D5.3 Summary of the conceptual understanding of the natural system in the case study

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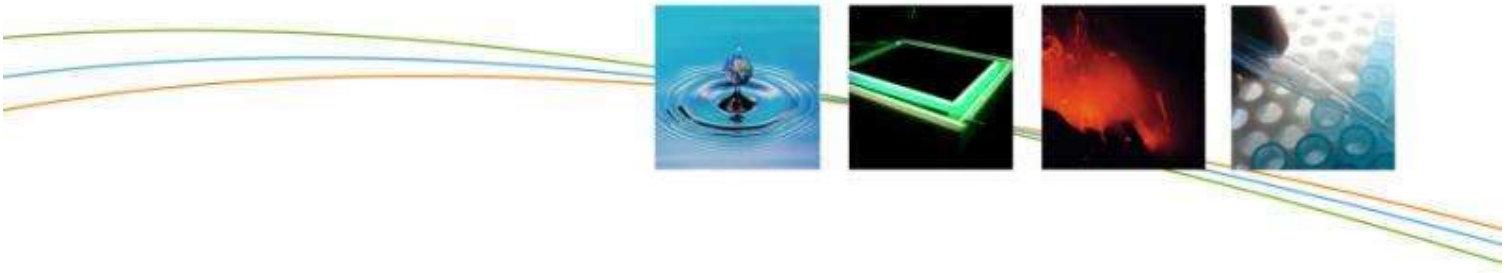

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List of abbreviations & acronyms

WFD	Water Framework Directive
DMI	Danish Meteorological Institute
ERT	Electrical Resistivity Tomography
TEM	Transient Electro-Magnetic
GEUS	Geological Survey of Denmark and Greenland
DHI	Danish Hydraulic Institute

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1 Introduction

This section to be completed in the final version of the deliverable by M18 (end November 2018)

1.1 Purpose of the study

1.2 Overview

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Action lab: Mara Catchment (Romania)

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3 Mara (Breboaia) Catchment (Romania)

3.1 Executive summary in *(native languages)*

Bazinul Văii Mara, județul Maramureş, România, este reprezentativ pentru sistemele agricole de subzistență din Munții Carpați - creșterea vitelor și ovinelor. Zona de studiu este un peisaj cultural tipic, modelat de practicile tradiționale. Aprovizionarea cu apă în zona (satul Breb) este asigurată de sistemul centralizat și de puțurile private utilizate de mai mult de jumătate din gospodăriile din sat; în plus, râul Mara este o zonă protejată de interes local datorită prezenței unor specii protejate importante: păstrăvul (Salmo trutta), graylingul (Thymallus thymallus) a cărui supraviețuire depinde de calitatea apei.

Creșterea bovinelor și a ovinelor în bazinul hidrografic afectează calitatea apei potabile, dar și calitatea apei de suprafață, deoarece gunoiul de grajd este folosit ca îngrășământ la scară largă și exista scurgeri din hambarele majorității gospodăriilor. Nitrații și nivelurile nutrienților sunt monitorizate de către autorităţi numai în apele de suprafață din aval pe două secțiuni ale râului Mara (în afara zonei de proiect). Nu există un sistem centralizat de canalizare în regiunea zonei pilot din Maramures, cee ace ridică probleme majore pentru calitatea apei de suprafață și subterane.

În cadrul proiectului, pentru realizarea unei baze de date au fost colectate date cu privire la: elemente administrative, categoriile de folosinţă ale terenurilor, structura vegetaţiei, geologie, soluri, hidrologia zonei, clima, precipitaţiile, elementele de infrastructura: drumuri, construcţii, obiective economice pensiuni, zona de captare a apei potabile pentru comuna Ocna Şugatag şi zonele de protecţie stabilite, zona staţiei de tratare a apei potabile, staţii de epurare existente în zona ţintă, arii protejate, punctele de monitorizare pentru calitatea apei, localizarea fântânile din Breb (cele utilizate).

În contextul proiectului încurajăm construirea unor facilități simple și îmbunătățite pentru depozitarea gunoiului de grajd, care ar reduce în mod semnificativ riscul de poluare a apei, contribuind, de asemenea, la îmbunătățirea calității mediului (inclusiv a calității apei) și a condițiilor de viață în numeroase gospodării. Lucrăm şi în scopul identificării mijloacelor financiare pentru a facilita implementarea sistemelor de management al gunoiului de grajd (platforme acoperite, impermeabile).

3.2 General description

The area of interest is located in the alpine and continental biogeographical region, in the volcanic area of the Eastern Carpathians, more precisely in the Gutai Mountains, and it is limited to the West by the Hopsia River, to the East by Rausor Valley, the villages of Mara and Hoteni, to the south by national road DN 18 and to the north by the ridge of the Gutai Mountains. The area is included in N2000 sites ROSPA0134 Munții Gutâi, ROSCI0089 Gutâi - Creasta Cocoșului and ROSCI0092 Igniș.

Maramures action lab is a rural region from North Western part of Romania, including a typical cultural landscape shaped by traditional practices, representative for small scale/ subsistence farming systems in the Carpathian Mountains – cattle and sheep breeding. The core area of the

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action lab is Breb village which is located in the central-northern part of the Maramures depression, in the upper part of the Mara river basin on the northern piedmont of the volcanic Gutâi massif, 25 km from Sighetu Marmatiei and 52 km from the Baia Mare county capital. (Fig 1 location of Breboaia action lab, core region Breb Village).

Figure 1 location of Breboaia action lab (Romania)

Breb village belongs to Breboaia river catchment (27,1 km^2). Breboaia River is a tributary of the Mara River and an important natural resource which also supports high biodiversity, including many protected species. Mara river is a protected area of local interest due to the presence of important protected species: trout (Salmo trutta), grayling (Thymallus thymallus) whose survival depends on the water quality.

Water coming from the action lab area enters Mara River. The quality of the water is considered good, according to official data. Source of the creeks from action lab is not considered nitrate sensitive. Destination of the water courses has a concentration of nitrates due to crossing of the village where farmers use manure as fertilizer. The water quality of the Mara River is affected by the diffuse pollution sources originating from the agricultural and forestry sector, even if the effect is moderate. In rural households located in the Mara River Basin, traditional agriculture is practiced on small areas, and the fertilization of crops is done only with organic fertilizers. There is a risk of contamination with nitrates but its impact is not significant on the aquatic life.

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90% of the population is using the current public drinking water system, managed by Ocna Sugatag Mayor House as for the rest there are some wells and individual water systems in use. The public water system uses water from the mountainous area (Gutai Mountains) and has a good quality (according to official data from Ocna Sugatag Mayor House). As part of Maramures depression, Breb village has some mineral springs, but they are not used anymore.

3.3 Previous investigations

The monitoring of the water quality from the basin of the Mara river is performed by the National Water Authority, Maramures Directorate, namely by the Laboratory for the Chemical Analyses in two reference control sections: the upstream of the river Mara (reference section) and the river Mara at Vadu Izei. (these 2 sections are at the boundaries of action lab area, and not included in WaterProtect lab case area). According to available public data for these 2 sections (2007, 2010 the indexes categories range within the first and the second quality classes (the quality categories for the surface waters are stipulated in the Order no.161/2006 of the Ministry of Environment and Waters & Forest Ministry.
Within the framework of Water Protect, a small scale area was investigated and 5 monitoring stations for surface waters were selected: 1. Upstream of Valea Sunătoare, 2. Valea Brebului upstream of Breb; 3. Valea Brebului downstream of the confluence of the Valea Sunatoare 4. Valea Brebului, downstream of Breb) and 5. Mara River – the Harniceşti sector (fig. 10).

There has not been additional local data collection or surveys in the area, and therefore many general data and maps have been collected and developed within the context of WaterProtect project. These data are described further in the next section.

3.4 System description

In Mara (Breboaia) action lab (Romania), the present threat to the water quality (especially surface water) is nitrate from agriculture, i.e. cattle and sheep breading in the catchment area affects the drinking water quality but also the surface water quality since manure is used as a large scale fertilizer and leaks from the barns of most of the households; there is no centralized sewage system in this case study (Breb village), which poses major problems for surface and underground water quality. In the present section the existing data relevant to the transport and fate of nitrate in the action lab is presented and discussed.

3.4.1 Topography

Mara (Breboaia) Catchment has an elevation that ranges from 395 m to 1413 m. The Gutâi Mountains cover the southern part of the Breboaia Catchment covering all the area situated above the 800 contour line. The central and north parts of the catchment represents a hilly area with

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numerous river valleys that belongs to Maramureș Depression. Breb Village is situated in the north central part of the action lab, in an area with mild to moderate slopes.

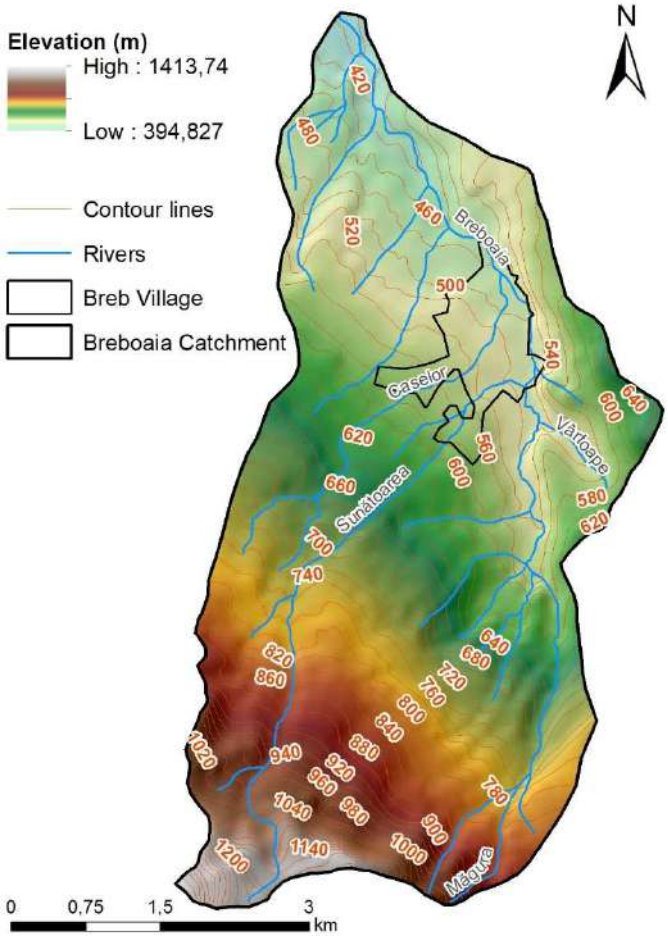

Figure 2 Topographical map of Breboaia Catchment

3.4.2 Land use / Land cover

Most of the agricultural land in Mara (Breboaia) Catchment consists of meadows and pastures. In and around Breb Village arable land and orchards (consisting of mostly plum trees) occupy the largest areas (fig. 3).

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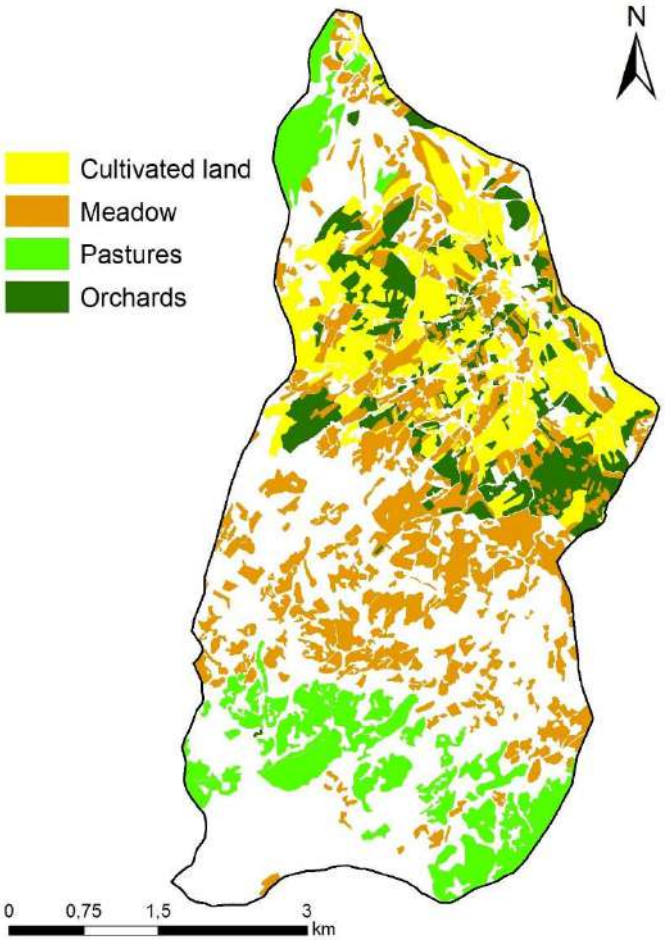

Figure 3 Agricultural land use map of Breboaia Catchment

3.4.3 Climate and hydrology (precipitation, evaporation and net precipitation)

The climate in Mara (Breboaia) action lab is typical for temperate continental climate with annual air temperatures values (fig. 4) ranging from 4^0C and 8^0C. During the May- September interval it's most likely to experience good weather with pleasant average temperatures. On average, the warmest month is August. On average, the coolest month is January.

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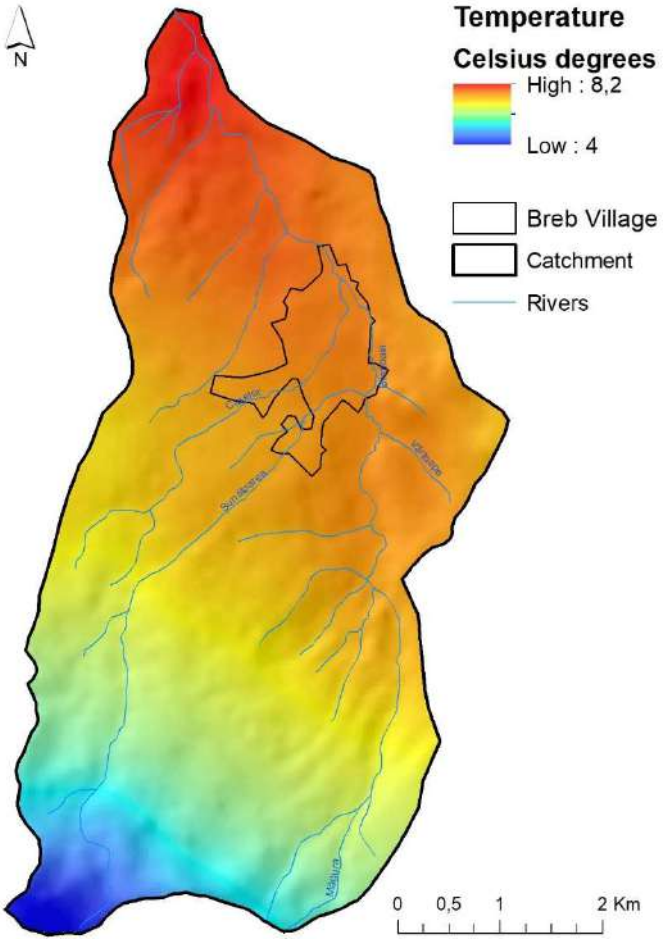

Figure 4 Temperature distribution map of Breboaia Catchment

The annual amount of precipitation (fig. 5) fluctuates between 750 mm (in the north of the catchment) and 900 mm in Gutâi Mountains. June is the wettest month. February is the driest month. The months with the most abundant rainfall are June, July and October, the poorest being recorded in September, February and March, but with significant annual variations. The average number of precipitation days is 170 in the mountain area, down to 150 in the rest of the catchment.

The first snowflakes that lay a continuous layer of snow in the mountain range occur at the end of November, but they can appear in October as well. The snow is kept in the mountains and on the northern slopes until April, the month of the last snowfalls. There are frequent years in which, at the end of April, the late snow are present on the subalpine pastures, while vegetation in forests at lower altitude are already blooming.

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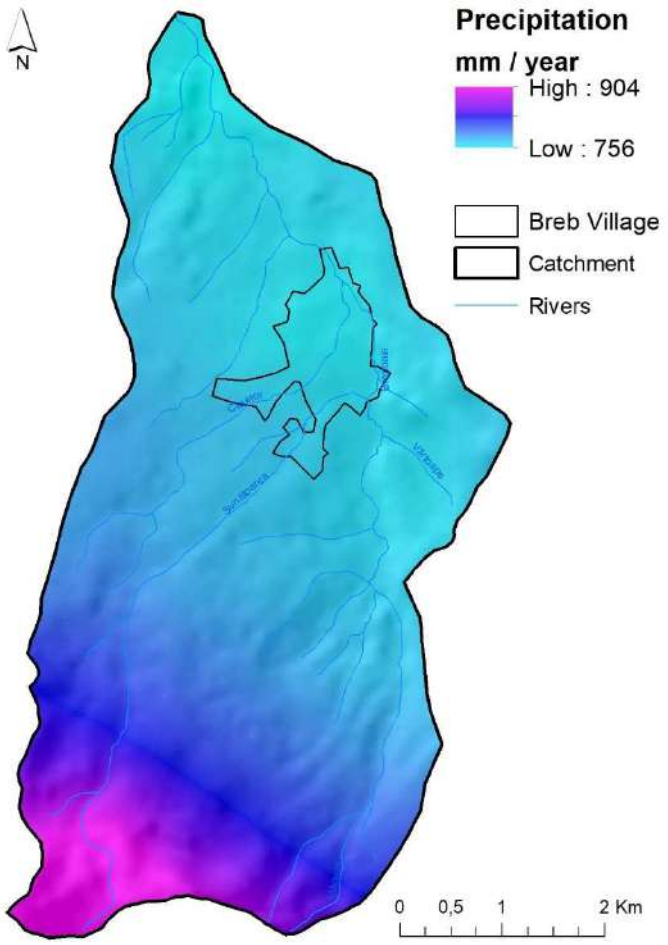

Figure 5 Precipitation distribution map of Breboaia Catchment

The potential evapotranspiration distribution map (fig. 6) shows high values (over 800 mm/year) in the northern areas of the action lab, and lower values (in the southern parts of the catchment.

The annual water availability values (precipitation minus evapotranspiration) vary between +240 mm/year in the mountainous areas to -67 mm/year in the northern parts of the catchment.

Wind. The calm weather (no wind) varies between 40-54% in the surrounding depressions, which is lower in the subalpine area. The predominant winds are west, northwest and southern direction, at an average speed not exceeding 4 m / s (except for the high peaks). In the Gutâi and Ignis Mountains the eastern and northeast winds are not felt. There are some storms (rare), with disastrous effects on forests due to extensive deforestation, and under the threat of climate change effects.

Cloud. The number of serene days does not exceed 40 in the mountain area, being over 50 in depressions. The relative humidity reaches 84% in the high mountain area, decreasing to 72-76% in December (7.2 tenths), and the minimum in July and September (4.7 tenths) in the Baia Mare area.

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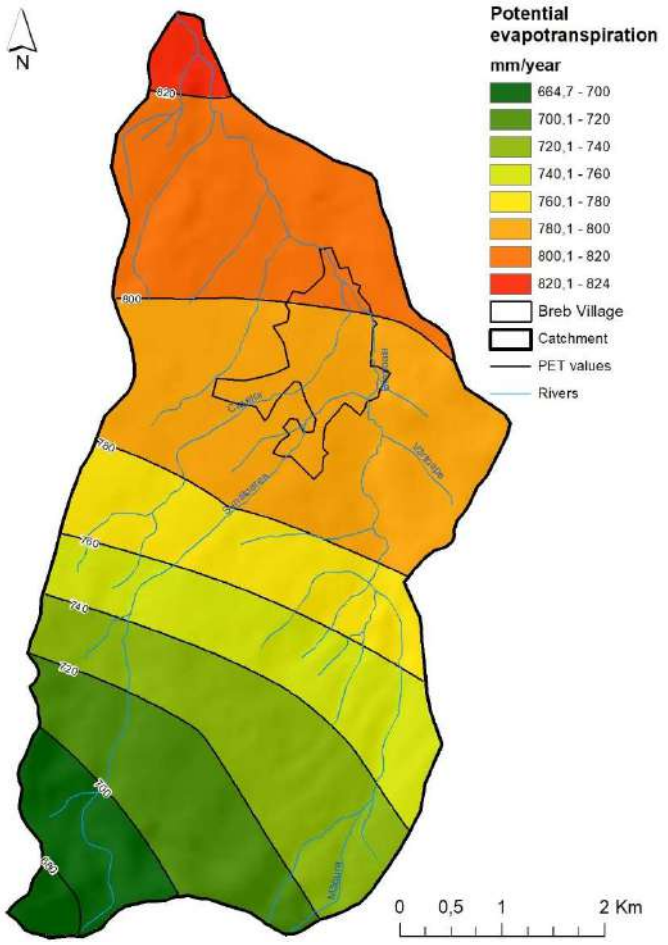

Figure 6 Potential evapotranspiration distribution map of Breboaia Catchment

The territory of Breb village is crossed by a rich hydrographic network (fig. 7). In the local toponymy, the main watercourses that spring from the Gutâi Mountains and flow into Mara are known under the following names: Valea Breboaia, Valea Mare, Valea Sunatoarei and Valea Caselor.

The depth of phreatic waters ranges from a few centimeters to a few meters and it is used for drinking water from dug wells in Breb Village.

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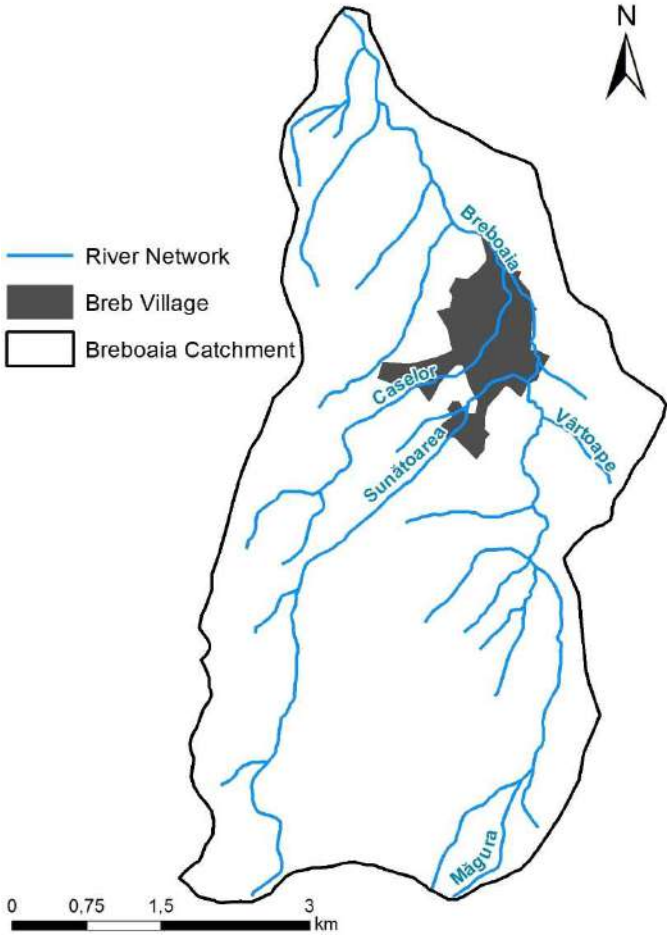

Figure 7 River network of Breboaia Catchment

3.4.4 Soil types and drainage

Leptosols and andosols characterize the mountainous areas (fig. 8). Fluvisols are found in the lower parts of the Breboaia River. Dystric cambisols dominate the hilly areas from the catchment, while haplic podzols are found in a small area in the north-west.

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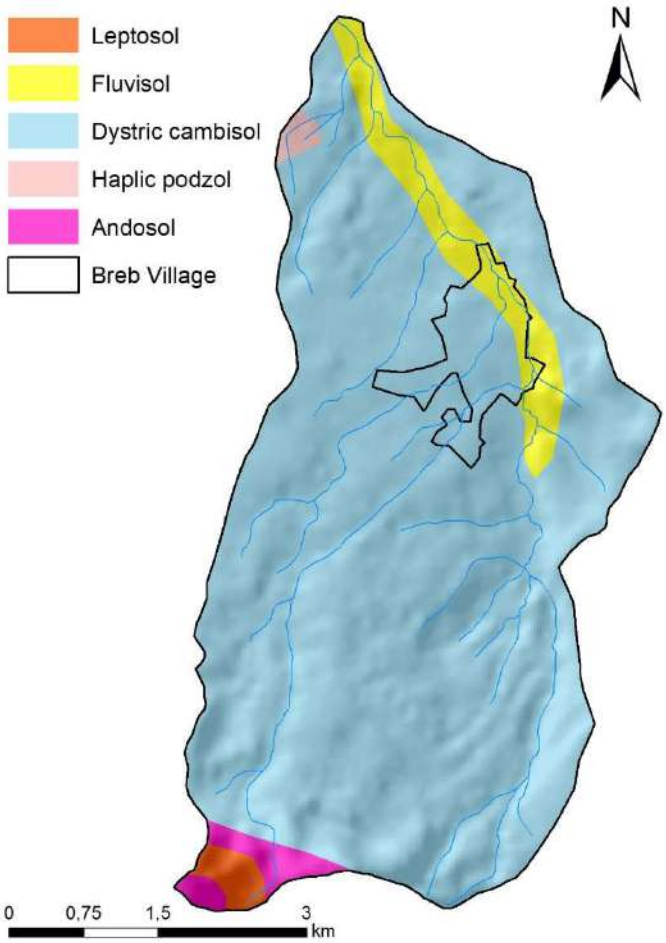

Fig 8 Soil types map in Breboaia action lab

3.4.5 Geology

The geological structure of the Gutâi Mountains (fig. 9), where volcanism was predominant, determines the present aspect of the morphology. They are composed almost exclusively of volcanic andesitic rocks, formed from Neogene-Quaternary lava eruptions. Tortonian deposits were later covered by delluvial deposits in the upper Pleistocene, mostly mixed with volcanic conglomerates from the surrounding volcanoes. Holocene fluvial deposits occur only in the lower part of the Breboaia River.

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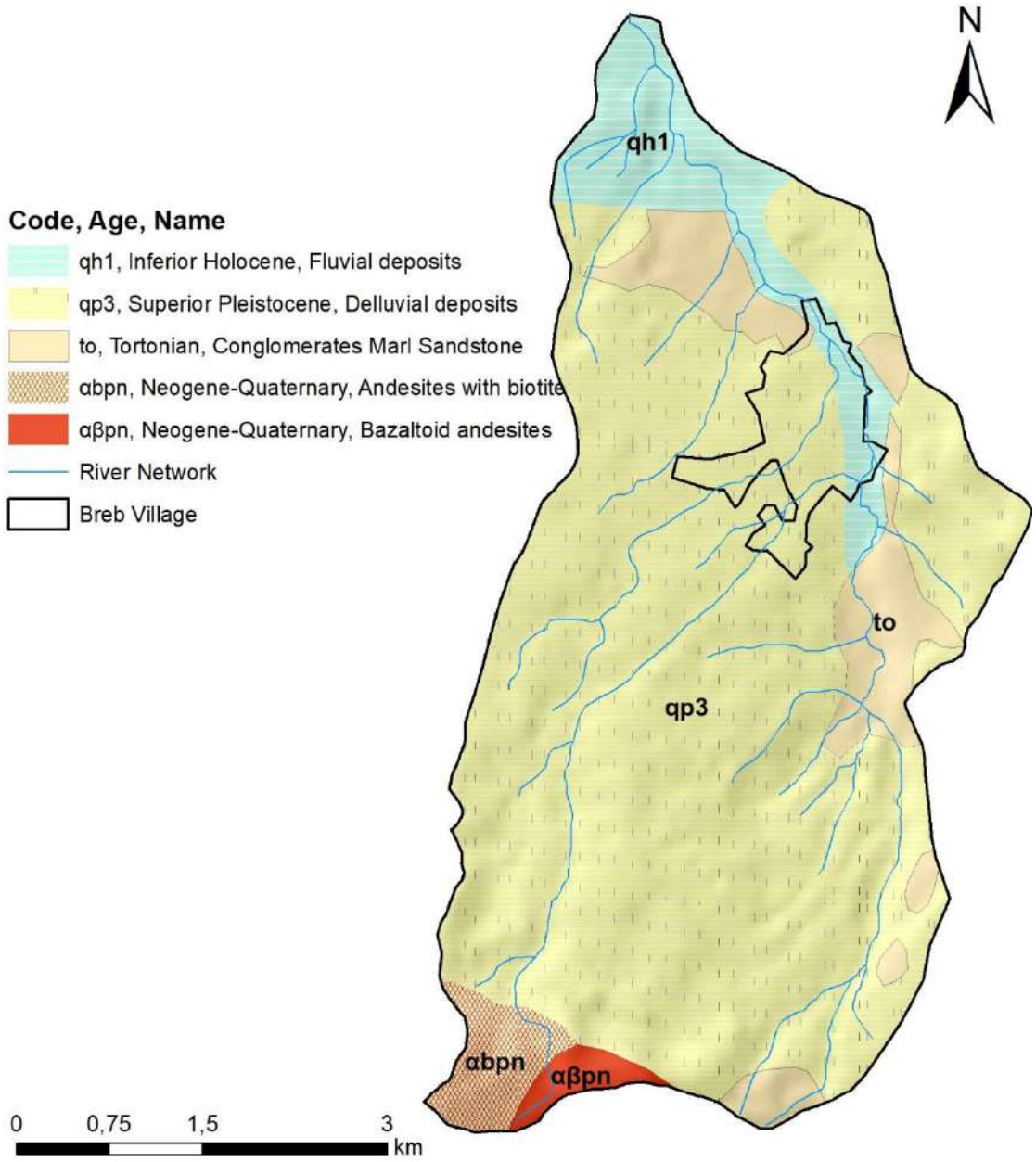

Figure 9 Geological map of Breboaia Catchment

3.4.6 Nutrients monitoring

According to official information, the water quality of the Breboaia River is good, and the vulnerabilities are recorded only at the nutrient regime, but at a moderate level.

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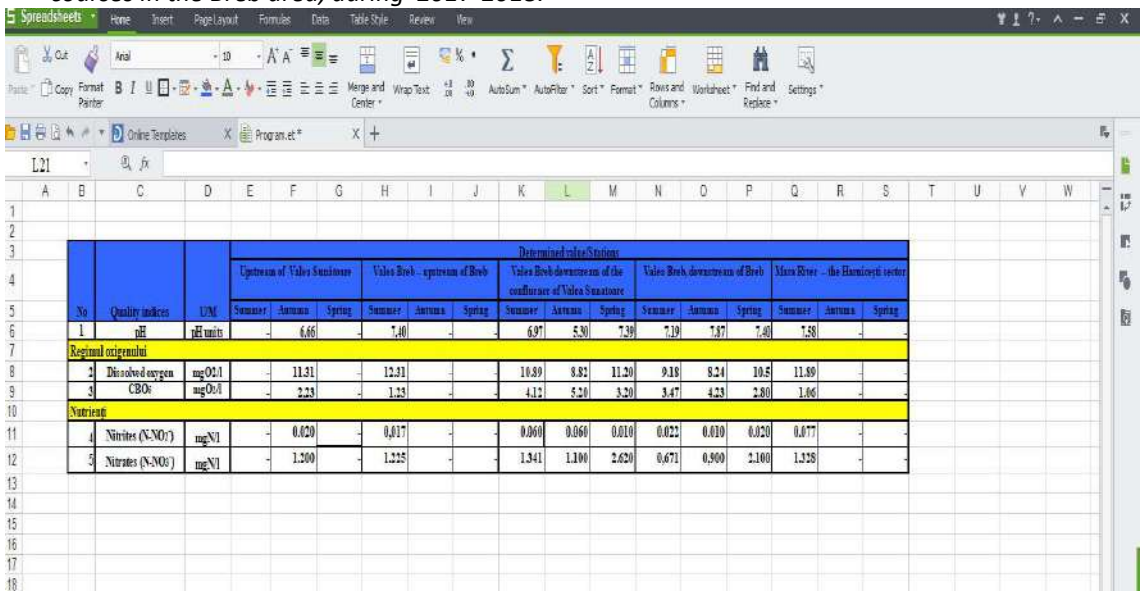
In the study area located in the Breboaia river basin, the rural type communities practice traditional semi-subsistence agriculture. Thus, hand labor and animal energy are widely used on small fields, along with natural fertilization and simple rotation of crops. As a result, pesticides or chemical fertilizers are not used in the region. Thus, there is a moderate impact on the environment, including on the aquatic life.

Problems only occur due to household waste, due to the use and storage of manure, due to their defective management. Monitoring from official authorities is performed on larger scale and thus not include study area of Breb.

Potential pressures on the water resource in the area could only be generated by the non-conforming use and storage of manure. As a result, the main objective of the research is to monitor the nutrients in the surface waters that drain the Breb area and to assess the riverside nitrofile vegetation. Seasonal water samplings were carried out during the vegetation period from 5 stations, for which the acidity regime, the oxygen regime and the nutrients were analyzed during the period from 2017 to 2018. Quantitative and qualitative samples of macrozoobenthos were taken from the same stations too. Macrozoobenthos, made up of a wide variety of invertebrates (dominant insect larvae) with varying degrees of tolerance to the anthropic pollution, operates as a real tool for assessing the biological quality of the aquatic environment.

Thus, the physical-chemical analysis of water, substantiated with the biological analysis, much more accurately reflects the ecological status of the analyzed water section and implicitly the magnitude of the anthropic impact.

Table 1 Values of the oxygen and nutrients regime in the monitored stations for the water courses in the Breb area, during 2017-2018.



No	Quality indices	UM	Determined value/Stations														
			Upstream of Valea Sunatoare			Valea Breb - upstream of Breb			Valea Breb downstream of the confluence of Valea Sunatoare			Valea Breb, downstream of Breb			Mara River - the Hamlet Stanciu sector		
			Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring
1	pH	pH units	-	6.66	-	7.40	-	-	6.97	5.30	7.39	7.19	7.87	7.40	7.58	-	-
Regimul oxigenului																	
2	Dissolved oxygen	mgO2/l	-	11.31	-	12.31	-	-	10.89	8.82	11.20	9.18	8.24	10.5	11.89	-	-
3	CBO5	mgO2/l	-	2.23	-	1.23	-	-	4.12	5.20	3.20	3.47	4.23	2.80	1.06	-	-
Nutrienti																	
4	Nitrites (N-NO2-)	mgN/l	-	0.020	-	0,017	-	-	0.060	0.060	0.010	0.022	0.010	0.020	0.077	-	-
5	Nitrates (N-NO3-)	mgN/l	-	1.300	-	1.225	-	-	1.341	1.100	2.620	0.671	0.900	2.100	1.328	-	-

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The monitoring of surface water, groundwater (wells) and drinking water will be carried out on nutrient contamination during 2018 to 2019 as well. Thus the assessment of nitrofile vegetation in the area of interest will be completed.

Values of the oxygen and nutrients regime in the monitored stations for the water courses in the Breb area, during 2017-2018, are presented in table 1 and figure 10.

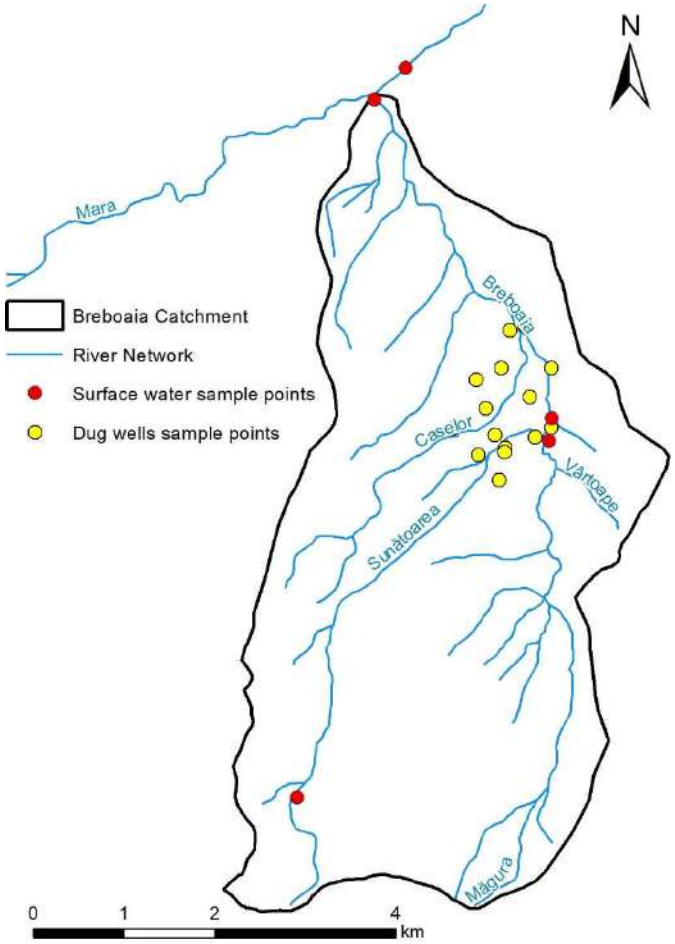

Fig 10 Water sampling locations in Breboaia action lab

Complementary, analysis of microbacteriological data were provided by Ocna Sugatag municipality (July 2017) based on analysis of water from central pipeline made by Maramures Sanitary Veterinary Directorate.

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3.5 Conceptual model

3.5.1 Landscape Analysis

The Mara catchment (20 km^2), Maramures County, Romania, is representative for small scale/ subsistence farming systems in the Carpathian Mountains – cattle and sheep breeding. The study area is a typical cultural landscape shaped by traditional practices.

Most of the agricultural land in Breboaia Catchment consists of meadows and pastures. In and around Breb Village arable land (agro-terraces with grass slopes) and orchards (consisting of mostly plum trees) occupy the largest areas.

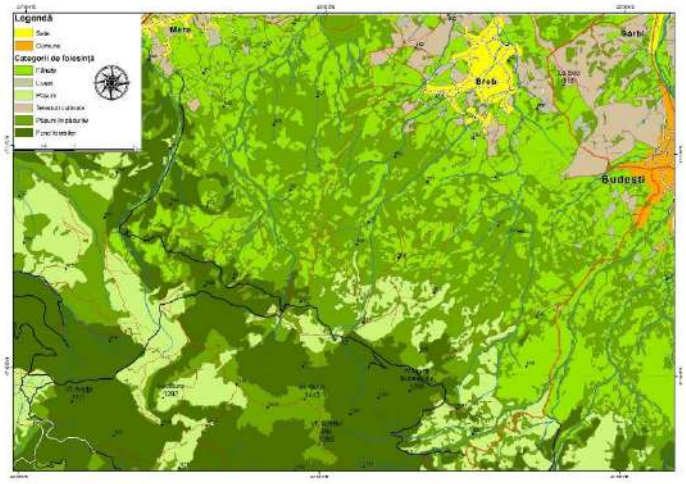

Fig. 11 Land use in Mara catchment

The area is dominated by animal husbandry (poultry, cows, pigs, sheep, horses, rabbits) and cereal production; many households own hayfields and orchards in the proximity of the village. Farmers usually have 2-4 cattle (left grazing on the fields in summer time during day), some sheep, 2-3 pigs and poultry, horses. The farmers having sheep take their animals to communal sheepfolds (there are 4 sheepfolds in Breb in 2018).

Farmers use organic fertilizers from their farms on their agricultural fields; the use of organic manure is a traditional practice for small scale mountain farms in Romania in Maramures. Farm animals are kept in barns close to households for most of the year. For example, pigs are usually permanently housed, cows graze during summer months but return to barns at night, and sheep spend 4-5 months away whilst grazing at pastures. At some point manure from all types of livestock that are kept in barns accumulates. This is regularly cleaned out (often daily) into a "store" located close to barns where it usually remains for 6-12 months – sometimes for a shorter period of time (1-6 months). Majority of households apply manure to hay fields, orchards and crops. 84% of households surveyed had manure "stores" which consisted of a carefully constructed heap adjacent to buildings, in which farm animals are kept. Less than 5% of manure stores in the survey have a hard base, but approximately 10% do have some form of a retaining wall – most commonly made of stone or brick, but also wooden. Unfortunately, the combination of human and animal waste is a common problem

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that was observed in over half of the households surveyed – commonly due to the construction of households' toilets directly next to the manure stores.

Picture 1 typical landscape in Mara catchment

3.5.2 Nitrate transport pathways

Due to the medium slope morphology of the catchment and the close to surface water table, the phreatic nitrate transport pathways follow the ones on land surface (fig. 11). Due to its positioning within the catchment, Breb Village is susceptible to increased nitrate values as more than half of the catchment pathways concentrate in the village perimeter.

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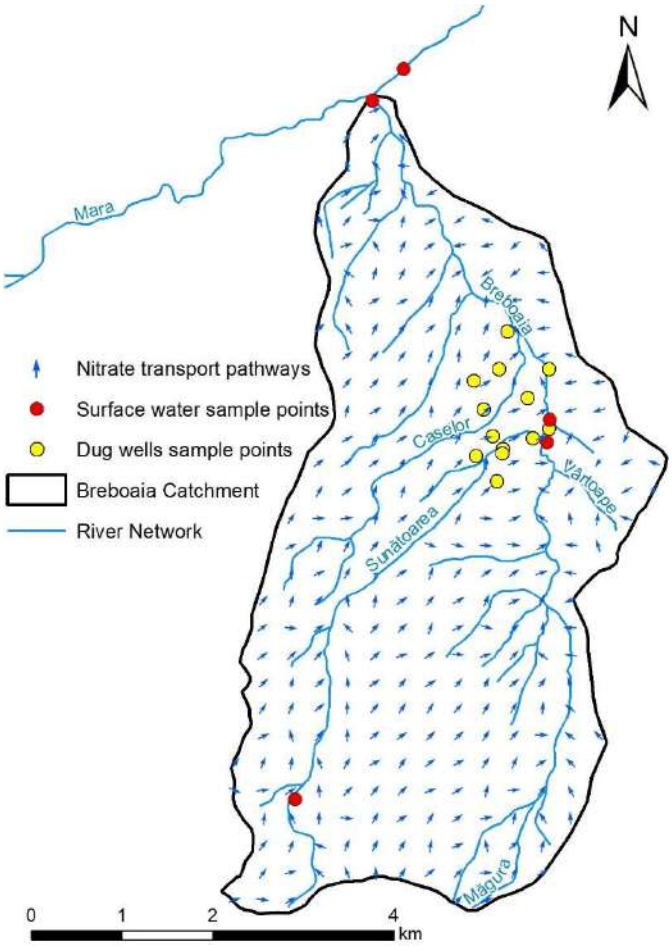

Fig 11 Nitrate transport pathways in Mara (Breboaia) Catchment

Assessment of water quality was done based on the following indicator groups: pH, oxygen regimen (O_2, CBO_5), nutrients ($N\text{-}NO_2^-$, $N\text{-}NO_3^-$).
Participatory monitoring for water quality is currently performed on surface waters (5 sections) and underground waters (14 wells) and results show concentrations of nitrates in the vicinity of the village. Nevertheless, monitoring results indicate moderate concentrations of nutrients that do not exceed the standard limits (certain exceptions are present for surface waters, please see below). In the current framework, it is a consequence of existing capacity of the ecosystem to naturally filter pollutants.

The most important anthropogenic threats have been identified along the Valea Sunatoarei, where a large proportion of the Breb households are located and they realte to:

- the non-compliant storage of manure and seasonal excess nutrient inputs in aquatic systems. As a rule residues and manure generated by livestock are stored directly on the soil. Under the influence of environmental factors and the activity of microorganisms, organic matter resulting from fermentation generates bad odorous substances. The livestock manure in individual households in the Breb area is stored under improper conditions,

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without measures against leakage and infiltration of liquid fractions (urine and rainwater) with a major risk to the environment and health. It is recommended to apply a sustainable manure management system for each household having livestock. An example from a monitoring station showing high NO2 concentrations is monitoring section 3 (Breboaia River, after the confluence with Sunătoarea River, Map 2, stations in RO action lab for monitoring of surface waters): April 2018 monitoring campaign, indicate 0.76 mg/l NO2, when maximum admitted limit is 0.5 mg/l). We assume that the high NO2 concentration is due to location of monitoring station in a place where there are many households with livestock and no manure management systems in place and there was reduced rain in the season).

- the abandonment of the residues resulting from the brandy distillation in the autumn season. After obtaining the brandy (traditional Maramures alcoholic drink obtained from fruit from orchards) there is a risk that large amounts of waste (fruit that underwent fermentation) will reach the bed of the Breb Valley. Such a problem was registered during monitoring campaign in the autumn of 2017 (NO2 concentration of 0.66 mg.l, when maximum admitted limit is 0.5 mg/l). Thus, in monitoring station 2 (Breboaia Valley before the confluence with Sunătoarea Valley on Map 2, stations in RO action lab for monitoring of surface waters), the water had a bad smell, it was cloudy and dark.

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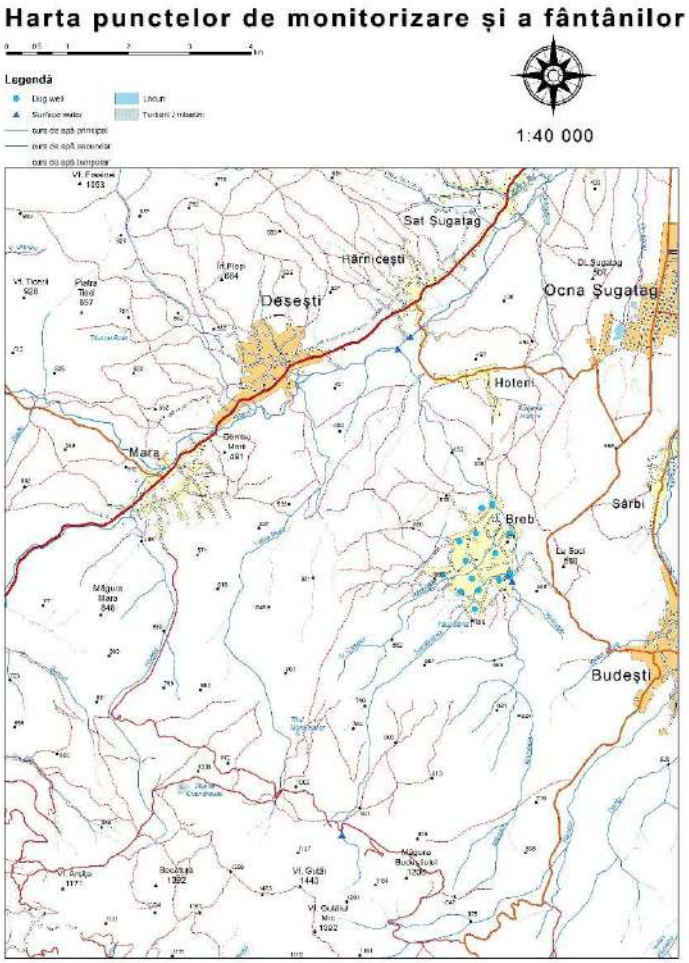

Figure 12, stations in RO action lab for monitoring of surface and underground waters (wells)

- lack of functional centralized domestic waste water evacuation system.

The surface water monitoring stations display the following characteristics:

1) Station of Valea Brebului River – upstream of Breb. The analysed site is located upstream of Breb, in an area free of significant pollution sources. Its shores are fully covered with vegetation. The global chemical status for this station is I. Thus, the water quality conditions for the analysed plant undergo changes to the unmodified natural conditions but to a low level. The water is of good quality, the anthropogenic alterations coming from the agricultural sector (animal husbandry, use of fertilizers) are of low intensity.
2) Upstream of Valea Sunătoare the station: the analysed site is located upstream of Breb, in an area free of significant pollution sources. Its shores are fully covered with vegetation. The structure of the riverbed is dominated by the boulders, the width of the riverbed being of 1m with a depth of 20-30 cm. In July 2017, the station is in the 1st grade of quality at the

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oxygen regime and the nutrient regime. Thus, the water quality conditions for the analysed plant undergo changes to the unmodified natural conditions but to a low level.

3) The Valea Brebului river downstream of the confluence of Valea Sunătoare river located in the Breb village, at a distance of about 15m downstream confluence with the Valea Sunătoare. The river bed structure is dominated by boulders of large diameters and gravel, the width of the bed being 3m, with a depth of 20-30cm. In the shore area and in the low-speed locations, there is a sandy matrix where large amounts of organic deposits are observed. In connection with these deposits, possible explanations can be: loading of cultivated land near the valley with manure and domestic / animal manure from individual households. In July 2017, with regard to the oxygen regime, the station range in the first grade of quality. In the nutrient regime, the first class quality has been found on the nitrate indicator and the third class quality for the nitrite indicator. High nitrogen content may reflect a recent contamination with animal manure or with runoff from cultivated lands fertilized with nitrogen-based substances. The high values of the total phosphorus indicator may be due to the inappropriate management of manure.
4) Valea Brebului station downstream of Breb: the width of the riverbed is between 6-8 m, the substrate being generally made of gravel and boulder, with a depth of 40-50 cm. Oxygen consumption indicators show the dissolved oxygen content and the chemical oxygen consumption proving the good water quality, corresponding to the first class I quality. The nutrient regime shows first class I quality for the both monitoring campaigns (July and September, 2017). The global chemical status for this station is the first – I for the both monitoring campaigns (July and September, 2017). Water quality is good.
5) Mara River – the Harniceşti sector Station: the water quality of the Mara River is affected by the diffuse pollution sources originating from the agricultural and forestry sector, even if the effect is moderate. In rural households located in the Mara River Basin, traditional agriculture is practiced on small areas, and the fertilization of crops is done only with organic fertilizers. There is a risk of contamination with nitrates but its impact is not significant on the aquatic life. In July 2017, the Mara River – the Harniceşti sector station ranges within the first class quality for the oxygen regime. Nutrient regimes show exceedances of the first class quality for the nitrite indicators (third quality class – III)).

In Maramures action lab, Romania, all farmers use primarily animal manure (solid manure, which comprises material from animal houses and consists of excreta mixed with the bedding materials e.g. straw) as fertilizer for their agricultural fields. In addition, there may also be varying amounts of slurry, which consists of liquid or semi-liquid excreta produced by livestock in a yard or areas of a building where there is little bedding used (e.g. passageways).

3.5.3 Additional field data and improving the conceptual model

Additional data collection is planned in the area for the coming months, which will continue improving the understanding of the system.

3.6 Numerical model – not the case

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