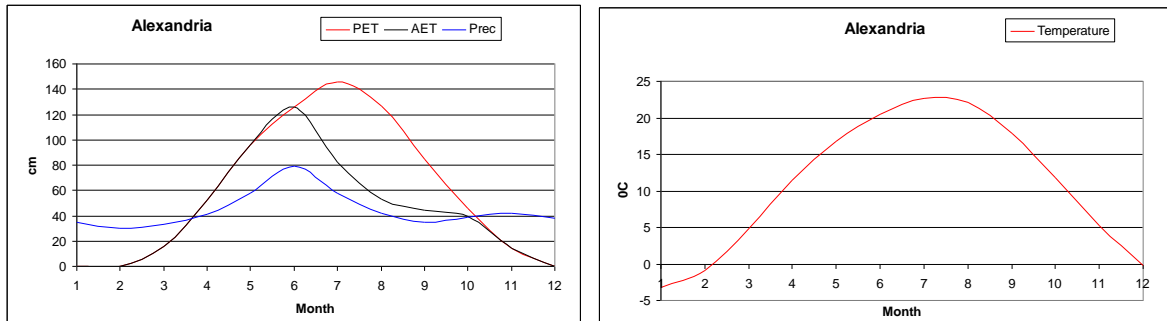


Figure 9. Monthly average values for the potential evapotranspiration (PET), actual evapotranspiration (AET), Precipitation (Prec) and Temperature for Alexandria – Longitude: 20.333 Latitude: 43.983 Altitude: 45 m

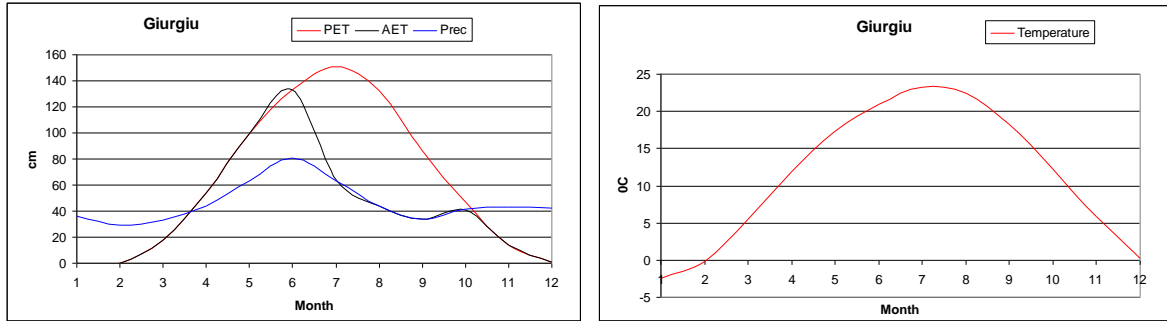


Figure 10. Monthly average values for the potential evapotranspiration (PET), actual evapotranspiration (AET), Precipitation (Prec) and Temperature for Giurgiu – Longitude: 25.967 Latitude: 43.917 Altitude: 17 m

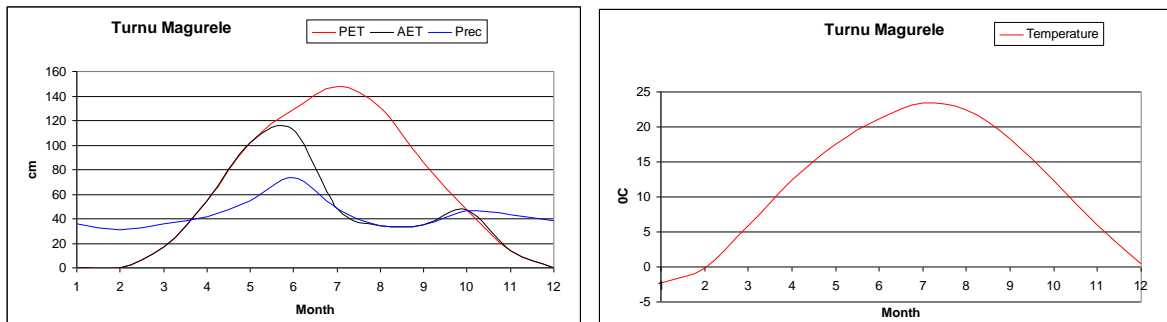


Figure 11. Monthly average values for the potential evapotranspiration (PET), actual evapotranspiration (AET), Precipitation (Prec) and Temperature for Turnu Magurele – Longitude: 24.867 Latitude: 43.75 Altitude: 29 m

1.3 Soil properties

Soil cover the case study area is very complex from soils specific to the high altitude grasslands and forests (litosols, brown acid soils) to the sandy soils in the Danube plain. In the central part of the area chernozems and vertisols with more than 45% clay content are dominant.

Figure 12 shows the soil texture classes. Based on analytical data for the soil profiles in the region the pedotransfer functions derived for organic carbon and saturated hydraulic conductivity (E.Dumitru, et all, 2009) give the values of these parameters at a 1:200,000 scale (figure 13).

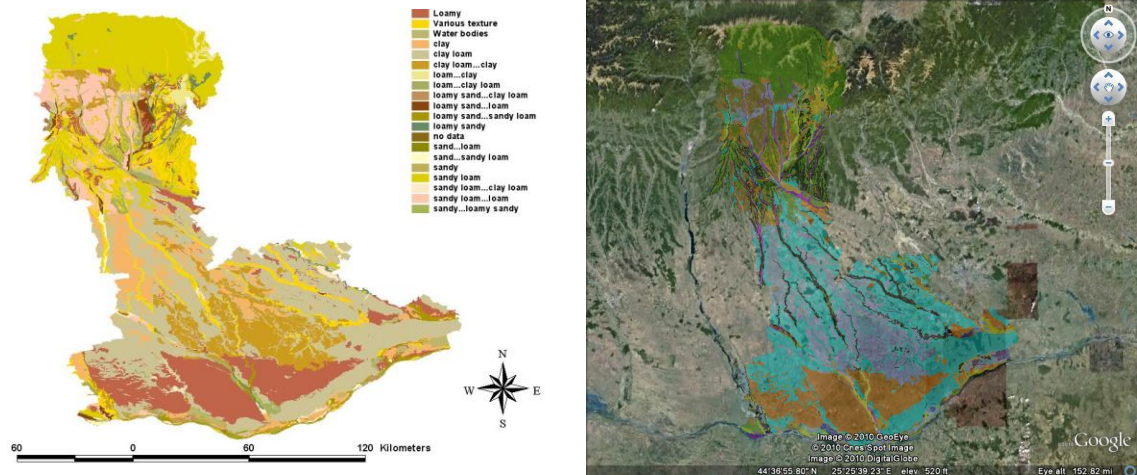


Figure 12. Soil texture classes in Arges-Vedea watershed

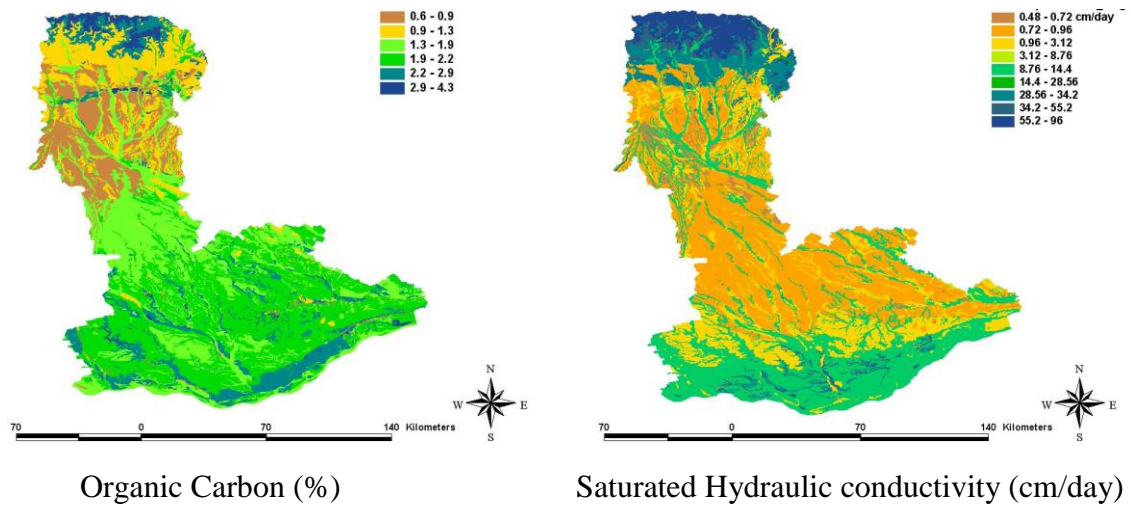


Figure 13. Organic carbon (%) and saturated hydraulic conductivity ($cm\ day^{-1}$) based on the soil map at 1:200,000 scale

1.4 Land use and agricultural land

Table 1 shows the land use pattern in the three counties in the case study area. The land use pattern is more complex in the Arges county due to its relief (arable, pastures and hayfields, orchards and vineyards) and arable dominant in the Giurgiu and Teleorman counties.

Figure 14 shows the spatial distribution of the land uses classes based on FAO-LCCS system using the remote-sensing data from 2002.

Table 1. Land use in the case study area

Land fund by use ha	Counties			Total
	Arges	Giurgiu	Teleorman	
Total area	682631	352602	578978	1614211
Arable	172114	259360	454980	886454
Pastures	102689	12631	35773	151093
Hayfields	45684	82	845	46611
Vineyards	1254	4119	7427	12800
Orchards	22824	552	150	23526
Forest and other forest vegetation lands	289947	37998	29735	357680
Waters and pounds	9354	13995	15538	38887

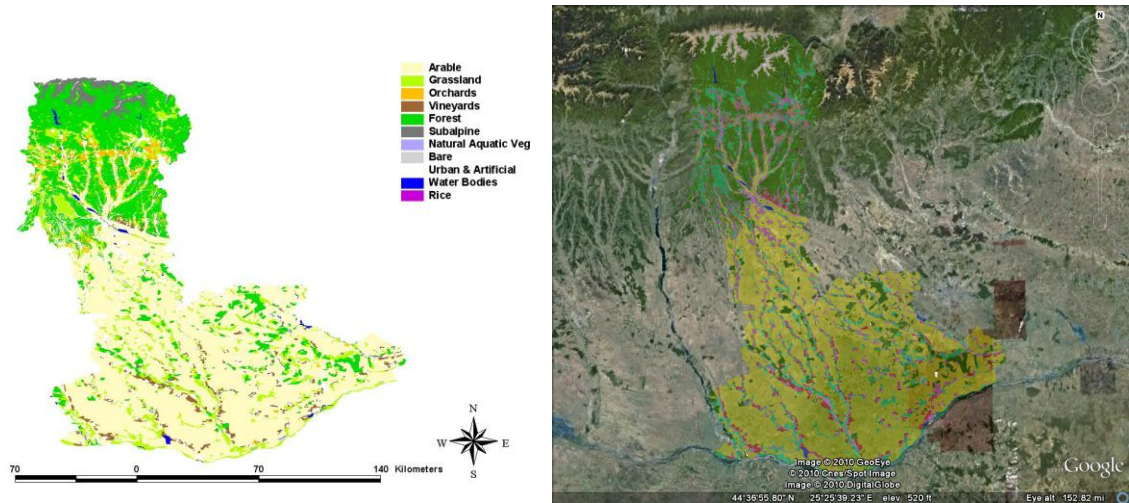


Figure 14. Land use distribution in the case study area

The farm structure for arable land (Table 2- Arges county, Table 3 – Teleorman county) shows the very complex pattern of the farms with the dominance of small farms (50% of the farm area belongs to farms less than 3 ha, the dominant farm size based on the number of farms is in the range 1-3 ha) but with large farms, too (the average farm area based on arable area is about 600 ha).

In small farms low-input agriculture (subsistence agriculture) is practiced. Here nitrogen inputs are in the range of 40-60 kg ha⁻¹. In large farms (mainly in Teleorman county) high input agriculture with nitrogen inputs up to 200 kg ha⁻¹ is used.

Irrigation is practiced on the plane areas near the Danube river.

Table 2. Farm size distribution for arable farms in the Arges county

AG	Nr. of farms	Agriculture area	Nr. of parcels	Average agriculture area per farm	Average agriculture area per parcel	Average nr. of parcels per farm	Cumulated area	Percentage of total area
<.1 ha	14009	654.94	15137	0.05	0.04	1.08	654.94	0.19129209
.1-.3	23729	4297.98	31720	0.18	0.14	1.34	4952.92	1.4466278
.3-.5	16965	6629.07	34446	0.39	0.19	2.03	11581.99	3.38281836
.5-1	33967	24886.61	95807	0.73	0.26	2.82	36468.6	10.6515935
1-2	34002	48587.73	142095	1.43	0.34	4.18	85056.33	24.842891
2-5	30544	91015.85	168883	2.98	0.54	5.53	176072.18	51.4264132
5-10	4077	26650.62	28347	6.54	0.94	6.95	202722.8	59.2104129
10-20	709	9530.44	5098	13.44	1.87	7.19	212253.24	61.9940233
20-30	63	1556.38	486	24.70	3.20	7.71	213809.62	62.4486042
30-50	66	2515.9	493	38.12	5.10	7.47	216325.52	63.1834375
50-100	239	17045.74	621	71.32	27.45	2.60	233371.26	68.1620847
>100	181	109005.68	1911	602.24	57.04	10.56	342376.94	100

Mean farm size :	2.16	ha
Dominating farm size		
based on agriculture area	602.24	ha
based on nr. of farms	1.43	ha
50 % of total area threshold	3	ha

Table 3. Farm size distribution for arable farms in the Teleorman county

TR	Nr. of farms	Agriculture area	Nr. of parcels	Average agriculture area per farm	Average agriculture area per parcel	Average nr. of parcels per farm	Cumulated area	Percentage of total area
<.1 ha	10058	464.34	11601	0.05	0.04	1.15	464.34	0.1003065
.1-.3	10460	1905.39	17907	0.18	0.11	1.71	2369.73	0.51190794
.3-.5	9637	3720.2	23752	0.39	0.16	2.46	6089.93	1.31554375
.5-1	17638	12148.35	44774	0.69	0.27	2.54	18238.28	3.93982448
1-2	23469	33743.22	83746	1.44	0.40	3.57	51981.5	11.2290186
2-5	37812	119488.77	194092	3.16	0.62	5.13	171470.27	37.0409253
5-10	9894	64704.52	68578	6.54	0.94	6.93	236174.79	51.0183646
10-20	1112	13454.8	10095	12.10	1.33	9.08	249629.59	53.924864
20-30	175	4154.93	1567	23.74	2.65	8.95	253784.52	54.82241
30-50	74	2846.92	852	38.47	3.34	11.51	256631.44	55.4374003
50-100	121	8069.56	1577	66.69	5.12	13.03	264701	57.1805828
>100	326	198220.13	4733	608.04	41.88	14.52	462921.13	100

Mean farm size :	3.83	ha
Dominating farm size		
based on agriculture area	608	ha
based on nr. of farms	3.16	ha
50 % of total area threshold	6.5	ha

For the arable land cereals for grains (winter wheat, maize, barley) are the most cultivated followed by oilseed crops (sunflower dominant). Table 4 shows the distribution of the areas used for the main arable crops in each county.

Table 4. Arable land by use (2008 Agriculture statistics)

Land fund by use ha	Counties			Total
	Arges	Giurgiu	Teleorman	
Cultivated area	156115	235112	367091	758318
Cereals for grains	110750	159130	261423	531303
- Wheat	42715	83070	153273	279058
- Barley and two-row barley	4276	15987	19688	39951
- Oats	9710	2730	3951	16391
- Maize grains	53203	57090	84030	194323
Dried pulses	151	903	1088	2142
- Peas	62	694	1057	1813
- Dried beans	89	209	31	329
Potatoes	4587	1354	1543	7484
Sugar beet	-	-	-	-
Fodder roots	913			913
Oilseed crops	18357	42864	80784	142005
- Sunflower	14246	26989	56047	97282
- Soya beans	20	886	96	1002
Vegetables	5573	6164	6621	18358
- Tomatoes	1514	1656	1405	4575
- White cabbage	1339	828	954	3121
Green fodder from arable land	18193	27315	17039	62547
- Annual green fodder	4999	20262	8240	33501
- Perennial fodder	13194	7053	8799	29046

Calculating the biophysical criteria defining the less favoured areas for agriculture most of the agriculture surface of the case study area is included in severe and very severe constrains (figure 15)

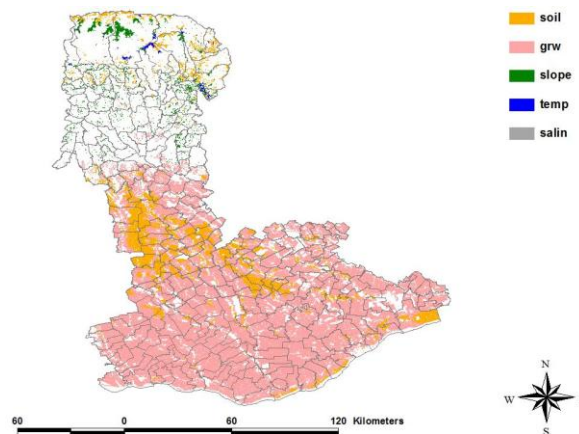


Figure 15. Areas with severe and very severe constrains for agriculture use (soil: vertic soils, soils with high clay content, soils with high sand content; grw: growing period- less than 75 days during the vegetation period with air temperature over 5°C and ratio between actual and potential evapotranspiration over 0.5; slope: terrains with slope over 12%; temp: sum of temperatures over 5°C less than and saline soils)

Based on the land evaluation system (land marks) used in Romania using soil surveys at comuna level at 1:50,000 scale the average yields for arable crop were evaluated for the major relief regions: plain, hill, mountain. Table 5 shows the average yields for the three relief regions and the minimum (average-standard deviation) and maximum (average + standard deviation) probable yields. The average and standard deviation were evaluated for the 1961-2000 climate data series.

Table 5. Average, minimum and maximum yields for the plain, hill and mountain regions

Crop	Relief	YIELD (kg / ha)		
		Average	Average-std	Average+std
winter wheat	plain	2368	1520	3216
	hill	1849	1043	2657
	mountain	1454	820	2088
barley	plain	2830	1555	4105
	hill	1843	970	2716
	mountain	832	438	1226
maize	plain	2892	1675	4109
	hill	1694	925	2474
	mountain	791	431	1151
sunflower	plain	1306	920	1692
	hill			
	mountain			
soybeans	plain	1195	681	1709
	hill	678	359	997
	mountain			
peas	plain	1604	1055	2153
	hill	1075	661	1489
	mountain	675	415	935
beans	plain	855	610	1101
	hill	838	596	1081
	mountain	526	374	678
sugarbeet	plain	18222	10739	25706
	hill	11546	5080	18011
	mountain	5239	2305	8173
potatoes	plain	8275	5611	10940
	hill	11932	6777	17084
	mountain	8172	4641	11702
winter oilseed rape	plain	1416	933	1898
	hill	804	530	1077
	mountain	635	419	851
alfalfa	plain	19235	16623	21848
	hill	11082	9444	12719
	mountain	5243	4468	6018
clover	plain	14493	5719	23268
	hill	13604	11769	15436
	mountain	12411	10737	14085

Table 6 shows the average yields recorded at the county level in the last year included in official agriculture statistics (2008).

Table 6. Average yields at county level recorded in 2008

Average Yield 2008 kg/ha	Counties		
	Arges	Giurgiu	Teleorman
Cereals for grains			
- Wheat	3244	3353	3395
- Barley and two-row barley	3027	3203	3543
- Oats	1127	2021	1832
- Maize grains	3326	3164	2247
Dried pulses			
- Peas	1645	2163	1824
- Dried beans	719	1536	710
Potatoes	13992	10309	11056
Sugar beet	-	-	-
Fodder roots	25249		
Oilseed crops			
- Sunflower	1198	1092	1171
- Soya beans	3000	2292	1000
Vegetables			
- Tomatoes	12180	15803	10847
- White cabbage	19622	13697	18321
Green fodder from arable land			
- Annual green fodder	12048	10214	12370
- Perennial fodder	15611	6137	10073

1.5 Surface waters

Arges and Vedea rivers are tributary to Danube. 75 % of the area of their catchment is included in the case study area. Figure 16 shows the river network and, separately, the irrigation systems in the case-study area.

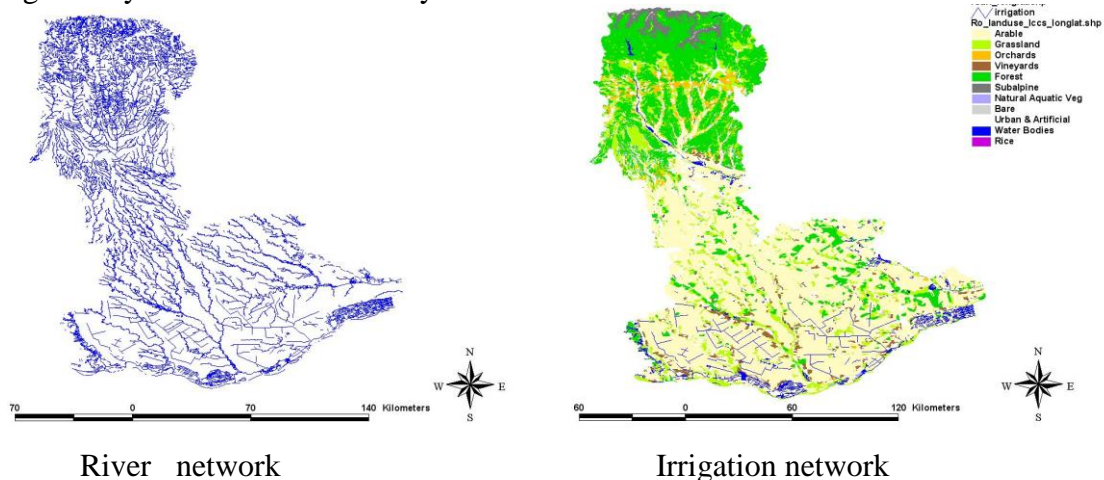


Figure 16. River and irrigation network in the case study area

1.6. Hydrogeology and groundwater quality

The case study area includes 5 aquifers (figure 17) of various origins (Holocene, Upper Pleistocene and Upper Pleistocene-Holocene), lithology of the vadose zone (siltic clay, clay-sandy clay, loess), thickness and hydraulic conductivity of the vadose zone.

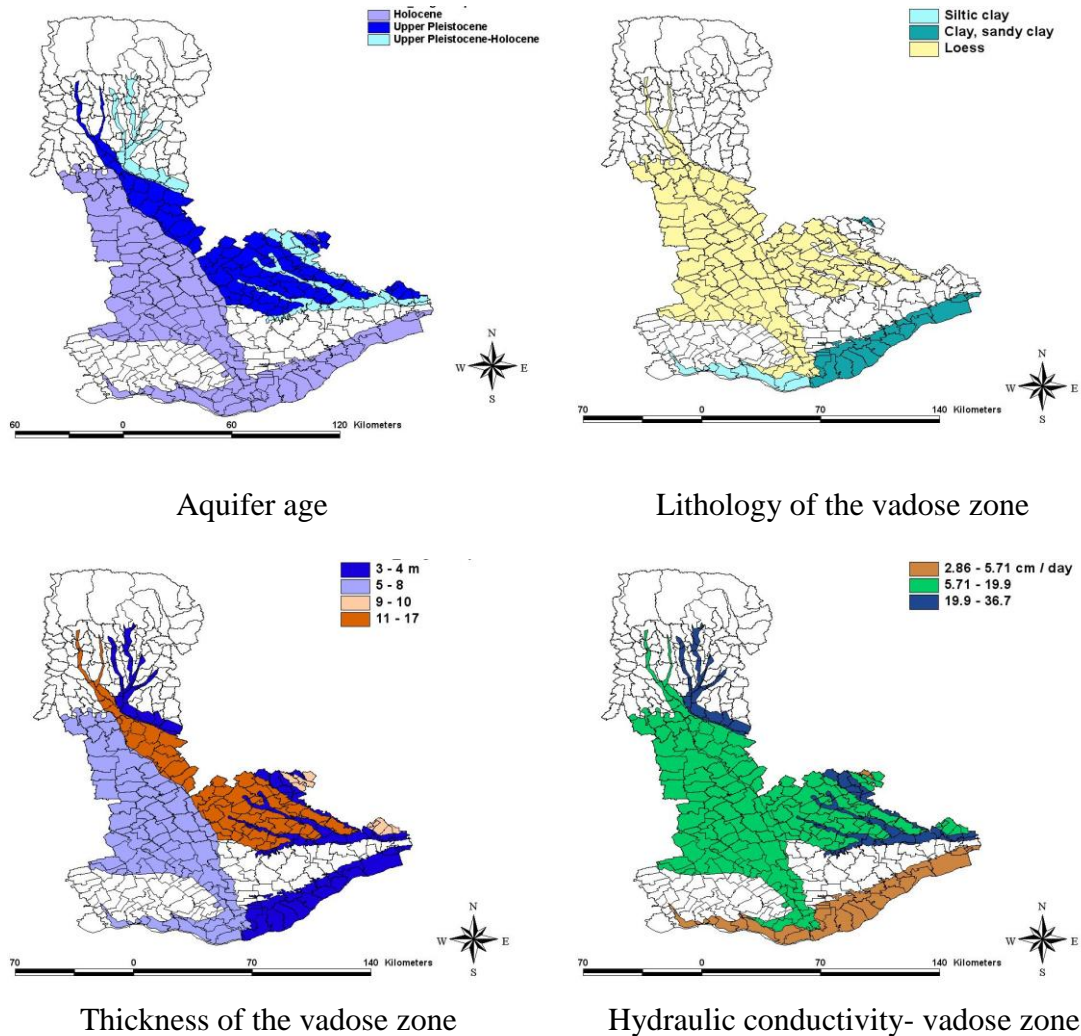


Figure 17. The main characteristics of the aquifers in the case study area

Using the methodology developed in the EU.WATER project by the Aristoteles University the vulnerability areas of the aquifer to the nitrate percolation were evaluated as percentage of nitrate leaching to the nitrogen applied at the topsoil and as the transit time from root zone to the aquifer (figure 18).

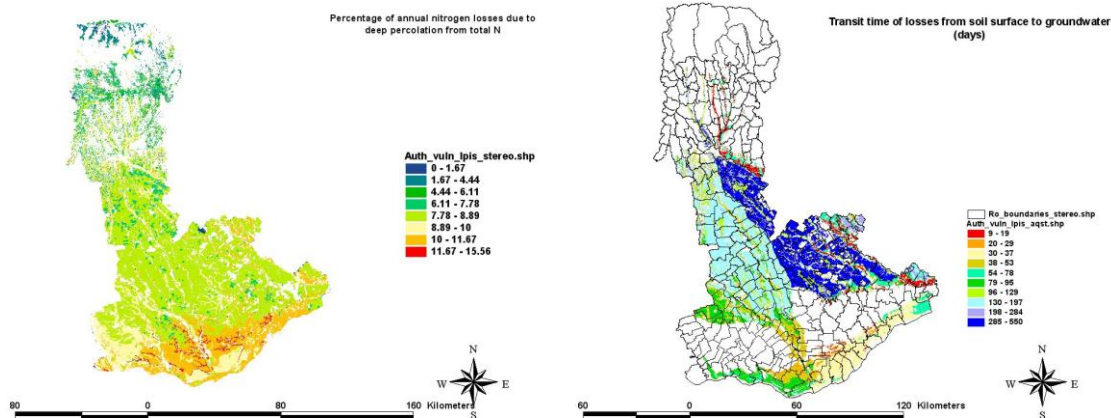


Figure 18. Percentage of annual nitrogen losses due to deep percolation from total nitrogen applied on topsoil and the transit time of losses from soil surface to groundwater

1.7. Pollution sources

The main pollution sources for nitrates in water bodies comes from animal wastes. Table 7 shows the total number of animals per species in Arges, Giurgiu and Teleorman counties.

Table 7. Total number of animals (per species) in Arges, Giurgiu and Teleorman counties

County	Cattle (heads)	Pigs (heads)	Sheep (heads)	Goats (heads)	Poultry (heads)
Arges	116666	233420	206790	23952	1426026
Giurgiu	35454	105496	61168	14590	858142
Teleorman	56852	153341	138366	40007	2045062
TOTAL	208972	492257	406324	78549	4329230

Most of the animals in small individual farms are inside the village area. Therefore, the pressure for groundwater pollution is inside the perimeter of build-in areas of villages. Figure 19 shows the location and capacity of the main animal complexes for pigs and poultry.

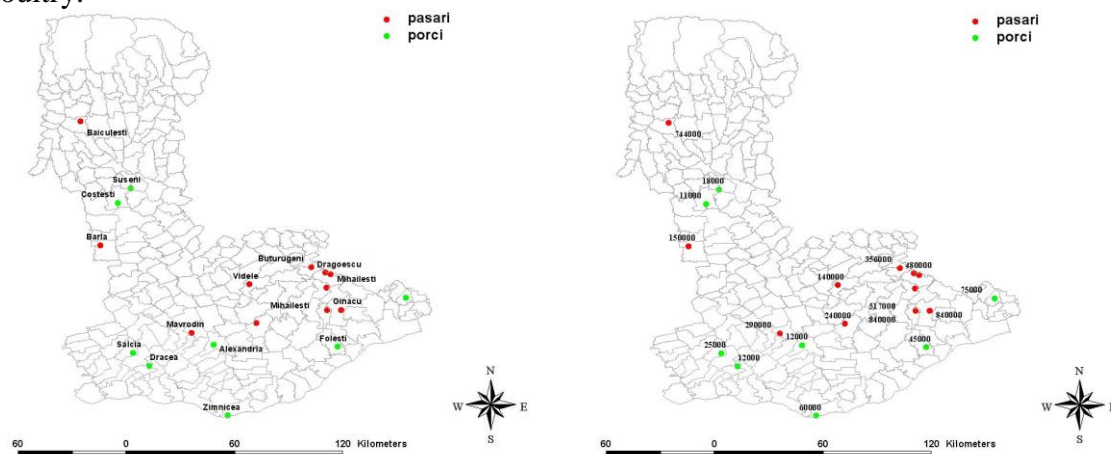


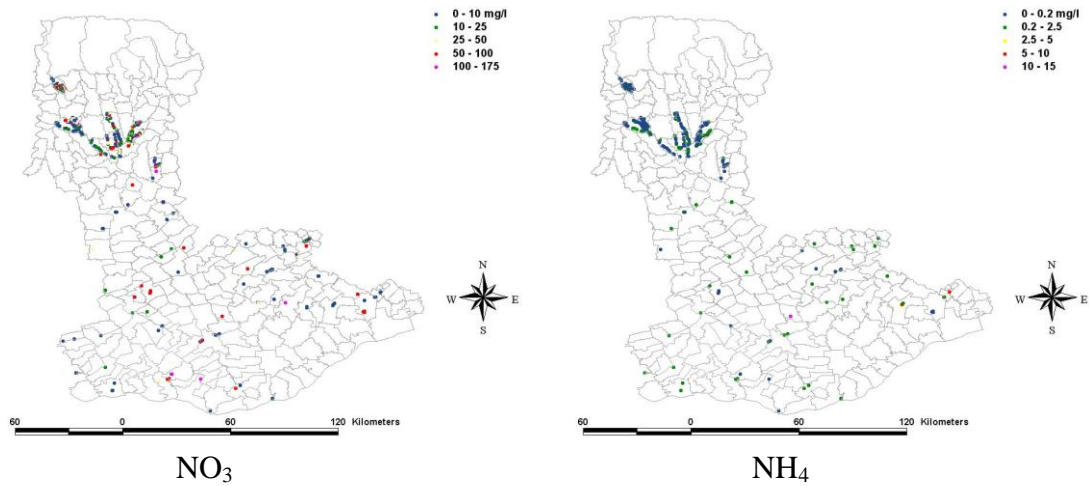
Figure 19. Location and number of the animal complexes (pasari: poultry; poci: pigs)

Most of animal complexes are near the built-in perimeter of localities and near a surface water course (figure 20)



Figure 20. Animal complexes infrastructure

The national network developed by Romanian Waters Administration was used for evaluating the nitrate concentration in the groundwater in the case study area. Field campaigns measuring the nitrate concentration in public and individual wells in hill region of the Arges county were added to the national network. Figure 21 shows the average nitrate and ammonium concentration for the years 2006-2008. The pattern of nitrate shows that the pollution of groundwater with nitrates is more a site-specific problem than a diffuse one (points with high nitrate concentration near points with low concentration, no correlation with high animal concentrations).



NO₃ **NH₄**
Figure 21. Nitrate and Ammonium concentration in the groundwater