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

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Chapter 1. Review on the critical factors/trends stressed by WP3 for each area/country

Introduction

This chapter reviews the critical factors/trends stressed by WP3 for each area/country. Two main priorities are followed:

- Water resource saving
- Prevention of water pollution from nitrates due to agriculture.

These tasks are accomplished by reviewing and summarizing the regional reports and the sensitivity/vulnerability maps for each area/country, and by assessing the implementation of the Water Framework Directive and the Nitrates Directive in the areas. The review is based on existing project deliverables, starting from information available in the regional reports as an “introduction” to the strategy, together with more generic information (EU policies, etc). The information existing in the maps supplements the analysis. The final goal of the chapter is to provide a summary and an understanding of the regional situation in a broader SEE and EU context.

1. “Introduction” to the strategy

EU.WATER, carried out in 9 rural study areas (Po River basin, Province of Rovigo, Sarigkiol basin, Hajdú Bihar county, Teleorman-Giurgiu-Arges region, Istrian region, Territory of Pancevo city, Odessa region, Ialoveni Rayon) belonging to 8 SEE Countries (Italy, Greece, Hungary, Romania, Croatia, Serbia, Ukraine, Moldova) tackles the emergency related to water consumption and contamination in Europe, and aims at spreading, at transnational level, integrated water resource management in agriculture, based on the optimization of water consumption and cutback of groundwater pollution.

All partners have collected available data (climate, geomorphological, geological, hydrogeological, land uses, protected areas etc) for each area. The region with the largest area is Odessa covering 33,313 km² and the smallest area is Sarigkiol covering 469.2 km². The min altitude is 0 m for the seaside regions (Po River basin, Province of Rovigo, Odessa and Istrian region) and the max 2,493 m at Teleorman-Giurgiu-Arges region (Carpathian mountains). The regions characterized by different climate types. The mean annual rainfall ranges from 245 mm (May to October in Sarigkiol basin) to 360 mm (November to April in Pancevo area) and the mean annual temperature ranges from 2.7°C (November to April in Odessa) to 19.9°C (May to October in Sarigkiol basin). The most important parameter for the applied methodology is the soil texture. The agricultural areas coverage ranges from 26,616 km² (Odessa) to 153.3 km² (Sarigkiol basin). The largest population is found in Teleorman-Giurgiu-Arges region (1,354,842 people) but the most densely populated area is Pancevo area with population density 172 people/km².

The water demands in each area are covered by groundwater abstracted by numerous boreholes and surface water. The main aquifer systems are developed in alluvial aquifers except of the karstic aquifer in Istrian region. Nitrates are the main pollutant for surface and groundwater in agricultural land and the pollution sources
for nitrates in water bodies are the animal wastes, fertilizers for the crops and septic tanks. Furthermore, data for protected areas were collected and delineated in each region (Natura 2000).

Based on the collected data presented in regional reports, each country will apply the common methodology in order to develop groundwater vulnerability maps and nitrate sensitivity maps using the common methodology developed within the EU-Water project.

1.1 Po River basin (Italy)

Po river basin is located in the north-eastern part of Italy and consists in the Provinces of Ferrara and Rovigo, covering a total area of 4460.2 Km².

The pilot area covers the basin of the Po river, a single territorial entity ruled by two different administrations, respectively located in the Region of Emilia Romagna and Veneto Region. The territories are flown through the main Italian rivers (Po, Adige and Reno) and is bordered to the north by the Province of Padova and Lombardia Region (Province of Mantova) along the Po river, on the west by the Province of Modena and the Province of Verona, on the southeast, along the Reno river, with the Province of Bologna and the Province of Ravenna and on the east by the Adriatic Sea, between the Adige river and the Reno river outlet.

Land uses and agricultural land of the Province of Ferrara

Land use map of Ferrara Province was realized using vector cover in shapefile format of Emilia-Romagna Region, realized according the Corinne land-cover european guidelines (2000 classification), identifying 5 different classes of land use: agricultural areas, (2164 km²), artificial areas (183.21 km²), natural and seminatural areas (27.25 km²), water bodies (95.32 km²) and wetlands (152.53 km²). Then, agricultural areas were divided into 12 categories: arable in irrigated lands, predominantly occupied by agricultural fields with the presence of important natural areas, complex cropping systems, wood crops, stable meadows, garden centers, orchards and minor fruits, forests, rice fields, annual crops associated with permanent crops, vegetable crops in open or covered fields, vineyards.

Land uses and agricultural land of the Province of Rovigo

The most important activities are related to what we call "terziary sector" and are related to commerce, repairs, tourism (hotel and restaurant), transportations, communications, constructions. The agricultural sector accounts for 9% in terms of employment and for 4% in terms of income. It’s important to remind the importance of fishery sector that develops in the fishing ponds, lagoons and in the sea (fishing and mussels).

Surface waters of the Province of Ferrara

Water surface bodies of Ferrara Province can be divided in natural and artificial. Three important rivers, the Po, Reno and Panaro with a mean discharge at the mouth of 1540 m³/sec, 95 m³/sec, 37 m³/sec, respectively.

More than 3500 km of the province surface are covered by artificial channels, that in some cases, have width, length and, in some period of the year, discharges much higher than Reno and Panaro rivers. On the South-East side of the province is located one of the largest saltwater wetland in Europe, the “Valli di Comacchio”, once important for eel (Anguilla anguilla) extensive aquaculture.
Soil data of the Province of Ferrara

The predominant soil textures in the province of Ferrara are silt loam and silty clay (68% of the territory), while peaty soils are less common (23% of the territory). The remaining 9% are sand and silty sand.

Soil data of the Province of Rovigo

Along the course of the rivers we can find big sediments (sand) while increasing the distance from the distance from them we find smaller particles (silt and clay). The major part of the soils is medium texture, deep, alkaline, with poor drainage.

Climate of the Province of Ferrara and Rovigo

The whole area can be defined as temperate climate with sub-continental characteristics with cold winters, warm summers, moderate diurnal (10-12 °C) and annual temperature excursions (20-25 °C) and precipitations from modest to moderate, but evenly distributed throughout the year.

1.2 Sarigkiol basin (Greece)

The EUWATER project is carried out in the pilot area “Sarigkiol basin”. Sarigkiol basin is part of the Region of Western Macedonia, which represents the 9th Greek Water District, including 65% of the national water resources. Sarigkiol basin is located in the north-west part of the Kozani prefecture territory with a surface of 469.2 Km2. At the west side there is Askio Mountain, at the east side there is Vermio Mountain, at the south side there is Skopos Mountain. The north border is nowadays the open pit of the south field lignite mines and partly the tectonic horst of Komanos.

Land uses and agricultural land

The area is covered by agricultural land (32.7% - 153.3 km2), by forests and semi natural areas (56.9% - 266.8 Km2) and by urban or artificial surfaces (10.4% - 49.1 km2), which includes coal mines and steam electric power plants that cover 31.7 km2 (Corine Land Cover 2000).

Surface waters

Important surface waters (e.g. lakes and rivers) are not existed in the study area except Soulou Torrent (non significant flow and small river bed, is used as a drainage pathway), which intersects the basin and was artificially opened up in 1954.

Groundwater

The alluvial aquifer of the Sarigkiol basin covers an area of 60 Km2 and its maximum depth reach at 110 m below ground surface (b.g.s.). The depth to water table in the alluvial aquifer ranges from 7 to 75 m below ground surface.

Soil data

The soil texture in the majority of the fields in Sarigkiol basin is medium, with low to medium organic matter content. Especially in the central part of the basin the soil is very fertile giving high yields.

Climate

The area is characterized by a semi-arid, Mediterranean climate, with an annual mean temperature 11.3 °C and an annual rainfall of 639.6 mm with the most raining periods, autumn and spring, while summers are usually dry.

Other information

Overexploitation and nitrogen pollution of agricultural origin are the main environmental pressures induced by humans; they have a significant negative effect
on the area’s groundwater. In a large part of the area irrigated agriculture is practiced. In Sarigkiol basin the most important pollution sources, which are related to human activities, are originated by agriculture activities, urban, industrial, mineral extraction mines, abandoned waste fields, animal breeding wastes and LCWM operations.

1.3 Odessa region (Ukraine)

Odessa region is located on the South-West of Ukraine, and occupies an area 33.3 thousand square kilometers (5.5% of Ukraine). Relief of the territory is flat. The elevations change from 281.3 m in northern part to -4 m on south shore of the Khadzybey estuary of the Black sea (near Odessa city). Greater part of the region (South and Center) lies within the limits of the Black Sea (Prychernomorska) Lowland. Northwards between the rivers Danube and Dniester there is the spurs of Upland Codry (maximum elevation equals 232 m), and between the rivers Dniester and Tylihul (Tiligul) – spurs of Podolia Upland (with maximum elevation 281.3 m).

Land uses and agricultural land

Of the total area of 33313 km², agricultural land covers 26616 km² or 79.9% of all region’s area. In composition of agricultural lands the area of plough-land is 20676 km² (62.1% of the region’s area and near 78% of agricultural lands), haymakings and pastures – about 4080 km² and gardens and vineyards – about 900 km². Forests occupy 2239 km², bogs and boggy lands – 722 km², internal waters – 2118 km², built-up lands – 1282 km².

Surface waters

There are three big rivers within the limits of the region - Danube, Dniester and Southern Buh, about thirty small rivers, 58 reservoirs with a volume of water from 1 to 100 million m³ and the total area of water table of 587.99 km², 37 lakes with a total water table area of about 734 km² and about 940 ponds with a total water table area more than 122 km².

Groundwater

Ground water is distributed in the deposits of all stratigraphic systems – from Archaean-Proterozoic to modern structures. Unconfined groundwater is contained in rocks of different genesis: alluvial, aeolian-deluvial, alluvial-deluvial, marine, estuary and other. Depth to groundwater in the valleys and floodplains, as a rule, is 0-3 m, on the watersheds – from 3-5 m up to 20 m. Groundwater in the region is classified as not protected from surface pollution. In some regions, particularly in the southwest part of the region, almost in 85% of the wells the content of nitrate is exceeded the standard.

Soil data

The soil cover is dominated by black soils (chernozems) of heavy texture (silty clay or sandy clay and clay) on loess, which are characterized by high natural fertility. The majority of soils of the Odessa region in granulometric composition (texture) belong to the heavy soils (sandy clay, silty clay, clay). On a north-west and, especially, on the south-west of the region, between Danube and Dniester rivers, moderate heavy soils (clay loam, sandy clay loam, silty clay loam) are widespread. More light soils occupy a small area within the bottoms of river valleys and on the coast of the Black sea.
Climate
The climate is continental with mild winters, hot and generally dry summers, especially in southern parts of the region. The average annual air temperature within the Odessa region increases from 8.1-8.3°C in the north to 10.6-11.1°C in the south. Annual precipitation equals 525-575 mm, in the central and 475-525 mm in the southern part, while in the coastal zone precipitation varies between 400-450 mm.

1.4 Istrian region (Croatia)
Land uses and agricultural land
Basic ways of land usage in the Region of Istria: about 30% cultivated land, 23% grassland/pastures and about 43% forests. Already at first sight one can notice a marked dispersal of habitat dominated by areas covered in forests, dry grassland and dispersed agricultural areas being a consequence of the traditional mixed production and tendency towards selfsufficiency.

Surface waters
The most important surface watercourses on the territory of the Region of Istria are: Mirna, Raša, Boljunčica, Dragonja and the subterranean river Pazinčica.

Groundwater
Drainage systems of the Istrian peninsula, namely of the Region of Istria, are distributed from the north, we distinguish: 1. Mirna river basin and part of the Dragonja river basin; 2. Raša river basin and 3. Southern Istria basin.

The majority of the available water quantity used to supply the Region of Istria with water is provided by groundwater: springs and wells. The state of the water quality in area of Region of Istria is being constantly monitored by two programmes on: 1) national level; 2) regional level. Compared to the springs, wells hardly ever become opaque and the bacteriological pollution is very low. The greatest problem with the wells in water supply is the high content of nitrates.

Soil data
The dominant types of soil in Istria, where the majority of farming production is carried out, are the red soil (terrarossa), brown earth on limestone and dolomite (calcocambisol), rendzina and anthropogenic soils (regosol).

Climate
The climate in the Region of Istria is Mediterranean along the coast, shifting into sub-Mediterranean towards the centre of the peninsula, and due to the closeness of the mountains and the Alps, even to continental or submountain-continental climate.

1.5 Tisza river basin – Hajdú Bihar county (Hungary)
Hajdú-Bihar is an administrative county in eastern Hungary, on the border with Romania. Capital is Debrecen with 207270 inhabitants (2nd largest city in Hungary).

Land uses and agricultural land
With a territory of 6210.56 km², Hajdú-Bihar County is the fourth largest in the country. The total area under cultivation is 5444.72 km², 3342.03 of which is arable land. The county ranks second in Hungary in this respect. This is what determines the importance of the county from the point of view of agricultural output.

Half of the area of the county is in the use of private farms. The structural change influenced land division according to lines of cultivation to a
slight degree. 14.3% of the county’s area is uncultivated land. The most frequently cultivated plants are corn, wheat, sunflower, sugar beet and potato. Livestock farming is the most productive agricultural branch in the county. It holds more than 45% of the whole agricultural output of the county. Cattle-breeding is the most important kind of livestock-farming in the county. Swine-breeding has gone through a number of crisis periods in the past 10-15 years, as there were only short periods when production costs were recovered.

**Surface waters**

In the project area there are only a few natural water flows with significant runoff. In north – north-west there is River Tisza.

**Groundwater**

The county may well be poor in surface waters, but it is rich in groundwater. Groundwater lies deeper above the elevated Pannonian block. Thus, groundwater above the elevated Pannonian block lies 6-20 m deep in Hajdúság, 3 m deep in the Southern Nyírség, but only 1-2 m meters below the surface in Hortobágy. The salt content of groundwater ranges on a wide scale. It is highest in Hortobágy, 2-3 g/l, but it can also be as high as 10-20 g/l.

**Soil data**

The soil types are diverse. The significance of good fertile chernozem is high in the county. At the same time weak and saline soils are also present.

**Climate**

Climate can be characterized as continental with 11°C average temperature and 500mm average precipitation. Although Hajdú-Bihar County extends on a small area and there are no big height differences among regions, significant climatic variations can be recorded both from the West to the East, and from the South to the North.

**Characteristics of water systems in the area**

There is only a little money for the establishment and maintenance of inland water systems, but at the same time the vulnerability against inland water flooding has increased in the settlements and in agricultural areas too in the last decade.

### 1.6 Pančevo Territory (Serbia)

Pančevo city is located in the Republic of Serbia, in southern part of the Autonomous Province of Vojvodina. Territory covers part of the south-west Banat within the river basins of Danube, Tamiš and Nadela. Territory covers 755 km², representing 3.51% of the area of AP Vojvodina. According to census made in 2002, the Municipality has 127,162 inhabitants, i.e. 168 inhabitants per km². In the Municipality of Pančevo distinguish three geomorphological units:

1) **Loess plain** are the highest parts of the field with an average altitude of 100 to 150 m above sea level and an area of 191 km²;
2) **Pančevo loess terrace** which sloped gently rolling plain the southeast, with an average altitude of 75 to 83 m above sea level and an area of 382 km²;
3) **Alluvial plain** are formed along the two rivers Tamiš and Danube with an average altitude of 70 to 73 m above sea level.

**Land uses and agricultural land**

Pančevo with its agricultural resources is one of the richest municipalities in the Republic of Serbia, with a relatively high degree of stability and arable of total agricultural areas. Agricultural land occupies 633.22 km², which is 83.87% of the City.
The largest area occupied by fields and gardens (58 981 ha), pasture (2 415 ha), meadow (564 ha), orchards (474 ha) and vineyards (168 ha), and the rest are: fish ponds, marsh and ponds (720 ha).

On the territory of the Municipality Pančevo, forest covered amounted to 129.25 km². Forests managed by Public Company "Vojvodinašume". The Municipality of Pančevo is characterized by a rather low percentage of forest cover concentrated in the narrow inundation zones along the rivers.

Surface waters
The main water bodies are the rivers Danube, Tamiš and Nadel and then the channel system in the northeastern part (the Danube-Tisa-Danube) and large reserves drinking water. Downstream from Pančevo the average breadth of the Danube is 600-700 m. During the periods with average and high flow, river depth increases by 2-7 m, and breadth by up to 50 m.

Groundwater
The territory of Municipality of Pančevo abounds both in surface and in ground waters. Ground waters encompass shallow (phreatic) and deep (artesian) water-bearing layers. Surface waters could be divided into natural ones (rivers Danube, Tamiš, Nadela and Ponjavica) or artificial (melioration canals and artificial lakes).

Soil data
Insignificant elevation differences in relief forms and overlapped young geological surface layers – they all contribute to the impression of a simple morphologic genesis and mono-genetic character of the respective processes and forms three relief entities can be identified in this region – the alluvial plains, the loess terraces and the loess plain.

Climate
Pančevo has the average monthly temperatures for 11 months per year that are higher (by 0.1 °C to 0.5 °C) than the average for Vojvodina. The south-eastern wind called “Košava” is dominant one. “Košava” is the most frequent in October, November, February and March. Variation of precipitation distribution in the Municipality of Pančevo is characterized (similarly to the rest of Vojvodina) by significant unevenness, i.e. by alternation of rather humid and rather dry periods. Two humid and two dry periods appear on average each year.

1.7 Arges-Vdea watershed (Romania)

The studied area covers three counties (Arges, Giurgiu, Teleorman) located in the Arges-Vdea watersheds, South Romania. 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-Vdea 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).

Land uses and agricultural land
The dominant land use is arable (886454 ha) followed by pastures (151093 ha), hayfields (46611 ha), orchards (23526 ha) and vineyards (12800 ha). Forest area is 357680 ha. Arges county shows the greatest variety of land use. Giurgiu and Teleorman counties are almost entire arable.
The farm structure for arable land shows the very complex pattern of the farms with the dominance of small farms (30-50% of the farm area belongs to farms less than 3 ha, depending on the county) but with large farms, too (dominating farm size based on agriculture area is about 600 ha).

In small farms low-input agriculture (subsidence 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.

**Surface waters**

Arges and Vedea rivers are tributary to Danube.

**Groundwater**

The case study area includes 5 aquifers 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.

**Soil data**

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.

**Climate**

The area shows a distribution of climate from mountain specific climate (low temperature, excedent of water) to the dry climate of the plain next to Danube river.

### 1.8 Botna river-Ialoveni rayon (Moldova)

Ialoveni Rayon is an administrative territorial unit of the Republic of Moldova with residence city Ialoveni. The rayon has 33 village-types of settlements. The area is 742.5 km\(^2\), population is 98000 people.

Rayon is located in western border of Chisinau municipality. Its territory is elongated from north-west to south-east, following Botna river bank.

**Land uses and agricultural land**

Total area of the Ialoveni Rayon’s land stock is 743 km\(^2\), including: 15 km\(^2\) of water tables, 80 km\(^2\) of suburban areas, 75 km\(^2\) of open areas (pastures), 1 km\(^2\) of wetlands, 87 km\(^2\) of forests and 485 km\(^2\) of cultivated areas.

**Surface waters**

Botna, Isnovat rivers valleys, wide and stretched from north-west to south-east watersheds. River’s high water beds can reah the width of 4 kilometers.

**Soil data**

Soils are quite diverse. The north of the region in the branches of Codri highland some areas are covered by brown luvic typical soils. River valleys are composed of deluvial and alluvial typical soils. On the watersheds leached and unhumic chernozems are dominating. The soil is mainly composed of chernozem - about 73%, forestry soil and soil of the river valleys approximately 11% each, colluvial soil – about 4%.

A negative influence is also produced by the soil dehumification processes. The humus content in the majority of agricultural land has decreased up to 1,8-2,0\%, whereas in some soil varieties even less than 1,8 %. These soils can be improved by use of chemical and organic fertilizers.
Climate

Ialoveni rayon is characterized by less humidity in comparison with northern agroclimatic rayon, longer warm period (182-193 days), and longer period of snow preservation in the elevated areas. Rainfall variability is very low. It varies from 460 mm the north-west to 420 mm the south-east.

The average temperatures range between -3.5°C in January and +21.4°C in July. The climate distinguishes by a relatively large number of warm and sunny days – 160-190 annually. The atmospheric circulation is characterized by the movement of cool air from the Atlantic Ocean zone eastwards and the movement of the warm and humid air from the Mediterranean Sea. Sometimes, an inflow of relatively cold and dry air intervenes from the northern latitudes.

The torrential rains, draughts, desertification processes, strong winds, tornadoes, hails, spring and autumn frosts are unfavourable phenomena frequently found on the Republic’s territory.

2. Vulnerability assessment

Using the methodology developed in the EU.WATER project by the Aristotle University of Thessaloniki the vulnerability areas of the aquifers 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

2.1 Vulnerability maps, Po River basin (Italy)

Rovigo

Regarding the total water losses (LOSW-PR), the most vulnerable zone is detected along existing rivers or ancient riverbed (paleoalvei) in the central and eastern part of the province: the total surface of these areas is however very small and the related value is 412-445 mm/year. The western part of the target area is characterized by values varying from 277 to 328 mm/year (Fig. 1).

Figure 1. Annual total water losses (LOSW-PR) in Po river basin.
Regarding the total nitrogen losses (LOSN-PRN), the most vulnerable zone is detected, as expected, on the dune belt and some small sandy areas in the Po delta showing values varying from 34 to 43 kg/Ha year. The middle class is not represented and the remaining part of the target area is characterized by the lower indices (18-26 kg/Ha year) (Fig. 2).

Figure 2. Annual total Nitrogen losses (LOSN-PRN) in Po river basin.

In order to include the unsaturated zone, an additional equation that gives the minimum relative transit time (TT) was calculated. The relative transit time is a measure of groundwater vulnerability. The less the transit time, the greater the chances of the pollutant to be transported to the groundwater surface (high vulnerability). It is pointed out that, the deeper the water levels are, the longer the pollutant takes to reach the groundwater table (low vulnerability). Regarding the TT, even if a ten classes scale as been set, the classes effectively represented in Rovigo Province are only five and vary from 0,28-3 days (first class) to 25-28 days (higher class). In the areas of the first class more studies seem necessary to prevent higher pollution potential (high vulnerability) of the underlying groundwater.

It is pointed out that, the calculated values of transit time are relative and a site of low pollution potential do not mean that it is free from groundwater pollution, but it is relatively less vulnerable to contamination compared to the sites with great TT values.
Figure 3. Relative transit time of the percolated water to reach the groundwater table in Po river basin.

**Ferrara**

The resulting total water losses (LOSW-PR) show that the most vulnerable zones in FP are the south central part, close to the Reno riverbank and secondly the coastal dunes (Fig. 4).

Figure 4. Annual total water losses (LOSW-PR) for the Ferrara Province.

The resulting total nitrogen losses (LOSN-PRN) identify the most vulnerable zone in the coastal region (Fig. 5). The coastal region presents also the lower values of minimum transit time TT (Fig. 6).
2.2 Vulnerability maps, Sarigkiol basin (Greece)

According to the total water losses (LOSW-PR), the most vulnerable zone is detected at the upland northeast part of the basin (Fig 7).
Figure 7. Annual total water losses (LOSW-PR) in Sarigkiol basin.

According to the total nitrogen losses (LOSN-PRN), the most vulnerable zone is detected at the upland northeast region.

Figure 8. Annual total Nitrogen losses (LOSN-PRN) in Sarigkiol basin.

Considering the above, two regions are identified to be more vulnerable to water and nitrogen losses and concern i) the distant region at the upland northeast area and ii) the regions at the edge and around the aquifer boundaries.

The areas of the second case need more attention because they are above the main aquifer. Considering the relative transit time map TT (Fig. 9), these areas present the minimum values of TT and are characterized by higher pollution potential (high vulnerability) of the underlying groundwater.
2.3 Vulnerability maps, Odessa region (Ukraine)

Total losses of water due to percolation and runoff (LOSW-PR) (Fig. 10) decreases from 200-220 mm on the slopes of the Podolsk Upland in the north to 80-90 mm on the flat watershed's spaces and within the bottoms of river valleys in the south.

In accordance with the maps of LOSN indexes (Fig. 11) the losses of nitrogen due to percolation and surface runoff also increases within the region from south to north. Range of annual total nitrogen losses is 12.7-27.4 kg/ha per year. It is required
to emphasize that the spatial distribution of nitrogen losses is mainly determined by surface runoff, nitrogen losses with which (8.8-27 kg / ha per year) greatly exceeds the loss due to percolation (0.3-4.6 kg / ha per year).

Figure 11. Annual total Nitrogen losses (LOSN-PRN) in Odessa region.

Figure 12. Relative transit time of the percolated water to reach the groundwater table in Odessa region.
The transit time map of the (Fig. 12) showed that in general the groundwater of Odessa region is not protected from surface contamination by agricultural chemicals, including nitrogen compounds.

The most vulnerable areas are flood plains and river valleys (the transit time less than 15 days, and in the floodplain of the Danube and on sections of the valleys of small rivers with sandy soils - less than 1 day), as well the most of the Black Sea coast (the transit time is equals 17.5-50 days).

For watershed spaces of northern and central parts of the region, composed of heavy loess sediments with groundwater depth on average 4-7 m, the transit time is 90-150 days. At the separate sites, where the depth of the groundwater rises to 15-20 m and more, the transit time exceeds 300 days.

Thus, it can be noted that the increased risk of nitrogen pollution of groundwater within the region is characteristic for the bottom of river valleys, especially large ones (the Danube) and the whole south-western part of the region, including the Black Sea coast, valley of the Danube River and the adjacent part of the Black Sea Lowland.

2.4 Vulnerability maps, Istrian region (Croatia)

Regarding the total water losses (LOSW-PR), the most vulnerable zone is detected at the northeast region. Similar situation is depicted by the LOSN indices (Fig. 13, Fig. 14).

Figure 13. Annual total water losses (LOSW-PR) in Region of Istria.
2.5 Vulnerability maps, Tisza river basin – Hajdú Bihar county (Hungary)
2.6 Vulnerability maps, Pančevo Territory (Serbia)

Regarding the total water losses (LOSW-PR) (Fig. 16), the most vulnerable zone is detected at the eastern zone of the region near the Deliblat desert.

Regarding the total nitrogen losses (LOSN-PRN) (Fig. 17), the most vulnerable zone is detected at the upland northeast region.

Figure 16. Annual total water losses (LOSW-PR) in Pančevo Territory.

Figure 17. Annual total Nitrogen losses (LOSN-PRN) in Pančevo Territory.
2.7 Vulnerability maps, Arges-Vdea watershed (Romania)

According to LOSW-PR values (figure 18), total water losses through percolation and run-off range between 101-141 mm/year and this is deemed representative for more than 2/3 (77.93%) the river basin surface.

The mountainous area where slopes inclinations reach 56.1%, index LOSW – PR has values between 438 and 1079 mm/year.

Along the toes located in the lower area and the plains, this index ranges between 304 - 367 mm/year.
Figure 19. Percentage of annual nitrogen losses due to deep percolation and surface runoff from total nitrogen applied on topsoil.

Total nitrogen losses which occur through percolation and also by slope run-off are indicated by LOSN-PRN index which showed values of 17 to 24 kg/ha per year on most of the river basin area (96.94 % of the total area). For the highest area of the Argeș-Vedea river basin area, this index ranges between 25-57 kg/ha per year.

According to the nitrogen losses through percolation map (Fig. 19), the higher values are observed at the south regions, in the center the values are intermediate while in the north the nitrogen losses are minimum.
Looking at the transit time diagram, one can notice that within the centre of the river basin area, there are two distinct perimeters:

- Central-western area where TT has values between 130 and 197 days;
- Central-eastern area where TT is in the range of 285 to 550 days.

To the south of the pilot area perimeter, the vulnerability of existing water bodies is very high, with TT values between 30 and 95 days.

Considering the relative transit time map TT (Fig. 20), the northeast areas present the higher values of TT and are characterized by low pollution potential (low vulnerability) of the underlying groundwater, while the northwest areas present high pollution potential (low TT values).

Considering the above, two regions are identified to be more vulnerable to water and nitrogen losses and concern i) the regions at the south which are the most vulnerable (high percentage of annual nitrogen losses and intermediate TT values) and ii) the northwest areas (intermediate percentage of annual nitrogen losses and intermediate TT values).
2.8 Vulnerability maps, Botna river-Ialoveni rayon (Moldova)

Transit time is not estimated in Botna river-Ialoveni rayon study, because information about ground water level for the study area does not exist.

According to the LOSW indices (Fig. 21), the water losses through percolation under the root zone of the 30 cm of soil profile (LOSW-P) are high in the lowland at the center of the basin. Regarding the water losses through surface runoff (LOSW-R), the higher values are observed at higher slopes and medium values are observed at the centre lowlands. Regarding the total water losses (LOSW-PR), the most vulnerable zone is detected at the mountains at the northwest region. Similar situation is depicted by the LOSN indices (Fig. 22).

Figure 21. Annual total water losses (LOSW-PR) in Botna river-Ialoveni rayon.
Figure 22. Annual total Nitrogen losses (LOSN-PRN) in Botna river-Ialoveni rayon.

2.4 Map clarification

The results provide important information, with the vulnerability map suitable for use by local authorities and decision makers responsible for groundwater resource management and protection zoning. Vulnerability and sensitivity maps could be used for planning, policy, management and contamination assessment.

For example: The higher the water losses LOSN-PN (blue color), the greater the water nitrate pollution risk and aquifer vulnerability. In this area, application of code for good agricultural practice, in order to reduce the groundwater pollution from nitrates. The proposed reduction will be achieved by the effectiveness increase in fertilization application, the application of alternative irrigation techniques, the optimization of crop selection as a function of soil characteristics and financial incentives etc. Training courses should be organized in order to educate people in using methods to optimize water and fertilizer use.

Furthermore, the new EC Directive 2006/118 on the protection of groundwater against pollution and deterioration, developed under Water Framework Directive 2000/60, sets out criteria with which to assess the chemical status of water bodies. The aforementioned Directives have also forced EC member states to ensure good chemical and ecological groundwater conditions.
3. The implementation of the Water Framework Directive (WFD) in the EU partner areas

The aim of this chapter is to assess the implementation of the Water Framework Directive in the project target areas. It refers to the laws, regulations and measurements that were developed to implement the WFD in the areas. It also analyzes the progress made, in terms of legislation, institutionalization and implementation at national and local level in order to achieve the directive goals.

3.1 The implementation of the WFD in Italy

WFD oblige only to obtain specific irrigation authorizations in case that they are requested in some areas. The controls are made by State Agencies on surface waters and do not affect directly farmers.

The law that applies to Italy the WFD is Legislative Decree 152/99, renewed and modified by another decree (152/2006). The objective of increasing the water quality is pursued by the writing and application of Regional Plans of Protection Water. According to these Regional Plans, with a monthly frequency for the period time of two years, the main superficial water bodies are check with bio-chemical analysis.

With a “points for quality” method, the water body is given a specific level of “Ecological Status” (ES) considering two indicators:

- **Pollution from Macroadescriptors** (PM) considering the following parameters: dissolved oxygen, BOD5, COD, NH4, NO3, total phosphorous, Escherichia coli.
- **Extended Biotic Index IBE** (Indice Biotico Esteso): it measures the effects of water chemical and chemical-physical quality on macroinvertebrates benthic organisms living in the riverbed

With these two parameters the ES is determined in 5 quality classes crossing the values of PM and EBI:

<table>
<thead>
<tr>
<th>ES</th>
<th>CLASS 1</th>
<th>CLASS 2</th>
<th>CLASS 3</th>
<th>CLASS 4</th>
<th>CLASS 5</th>
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<tr>
<td>EBI</td>
<td>≥ 10</td>
<td>8-9</td>
<td>6-7</td>
<td>4-5</td>
<td>1-2-3</td>
</tr>
<tr>
<td>PM</td>
<td>480-560</td>
<td>240-475</td>
<td>120-235</td>
<td>60-115</td>
<td>&lt; 60</td>
</tr>
</tbody>
</table>

3.2 Implementation of the WFD in Greece

The transposition of the WFD (European Water Framework directive) into Greek legislation has led to a new institutional organization with a new Central Water Agency, 13 Regional Water Directorates, a National water Committee (interministerial political body), national and regional water councils (consultative bodies). The protection and management of the river basins and the implementation of the WFD are a responsibility of the 13 Regional Water Directorates. In case of shared river basins, the National Water Committee must determine which regional authority is responsible. The National Water Agency is responsible for defining a national water policy and coordinating the activities of the regional directorates. Note that the regional directorates are under the General Secretary of each region. The current laws related to water resources have individuated institutions concerned
with water resources that form a specific administrative structure that concerns the water resources management in Greece. These institutions are the following:

**National Water Committee**, composed by ministers from:
1. Ministry for the Environment, Energy and Climate Change
2. Ministry of Economy and Finance
3. Ministry of Interior Decentralization and E-government
4. Ministry of Development
5. Ministry of Health and Social Solidarity
6. Ministry of Rural Development and food

National Water Committee plans the policy for the protection and management of water resources, monitors and controls the application of policy, approves the national management and protection of water resources plans after proposals of the respective ministries after the approval of the National Water Council. The National Water Committee submits to the Parliament and to the National Water Council annual report regarding the status of national water resources, the application of legislation about the protection and management of water resources, as well as legislation compatibility with European status.

**National Water Council**, composed by 24 members, including representatives of political parties, Municipal Societies for aqueducts and sewage, etc. The Council mainly has a consultant role regarding management and protection programs for water resources.

**Central Water Agency**, within the Ministry for the Environment, Regional Planning and Public Works. Its principal task is to coordinate all public services involved in water management, as well as to supervise all the administrative, economic and monitoring processes in progress.

**Regional Water Councils**, Consisted in each region and each one include 40-50 members and play a consultant role related to the Water District Management Plans, which are proposed by the Regional Water Office, before their approval. The Regional Water Council publishes the Water District Management Plans, before its approval, so as the public to be informed about the content of Management plans and to participate in a debate.

**Regional Water Offices/Directorates**, consisted in each region; their task is to implement in their own regions all the rules and measures indicated in law 3199/03. A Regional Water Office has been created in every region.

### 3.3 Implementation of the WFD in Ukraine

Water Framework Directive is not implemented in the country. Therefore, no management zones or "nitrate-vulnerable zones" (NVZs) have been developed.

Within the target area there are the following protective sites:

- Biosphere reserve "Danubian"
- Regional landscape parks:
  1. "Izmail islands"
  2. "Tiligul"
  3. "Tuzla firth"
- Partial reserve - 33 items
- Nature sanctuary - 57 items
- Wildlife sanctuary - 4 items
3.4 Implementation of the WFD in Croatia

Water management works comprise a number of activities ranging from legislation activities to organization of immediate management and monitoring of the water system status. The authorized and responsible leaders of such activities are: Croatian Parliament, National Water Council, Croatian Government, Ministry of Regional Development, Forestry and Water Management, as well as other state administration organisations, local and regional selfgovernment units and Hrvatske vode as the company in charge of water management.

The National Water Council (appointed by the Croatian Parliament) is a body established to harmonize various interests and to examine systematic issues related to the water management area at the highest level. The broadest administrative authority in water management belongs to the Ministry of Regional Development, Forestry and Water Management, within whose framework function the Water Management Directorate and the Water Policy and International Projects Directorate. The Ministry of Regional Development, Forestry and Water Management perform administrative and similar expert tasks, in particular:

(i) Water policy and strategic planning;
(ii) Monitoring of the status, implementation of administrative and inspection supervision;
(iii) Preparation of laws and regulations;
(iv) Provision of financial means to fund the activities in the field of water management;
(v) Decision-making in single important cases and adopting decisions of second instance in cases already decided upon by other bodies.

Other state administrative organizations are: the Ministry of Environmental Protection, Physical Planning and Construction, the Ministry of Culture and the Ministry of Health and Social Care. Units of local and regional self-government are authorized and responsible for water issues within their territories.

Hrvatske vode is the legal person in charge of water management. The company was established by the Water Act, which represents their deed of incorporation, for "permanent and unimpeded performance of public services and other activities of water management within the scope defined by the plans and in line with the financial means." These are in particular: preparation of groundwork as the basis of water policy creation, preparation of programs, plans and other acts representing the basis for providing sufficient quantities of suitable water for various intended uses, protection of water from pollution, regulation of watercourses and other waters and protection from adverse effects of water, investment and other tasks applied to carry out these plans and programs, implementation of measures ensuring rational use of water, protection of water and protection from flooding and other adverse effects of water. Hrvatske vode are operative on the whole territory of Croatia and cover all river basin districts and river basins. The company is organized in five water management divisions further divided in water management subsidiaries for various river basin districts.

Act on Amendments to the Water Act provides the adoption of the Water Management Strategy which is the fundamental planning document for water management at national level. The Strategy is adopted by the Croatian Parliament.
In accordance with the provisions of the Water Act, the territory of the Republic of Croatia is, for water management purposes, divided into 4 river basin districts, namely: the Sava river basin district, the Drava and Danube river basin district, the littoral and Istrian river basin district and the Dalmatian river basin district. The Decision on setting out a river basin district takes into consideration, apart from minor exception, watersheds of the Sava, Drava and Danube and the Adriatic Sea. Lower water management territorial units are the river basins. A river basin, as part of a river basin district, comprises one or more basins of smaller watercourses which, due to the interlacing of water policy, constructed water system and economic requirements, ensure single water management. The territory of Croatia is organized in 34 river basins managed by 32 water-management subsidiaries plus the Water Management Department for the river basin district of the City of Zagreb.

As candidate country for the EU membership, the Republic of Croatia is liable to harmonize the national legislation with the EU acquis communautaire. An extremely important document, which sets out the operational framework in the area of water policy, is the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (Water Framework Directive). Apart from harmonization with the Water Framework Directive, the national legislation is harmonized with other water directives. The water protection is also governed by a range of directives regarding the protection of nature and environment in general.

3.5 Implementation of the WFD in Hungary

According to the Water Framework Directive of EU Hungary has to reach the good conditions of waters till 2015. More significant users of environment (sewage emitter) have to comply with the Hungarian laws harmonized according to EU provisions since 31st of October, 2007. That means that the toleration” time’s up for them. Beyond this toleration time, in case of significant or frequent exceeding of threshold limits, the sewage emitters are obliged to prepare pollution reducing schedule and are obliged to realize it by the authority.

So the effective laws do not allow the constant and harmful pollution even besides paying penalty. The common deadline for toleration time is 31st of December, 2010. In sensitive areas, for emitters who emit sewage above 10 000 population equivalent the deadline is more severe: 31st of December, 2008, in non sensitive areas emitters who emits sewage above 15 000 population equivalent the deadline is less severe: 31st of December, 2015.

The necessary measurements to the realization of the aims of „Water Framework Directive“ (2000/60/EC) are included in the water catchment basin management plan (WCBMP). During the planning of water catchment basin management – that is happening these days – the classification of underground waters and water bodies that are the basic units (maps No 1-2.) is based on the quantitative and chemical (quality of water) aspects. According to the Water Catchment Basin Management Plan prepared on the basis of the water Framework Directive of the EU the emissions of baths have to be reconsidered and have to be re-regulated.

A decree controls the protection of underground stock of waters, that controls additionally the working and proposed stock of waters. In case of vulnerable, public
purposes stock of waters the external and internal defender profiles and areas have to be determined by official orders. Although a national investment project has started in 1997 that defines defender profiles and areas, as well as defines status rating and monitoring network, it has heavy arrears. Currently only **400 public purpose stocks of waters ruled by decree**, including those where the project is in process. Vulnerable public purposes stock of water areas can be defined by EU and state assistance by KEO 2.2.3/A and C constructions. Within these areas agriculture proposed water take outs (such as irrigation and farming livestock) can be authorized in limited amount and after interference examinations, primarily using other aquifer beds.

The regulation on irrigation of 2010 says that for these purposes surface waters must be used. If it is not possible, there underground water can be used, primarily shallow groundwater. Aquifer beds can be used only for micro irrigation. Obviously the aim of these orders is the thriftiness of underground waters, but another question is how to apply them in practice.

The catchment area management plans (CAMP) accepted in 2010, summarizes the aims of WFD. In CAMP, underground waters and water bodies are also qualified by quantitative and chemical the aspects. All qualification has two values: good or poor quality. The criterion of good quantity status is that the quantity of water taken out does not exceed the stock of waters that can be utilized.

### 3.6 Implementation of the WFD in Serbia

Water Framework Directive is not implemented in the country. Therefore, no management zones or "nitrate-vulnerable zones" (NVZs) have been developed.

### 3.7 Implementation of the WFD in Romania

In Romania, the adopted acts that aim to harmonize with existing EU legislation on water resources and their quality protection include among others:

- Water Law no. 107/1996, together with its subsequent amendments and completions included within Law no. 310/2004 and Law no. 112/2006;
- Government Decision no. 472/2000 on several measures aimed to ensure protection of the water resources’ quality;
- Order no.1146/2002 on approval of the Norms regarding the reference criteria for the classification of surface waters;
- This is intended to replace the Romanian Standard STAS 4706-88 – Surface Water – Quality technical terms and categories.
- Government Decision no. 930/ 2005 on approval of special norms referring to properties and size of sanitation and hydro-geological protection areas;
- Water Law no.107/ 1996 stipulates among other clauses, that monitoring responsibilities of the quality of drinking water falls under the Ministry of Health, by means of the county level territorial Public Health Inspectorates.
4. The implementation of the Nitrate Directive (ND) in the EU WATER project areas

In this chapter is presented an assessment of the implementation of the Nitrates Directive in the project target areas. It refers to the laws, regulations and measurements that were developed to implement the ND in the areas. It also analyzes the progress made, in terms of legislation, institutionalization and implementation at national and local level in order to achieve the directive goals.

4.1 Implementation of the ND in Italy

The ND is taken in account and respected by all farmers above all because the EU grants to crops are paid only to whom respect this directive. Also the relative controls, made by Regional Agencies, are made on 5%-10% farmers base. The biggest problem in the application of this directive is that the content of nitrogen and the volume of animal dejection are calculated not considering each single reality but utilizing State parameters that have been proved much higher than in many cases: the consequence is over estimating both N produced and the need itself of storages.

In our Action Plan (Agricultural Ministry Decree 07/04/2006), that has been revised in August 2011 by Veneto Region, the farmers that produce and/or utilize manure or sewage have to fulfill the following obligations:

- respect the maximum amount of 170 kg N per hectares in Nitrates Vulnerable Zones (NVZ); 340 kg N in Nitrate NOT Vulnerable Zones (NNVZ);
- respect the prohibition of application to soil of both chemical and organic fertilizers (for sewage and for chicken manure from 1 November to 28 February; for cattle manure from 15 November to 15 February); adequate storages; trace the distribution of manure/sewage with transport documents;
- for farms producing/utilizing <1000 kg N: obligation for maximum 170 kg/Ha N to the soil;
- for farms producing/utilizing 1000 ÷ 3000 kg N: fill in a form (simplified version) in which declare the number of animals bred, kind, sex, the type of housing, the amount of Tons and cubic meters of manure/sewage produced per year, describe the storages that have to be big enough to properly mature manure/sewage;
- for farms producing/utilizing 3000 ÷ 6000 kg N: fill in a form (full version) in which declare the number of animals bred, kind, sex, the type of housing, the amount of Tons and cubic meters of manure/sewage produced per year, describe the storages that have to be big enough to properly mature manure/sewage; prepare a fertilization plan (simplified version);
- for farms producing/utilizing > 6000 kg N: fill in a form (full version) in which declare the number of animals bred, kind, sex, the type of housing, the amount of Tons and cubic meters of manure/sewage produced per year, describe the storages that have to be big enough to properly mature manure/sewage; prepare a fertilization plan (full version);
- for farmers that breed >2000 pigs, or 40000 chickens: IPPC
4.2 Implementation of the ND in Greece

In this chapter is presented the implementation of the Nitrate Directive in the target area (Sarigkiol basin, Western Macedonia). It refers to the laws and measurements that were developed to implement the directive in the area. Additionally, the latest official report for the quality of groundwater and surface waters and the characterization of the surface waters in Sarigkiol basin are analyzed.

The Nitrates Directive came into force in Greece through Joint Ministerial Decree (JMD) 1190/133/1997 – “Terms and Measures for the Protection of Waters from Nitrates Pollution from agricultural Sources”. Designated vulnerable zones were incorporated into the Country’s legal framework. Seven action plans for NVZs were established. Each one provides detailed information about the situation in the area they refer. It also gives detailed guidelines about irrigation, fertilization management (types, rates and number of applications of fertilizers per crop), transportation and storage of fertilizers, livestock waste management. Code(s) of Good Agricultural Practice have been established to prevent and reduce the pollution of waters. It was established with the 85167/820/20-3-2000 Ministerial Decision, the "Codes of Good Agricultural Practice for the protection of waters by nitrates pollution from farm origin" (Government Gazette B 477/6-4-2000). They include codes for the storage transport and application of nitrogen fertilizer, the quantity and time of application and land cover during the winter.

According to report for the water quality of Sarigkiol basin, issued by the Hellenic republic, ministry of environment physical planning and public works central water agency, report on the pressures and qualitative characteristics of water bodies in the water districts of greece and a methodological approach for further analysis, in June 2006, Sulu stream appears to be heavily polluted due to the fact that the stream is the receiver of agricultural runoffs of the wider area as well as industrial effluents from the Ptolemaida region, (including slaughterhouse wastewater) and urban wastewater from neighboring agglomerations. Its water quality characteristics, regarding NO3, NO2, NH4 PO4 and SO4 , do not satisfy the requirements of Directive 75/440/EEC regarding the quality of surface waters intended for the abstraction of drinking water. Concentrations of microorganisms, and dangerous substances are generally low (below detection limits), which indicates that the majority of the industrial activities in the area do not produce significant toxic pollution loads. The surface waters in Sarigkiol basin were characterized as ‘mesotrophic’ regarding the total N and the total P concentration (Table 1).

Table 1. Characterization of the surface waters in Western Macedonia.

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<tr>
<td></td>
<td></td>
<td>Chl-a (µgN / l)</td>
<td>Total-N (mg N / l)</td>
<td>Total-P (mg P / l)</td>
<td>DO (mg / l)</td>
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<td>MESOTROPHIC</td>
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</tbody>
</table>

In relation to groundwater quality characteristics, Nitrates concentrations greater than 50mg/l are reported in the Perfecture of Kozani, in the water basin of Ptolemaida, which are associated with the intense use of fertilizers (Pontokimi area) and the existing natural lignite reserve.
In the Prefecture of Pelia nitrate concentrations are reported in relatively low levels with the exception of Flamouria area were concentrations greater than the guide value of 25mg/l are reported. Nitrate concentration higher than 50mg/l are reported in the north part of Vegoritida lake and are associated with the intense agricultural activity in the area as well as the industrial activity around the lake.

The total annual pollution loads of conventional pollutants for the Water District of West Macedonia are 43.491 tn BOD5, 60.749tn SS, 25.713 tn N and 2.805 tn P.

The organic load and the load of suspended solids are primarily associated with livestock activities (59% and 51% respectively) and secondarily with industrial activities (21% and 31% respectively) and urban wastewater (20% and 18% respectively).

The last two activities are related to point source pollution whereas the 1/3 of the pollution load from livestock activities is mainly diffuse pollution and it is mainly located (50%) at the Prefectures of Florina and Kozani. Main nitrogen pressures are associated with agriculture run offs and free livestock activities (54%). The major pressures for phosphorus include, primarily confined livestock wastes (61%) and secondarily agricultural run offs and free livestock wastes (18%) as well as urban wastes (17%).

The river basins of Grevenitis and Sakulevas as well as Sulu stream and lake Petron are designated as sensitive areas according to the provisions of Directive 91/271/EEC.

4.3 Implementation of the ND in Ukraine

Nitrate Directive is not implemented in the country. Therefore, no management zones or "nitrate-vulnerable zones" (NVZs) have been developed. No fertilization plans and limits are set. The only practice that takes place in order to limit leaching during the wet seasons is crop rotation.

4.4 Implementation of the ND in Croatia

Apart from harmonization with the Water Framework Directive, the national legislation is harmonized with other water directives. One of them is the Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (The Nitrates Directive) – requires designation of nitrate vulnerable zones affected by pollution caused by nitrates from agricultural sources and promotes good agricultural practice;

4.5 Implementation of the ND in Hungary

The Nitrate Framework Directive is in operation. "nitrate-vulnerable zones" (NVZs) are designated in the target area. The Nitrate Directive and the Water Framework Directive brought changes in fertilization management. The Good Agricultural Practice then the Good Agricultural and Environmental Condition defines the minimum requirements (at the same time premise for single area payment scheme). In the field of the reduction of nitrate pollution the „Statutory management requirements” are determinant and required for the single area payments and livestock-based payments. As these are basic requirements for EU as well as national subsidies (top-up) the compliance with these regulations is
essentially ensured (it is known that an adequate controlling body was formulated with a single penalty system).

**Use of sewage sludge in agriculture** (Statutory management requirement No. 3)
- permission by the soil protection authority is required
- keeping the dose and the area
- the sludge should be applied in the soil directly or applied as soon as possible
- documentation and keeping records

**Protection of waters against pollution caused by nitrates from agricultural sources** (Statutory management requirement No. 4)

The protection of waters against pollution caused by nitrates from agricultural sources is supported by the Action Plan. The Action Plan provides the compliance with the „Good Agricultural Practice” regulations (Decree No. 59 of 2008 by the Ministry of Agriculture and Rural Development amended in 2009 with Decree No. 55 of 2009 by the Ministry of Agriculture and Rural Development). It controls the quantity of fertilizing, the protection of water, nutrient management planning, fertilizing technology, the necessity of soil examination, groundwater level and groundwater quality control in every 5 year in irrigated areas, manure storage and data provision.

In nitrate vulnerable areas it controls/prohibits the timing of fertilizer application, grazing in the winter if it exceeds 120 kg/ha at annual level, fertilizing in the winter, maximum 170 kg/ha/year organic manure use, etc.

Nitrate vulnerable zones (map): designated areas/blocks; animal husbandry farms and manure storage with IPPC permission. Recording farm management data is obligatory (nitrate data sheet); calculation assistance, forms are available electronically.

The main steps of the Hungarian legislation:
- Act on the protection of the environment (1995)
- Government Decree No. 49 of 2001 regulating the designation of Nitrate Vulnerable Zones:
  - surface water above 50 mg/l nitrate content
  - surface water for drinking water use above 25 mg/l nitrate content
  - danger of eutrophication
  - sensitive waters and areas (e.g. lakes, drinking water base, gravel lakes, karst areas; designation - see map).

Since 2007, the database of nitrate sensitive agricultural areas at block level is available. The Government Decree No. 27 of 2006 already includes the Action Plan and upgrades nitrate sensitive zones.

### 4.6 Implementation of the ND in Serbia

Nitrate Directive is not implemented in the country. Therefore, no management zones or "nitrate-vulnerable zones" (NVZs) have been developed. No fertilization plans and limits are set.

### 4.7 Implementation of the ND in Romania

Regulation of pollution control, including from existing agricultural sources, is enforced by means of the following Romanian legislative acts:
- Government Decision no.964/2000 on approval of the Action Plan for the protection of waters against nitrates pollution from agricultural sources;
- Government Decision no.964/2000 on approval of the Action Plan for the protection of waters against nitrates pollution from agricultural sources;
- Order no.1552/2008 of the Minister of Environment and Sustainable Development and Order no.743/2008 of the Minister of Agriculture and Rural Development, on the list of localities in each county, where there is nitrates pollution from agricultural activities.

Council Directive 91/676/EEC on the protection of waters against nitrates pollution from agricultural sources has been integrally adopted at national level, by means of the national legislative acts listed below:

- Government Decision no.964/2000 on approval of the Action Plan for the protection of waters against nitrates pollution from agricultural sources and on the setting up of the Commission and Support Group nominated to implement provisions of this Action Plan; this Commission is constituted of specialists from the Ministry of Agriculture and Rural Development, from the Ministry of Environment and Forests and from the Ministry of Health; the adjacent Support Group includes representatives of the “Apele Române” National Administration, of basin level committees and also of certain institutes and specialized units, either under subordination or co-ordination of the aforementioned ministries;
- Common Order no.425/2001 and 105.951/2001 of the Minister of Waters and Environment Protection and of the Minister of Agriculture, Food and Forests, on approval of the rules and regulations concerning the organization, structure and role of the Commission and Support Group which have to implement the Action Plan for the protection of waters against nitrates pollution from agricultural sources;
- Order no. 740/2001 of the Minister of Waters and Environment Protection on approval of the nominal structure of the Commission to implement the Action Plan for the protection of waters against nitrates pollution from agricultural sources;
- Order no. 1072/2003 of the Minister of Agriculture, Forests, Waters and Environment, on approval of the setting up the National Integrated Support System for the monitoring, control and decision making to reduce the loads of pollutants from agricultural sources that reach the surface and underground waters;
- Order no.1270/2005 of the Minister of Agriculture, Forests and Rural Development and Order no. 1182/2005 of the Minister of Environment and Water Management, on approval of the Code of Good Agricultural Practices, for the protection of waters against nitrates pollution from agricultural sources;

This ‘Code of Good Agricultural Practices’ is devised with the purpose of being able to recommend the best practices, measures and methods possible to be applied by each farmer/agricultural producer to protect waters against pollution with fertilizers (especially nitrates) used in agricultural activities.
Current or historic nitrates vulnerable zones from agricultural sources encompass the territory of 251 localities in Romania, representing 1,217,147 ha, namely 8.20% of the total agricultural land at country level.

The surface of arable land within the vulnerable zones amounts to 866,961 ha and this represents 9.22% of the total arable area at country level.

The vulnerable zones have been differentiated depending on the type of nitrates sources:

- Current sources: present agricultural activities generate a surplus of nitrates as a direct consequence of high livestock densities (within individual households and/or livestock farms);
- Historical sources: industrial type, livestock breeding farms that used to operate in the area and which are now decommissioned.

The amount of mineral and organic fertilizers applied per surface area (hectare) must not exceed 170 kg nitrogen active ingredient per year. One includes here also the nitrogen from the slurry that directly reaches the ground from livestock during grazing activities.

For the agricultural exploitations situated in areas designated as vulnerable to nitrates pollution, it is prohibited to apply higher amounts of fertilizers than the above mentioned limit.

However, the Nitrates Directive allows for the possibility for a derogation in respect to the maximum amount of 170 kg nitrogen per hectare per year for livestock manure, provided that it is demonstrated that the directive’s objectives are still achieved and that the derogation is based on objective criteria such as long growing seasons, crops with high nitrogen uptake, high net precipitation or soils with a high denitrification capacity.
Chapter 2. Identification / estimation of the contribution of agriculture in water consumption and in water pollution

1. Introduction
The main goal of the current chapter is the Identification and estimation of the contribution of agriculture in water consumption and in water pollution, in comparison with other activities. In order to suggest a strategy for reduction of water consumption in agriculture, and reduction of pollution by agriculture, it is important to know how much agriculture contributes to this. Therefore we review these aspects here. Especially we present what types of crops are cultivated, what their needs in water and in fertilizer are, and how big their contribution to water consumption and to nitrates pollution in relation to other activities in the area is. To understand this, we review information from WP3 and compare it with benchmarks from bibliography and good practices found elsewhere. These benchmarks and good practices help us setting targets for the strategy. In essence this chapter sets the targets for the strategy, by looking at what can be improved and to what extent. The next chapters will show how it can be improved.

1.1 Po river basin, Italy

1.1.1 Land uses and agricultural activities
In the Province of Ferrara five different classes of land use were identified:
Agricultural areas, which cover an area of 2164, km² artificial areas (183.21 km²), natural and semi-natural areas (27,25 km²), water bodies (95,32 km²) and wetlands (152,53 km²).

In Province of Rovigo the most important activities are related to commerce, repairs, tourism (hotel and restaurants), transportations, communications and construction. Agriculture accounts for 9% in terms of employment and 4% in terms of income. The total surface of Province of Rovigo is km² 1.789,9 and 1.230,3 Km² is the agricultural coverage.

Types of crops that are cultivated
Twelve main crop categories are cultivated in the agricultural land of the Province of Ferrara (Table 1).
Table 2. Types of crops cultivated in Ferrara Province.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area</th>
<th>Winter or summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit trees</td>
<td>1450</td>
<td>perennial</td>
</tr>
<tr>
<td>Vineyard</td>
<td>709</td>
<td>perennial</td>
</tr>
<tr>
<td>Winter cereals</td>
<td>5312</td>
<td>winter</td>
</tr>
<tr>
<td>Maize</td>
<td>3670</td>
<td>summer</td>
</tr>
<tr>
<td>Rice</td>
<td>7995</td>
<td>summer</td>
</tr>
<tr>
<td>Beet</td>
<td>7486</td>
<td>summer</td>
</tr>
<tr>
<td>Energy plants</td>
<td>1631</td>
<td>summer</td>
</tr>
<tr>
<td>Tomato</td>
<td>7133</td>
<td>summer</td>
</tr>
<tr>
<td>Grain legumes</td>
<td>3120</td>
<td>winter</td>
</tr>
<tr>
<td>Annual forage</td>
<td>1729</td>
<td>perennial</td>
</tr>
<tr>
<td>Gardening fruits</td>
<td>1440</td>
<td>summer</td>
</tr>
<tr>
<td>Other</td>
<td>1369</td>
<td>-</td>
</tr>
</tbody>
</table>

In Rovigo Province a wide variety of crops is cultivated. The most important are presented in the following table (Table 2) in terms of cultivated land.

Table 3 Types of crops cultivated in Rovigo Province.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Surface (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize grain</td>
<td>51.664</td>
</tr>
<tr>
<td>Soybeans</td>
<td>22.354</td>
</tr>
<tr>
<td>Wheat</td>
<td>21.077</td>
</tr>
<tr>
<td>Not used land (tares)</td>
<td>15.763</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>5.388</td>
</tr>
<tr>
<td>Sugarbeet</td>
<td>4.203</td>
</tr>
<tr>
<td>Set aside</td>
<td>3.654</td>
</tr>
<tr>
<td>Durum Wheat</td>
<td>3.537</td>
</tr>
<tr>
<td>Fodder</td>
<td>2.335</td>
</tr>
<tr>
<td>Rice</td>
<td>1.808</td>
</tr>
<tr>
<td>Pear</td>
<td>1.362</td>
</tr>
<tr>
<td>Barley</td>
<td>1.264</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>1.21</td>
</tr>
<tr>
<td>Sunflowers (food and no foods)</td>
<td>941</td>
</tr>
<tr>
<td>Set aside</td>
<td>510</td>
</tr>
</tbody>
</table>

1.1.2 Water demands- irrigation

For each crop category the average water quantity required, crop type, crop factor and the percentage of land cover was indicated (Table 4).

Table 3. Irrigation needs and application methods.
Irrigation practices
Table 4. Main irrigated crops and water needs in Ferrara Province.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Irrigation method</th>
<th>Irrigation amount (mm)</th>
<th>Average crop factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit trees</td>
<td>drip irrigation - asperation - irrigation on/under foliage - spray irrigation</td>
<td>600-700</td>
<td>0.81</td>
</tr>
<tr>
<td>Vineyard</td>
<td>flow irrigation - irrigation under foliage</td>
<td>550-650</td>
<td>0.73</td>
</tr>
<tr>
<td>Winter cereals</td>
<td>non-irrigated</td>
<td>350-400</td>
<td>0.75</td>
</tr>
<tr>
<td>Maize (sillage/grain)</td>
<td>lateral infiltration - aspersion</td>
<td>350-450/550-650</td>
<td>0.75/0.78</td>
</tr>
<tr>
<td>Rice</td>
<td>flood irrigation</td>
<td>1200-1500</td>
<td>1.15</td>
</tr>
<tr>
<td>Beet</td>
<td>aspersion</td>
<td>600-700</td>
<td>0.88</td>
</tr>
<tr>
<td>Energy plants</td>
<td>aspersion</td>
<td>600-700</td>
<td>0.87</td>
</tr>
<tr>
<td>Tomato</td>
<td>aspersion - drip irrigation - lateral infiltration</td>
<td>550-650</td>
<td>0.92</td>
</tr>
<tr>
<td>Grain legumes</td>
<td>aspersion - lateral infiltration</td>
<td>350-450</td>
<td>0.78</td>
</tr>
<tr>
<td>Annual forage crops</td>
<td>non-irrigated</td>
<td>400-500</td>
<td>0.63</td>
</tr>
<tr>
<td>Gardening fruits</td>
<td>aspersion - drip irrigation</td>
<td>400-600</td>
<td>0.80</td>
</tr>
</tbody>
</table>

In Ferrara Province surface waters are used to irrigate the cultivated crops. Irrigation water is charged per ha of cultivated land. Therefore water consumption is not considered. Irrigation method varies according to crop category as shown in the irrigation table (Table 4). The most common irrigation methods are represented by artificial rain practiced in 64% of cases, particularly on open field crops such as corn and soybeans, followed by lateral flow and infiltration (18%), common in the western provinces, and the micro-irrigation (drip), mainly used on orchards and on vegetables.

The effects of irrigation water into the artificial network are beneficial on quality of inland waters and the environment itself and therefore, it seems desirable to underline this environmental positive effect of water caption from the Po River, generally mentioned as "loss" to avoid. Therefore it is important to evaluate, in accordance with the Provincial Department for Environment, the concrete possibility to maintain water withdraw from the Po even in winter to induce a sort of minimal vital flow in the artificial canals’ network;

Table 5. Main irrigated crops and water needs in Rovigo Province.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Irrigation method</th>
<th>Irrigation amount (mm)</th>
<th>Average crop factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>hose reel irrigators</td>
<td>50 x 2</td>
<td>0.75</td>
</tr>
<tr>
<td>Soybean</td>
<td>non irrigated</td>
<td>0</td>
<td>0.87</td>
</tr>
<tr>
<td>Wheat</td>
<td>non irrigated</td>
<td>0</td>
<td>0.75</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>non irrigated</td>
<td>0</td>
<td>0.63</td>
</tr>
<tr>
<td>Sugarbeet</td>
<td>hose reel irrigators</td>
<td>40 x 2</td>
<td>0.88</td>
</tr>
</tbody>
</table>

In Rovigo Province surface waters are used to irrigate the cultivated crops. Irrigation water is charged per ha of cultivated land for the 90% of the target area using collective network. For the farmers using this network water consumption is
not considered. Additionally consumption based pricing is applied in some farmers who use private wells (10%) or collective network (10%). Finally for 30% of the farmers using collective network both consumption and crop type are considered.

Hose reel irrigators are used to apply irrigation as shown in the irrigation table (Table 5).

1.1.3 Needs in fertilizer – fertilization

In Po basin agricultural land a variety of fertilizer types are being used such as zootechnical effluent (cattle sewage, chicken manure), synthetic fertilizers (urea, ternary fertilizers and ammonium nitrate) and in some cases sludge from water treatment. The general requirements in nitrogen fertilization for the main crop that are cultivated in the region are presented in Table 6.

Table 6. Nitrogen inputs for the main crops cultivated in Po river basin.

<table>
<thead>
<tr>
<th>Crop</th>
<th>maize</th>
<th>wheat</th>
<th>sugarbeet</th>
<th>durum wheat</th>
<th>rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>36,700</td>
<td>24,050</td>
<td>7,486</td>
<td>28,200</td>
<td>7,995</td>
</tr>
<tr>
<td>Winter or summer crop</td>
<td>summer crop</td>
<td>winter crop</td>
<td>summer crop</td>
<td>winter crop</td>
<td>summer crop</td>
</tr>
<tr>
<td>kg N/ha/year maximum allowed</td>
<td>240</td>
<td>155</td>
<td>135</td>
<td>160</td>
<td>120</td>
</tr>
<tr>
<td>kg N/ha/year amount effectively applied</td>
<td>240</td>
<td>155</td>
<td>120</td>
<td>160</td>
<td>70</td>
</tr>
</tbody>
</table>

Fertilization practices

Nitrogen fertilizers are usually applied in one or two doses. Depending on the crop and the type of fertilizer liquid or solid spread is performed. For the management of nitrogen fertilization are considered the following:
- Nitrogen consumption of the crops
- Leaching of nitrogen in the soil
- Nitrogen run-off
- Rain
- Contribution of crop Residuals

1.1.4 Pollution sources

The most important pollution sources are divided in point sources and diffuse sources (Water Protection and Restoration Unit, Emilia-Romagna region). The most important point sources are:
- industrial and domestic wastewater discharging into sewers
- public storm drains
- discharges from productive / industrial system

For the determination of the load carried in surface water by the drainage and depuration system, it is important to consider the contribution of the various elements of the systems affected:
- The load spilled from localities having no sewerage system. It is the portion of load not served by the network.
- The load spilled from sewerage system not purified. These quantities are spilled in surface water body without any treatment.
- The overload from sewage-treatment system. This is the case when a load exceeding the design capacity is conveyed to the system. This load, not purified, is spilled directly into surface water body.
- The load spilled from wastewater treatment plant. Represents the load spilled from the treatment plants into surface water body or soil.

The diffuse pollution sources are largely identifiable in the varied and complex farming practices, that can be divided in effluents deriving from livestock farming, sludge from civil and agroindustrial treatment plants and chemical fertilizers.

### 1.1.5 Contribution of agriculture to water pollution and water scarcity

The impact on groundwater quality by fertilizers used to maintain the productivity of the soil can be mostly associated with nitrate pollution. In general, nitrates are absent from the groundwater, while there are systematic iron and ammonia (reducing environment, often associated with organic matter).

The structure of the hydrogeological complex does not allow recharge from rain and exchange with the drainage network, for the confined aquifers. Pumping from wells is the main output from the system.

### 1.2 Sarigkiol basin, Greece

#### 1.2.1 Land uses and agricultural activities

The most important activities in the Sarigkiol basin are:
- The lignite mining by the Lignite Center of Western Macedonia (LCWM)
- The agricultural exploitation of the lowland region
- The livestock-farming on the fringes of the mountain ranges which surround the basin

The first two and foremost activities occupy land in the central area of the basin. The total extent of the basin covers an area of 469.2 Km², covered by agricultural land (32.7% - 153.3 Km²), forests and semi natural areas (56.9% - 266.8 Km²) and urban or artificial surfaces (10.4% - 49.1 Km²) including coal mines which occupy a central section of the basin and steam electric power plants that cover 31.7 Km².

**Types of crops that are cultivated**

The crop distribution is: 61.45% hard wheat, 6.56% soft wheat, 6.28% barley, 9.89% sugar beet, 8.96% maize, 1.25% potatoes, 0.38% oat and 5.25% pastures. Detailed information about the main crops that are cultivated in Sarigkiol basin is presented in Table 6. Sarigkiol agricultural area is divided in three main sectors: 1) non irrigated arable land (9318.7 ha), 2) permanently irrigated land (5207.0 ha) and 3) pastures (804.9 ha).
Table 7. Main crops cultivated in Sarigkiol basin and details about irrigation.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Soft Wheat</th>
<th>Hard Wheat</th>
<th>Barley</th>
<th>Maize</th>
<th>Sugarbeet</th>
<th>Oat</th>
<th>Potatoes</th>
<th>Set aside/Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>1004.88</td>
<td>9419.58</td>
<td>963.13</td>
<td>1372.98</td>
<td>1515.66</td>
<td>57.68</td>
<td>191.26</td>
<td>804.9</td>
</tr>
<tr>
<td>Season</td>
<td>Winter</td>
<td>Winter</td>
<td>Winter</td>
<td>Summer</td>
<td>Summer</td>
<td>Winter</td>
<td>Summer</td>
<td>Perennial</td>
</tr>
<tr>
<td>Irrigation method</td>
<td>Non irrigated</td>
<td>Non irrigated</td>
<td>Non irrigated</td>
<td>surface, sprinkler, drip irrigation</td>
<td>surface, sprinkler, drip irrigation</td>
<td>No</td>
<td>surface, sprinkler, drip irrigation</td>
<td>Non irrigated</td>
</tr>
<tr>
<td>Water needs (mm)</td>
<td>300-350</td>
<td>300-350</td>
<td>300-350</td>
<td>600-700</td>
<td>600-700</td>
<td>300-350</td>
<td>600-700</td>
<td>-</td>
</tr>
<tr>
<td>Average crop factor</td>
<td>0.75</td>
<td>0.75</td>
<td>0.75</td>
<td>0.87</td>
<td>0.82</td>
<td>0.75</td>
<td>0.9</td>
<td>-</td>
</tr>
</tbody>
</table>

1.2.2 Water demands- irrigation

The irrigated land in Sarigkiol basin increased greatly during the last decades. The most important limiting factor is the seasonal variation in water availability and demand. Furthermore, agriculture requires increased supplies in late spring, summer, and early autumn, when the water availability is low. Irrigation takes place mainly through private drillings, and in some cases by pumping from Soulou stream and draining channels where the waters that drawn from the LCWM mines are channelled.

The area of the basin occupied by xeric (dry) crops (wintry cereals) is a dependence of the generally applied rural policy (construction of irrigatory works, drilling permits), as well as the particular policy of PPC for reestablishment and output in the cultivation of grounds which are today occupied by the mines. The winter crops (soft wheat, hard wheat, barley, oat), occupy 75.67% of the total area of the cultivated land (11445.3 ha) and among with the set aside/pastures the area of the non irrigated land reaches 12250.2 ha (79.9% of the total agricultural land). The rest of the agricultural area (20.1%, 3079.9 ha) is cultivated with summer crops, maize, sugar beet and potatoes that demand great amounts of irrigation water (Table 8).

Table 8. Main irrigated crops and water needs in Sarigkiol basin.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Maize</th>
<th>Sugar-beet</th>
<th>Potatoes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>1372.98</td>
<td>1515.66</td>
<td>191.26</td>
<td>3079.9</td>
</tr>
<tr>
<td>Water needs (*10^6 m^3)</td>
<td>5.56</td>
<td>6.14</td>
<td>0.77</td>
<td>12.47</td>
</tr>
</tbody>
</table>

The water needs of winter crops are covered by precipitation while the water needs of summer crops are covered mostly by the exploitation of alluvial aquifer, through a large number of boreholes. Additionally many farmers find it easier and less expensive to pump water straight from the Soulou stream using hoses and small pumps or even the pumps from their own boreholes.

The irrigation method used by the farmers in Sarigkiol basin varies. Surface, sprinkler and drip irrigation methods are being used to irrigate the above mentioned crops in the area.
Due to the fact that irrigation takes place through drillings and by pumping water from the Soulou stream and the draining channels, irrigation cost depends on the amount of the irrigation water applied (energy cost for water pumping).

Farmers should realize that in order to maintain or even extend the cultivation of high value crops and achieve high yields, the quality and quantity of irrigation water is vital. The indiscriminate use and excessive pumping of water not only does not lead to increased productivity of the farm, but also it undermines its future, since it reduces the available water resources.

**Irrigation practices**

The main objective for a successful irrigation is provided to the plant the proper amount of water according to its real needs. The application should perform in a way that water and nutrients losses, from deep percolation and surface runoff, are minimized.

The current irrigation methods used in Sarigkiol basin are:
- Surface irrigation
- Artificial rain / sprinkler irrigation
- Drip irrigation

**1.2.3 Needs in fertilizer – fertilization**

In Sarigkiol basin, fertilization takes place in 2 doses, the first one is pre-seed (representing b, Table 8) and the second takes place 1.5 months after sowing by applying an amount of surface nitrogen (representing s, Table 8). Specifically in Table 3, column "Nitrogen fertilization rates and type (kg N / ha) and methods" the value b100/s50 means that 150 kg N / ha are applied. According to the codes of good agricultural practice fertilization of winter cereals should not exceed 160kgN/Ha (16 units of nitrogen per acre) applied at two doses at least, and first application of fertilizers should not exceed 50 kg N / ha (5 units of nitrogen per acre). However, the first dose of fertilizer that the farmers apply in Sarigkiol is usually higher than recommended.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Soft Wheat</th>
<th>Hard Wheat</th>
<th>Barley</th>
<th>Maize</th>
<th>Sugarbeet</th>
<th>Oat</th>
<th>Potatoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen rates (kg N/ha)</td>
<td>B40/ s40</td>
<td>B40/ s40</td>
<td>B40/ s40</td>
<td>b150/ s150</td>
<td>b100/ s100</td>
<td>b80/ s50</td>
<td>b100/ s50</td>
</tr>
<tr>
<td>Average yield (kg/ha)</td>
<td>3500</td>
<td>2900</td>
<td>4000</td>
<td>12000</td>
<td>55000</td>
<td>3000</td>
<td>45000</td>
</tr>
</tbody>
</table>

Concerning the fertilization the actual inputs that the farmers use have decreased, especially in cereal crops. The farmers have reduced fertilizer rates on an effort to reduce the production cost. In addition to winter cereals, the fertilizer rates are quite high in more dynamic and high productive crops such as corn and potatoes.
Fertilization practices

During cultivating season, plants are abstracting nutrient elements from the soil in order to grow and develop. At harvest a great amount of these elements are removed from the field by collecting the useful part of the crop (grains, fruits etc.) while a small amount remains in the field as crop residues. The nutrient loss has to be replaced. The role of fertilization is to maintain soil fertility leading to maximization of the crop yield and quality. To achieve the best application of fertilizers three basic parameters are taken into account, the amount of fertilizer, the time of application and the manner of application.

The use of fertilizers, without choosing the appropriate type and applying the right quantity at the right time increases the cost of production and leads to overuse of fertilizers. Apart from the cost increase this causes problems in soil and pollutes groundwater and surface water.

Nitrogen fertilizers are soluble in water and therefore they represent the most polluting ones due to increased mobility in soil in contrast to phosphate and potassium.

If nitrogen application takes place in the inappropriate time or in excessive amounts part of it is not absorbed by plants and remains in the soil. These amounts are rinsed with rain or irrigation water, ending in groundwater where they accumulate. A second possibility is to drift away with irrigation or rain water ending in the water receiver in the area, rivers, lakes or sea causing eutrophication. The phenomenon is more intense when the ground is sloping or of low permeability (it is heavy or impermeable), or the application takes place near or within watersheds. Under these circumstances nitrates and phosphates are transported causing eutrophication of surface waters and their degradation. When the nitrogen content exceeds certain limits (50 mgr / lt) the water is unsuitable for consumption.

Synthetic nitrogen fertilizers are usually applied in two doses. The basic is performed with seeding and surface when crop grows. Basic fertilization is performed using either fertilizer distributor or seeder while for surface fertilization fertigation is performed in case drip irrigation system is available. For the management of nitrogen fertilization are considered the following:

- Type of crop
- Type of soil
- preceding crop
- Climate data
- Type of irrigation

Finally good agricultural practices are applied in the area.

1.2.4 Pollution sources

In Sarigkiol basin the most important pollution sources, which are related to human activities, are originated by agriculture activities, urban, industrial, mineral extraction mines, abandoned waste fields, animal breeding wastes and LCWM operations (surface lignite mines, solid deposits and solid wastes from lignite mines, steam-electric power plants). Untreated waste effluent from industrial and livestock units and waste water treatment plant shortage form major pollution sources of surface water bodies; Soulou stream which is the basic receiver of the surface waters in Sarigkiol basin, was reported to be polluted with diesel oil leaking from the electric
power plant Agios Dimitrios in 2009. According to the technical report (Environmental centre, 2009) a slight pollution of the waters was observed. Nevertheless the concentration of benzene and polycyclic aromatic hydrocarbons measured in all samples (14 samples along the Soulou stream) were significantly lower than the limit values (5 mg / L and 0, 20 mg / L respectively).

The aforementioned circumstances are responsible in conjunction with the agricultural activities for the groundwater quality degradation. Groundwater quality deterioration is also caused by the discharge of liquid and solid waste directly into abandoned shallow wells in urban areas or abandoned quarries in rural areas. Central municipal sewage-treatment systems do not exist in small villages. Fertilizers and agricultural chemical compounds are being used intensively to maintain the productivity of the soil. Agricultural impact on groundwater quality has been mostly associated with nitrates pollution. The technical report (Environmental centre, 2009) pointed that in all samples the concentration of ammonia was lower than the limit value (3 mg / L) but the nitrates concentration exceeds limit value (0,03 mg / L). Additionally other possible pollution sources were found along the stream coming from agricultural activities, eg packs from lubricants and pesticides. Also, Soulou stream receives urban and industrial wastewater in the area which is carried towards lake Vegoritida (Environmental centre, 2009).

Soulou stream appears to be heavily polluted due to the fact that the stream is the receiver of agricultural runoffs of the wider area as well as industrial effluents from the Ptolemaida region, (including slaughterhouse wastewater) and urban wastewater from neighboring agglomerations. Its water quality characteristics, regarding NO3, NO2, NH4 PO4 and SO4, do not satisfy the requirements of Directive 75/440/EEC regarding the quality of surface waters intended for the abstraction of drinking water. Concentrations of microorganisms, and dangerous substances are generally low (below detection limits), which indicates that the majority of the industrial activities in the area do not produce significant toxic pollution loads (Central Water Agency report, 2006).

For lakes Vegoritida, Petwn and Soulou stream and in accordance with the demands of the Directive 76/464/EEC for dangerous substances, a special program for the reduction of pollution problems of the lakes has been initiated (JMD 15782/1849/20.06.2001) (Central Water Agency report, 2006).

In Sarigkiol basin point pollution sources are mostly concentrated at the perimeter of the agricultural land and within or near the urban areas. At the centre of the basin where agricultural land is laid the main pollutant factor comes from the intensive agriculture activities and in some cases the irrational use of fertilizers and pesticides.

1.2.5 Contribution of agriculture to water pollution and water scarcity

As mentioned in the previous chapters, the main pollution sources in Sarigkiol basin are:

The lignite mines that have impact mainly near the excavation points by the disturbance of the ecosystem due to the mining activities, solid deposits and solid wastes, the air pollution and the groundwater affected by the drillings.

The steam-electric power plants (diesel oil leaking was reported).

The untreated waste that effluent from industrial and livestock units.
The overexploitation of the water sources and the impacts from agricultural activities. The main impacts from agriculture in the area are related to eutrophication problems in the groundwater, surface waters (Soulou stream) and the receivers of these waters (lake Vegoritida) due to insufficient management of fertilization and irrigation. Additionally other possible pollution sources were identified along the Soulou stream like packs from lubricants and pesticides.

Implementation of the good agricultural practices in the area may lead to the appropriate solution of the environmental problems in the region. To achieve this, the farmers must be aware of the impact to the environment that their actions and activities have and the situation they will be facing in the future in case this condition wouldn’t be reversed. Finally the farmers should be trained to apply the codes for good agricultural practices and the new methods and technologies that can assist on minimization of inputs in agriculture.

1.3 Odessa region, Ukraine

1.3.1 Land uses and agricultural activities

Of the total area of 3331.3 thousand hectares, agricultural land covers 2661.6 thousand ha or 79.9% of all region’s area. In composition of agricultural lands the area of plough-land is 2067.6 thousand ha (62.1% of the region’s area and near 78% of agricultural lands), haymakings and pastures – about 408 thousand ha and gardens and vineyards – about 90 thousand ha. Forests occupy 223.9 thousand ha, bogs and boggy lands – 72.2 thousand ha, internal waters – 211.8 thousand ha, built-up lands – 128.2 thousand ha (Table 10).

Table 10. Structure of land-use.

<table>
<thead>
<tr>
<th>Type of land use</th>
<th>Area as of 1.01.2005</th>
<th>Area as of 1.01.2007</th>
<th>Area as of 1.01.2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>thousand ha</td>
<td>% of total area</td>
<td>thousand ha</td>
</tr>
<tr>
<td>Agricultural lands</td>
<td>2662.4</td>
<td>79.9</td>
<td>2662.1</td>
</tr>
<tr>
<td>plough-lands</td>
<td>2068.3</td>
<td>62.1</td>
<td>2057.4</td>
</tr>
<tr>
<td>hayfields and pastures</td>
<td>403.6</td>
<td>12.2</td>
<td>405.6</td>
</tr>
<tr>
<td>gardens and vineyards</td>
<td>90.3</td>
<td>2.7</td>
<td>90.8</td>
</tr>
<tr>
<td>Forests</td>
<td>223.3</td>
<td>6.7</td>
<td>223.4</td>
</tr>
<tr>
<td>Bogs and boggy lands</td>
<td>72.2</td>
<td>2.2</td>
<td>72.6</td>
</tr>
<tr>
<td>Internal waters</td>
<td>211.6</td>
<td>6.4</td>
<td>211.7</td>
</tr>
<tr>
<td>Built-up lands</td>
<td>127.8</td>
<td>3.8</td>
<td>127.8</td>
</tr>
<tr>
<td>Protected areas</td>
<td>102.2</td>
<td>3.0</td>
<td>102.4</td>
</tr>
</tbody>
</table>

**Types of crops that are cultivated**

Cereal crops (wheat, barley, rye, maize) prevail in the structure of sowing areas (Table 11). Considerable areas are occupied by technical crops (mainly sunflower, sugar beet and the last years the rape).
### 1.3.2 Water demands - irrigation

Water consumption is divided as follows: domestic and drinking needs - 123.5 million m$^3$ (40%); industrial needs - 68.25 million m$^3$ (22.2%), agricultural water - 12.19 million m$^3$ (4%); irrigation - 63.79 million m$^3$ (20.7%), fisheries - 67.1 million m$^3$ (21.8%), other needs - 7.972 million m$^3$ (2.6%).

In the region there are 58 irrigation systems, most of which was built in 60s – 80s of last century. The total area of irrigation systems equals 226,861 hectares, the total length of irrigation network - 5388.1 km. Irrigated land almost entirely (95%) are located on the south and south-west of the region. Sprinkler irrigation with using a different sprinkling machines is the predominant method of irrigation in the region, although there are irrigation systems where are used surface irrigation methods.

It must be emphasized, that from a total area of irrigated lands, which exceeds 200 thousand hectares, due to economic difficulties in the past two decades in the country actually are irrigated only 30-50 thousand hectares.

### Table 11. Main crops cultivated in Odessa agricultural land.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn crops (wheat, barley, rye, maize)</td>
<td>1155.3</td>
<td>1219.8</td>
</tr>
<tr>
<td>Technical crops (sunflower, sugar beet, rape)</td>
<td>342.5</td>
<td>432.3</td>
</tr>
<tr>
<td>Potato, vegetable and melon crops</td>
<td>75.4</td>
<td>72.8</td>
</tr>
<tr>
<td>Fodder crops (grass, forage beet etc.)</td>
<td>168.0</td>
<td>99.0</td>
</tr>
<tr>
<td>General sowing area</td>
<td>1741.2</td>
<td>1823.9</td>
</tr>
</tbody>
</table>

### Table 12. Main irrigated crops in Odessa Region.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Winter or summer crop</th>
<th>Irrigation method</th>
</tr>
</thead>
<tbody>
<tr>
<td>tomato</td>
<td>1991</td>
<td>summer</td>
<td>drip irrigation</td>
</tr>
<tr>
<td>onion</td>
<td>724</td>
<td>summer</td>
<td>drip irrigation</td>
</tr>
<tr>
<td>cucumber</td>
<td>395</td>
<td>summer</td>
<td>drip irrigation</td>
</tr>
<tr>
<td>cabbage</td>
<td>674</td>
<td>summer</td>
<td>drip irrigation</td>
</tr>
</tbody>
</table>

### Irrigation practices

In Odessa Region groundwater is used to irrigate the cultivated crops. For the pricing of Irrigation water both consumption and crop type are considered. The most common Irrigation method used for the main crops is drip irrigation.

On farms of Odessa region there is a great number of watering or irrigation types. They differ from each other by a principle of application depending on growing plants, geography of application, cost, and sources of water and power resources. Basically it is differentiated between furrow watering (watering by flooding), overhead irrigation (including micro overhead irrigation), hose watering, and drop irrigation.

All above mentioned type have their advantages and drawbacks. Sprinkler irrigation in the region is applied in growing of crops, vegetables with enough high plant population. Despite wide range of application sprinkler systems cause rather
significant losses of water, consolidation of top layer of soil, formation of superficial crust with deterioration of water-air exchange. Overhead irrigation increases danger of blights.

Long-term experience of use of traditional irrigation methods in the region showed other their drawbacks: moisture supersaturation in row spacing causes minimization or general impossibility of modern carrying out of technological operations with machinery application and significant increase of weed quantity, and also it is observed over-expenditure of water (in region where water is a tight resource), mineral fertilizers.

Therefore agriculture undergoes serious changes in sphere of innovative irrigation, technologies of fertilization and agronomy, one of which is drip irrigation.

As may be inferred from data of irrigation efficiency most economically feasible, ecologically safe method of watering of gardens, vineyards, small fruit acreages, vegetables and gourds in Odessa region is drip irrigation.

1.3.3 Needs in fertilizer – fertilization

Table 13. Nitrogen fertilization rates per crop in Odessa Region.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Winter or summer crop</th>
<th>Nitrogen rates allowed (kg N/ha/year)</th>
<th>Nitrogen rates applied (kg N/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>winter wheat</td>
<td>450000</td>
<td>winter</td>
<td>44</td>
<td>40</td>
</tr>
<tr>
<td>winter barley</td>
<td>345000</td>
<td>winter</td>
<td>37</td>
<td>33</td>
</tr>
<tr>
<td>sunflower</td>
<td>228000</td>
<td>summer</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>winter rape</td>
<td>185000</td>
<td>winter</td>
<td>51</td>
<td>48</td>
</tr>
</tbody>
</table>

Fertilization practices

Mainly synthetic fertilizers are used which are applied once every year. Small amounts of manure are also applied distributed straight on the soil. Also, in high value crops, where drip irrigation is applied, fertilization is applied simultaneously with irrigation using the drip irrigation network (fertigation).

Due to various systems of drip irrigation with simultaneous application of the fertilizer solution in Odessa region last year in all categories of farms harvested 3.3 million tons of grain, sunflower – 435 thousand tons, potato – 554 thousand tons, vegetables – 507 thousand tons, 34 thousand tons more than in 2010. Production of fruit and berry crops increased in comparison to 2010 by 18.7 % producing 85 thousand tons. 201 thousand tons of grapes were harvested, 25 thousand tons more than in 2010.

For the management of nitrogen fertilization is considered only the preceding crop. Finally traditional and good agricultural practices are applied, adopted and improved in the area nitrogen saving and nitrogen fertilization efficiency practices applied in the area.
1.3.4 Pollution sources

The main pollution sources of surface water bodies (rivers, reservoirs and lakes) are: untreated and inadequately treated sewage of settlements, industrial and agricultural enterprises; placing the livestock farms and complexes as well as rubbish dumps without safeguard measures within the coastal strips of rivers and reservoirs; improper storage and use of mineral and organic fertilizers and pesticides.

The main sources of groundwater pollution are an infiltrated on the agricultural land fertilizers and agricultural chemicals (mainly pesticides), as well as the places of storage of fertilizers and pesticides, livestock farms and complexes and dumps of solid waste.

In 2008 in the region used 307.7 million m$^3$ of water and into water bodies dumped 257 million m$^3$ of reverse waters, of which 187.6 million m$^3$ (73%) are untreated or insufficiently treated. In some settlements, including even in district centers (such as Savran, Frounzivca, Shiryaev, V. Mihayliv, Micolaivca) treatment facilities are not available. Treatment facilities, which are in satisfactory condition in violation of wastewater treatment technologies do not achieve the design parameters.

Important environmental problem in the region represent an improper use and storage of fertilizers and pesticides. And although in recent years the use of organic fertilizers and pesticides due to the reduction of livestock and poultry dropped significantly due to the deep economic crisis in agriculture, the use of mineral fertilizers is growing. So, from 2000 to 2008, the total amount of used mineral fertilizers has increased. Losses from storage of fertilizers reaches 20-30%.

Significant environmental load associated with livestock farms and complexes. There are cases of arrangement of storages of manure within the coastal strips of water objects, and in some cases - within the river-beds of small rivers and beams. Manure and contaminated sewage, which are concentrated here in large numbers, become the sources of contamination of atmospheric air, surface and underground waters.

The volume of household waste in the region is about 5 million cubic meters per year. The number of dumps of solid waste is 614 (on the area 4219.7 ha), which is 52% of the settlements of the region (1190).

1.3.5 Contribution of agriculture to water pollution and water scarcity

According to researches on nitrate pollution of groundwater near arable land in seven administrative districts of the region (Rotar, 2006), the nitrate content in groundwater ranged from 117 to 1091 mg/L that exceeds appropriate standard in 2.6-24 times. The main sources of nitrate pollution of groundwater under the cropland are nitrogen fertilizers. Soil erosion is widespread in the region. Pollutants (fertilizers and pesticides) are infiltrated into the soil or are drifted by surface runoff. Additionally, inefficient storage of fertilizers and pesticides, intense the pollution issue.
1.4 Istrian region, Croatia

1.4.1 Land uses and agricultural activities

Basic ways of land usage in the Region of Istria: about 30% cultivated land, 23% grassland/pastures and about 43% forests. Agricultural activities are among the most important activities in the Region of Istria despite the fact that its contribution to the total GDP of the Region of Istria is rather low (just above 5%, including forestry and hunting, and about 8% including fishery), it has a key role in rural development and sustainable management of rural regions which cover a considerable part of the Region of Istria.

Types of crops that are cultivated

Table 14 provide information on the basic division of various types of agricultural areas in the Region of Istria according to ownership.

Table 14. Various types of agricultural areas in the Region of Istria according to ownership

<table>
<thead>
<tr>
<th>Ownership type</th>
<th>Arable land and gardens</th>
<th>Orchards</th>
<th>Olive groves</th>
<th>Vineyards</th>
<th>Meadows</th>
<th>Pastures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total [ha]</td>
<td>187,136</td>
<td>62,523</td>
<td>919</td>
<td>1,421</td>
<td>5,821</td>
<td>15,045</td>
</tr>
<tr>
<td>State land and private land [ha]</td>
<td>46,965</td>
<td>15,349</td>
<td>23</td>
<td>287</td>
<td>381</td>
<td>1</td>
</tr>
<tr>
<td>Family farms[ha]</td>
<td>120,771</td>
<td>47,174</td>
<td>896</td>
<td>1,154</td>
<td>4,440</td>
<td>16,044</td>
</tr>
<tr>
<td>Family farms[%]</td>
<td>72</td>
<td>75</td>
<td>97</td>
<td>81</td>
<td>93</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Environmental Protection Plan for the Region of Istria (with Environmental Status Report)

The Region of Istria does not belong to the leading farming regions of Croatia with the exception of certain cultures (e.g. grape vine, olive trees and other woody plants). Crop production on family farms in the Region of Istria is characterized by the growing of traditional crop: wheat, barley, maize and alfalfa. These crops cover 2/3 of the total arable area.

Table 15. Crop production per culture.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Wheat</td>
<td>t</td>
<td>31,537</td>
<td>33,822</td>
<td>33,967</td>
<td>35,102</td>
<td>24,586</td>
</tr>
<tr>
<td>2. Rye</td>
<td>t</td>
<td>1,809</td>
<td>985</td>
<td>324</td>
<td>574</td>
<td>36</td>
</tr>
<tr>
<td>3. Barley</td>
<td>t</td>
<td>8,547</td>
<td>6,339</td>
<td>7,900</td>
<td>7,225</td>
<td>6,679</td>
</tr>
<tr>
<td>4. Corn</td>
<td>t</td>
<td>10,945</td>
<td>5,586</td>
<td>12,012</td>
<td>10,129</td>
<td>3,974</td>
</tr>
<tr>
<td>5. Beans</td>
<td>t</td>
<td>575</td>
<td>517</td>
<td>631</td>
<td>650</td>
<td>477</td>
</tr>
<tr>
<td>6. Potato</td>
<td>t</td>
<td>49,098</td>
<td>41,869</td>
<td>51,146</td>
<td>57,917</td>
<td>38,911</td>
</tr>
<tr>
<td>7. Cabbage and kale</td>
<td>t</td>
<td>9,183</td>
<td>7,446</td>
<td>8,284</td>
<td>8,300</td>
<td>7,839</td>
</tr>
<tr>
<td>8. Onion</td>
<td>t</td>
<td>6,594</td>
<td>4,721</td>
<td>5,819</td>
<td>7,225</td>
<td>6,634</td>
</tr>
<tr>
<td>9. Tomato</td>
<td>t</td>
<td>6,794</td>
<td>4,332</td>
<td>6,996</td>
<td>3,200</td>
<td>4,043</td>
</tr>
<tr>
<td>10. Lucerne (alfalfa)</td>
<td>t</td>
<td>20,735</td>
<td>27,988</td>
<td>28,543</td>
<td>21,800</td>
<td>21,675</td>
</tr>
<tr>
<td>11. Peaches</td>
<td>t</td>
<td>994</td>
<td>1,018</td>
<td>1,166</td>
<td>916</td>
<td>730</td>
</tr>
<tr>
<td>12. Grape</td>
<td>t</td>
<td>48,480</td>
<td>35,507</td>
<td>40,524</td>
<td>45,380</td>
<td>41,714</td>
</tr>
<tr>
<td>13. Wine</td>
<td>hl</td>
<td>339,396</td>
<td>248,849</td>
<td>283,670</td>
<td>317,860</td>
<td>292,000</td>
</tr>
<tr>
<td>14. Olive fruit</td>
<td>t</td>
<td>434</td>
<td>839</td>
<td>908</td>
<td>1,415</td>
<td>1,416</td>
</tr>
<tr>
<td>15. Olive oil</td>
<td>hl</td>
<td>801</td>
<td>1,363</td>
<td>1,208</td>
<td>2,122</td>
<td>1,702</td>
</tr>
</tbody>
</table>

Source: Environmental Protection Plan for the Region of Istria (with Environmental Status Report)
1.4.2 Water demands- irrigation

Only about 500 ha (1.5 % of the used areas) are being irrigated. Farmers have expressed their interest to introduce irrigation over the total surface area of agricultural soil, which presents an increase from the planned 21,752 ha to the total figure of 56,183 ha.

It is assessed that cultures grown under the irrigation system will be the following: 18% vegetables, 26% woody plants, 22% vineyards, 34% crops. Taking into consideration the required needs of single farming cultures, the assessed current annual requirements for water amount to 83.4 M m³.

Generally, from the today's point of view, the development of the irrigation system can be divided into three phases. The first phase harvest 10-15M m³/year from local ground and surface water resources (including additional/standby technical systems) in agricultural areas of western and southern Istria, which have already entered the Basic Irrigation Plan for the Region of Istria as the most attractive in terms of irrigation. The second phase, harvest further 52M m³/year of water from large surface accumulation reservoirs which have been proposed in the third (final) phase the water requirements (estimated to 28M m³) for a long-term period shall be covered by the construction of additional large reservoirs.

Irrigation water amount and other information for each of the main crops are presented in table 16.

### Table 16. Amount of irrigation water applied for each crop.

<table>
<thead>
<tr>
<th>Crop</th>
<th>grape vine</th>
<th>Olive</th>
<th>early potato</th>
<th>wheat</th>
<th>corn</th>
<th>barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>5,846</td>
<td>3,000</td>
<td>2,500</td>
<td>7,000</td>
<td>3,300</td>
<td>2,100</td>
</tr>
<tr>
<td>Winter or summer crop</td>
<td>summer</td>
<td>summer</td>
<td>summer</td>
<td>winter</td>
<td>summer</td>
<td>winter</td>
</tr>
<tr>
<td>Irrigation method</td>
<td>drip irrigation</td>
<td>drip irrigation</td>
<td>drip irrigation</td>
<td>sprinkler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation amount (m³/ha)</td>
<td>150-400</td>
<td>1000-2000</td>
<td>1,500-1800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transpiration coefficient</td>
<td>500-800</td>
<td>450-600</td>
<td>250-300</td>
<td>450-600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface water</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Irrigation practices**

Irrigation is performed mostly from alternative resources (groundwater, water main). Extraction of groundwater at private drill-wells for individual and very intensive vegetable growing is substantial. Both surface water and ground water are used to irrigate (Table 12).

1.4.3 Needs in fertilizer - fertilization

The general requirements in nitrogen fertilization for the main crops that are cultivated in the region are presented in Table 17.
Table 17. Nitrogen inputs for the main crops cultivated in Istria region.

<table>
<thead>
<tr>
<th>Crop</th>
<th>grapevine</th>
<th>olive</th>
<th>early potato</th>
<th>wheat (crop rotation corn/potato - wheat)</th>
<th>corn</th>
<th>barley (crop rotation corn/potato - barley)</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg N/ha/year maximum allowed</td>
<td>150</td>
<td>260</td>
<td>400</td>
<td>150</td>
<td>380</td>
<td>140</td>
</tr>
<tr>
<td>kg N/ha/year effectively applied</td>
<td>150</td>
<td>235</td>
<td>300</td>
<td>90</td>
<td>350</td>
<td>90</td>
</tr>
</tbody>
</table>

**Fertilization practices**

In Istrian region agricultural land a variety of fertilizer types are being used such as zootechnical effluent (solid manure) and synthetic fertilizers (urea, ternary fertilizer). Wide spread distribution is the way of fertilizer application.

Nitrogen fertilizers are usually applied in one, two or three doses depending on the crop and the type of fertilizer. For the management of nitrogen fertilization the overall nitrogen management plan for the area is considered. Existing laws regarding nitrogen pollution from agriculture, on national and regional level, are implemented and controlled in areas of special importance like restricted zones around springs and water wells included in water supply system. There is lack of control and supervision regarding agriculture activity in other areas outside of restricted zones. Target area of Region of Istria in general is a "karst" area that is very vulnerable to nitrate pollution from agriculture and every other type of pollution caused by human activity.

Traditional practices, nitrogen savings and nitrogen fertilization efficiency practices are applied in the area. Farmers are guided by economic principle. All actions are aimed to generate savings in fertilization of crops. Application of fertilization is in preferable time limits and dose of fertilization are in optimum to achieve savings.

1.4.4 Pollution sources

The greatest problem with the wells in water supply is the high content of nitrates, which has already resulted in closing a range of wells from the water supply system (Peroj, Rizzi, Lokvere, Karpi, Campanož, Škatari and Tivoli). Almost all of them are situated in urbanized areas of towns or suburban settlements where the waste water drainage system is inadequate or non-existing.

Karst aquifers of the Region of Istria are exceptionally sensitive to external pollution due to: speed of flow with lower self-cleaning potential; dense networks of cracks drain a large river basin area; drained water does not undergo cleaning processes on the ground on its way into the ground because it reaches the underground through a crack or through the thin earth cover over a limestone bad.

Major pressures/sources of pollution on the territory of the Region of Istria include: municipal waste water, 2) untreated industrial waste water; 3) leachate water from landfills 4) untreated rainfall water which leach pollution from urban areas and roads; 5) agricultural (crop and animal production); 6) occasional exceptional pollutions (industrial, traffic accidents and similar).
1.4.5 Contribution of agriculture to water pollution and water scarcity

Severity of the problem is proportional to the intensity of farming production (synthetic fertilizers and pesticides). As reported, agricultural activities are not very intense in the area. Therefore the contribution of agriculture to water pollution and water scarcity seems to have low impact in the environment. However, the future plans to develop irrigation and enhance agriculture will increase the environmental impact from agricultural activities.

1.5 Tisza river basin – Hajdú Bihar count, Hungary

1.5.1 Land uses and agricultural activities

The total area under cultivation is 544,472 hectares, 334,203 of which is arable land. The county ranks second in Hungary in this respect. This is what determines the importance of the county from the point of view of agricultural output. Besides co-operatives, private and family farms also play an important part in this sector. Half of the area of the county is in the use of private farms. The structural change influenced land division according to lines of cultivation to a slight degree. 14.3% of the county’s area is uncultivated land. The most frequently cultivated plants are corn, wheat, sunflower, sugar beet and potato. Livestock farming is the most productive agricultural branch in the county. It holds more than 45% of the whole agricultural output of the county. Cattle-breeding is the most important kind of livestock-farming in the county.

Types of crops that are cultivated

Filed cultures are dominant in the peripheries of the settlements. Raised plants are the followings: corn, wheat, barley, potato, cabbage, tobacco, horseradish es fruits (apple, sour cherry, raspberry, red currant, strawberry, cherry, peach, grape, etc.).

Table 18. The main crops cultivated in Tisza river basin.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Wheat</th>
<th>Maize</th>
<th>Sugar beet</th>
<th>Sweet corn</th>
<th>Green Peas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter or summer crop</td>
<td>summer</td>
<td>summer</td>
<td>summer</td>
<td>summer</td>
<td>summer</td>
</tr>
</tbody>
</table>

1.5.2 Water demands - irrigation

Regarding water management, most of our stock of water is originated from Tisza. The users obtain its water through the Irrigation-system of Tiszalok However this biggest irrigation system of our country has been established for irrigation, it also serves other significant water management tasks such as water supply for ponds, conservational tasks (ecological water demand, water supply for wetlands), supply of drinking-water and water for industry, taking in inland waters and water quality control tasks (dilution of contaminated surface waters, refreshing waters).

In the project area there are irrigated sites of significant size in Nagyhegyes, ajduszovat and Hajdunanas-Tedej. In the “boge” of Western-main canal I.-II.-III., the amount of engaged water for irrigation — according to the data processed till April of 2009 — is 581,47 l/s. Beyond this — till the above mentioned date — the water
demand of authorized ponds is 5406 l/s. Based on the above described the total amount of engaged water in Western-main canal is 5987 l/s, while the amount of water available — according to what is included in the plan of water-limitation in 2009 of TIKOVIZIG — is 12 400 l/s that means that there are plus water stock in the Western-main canal. Regarding the Eastern-main canal it can be also stated that — based on the above referred plan — the amount of available water stock exceeds the amount of engaged water (for irrigation, for ponds and for industry and households).

The water utilization for drinking water, for industrial and agricultural use takes place form the Pleistocene alluvial beds that hold cold freshwater. The public utility water is taken from the deeper Pleistocene groundwater that are the most appropriate regarding both its quality (better chemical characteristics, greater natural protection) and quantity (great thickness, existing also in regional spread, better hydro geographical parameters etc.).

The quality of underground waters is usually objectionable because of containing methane, arsenic, ammonia, nitrate, iron, manganese. For providing drinking-water, the water from the pumps has to be treated nearly everywhere.

In the project area there are 88 settlements. The water demand of these settlements is supplied from groundwater by water works. In 7 settlements of these, water is supplied from 18 thermal water, in the other settlements drinking-water is supplied from porous bodies (that is ground water from deeper beds).

The needs in irrigation water for the main irrigated crops in the region are provided in table 19.

Table 19. Irrigation needs for the main crops in the Tisza river basin.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Maize</th>
<th>Sugar beet</th>
<th>Sweet corn</th>
<th>Green Peas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation method</td>
<td>linear/sprinkler</td>
<td>linear/sprinkler</td>
<td>linear/sprinkler</td>
<td>linear</td>
</tr>
<tr>
<td>Irrigation amount (mm)</td>
<td>60-80</td>
<td>40-100</td>
<td>60-80</td>
<td>30-60</td>
</tr>
<tr>
<td>Average crop factor</td>
<td>0.95</td>
<td>0.8</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>Groundwater</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Irrigation practices

In Hungary irrigation has to be managed parallel with flood protection, drainage control, namely good spatial water management should be implemented. Permission is needed for irrigation. The actual irrigated area is significantly decreased, today there is about 62.000 ha irrigated. Corn and sweet corn fields are determinant (50% of total irrigated area) as well as vegetables (green pea, French bean, paprika) as fruits (7.600 ha).

The county may well be poor in surface waters, but it is rich in groundwater. In case of groundwater utilization, there are two different types such as direct utilization – from pumps or wells – and indirect utilization that have similar effects as direct water Utilization. According to estimations the amount of water utilized by farms, illegally irrigated areas or hobby gardens is nearly equal to the industrial water demand of the whole region.

In the project are there are nearly 900 irrigation sites that have effective permission to use surface water for irrigation. The quantity of water demanded by these irrigation sites was between 2-10 million $m^3$ in last five years. The amount of
water used for irrigation is mainly depending on the weather and the situation of agricultural sector.

The main crops in the project area are, sweet corn, green pea, potato, and from the fruits the apple are the most current. The crops are mostly irrigated with rain-like irrigation while the fruit trees are irrigated with dripping method. In the last decades, flooding irrigation also occurred but these days it is not typical in the region of Hajdúság.

In the areas that can be found directly along the Eastern- and Western-main canals, the irrigation water reaches the irrigation equipments through pipes from pumping water take outs.

Till today it was common that the designers designed water supply for irrigation from deeper beds where the quality and refill is appropriate. However the current regulations limit the use of water from these deeper beds for irrigation. One of the restriction is that groundwater (primarily shallow water) can only be used for irrigation when there are no opportunity for using surface water. The other restriction is that groundwater from deeper beds can only be used for micro-irrigation – if possible without using those beds that are also used by water works of settlements.

### 1.5.3 Needs in fertilizer – fertilization

In Tisza river basin agricultural land synthetic fertilizers (ternary fertilizers) are being used. The general requirements in nitrogen fertilization for the main crop that are cultivated in the region are presented in table 20.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Wheat</th>
<th>Maize</th>
<th>Sunflower</th>
<th>Sweet corn</th>
<th>Green Peas</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg N/ ha/year maximum allowed</td>
<td>170 kg/ha/Nitrate vulnerable area</td>
<td>170 kg/ha/Nitrate vulnerable area</td>
<td>170 kg/ha/Nitrate vulnerable area</td>
<td>170 kg/ha/Nitrate vulnerable area</td>
<td>170 kg/ha/Nitrate vulnerable area</td>
</tr>
<tr>
<td>kg N/ ha/year amount effectively applied</td>
<td>80-150</td>
<td>80-150</td>
<td>80-150</td>
<td>80-150</td>
<td>80-150</td>
</tr>
</tbody>
</table>

**Fertilization practices**

Traditional as well as recent farming is based on the use of organic manure with the additional use of chemical fertilizer. The modernization of liquid manure management of large animal husbandry farms and the application of liquid manure are new elements. The integration of the application of liquid manure into traditional nutrient management practice is a new element. The liquid manure remaining after the energy production is applied assuming a new solution.

Synthetic nitrogen fertilizers are usually applied in one dose performing spread and plough. For the management of nitrogen fertilization are considered the following:

- Type of crop
- Type of soil
- preceding crop
• Climate data
• Type of irrigation
• The Water Framework Directive
• Nitrate sensitive area, Natura 2000 sites

Finally traditional and good agricultural practices are applied, adopted and improved in the area

1.5.4 Pollution sources

Surface waters also serve as receivers of sewage and waste water of settlements, agriculture and industry.

The main pollution sources are municipal sewage/wastewater, industrial waste water, baths, ponds and agriculture. In case of comparing the areas directly next to settlements and farming sites and the other areas, the difference is obvious but also on plough lands – in 20-30 % of the cases – the nitrate concentration exceeds 50 mg/l in the upper shallow groundwater zone. There are even greater nitrate concentrations in orchards.

1.5.5 Contribution of agriculture to water pollution and water scarcity

The use of fertilizers and chemicals decreased due to the reduction of productiveness and this had a good effect on the quality of surface- and groundwater.

Point-like pollution sources in the agriculture are stock-raising sites, pig-raising sites and poultry raising sites because of the storage of the manure – in most cases on an area without coating. In case of stock-raising with liquid manure technology when the requirements are not complied with and the leakage from non-isolated reservoirs can cause pollution.

The pollution from organic fertilizers can be calculated from the number and type of raised animals in the peripheries of settlements, accepting that beeves produce 60 kg Nitrogen/year, pigs 10 kgN/year, sheep and goat 9 kgN/year and poultry 0,4 kgN/year.

The irrigating farming in Hungary is in a hard situation, the area of fields that are irrigated is nearly 2% of the seeding area. 75 % of the agricultural area that can be irrigated is located in Alfold. The amount of authorized area that can be irrigated has only altered a little. The amount of areas that are effectively irrigated altered more significantly: the different between two years can be even 30%.

The water utilization of agricultural irrigation and stock-raising together is nearly equal to water consumption of industry and baths together. Water consumption in agriculture (irrigation, farming livestock and fish) is 30% of entire water consumption on the basis of average of the last five years.

1.6 Pančevo Territory, Serbia

1.6.1 Land uses and agricultural activities

Pančevo with its agricultural resources is one of the richest municipalities in the Republic of Serbia, with a relatively high degree of stability and arable of total agricultural areas. Agriculture is one of the primary activities in the Municipality of Pančevo. Agricultural land occupies 63 322 ha, which is 83.87% of the City.
The largest area occupied by fields and gardens (58,981 ha), pasture (2,415 ha), meadow (564 ha), orchards (474 ha) and vineyards (168 ha), and the rest are: fish ponds, marsh and ponds (720 ha). On the territory of the Municipality Pančevo, forest covered amounted to 12,925 ha.

**Types of crops that are cultivated**

The largest area occupied by fields and gardens (58,981 ha), pasture (2,415 ha), meadow (564 ha), orchards (474 ha) and vineyards (168 ha), and the rest are: fish ponds, marsh and ponds (720 ha).

Table 21. Main agricultural products in the Municipality of Pančevo.

<table>
<thead>
<tr>
<th>Agricultural products</th>
<th>Mark</th>
<th>Quantity (ton)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereals</td>
<td>38,000 ha</td>
<td>250,000</td>
<td>wheat, maize</td>
</tr>
<tr>
<td>Fruits</td>
<td>220 ha</td>
<td>440</td>
<td>apple, peach tree, plum, apricot, hazel etc.</td>
</tr>
<tr>
<td>Oil</td>
<td>9,500 ha</td>
<td></td>
<td>sunflower, soy bean, rapeseed</td>
</tr>
<tr>
<td>Wine</td>
<td>60 ha</td>
<td></td>
<td>grape vine, table vine sorts</td>
</tr>
<tr>
<td>Dairy products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>2,200 ha</td>
<td></td>
<td>pepper, cabbage, potato, tomato, lettuce etc.</td>
</tr>
<tr>
<td>Other</td>
<td>500 ha</td>
<td></td>
<td>water-melon, melon etc</td>
</tr>
</tbody>
</table>

Source: The Municipality of Pančevo, PDS Institute "Tamis".

Table 22. The main crops cultivated in the Municipality of Pančevo.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Wheat</th>
<th>Maize</th>
<th>Sunflower</th>
<th>Sugar beet</th>
<th>Vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ha)</td>
<td>8,000</td>
<td>30,000</td>
<td>7,900</td>
<td>1,650</td>
<td>2,200</td>
</tr>
<tr>
<td>Winter or summer crop</td>
<td>winter</td>
<td>summer</td>
<td>summer</td>
<td>summer</td>
<td>summer</td>
</tr>
</tbody>
</table>

1.6.2 Water demands- irrigation

For each crop category the average water quantity required, crop type, crop factor and the percentage of land cover was indicated (Table 23).

The settlements are supplied with water from local sources of groundwater and surface water. In periods when local water sources cannot meet the needs of the population, the necessary quantities are provided from large regional systems. For technological needs, the municipality uses water from rivers.

Table 23. Irrigation needs for the main crops cultivated in the Municipality of Pančevo.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Wheat</th>
<th>Maize</th>
<th>Sunflower</th>
<th>Sugar beet</th>
<th>Vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation method</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>drip</td>
</tr>
<tr>
<td>Irrigation amount (mm)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>200-400</td>
</tr>
</tbody>
</table>

**Irrigation practices**

Groundwater is used to irrigate the cultivated crops (mostly vegetables). Drip irrigation method is used (Table 22). Water is charged per ha of cultivated land, or based on consumption, or both.
1.6.3 Needs in fertilizer – fertilization

The nitrogen fertilizer applications for the main crops that are cultivated in Pančevo Territory are presented in table 24.

Table 24. Nitrogen inputs for the main crops cultivated in Pančevo.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Wheat</th>
<th>Maize</th>
<th>Sunflower</th>
<th>Sugar beet</th>
<th>Vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg N/ha/year</td>
<td>175</td>
<td>175</td>
<td>175</td>
<td>175</td>
<td>175</td>
</tr>
<tr>
<td>maximum allowed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>kg N/ha/year</td>
<td>120</td>
<td>140</td>
<td>80</td>
<td>140</td>
<td>120</td>
</tr>
<tr>
<td>amount effectively applied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fertilization practices

In Pančevo agricultural land nitrogen fertilization is applied in two doses for the main crops that are cultivated except for sunflower where fertilization is applied only once every year. Only synthetic fertilizers (ammonium nitrate and ternary fertilizers) are used, which are distributed in the soil mechanically.

1.6.4 Pollution sources

The most important pollution sources in the area are:

- High concentration of chemical and oil industry production facilities at a single locality.
- Vicinity of industrial complexes of Oil Refinery, Petrochemicals Plants and Fertilizer Plant in direction of dominant winds blowing towards the residential areas.
- Use of obsolete technologies with plant installations aged over 20 years.
- Permanent threat from major chemical incidents.
- Disregard of legal requirements concerning environment protection.
- Significant adverse effects of the 1999 NATO air strikes.

1.6.5 Contribution of agriculture to water pollution and water scarcity

Water pollution within the territory of Municipality of Pancevo is caused by releases of large quantities of ammonia, oil, and oil derivatives, ethylene-dichloride and mercury into the phreatic zone of groundwater and into the Danube. Nitrates and other agrochemicals have already found in the majority of aquifers, which are laid below of agricultural land. Therefore agriculture contributes to water pollution loading the groundwater with agrochemicals.

1.7 Arges-Vedea watershed, Romania

1.7.1 Land uses and agricultural activities

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. Table 25 shows the land use pattern in the three counties in the case study area.

Table 25. Land use in the case study area.
The farm structure for arable land 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).

**Types of crops that are cultivated**

For the arable land cereals for grains (winter wheat, maize, barley) are the most cultivated followed by oilseed crops (sunflower dominant).


<table>
<thead>
<tr>
<th>Land fund by use</th>
<th>Counties</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arges</td>
<td>Giurgiu</td>
<td>Teleoman</td>
<td>Total</td>
</tr>
<tr>
<td>Total area</td>
<td>682631</td>
<td>352602</td>
<td>578978</td>
<td>1614211</td>
</tr>
<tr>
<td>Arable</td>
<td>172114</td>
<td>259300</td>
<td>454580</td>
<td>880454</td>
</tr>
<tr>
<td>Pastures</td>
<td>102689</td>
<td>12631</td>
<td>35773</td>
<td>151093</td>
</tr>
<tr>
<td>Hayfields</td>
<td>45684</td>
<td>82</td>
<td>645</td>
<td>46611</td>
</tr>
<tr>
<td>Vineyards</td>
<td>1254</td>
<td>4119</td>
<td>7427</td>
<td>12600</td>
</tr>
<tr>
<td>Orchards</td>
<td>22824</td>
<td>552</td>
<td>150</td>
<td>23526</td>
</tr>
<tr>
<td>Forest and other forest vegetation lands</td>
<td>239947</td>
<td>37998</td>
<td>29735</td>
<td>357680</td>
</tr>
<tr>
<td>Waters and ponds</td>
<td>9354</td>
<td>13995</td>
<td>15538</td>
<td>39887</td>
</tr>
</tbody>
</table>

1.7.2 Water demands - irrigation

Irrigation is practiced on the plane areas near the Danube river. Existing irrigation schemes proved to be inefficient in terms of energy consumption per 1000 cubic metres of pumped water and of specific irrigation water conveyance and distribution efficiencies. Moreover, this was made worse by the continuous increase of the electricity tariffs and culminated in 2010 with the total elimination of the subsidy for irrigation water application.
These were the principal grounds for the lack of irrigation application in almost all major schemes throughout the country, in most of rural communes/localities irrigation infrastructure being either damaged, decommissioned or simply vandalized.

Given such circumstances, subsistence farmers and agricultural producers had to turn to local sources of water such as the lakes, ponds, small rivers and wells. In the most favourable situations, parts of the existing buried pressurized pipes fitted with hydrants were used to apply irrigation water to high value crops, on small to medium size surfaces.

As there are no water meters installed at the water source, the pumped volumes of water are calculated by taking into account technical characteristics of the pumping aggregates (pumps + motors) and duration of water application.

The estimated irrigation water consumption given the presented circumstances adds up to 1,200 – 3,500 m\(^3\)/ha and irrigating season, for field crops.

**Irrigation practices**

Irrigation application is performed either by using drip irrigation equipment or by means of manual move sprinkler irrigation machines.

**1.7.3 Needs in fertilizer – fertilization**

**Fertilization practices**

In small farms low-input agriculture (subsidence 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.

**1.7.4 Pollution sources**

The main pollution sources for nitrates in water bodies comes from animal wastes. According with agriculture statistics in the case study area the number of animals are: cattle: 208972 heads, pigs: 492257 heads, sheep: 406324 heads, goats: 78549 heads and poultry: 4329230 heads. 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.

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.

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).

**1.7.5 Contribution of agriculture to water pollution and water scarcity**

In the majority of communes the water consumption for agricultural activities is low; this has nevertheless an increasing trend, given by the benefits rendered through the introduction of centralized drinking water supply systems. It is worth mentioning that pollution of the water table is due to historical polluting sources (communist era industrial-type animal breeding complexes, warehouses which used
to accommodate various types of chemical fertilizers, makeshift tanks where animal wastes have been accumulated, dumps of manure) and irrespective of the measures to be taken, any increased loads of nitrates leached into the underground waters will always depend upon the amount of fallen precipitations and on the frequency of their occurrence.

The estimated irrigation water consumption given the presented circumstances adds up to 1,200 – 3,500 m³/ha and irrigating season, for field crops.

### 1.8 Botna river-Ialoveni rayon, Moldova

#### 1.8.1 Land uses and agricultural activities

Total area of the Ialoveni Rayon’s land stock is 74,3 thousands ha, including:
- Water tables: 4400 lakes and reservoirs covering 1.5 thousand ha.
- Suburban areas: 8 thousand ha
- Open Areas (Pastures) 7.5 thousand ha
- Wetlands 0.1 thousand ha
- Cultivation areas 48.5 thousand ha
- Forest 8.7 thousand ha

Types of crops that are cultivated
The main crops cultivated in Botna river-Ialoveni rayon are presented in Table 27.

Table 27. Main crops cultivated in Botna river-Ialoveni rayon.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Winter or summer crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>1,800</td>
<td>summer</td>
</tr>
<tr>
<td>Wheat</td>
<td>3,000</td>
<td>summer</td>
</tr>
<tr>
<td>Vegetables</td>
<td>400</td>
<td>summer</td>
</tr>
<tr>
<td>Potatoes</td>
<td>280</td>
<td>summer</td>
</tr>
<tr>
<td>Greenhouses</td>
<td>8</td>
<td>summer</td>
</tr>
</tbody>
</table>

#### 1.8.2 Water demands- irrigation

The irrigation is not applied in the model, because there is no reliable official information in the Republic of Moldova to adopt it in the model available.

Table 28. Main irrigated crops in Botna river-Ialoveni rayon.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Irrigation method</th>
<th>Irrigation amount (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables</td>
<td>drip</td>
<td>1600</td>
</tr>
<tr>
<td>Potatoes</td>
<td>sprinkler</td>
<td>1200</td>
</tr>
<tr>
<td>Greenhouses</td>
<td>drip</td>
<td>1000</td>
</tr>
</tbody>
</table>

Irrigation practices
Only surface water is used to irrigate in Botna river-Ialoveni rayon. The main irrigation systems that are used are drip irrigation, mainly in vegetables and greenhouses, and sprinkle irrigation which is mainly applied in potatoes.

Consumption based pricing is performed and therefore crop type is not considered. In the irrigation management are considered the following:
Climate data  
Type of crop  
Type of soil  
slope  
irrigation infrastructure  
Overall management plan for the area  
The Water Framework Directive

Finally traditional practices and energy efficiency practices applied.

### 1.8.3 Needs in fertilizer - fertilization

Table 29. Nitrogen inputs for the main crops cultivated in Botna river-Ialoveni rayon.

<table>
<thead>
<tr>
<th>Crop</th>
<th>kg N/ha/year maximum allowed</th>
<th>kg N/ha/year applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>150kg/ha</td>
<td>60</td>
</tr>
<tr>
<td>Wheat</td>
<td>140 kg/ha</td>
<td>60</td>
</tr>
<tr>
<td>Vegetables</td>
<td>150kg/ha</td>
<td>60</td>
</tr>
</tbody>
</table>

As viewed in the nitrogen inputs table (Table 28) the nitrogen rates applied are considerably lower than the maximum rates allowed.

**Fertilization practices**

Only synthetic fertilizers are used which are distributed on the soil in two or three doses. No manure is used.

In the nitrogen management are considered the following factors:
- Type of crop
- Type of soil
- Preceding crop
- slope
- Climate data
- Type of irrigation
- Overall nitrogen management plan for the area
- The Water Framework Directive

### 1.8.5 Contribution of agriculture to water pollution and water scarcity

The reproductive capacity of the soil fertility was seriously affected by the large agricultural exploitation based on intensive technologies. The economic and energy crisis, way of implementing reforms in agriculture along with creation of many owners deprived of necessary machinery and specialized knowledge, old technologies and the drastic reduction of fertilizers (organic and mineral), wear and tear of irrigation systems, have all led to intensified process of soil degradation. The soil degradation is also conditioned by erosions, ravines, landslides, and under flooding.
2. Comparison with international practices - benchmarking

2.1 Crops

According to the filled questionnaires and the regional reports, the main crops cultivated in the study areas of the EU WATER project are:

Arable crops: wheat, barley, oat, rye, maize, sunflower, soybean, alfalfa, rice
Vegetables: potatoes, green peas
Industrial crops: sugarbeet
Fruit trees: pear, grape vines, olive
Set aside – pastures

Wheat. High rates of nitrogen fertilization may lead to a decrease of yield because the plants become more vulnerable to diseases and recumbent. In Greece the recommended rates of nitrogen fertilization are from 30 kg/ha to 60 kg/ha depending on the climate (temperature, rain) and soil properties (Dalianis, 1983).

New technologies may enhance the fertilization efficiency. In India an experiment was set to examine aspects of input efficiencies focusing on combinations of N-fertilizer and irrigation input in wheat crops. The use of the GreenSeeker instrument with the rice–wheat rotation resulted in N saving of 21–25 kgNha−1 with similar grain yield, protein and grain hardness to that provided by using the recommended 150 kgNha−1. Where the GreenSeeker was used the apparent recovery was 70–75% compared with 60% with the wheat receiving the recommended 150 kgNha−1, suggesting farmers are likely to be over-fertilizing their wheat crop. For irrigated wheat grown in Haryana the use of a 3-way split of N fertilizer applied at seeding, early tillering and first node stage provides the highest grain yields, protein, grain hardness and chapatti quality (Coventry et al., 2011).

Barley. It is less demanding in water than wheat. It can grow well with only 200 – 250 mm rain per year. As for the nitrogen fertilization needs, the are about the same with wheat. In general nitrogen fertilization rates more than 60 kg/ha are not recommended due to the increase of sensitivity to recumbent (Dalianis, 1983).

Latest research on spring malting barley (Hordeum vulgare L.) took place in Southern Finland. The results suggest that it is rational for a landowner to adjust fertilizer application according to the state of the crop instead of applying a fixed amount each year split fertilization is efficient in reducing the amount of leaching per kg of barley produced. In comparison to a single application of fertilizer at sowing, split fertilization improves yields, increases the total amount of fertilizer used, and reduces nitrogen leaching (Hyytiöinen et al., 2011).

Oat. Oat is the most demanding cereal in water. The recommended rates of nitrogen fertilization vary from 30 kg/ha to 40 kg/ha while more than 50 kg/ha may lead to decrease of productivity due to increase of recumbent (Dalianis, 1983).

Maize. It is a very demanding crop in terms of irrigation. The final yield is highly correlated to availability of water (www.cerealinstitute.gr).
Several simulation models have been developed to assess and assist in crop irrigation. FAO has developed a simulation model ‘AquaCrop’ to assist farmers to manage their fields more efficiently. Stricevic et al. (2011) attempted to assess the simulation efficiency of rainfed and supplementally irrigated maize, sugar beet and sunflower using ‘AquaCrop’. They suggest that the AquaCrop model can be used with a high degree of reliability in practical management, strategic planning of the use of water resources for irrigation, or estimation of yield with regard to climate change. They noted that the model is relatively easy to use and it works properly even if limited input data are available ending that it is highly reliable for the simulations of biomass, yield, and water demand.

The use of legume crops in maize rotation systems may decrease the need for nitrogen (N) fertilization and increase total output. The effect of previous crops (wheat, barley, lentil, Hungarian vetch, and fallow) and different N fertilization rates (0, 120, 160, 200, and 240 kg of N ha-1) on yield and N content of silage maize (Zea mays L.) were evaluated under irrigated conditions in Diyarbakir, Turkey. According to the research results the highest dry matter and N yields were obtained from the application of 198, 254, 211, 80, and 210 kg of N ha-1 after previous crops of wheat, barley, lentil, Hungarian vetch, and fallow, respectively. Crop rotation and N fertilization are management methods that can increase corn (Zea mays L.) grain yields. Stanger et al., (2008) set a long term experiment to determine the corn grain yield response to six crop rotation sequences and four N rates in a long-term (35-yr) study. Using rotation first-yr corn grain yields increased from 79 to 100 kg ha-1 yr-1. Increasing N rates did not influence grain yield trends, indicating that an alfalfa crop produced the N required by first-yr corn. However, 224 kg N / ha was needed to improve second and third-yr grain yield trends. The 2-yr rotation was not sufficient to improve grain yield trends, whereas the 5-yr rotation was able to enhance corn grain yield and decrease the need for fertilizer N. Overall, this data shows that extended rotations involving forage crops reduce N inputs, increase corn grain yields, and are more agronomically sustainable than current short-term rotations (Stanger et al., 2008).

Sugar beet. The total water needs depends on the climate and the growing season of the area where it is cultivated. In Greece the total amount of water needs varies from 800-1000 mm (Galanopoulou, 2002).

Nitrogen fertilization is significantly increasing yield but simultaneously it decreases the sugar content (Sfikas, 1998). Walker et al., (1950) calculated the yield and the sugar yield when applying four different doses of nitrogen fertilization (Table 30).

Table 30. Sugar beet yield for different doses of nitrogen fertilization

<table>
<thead>
<tr>
<th>N input (kg/ha)</th>
<th>Root productivity (kg/ha)</th>
<th>Sugar content (%)</th>
<th>Sugar yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>46000</td>
<td>18</td>
<td>8200</td>
</tr>
<tr>
<td>90</td>
<td>54000</td>
<td>17</td>
<td>9000</td>
</tr>
<tr>
<td>180</td>
<td>59000</td>
<td>16</td>
<td>9500</td>
</tr>
<tr>
<td>269</td>
<td>61000</td>
<td>15</td>
<td>9000</td>
</tr>
</tbody>
</table>

(Source: Walker et al., 1950)
According to Wakler et al., (1950) nitrogen fertilization using 90 – 180 kg N per ha increases root productivity and sugar yield. More than 180 kg N per ha leads to a slight increase of root productivity but of sugar yield decreases sharply due to reduced sugar content in the roots.

**Potato.** Potatoes tolerance for water stress is limited and it is the main limiting factor for tuber grade, tuber specific gravity and quality (Shock et al., 2006).

Nitrogen deficiency leads to recess of the development and yellowness of the old leaves. On the other hand overfertilization delays the ripening of the potatoes (Ha, 2007). In potato cultivation, nitrogen fertilizers are usually applied once just before planting (Harris, 1992). 100 – 130 kg / ha to achieve 31 t/ha tuber yield. Above that amount yield doesn’t increase and more than 375 kg /ha yield decreases (Holiday et al., 1965). Neeteson and Zwetsloot (1989) performed a 10 year series of 98 experiments on potatoes. They concluded that yield and nitrogen fertilization are described by a common exponential curve according to which application of more than 200 kg N/ha doesn’t increase yield. With 100 kg N/ha yield reaches approximately 51 t/ha while with 200 kg N/ha yield reaches approximately 55 t/ha. Therefore, according to this curve the ideal nitrogen application varies between 100 and 125 kg N/ha.

**Green peas:** It is one of the species of the Leguminosae family. This means that it has the ability to bind nitrogen from the atmosphere. Therefore the needs for nitrogen fertilization are the limited. In some cases a small amount (25 kg N/Ha) is added in the soil to enhance the development of the plants. It develops deep root system so it can grow well in dry climates. The needs in water are increased during blooming (Ha, 2007).

**Reduction of nitrogen leaching:**

Shrestha et al., (2010) presented a literature review on nitrogen fertilization. They noted that the amount of fertilizer-N should be decided based on an integrated evaluation of soil organic matter content, soil texture, residual soil N, crop residues, credit to organic N sources, crops to be grown including varieties and crop physiological needs, cropping systems, yield potential, water management, and N concentrations in irrigation water. Research advances have no quick fix for controlling NO3 leaching to groundwater. However, the best combination of proven strategies can reduce leaching potential significantly.

**Nitrogen Management:** Reducing over fertilization, applying the right source of N at the right time and place, and matching N application rate with crop need increases N use efficiency and reduces NO3 leaching (Shrestha et al., 2010).

**Irrigation Management:** Careful management of irrigation amount and schedule considering water-holding capacity of soil, evaporation, rainfall, and crop growth stage help to reduce NO3 leaching. Irrigation scheduling programs or soil tensiometers are useful tools (Shrestha et al., 2010).
Cover Crops and Residue Management: It is important to select efficient N scavenging fall cover crop and plant as early as possible. The ability of cover crops to scavenge and deplete soil NO3 depends on large biomass growth (e.g., Brassicas and grasses) to be an efficient N sink, and deep rooting system (e.g., alfalfa, Italian ryegrass and fodder radish) to capture NO3 from deeper depth. Winter hardy cover crop with high biomass such as winter wheat, rye (Secale cereale), ryegrass (Lolium multiflorum) and Triticale can be planted in fall immediately after harvesting potato, and incorporated in spring before planting succeeding crop. This can recycle nutrients for the succeeding main crop potato. Crop residues with high fiber content such as corn can be left on the soil and incorporated next spring before planting potato. Claiming N credit from crop residues, compost, and previous legume crops is vital for economical crop production and water quality protection (Shrestha et al., 2010).

Site-Specific N management: Variability in soil fertility can be high within a field due to variation in soil profile, topography, and hydrology. Therefore, efforts should be made to manage fields according to spatial soil variability, which can reduce potential for over fertilization and NO3 leaching. Site-specific N management can be done using chlorophyll meter for small scale (Shrestha et al., 2010).

2.2 Irrigation systems

The main irrigation systems in the study areas of the EU WATER project are:
- Drip irrigation
- Sprinkle irrigation
- Surface irrigation / flood irrigation

Surface irrigation. It is a method which shows high consumption of water, leaching of nutrients, uneven distribution of irrigation water and finally in fields where slope is more than 2-3% it presents high water losses by surface runoff. Therefore it is not suggested.

Artificial rain / sprinkler irrigation. With this system, water is applied to the entire field evenly simulating rain.

Drip irrigation. It is the most efficient irrigation system. The water is dripping over the root system of each plant. Therefore it is used to irrigate linear crops.

2.3 Good Agricultural Practices

Traditional practices that were abandoned due to intensification of agriculture were enriched, to result the Codes for Good Agricultural Practices. These codes involve all the basic agricultural activities.

Following these practices combined with the use of new techniques and technologies in irrigation and fertilization will lead to optimization of production and minimization of the environmental impacts due to agriculture.
Chapter 3: Identification of alternative irrigation methods in order to save water

Introduction

The aim of the current chapter is to identify alternative irrigation methods in order to save water. This is based on bibliographical references and further elaborated with the use of the codes of good practice for each target area / country. These codes consider many issues, including water consumption which is the main issue considered. Codes of good practices are identified for each country, and critical suggestions are made on what is appropriate for the purposes of the EU WATER project in relation to water consumption. A significant element is the traditional agricultural practices that are implemented in each area. In most of the cases, the codes of good practices refer to traditional agricultural practices.

In order to study the alternative irrigation methods for better management of the irrigation water we should take under consideration previous experience of local and central services – responsible for water management, the available technology, the international literature, the relevant technical reports of good practices and the results of other related projects in combination with the good practices.

1. Crop irrigation needs, international practices - benchmarking

1.1 Crops cultivated in the EU WATER areas

According to the filled questionnaires and the regional reports, the main crops cultivated in the study areas of the EU WATER project are:

- Arable crops: wheat, barley, oat, rye, maize, sunflower, soybean, alfalfa, rice
- Vegetables: potatoes, green peas
- Industrial crops: sugarbeet
- Fruit trees: pear, grape vines, olive
- Set aside – pastures

1.2 Crop irrigation needs

Wheat. Wheat is not a very demanding crop by means of irrigation. According to FAO the total growing period for wheat crop varies from 120 to 150 days and during this period the seasonal crop water needs are approximately 450 – 650 mm (www.fao.org). It can be cultivated as non irrigated but the yields are relatively low. Table 31 contains the amount (mm) and timing of irrigation for maximizing yield in the Mediterranean region (Zhang and Oweis, 1999).
Table 31. Estimated amount (mm) and timing of supplemental irrigation for maximizing yield, maximizing the net profit and a targeted yield under different rainfall conditions.

<table>
<thead>
<tr>
<th>Rainfall</th>
<th>$W_{a}$</th>
<th>$W_{b}$</th>
<th>$W_{c}$</th>
<th>$W_{d}$</th>
<th>$W_{e}$</th>
<th>Time of irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>430</td>
<td>336</td>
<td>260</td>
<td>161</td>
<td>158–254</td>
<td>Stem elongation, booting, flowering and grain filling</td>
</tr>
<tr>
<td>300</td>
<td>380</td>
<td>286</td>
<td>210</td>
<td>111</td>
<td>108–204</td>
<td>Stem elongation, flowering and/or grain filling</td>
</tr>
<tr>
<td>350</td>
<td>330</td>
<td>236</td>
<td>160</td>
<td>61</td>
<td>58–155</td>
<td>Flowering and/or grain filling</td>
</tr>
<tr>
<td>400</td>
<td>280</td>
<td>186</td>
<td>110</td>
<td>11</td>
<td>0–144</td>
<td>Grain filling</td>
</tr>
<tr>
<td>450</td>
<td>230</td>
<td>136</td>
<td>60</td>
<td>0</td>
<td>0–55</td>
<td>Grain filling</td>
</tr>
<tr>
<td>Durum wheat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>510</td>
<td>454</td>
<td>314</td>
<td>180</td>
<td>144–207</td>
<td>Stem elongation, booting, flowering and grain filling</td>
</tr>
<tr>
<td>300</td>
<td>460</td>
<td>404</td>
<td>294</td>
<td>130</td>
<td>94–157</td>
<td>Stem elongation, flowering and/or grain filling</td>
</tr>
<tr>
<td>350</td>
<td>410</td>
<td>354</td>
<td>244</td>
<td>80</td>
<td>44–107</td>
<td>Flowering and/or grain filling</td>
</tr>
<tr>
<td>400</td>
<td>360</td>
<td>304</td>
<td>194</td>
<td>30</td>
<td>0–57</td>
<td>Grain filling</td>
</tr>
<tr>
<td>450</td>
<td>310</td>
<td>254</td>
<td>144</td>
<td>0</td>
<td>0</td>
<td>Grain filling</td>
</tr>
</tbody>
</table>

$^{a}$ Amount of water required for maximizing grain yield.
$^{b}$ Amount of water required for maximizing the net profit under limited land resources.
$^{c}$ Amount of water required for maximizing the net profit under limited water resources.
$^{d}$ Amount of water required for deficit irrigation at which the net profit equals that at full irrigation under limited water resources.
$^{e}$ Amount of water required for targeted yield of 4-5 t/ha

Maximizing the net profit under limited water resources conditions or achieving a targeted yield of 4-5 t/ha is recommended for sustainable use of water resources, and these two scenarios can save 36-100% of water required for maximizing grain yield with a limited yield loss (Zhang and Oweis, 1999).

In Texas (USA) a study on efficient wheat irrigation with limited water took place. According to the results, one well-timed spring irrigation can increase yields more than two poorly timed applications indicating that even if only one spring irrigation is used, the water can be used efficiently if the application is well-timed (Schneider et al., 1969).

The critical growth stages for irrigating winter wheat are in general from early spring to the beginning of the grain development (Schneider and Howell, 2001).

**Barley.** It is less demanding in water than wheat. It can grow well with only 200 – 250 mm rain per year (Dalianis, 1983). According to FAO the total growing period is the same as for wheat crop varying from 120 to 150 days and during this period the seasonal crop water needs are approximately 450 – 650 mm (www.fao.org).

**Oat.** Oat is the most demanding cereal in water (Dalianis, 1983). FAO reports that the total growing period for oat crop is the same as for wheat and barley varying from 120 to 150 days and the seasonal crop water needs are approximately 450 – 650 mm (www.fao.org).
Maize. It is a very demanding crop in terms of irrigation. The final yield is highly correlated to availability of water. Increased water needs are presented during blooming season. In general it demands 500 – 600 mm of water during the cultivating period. About half of this amount is applied through rainfall, while the other half (250 – 300 mm) must be applied through irrigation (www.cerealinstiute.gr).

The total growing period is approximately 125 to 180 days and during this period the seasonal crop water needs are approximately 500 – 800 mm (www.fao.org).

In Egypt a two year experiment was set to evaluate the effects of drip irrigation frequency and its interaction with nitrogen fertilization on vegetative growth and nitrogen use efficiency of maize crop in sandy soils. According to the research results irrigation once every 2 and 3 days is recommended to enhance growth and nitrogen use efficiency of drip-irrigated maize in sandy soil in Egypt (Hokam et al., 2011).

Sugarbeet. The total water needs depend on the climate and the growing season of the area where it is cultivated. In Greece the total amount of water needs varies from 800-1000 mm. In Macedonia, Northern Greece where the climate is humid for the Greek conditions, irrigation needs for the sugar beets cultivation vary from 150 to 300 mm (Galapoupolou, 2002). According to FAO the approximate values of seasonal crop water needs are 550-750 mm while the growing period for sugar beet crop varies from 160 to 230 days (www.fao.org).

An experiment was conducted in Southern Iran, to evaluate the effects of irrigation method and water quality on sugar beet yield, percentage of sugar content and irrigation water use efficiency (IWUE). The irrigation methods investigated were subsurface drip, surface drip and furrow irrigation. The two waters used were treated municipal effluent (EC = 1.52 dS m\(^{-1}\)) and fresh water (EC = 0.509 dS m\(^{-1}\)). Statistical testing indicated that the irrigation method and water quality had a significant effect (at the 1% level) on sugar beet root yield, sugar yield, and IWUE. The highest root yield (79.7 Mg ha\(^{-1}\)) was obtained using surface drip irrigation and effluent and the lowest root yield (41.4 Mg ha\(^{-1}\)) was obtained using furrow irrigation and fresh water. Irrigation with effluent led to an increase in the net sugar yield due to an increase in the sugar beet root yield. However, there was a slight reduction in the percentage sugar content in the plants. The highest water saving was achieved with surface drip irrigation but the difference with subsurface drip irrigation was not significant (Hassanli et al., 2010).
Potato. Potatoes tolerance for water stress is limited and it is the main limiting factor for tuber grade, tuber specific gravity and quality. These characteristics are influenced by water stress during tuber bulking. Therefore it is significant to keep soil water potential within a range of values. In case of overirrigation other porblems may occur, erosion, diseases, nitrogen leaching and increased N needs (Shock et al., 2006). Research results from International Potato Center (1985) in Peru indicated that there is linear correlation between tuber dry weight and the amount of irrigation applied. When applying 350mm the tuber dry weight yield is approximately 1 t/ha while for 700mm of irrigation water yield is approximately 4 t/ha in tuber dry weight (Harris, 1992).

FAO refers to potato water needs to be approximately 500 – 700 mm while the total growing period is 105 – 145 days (www.fao.org). Research results from International Potato Center (1985) in Peru indicated that there is linear correlation between tuber dry weight and the amount of irrigation applied. When applying 350mm the tuber dry weight yield is approximately 1 t/ha while for 700mm of irrigation water yield is approximately 4 t/ha in tuber dry weight (Harris, 1992). Adoption of drip irrigation and fertigation in potato has proved to be technically feasible and economically viable and beneficial in many ways both in developed and developing regions of the world. Drip irrigation in many diverse agro-ecological situations registered higher yields (40 to 72 tons/ha) apart from saving in water (30 to 40%), fertilizer (20 to 25%) and improving quality of tubers (grade and composition) in comparison to conventional furrow, overhead and centre pivot sprinkler irrigation methods (www.netafim.com).

Green peas: The total growing period for green peas last 90 – 100 days while the crop water needs during this period are approximately 350 – 500 mm (www.fao.org). It develops deep root system so it can grow well in dry climates. The needs in water are increased during blooming (Ha, 2007).

Fruit trees: During the last decades there has been an effort to investigate more efficient irrigation techniques that minimize water consumption without affecting yields. Regulated deficit irrigation (RDI) of fruit trees increased water use efficiency up to 60 percent with no loss in yield or substantial reductions in vegetative vigor.
Control of excessive vegetative growth and vigor is desirable in these crops. Studies on peach (*Prunus persica*) (Li et al., 1989; Williamson and Coston, 1990), Pear (*Pyrus communis, Pyrus serotina*) (Brun et al., 1985a, 1985b; Caspari et al., 1994) and apple (*Malus domestica*) (Irving and Drost, 1987) have shown that mild water stress applied during the period of slow fruit growth controlled excessive vegetative growth while maintained or even increased yields. Alegra et al. (1999) concluded that no adverse effect on oil production occur when applying RDI to olives over a ten-week period following pit hardening.

RDI technique has been performed in grapes providing very good results, e.g. improvements in wine quality, WUE. Partial rootzone drying (PRD) is a new irrigation technique that improves the water use efficiency of winegrape production without significant crop reduction. According to PRD half of the root system is always in a dry or drying state while the remainder is irrigated. Drip and other forms of micro-irrigation facilitate the application of RDI and PRD (McCarthy et al, 2002).

### 2 Irrigation systems

#### 2.1 Main irrigation systems used in the EU WATER areas

The main irrigation systems in the study areas of the EU WATER project are:
- Drip irrigation
- Sprinkle irrigation
- Surface irrigation / flood irrigation

**Surface irrigation.** Surface irrigation is the application of water by gravity flow to the surface of the field. Either the entire field is flooded (basin irrigation) or the water is fed into small channels (furrows) or strips of land (borders)(www.fao.org). It is a method which shows high consumption of water, leaching of nutrients and uneven distribution of irrigation water and finally in fields where slope is more than 2-3% it presents high water losses by surface runoff. Therefore it is not suggested. The application of surface irrigation may be necessary in special cases such as in saline soils or crops such as rice.

**Artificial rain / sprinkler irrigation.** Sprinkler irrigation is similar to natural rainfall. Water is pumped through a pipe system and then sprayed onto the crops through rotating sprinkler heads. Sprinkler irrigation is suited for most row, field and tree crops and water can be sprayed over or under the crop canopy (www.fao.org). With this system, water is applied to the entire field evenly. The timing of irrigation should be such as to prevent infiltration of water into deeper layers. This system often shows increased loss of irrigation water when irrigation is performed between 11am-3pm due to evaporation. Water loss also occurs when the weather conditions are unsuitable (wind over 5 degrees of the Beaufort scale, due to increased drifting). It is advisable to avoid sprinkler irrigation under these circumstances.

**Drip irrigation.** With drip irrigation, water is conveyed under pressure through a pipe system to the fields, where it drips slowly onto the soil through emitters or drippers which are located close to the plants. Drip irrigation is sometimes called trickle
irrigation (www.fao.org). It is the most efficient widely used irrigation system. The water is dripping over the root system of each plant. Therefore it is used to irrigate linear crops like cotton, tomatoes or perennial crops like vines, orchards etc. The water flow from each drip is very low, 2-4 liters per hour depending on the drip type and the irrigation network pressure. The total amount of applied water is filtered through the ground soaking the active root zone and not the ground surface leading to minimization of water loss through evaporation. This system ensures: full irrigation control, minimization of nutrient leaching, ideal water application in sloping land and reduced labor costs. Finally, it provides the potentiality to apply fertilizers while irrigating, called fertigation. The only drawbacks are the high initial purchase cost and the high level of expertise that is required for operation and maintenance (eg. care to prevent the clogging of the sprinklers).

2.2 New more efficient irrigation systems

2.2.1 Subsurface drip irrigation

Subsurface drip irrigation (SDI) is a widely accepted irrigation method of both perennial and annual crops. In an SDI system the design is the same with the surface systems except the tubing is buried. Results from many studies demonstrated significant yield and water use efficiency increases in all crops. Increasing the irrigation frequency reduction of deep percolation was obtained (Ayars et al., 1999). Water use efficiency has been significantly improved through the use of subsurface drip irrigation (Phene et al., 1986b). If water and nutrients are managed properly SDI provides an efficient system. Yield response for 30 crops using SDI, showed that yield was greater or equal to other widely used irrigation methods by applying less irrigation water (Camp, 1998).

The system installation depth depends on the soil type and crop. If the soil is silty clay loam to clay loam, which means that the soil is capable of moving water long distances from the drip emitter, the system can be installed and perform well in 45cm depth. In sandy or 'lighter' soils installation depth has to be reduced (Ayars et al., 1999). Lateral depths may range from 0.02 to 0.70m. For permanent installation the installation depth should be sufficient enough to avoid wetting the soil surface and potential damages from soil treatments like tillage water (Camp, 1998).

Application of the irrigation water directly into the root zone of the plants minimizes the water losses due to evapotranspiration since the soil surface is dry.

A 10 year research was conducted in Kansas (USA) on subsurface drip irrigation for corn. The corn lines were spacing 0.76 m. A dripline spacing of 1.5 m was found to be most economical. Dripline was centered at a depth of 40–45 cm between two rows raised bed (Figure 19). Compared with more
traditional forms of irrigation, water use for corn can be reduced by 35–55% when using SDI (Lamm et al., 2003).

The main issue of the subsurface drip irrigation systems is the system maintenance. Economics of the typical row crops do not allow frequent system replacement or major renovations. Therefore, irrigators should carefully monitor and maintain the SDI system to assure a long system life (Lamm et al., 2003).

Additionally this specific irrigation system provides the benefit of application of fertilizers among with irrigation (called fertigation) or irrigation with wastewater from livestock farms or urban wastes. Trooier et al., (2000) used water collected from pens runoff containing beef cattle to estimate the possibility of using it to irrigate in a SDI system. They concluded that small emitter sizes (less than 0.9 l/h) may be risky for emitter clogging when using wastewater.

2.2.2 Variable rate irrigation

Recent developments in agricultural technologies refer to management of the fields not as one piece but partially. Because fields are not homogenous but show spatial and temporal variability in yield, quality, soil properties etc., the agricultural treatments should be performed accordingly. This new concept of farm management is called precision farming and is being increasingly used globally. The procedure begins with data collection (elevation mapping, yield mapping, soil properties, plant attributes etc.). The next step is the data elaboration which leads to management zones delineation and finally variable rate applications (irrigation, fertilization etc.) are performed. Therefore, each part of the field is treated according to the real needs maximizing the application efficiency and minimizing the over or under application of inputs.

In a feasibility study of Variable Rate Irrigation in Black Sea area, researchers estimated the water and energy saving from the application. The research results showed a potential to save irrigation water up to 7.3 % in the case study fields. An energy saving from 3000 to 17000 toe (tons of oil equivalent) can be achieved by the introduction of VRI. The current study also includes a technical description and features of the VRI technology for the linear travelling sprinkler and cost-benefit of the system (Turker et al., 2011).

Precision agriculture techniques were used for irrigation scheduling. Comparing yield using variable rate irrigation to traditional cotton irrigation scheduling showed reduced water use by 7 to 9%, whereas it attained 19% higher yield compared to scheduling based on uniform application (Hunsaker et al., 2010).

Variable rate irrigation systems have been developed in order to apply precision irrigation. Initially these systems were introduced in pivot irrigation systems in order to perform differential irrigation according to management zones. Initially the irrigation management zones are delineated which are inserted in variable rate irrigation software in order to perform the application accordingly. Application mapping was performed according to ECa mapping (Figure 20) (LaRue, 2011).
In recent works researchers have started to develop site-specific irrigation machines for precision irrigation on self-propelled irrigation systems (King et al., 1995, 1999, Türker, 1999, Al-Karadsheh et al., 2002, Rodriguez-de-Miranda, 2003, Klocke et al., 2003, Coates and Brown, 2004 and Ohyama et al., 2005).

2.2.3 Sensor irrigation

There is a variety of soil moisture sensors commercially distributed that may assist in irrigation scheduling.

As mentioned in previous chapter, regulated deficit irrigation (RDI) of fruit trees is a very promising technique that increases WUE and helps to regulate the tree development and vigor with no loss in yield. Both the timing and level of water stress are critical to the success of RDI. In a relevant study soil moisture sensors were installed and irrigation was applied when soil suction reached 200 kPa. Irrigation run time was adjusted by measuring soil moisture immediately following irrigation (Goodwin and Boland, 2002).

In state of Georgia wireless sensor network was utilized to program and control of irrigation (Vellidis et al., 2008). Wireless sensor network combined with automation technologies were utilized to develop smart irrigation system for viticulture and model the viticulture soil-water dynamics (Ooi et al., 2008).

2.2.4 Simulation models

Several simulation models have been developed to assist in crop irrigation. FAO has developed a simulation model ‘CropWat’ to assist farmers to manage their fields more efficiently. Stricevic et al. (2011) attempted to assess the simulation efficiency of rainfed and supplementally irrigated maize, sugar beet and sunflower using ‘AquaCrop’. They suggest that the AquaCrop model can be used with a high degree of reliability in practical management, strategic planning of the use of water resources for irrigation, or estimation of yield with regard to climate change. They noted that the model is relatively easy to use and it works properly even if limited input data are available ending that it is highly reliable for the simulations of biomass, yield, and water demand.

Figure 20. Variable rate irrigation according to ECa mapping using pivot system (deep ECa on the left, shallow ECa in the middle and application map on the right) (source: LaRue, 2011).
2.2.5 Use of treated wastewater

One of the options for developing a ‘new water resource is the use of water that would otherwise go to ‘waste’. ’Recycling is both technically and economically feasible, and can create significant quantities of useable water from sources such as run-off and treated effluent. Under certain conditions it is feasible to irrigate using treated wastewater. The origin of this water can be either from urban wastes or from livestock effluences (www.npsi.gov.au). The use of treated municipal wastewater is relatively low in Europe. It may become a significant source of water, particularly for the irrigation of crops, provided that guidelines and standards are adhered to. Treated urban wastewater provides a water source which is relatively unaffected by periods of drought or low rainfall. Additionally depending upon the level of treatment, it can be relatively nutrient rich, reducing the fertilization needs.

3. Codes of Good Agricultural Practices in the EU WATER countries

European Union has started an effort to introduce or reintroduce good agricultural practices in the modern farm management. Most of them were traditional practices that were abandoned due to intensification of agriculture. These practices were enriched, to result the Codes for Good Agricultural Practices. These codes involve the following agricultural activities:

- Inputs management
- Soil management
- Crop rotation
- Fertilization
- Water management
- Plant Protection
- Management of native vegetation
- Harvest
- Managing of crop residues
- Waste management

Following these practices combined with the use of new techniques and technologies in irrigation and fertilization will lead to optimization of production and minimization of the environmental impacts due to agriculture.

3.1 Codes of Good Agricultural Practices in Italy

The considerations that follow are derived from the Italian Code of Good Agricultural Practices (CGAP, Agricultural Ministry Decree 19/04/1999):

A good irrigation practice has to minimize percolation and surface runoff both of water and nitrates; to achieve this objective the amount of water distributed in each irrigation round has to be strictly calculated to restore the hydraulic field capacity in the root zone; to determine this amount of water several parameters are needed as hydrological soil characteristics, initial water content in the root zone, depth of root zone;

Moreover a good irrigation practice has to pursue a high distribution efficiency which is strictly related to irrigation methods; the parameters that have to be
considered to choose the best irrigation method are: soil texture, soil chemical characteristics, slope, crop needs, water quantity and quality, environmental characteristics.

Surface irrigation (flood irrigation)

It is recommended only in deep soils, mainly clay soils, for crops with deep roots that require frequent irrigations; when furrow irrigation is adopted the farmer has to remind that the risk of nitrate percolation decreases from the beginning of the furrow to the end, decreases from sandy soils to clay soils, decreases from shallow soils to deep soils, from superficial root crops to deep root crops, in very swellable soils: long irrigation rounds are not advised because they can cause cracks through which huge amounts of water can be lost and nutrients (becoming pollutants) are leached;

Sprinkler irrigation

A very strict control has to be put on how to distribute sprinkler on the field, on rain intensity related to soil permeability, to wind effects on sprinklers distribution diagram, to the effect of the crop on water soil distribution;

Drip irrigation

During the application of fertilizers using drip irrigation system, the fertilizer injection has to be done not right at the beginning of the irrigation but only after having distributed at least 20-25% of the planned water amount; in the mean time has to be considered that the fertilizer application must end when the 80-90% of the planned water amount has been applied.

The experience of farmers and local actors with implementation / adaptation of the practices and their relation with traditional practices

In our Target Area, especially on sandy soils, it is quite common the lateral infiltration irrigation method combined with the use of subsurface drainage; the drainage net is COSTITUITO of hoses of 60-80 mm diameter, with or without cover of coconut fibers, at the distance of 8-12 m one from the other, located at a depth ranging from 80 to 100cm below surface; these drainage net is in connection with an irrigating canal (or ditch), generally located in the middle of the field, that has the double function to adequate and to bring water away (during the off irrigation season). This irrigation net is not directly connected to the Collective network but is characterized by devices that can delay water delivery in case for example of heavy rains: in this case also the leaching of nutrients is not delivered to the Collective network immediately but after an adequate time of sedimentation within the farm; finally when an authorization for extraordinary maintenance like smoothing (of the surface level) is needed (for example in cases of EU grants), the minimum water storage capacity of 150 mc/hectares is prescribed.

Existing good practices of irrigation and water management in the area / country.

In orchards and vegetables crops almost only drip irrigation is used. It is getting quite popular the use of low pressure sprinkler held at about 60 cm over crop level
applying about 2 mm (20 mc/Ha) each day for half of the biological cycle (30 days) of leaf vegetables.

For mais and sugarbeet the most common irrigation method is based on the hose reel irrigators with computerized functions to control water amount distribution. For the amount of water and its costs see the table on first page.

3.2 Codes of Good Agricultural Practices in Greece

Soil treatment
The treated bare soil is vulnerable to erosion by wind or water. Therefore, treatment of soil must be limited as far as possible.

**Recommended:**
- Soil treatments should take place at the right time with the appropriate equipment.
- Soil treatments should be made after the first autumn rains. It is desirable to avoid summer tillage.
- Avoid deep tillage below 40 cm. Where deep tillage is needed, the soil should not be reversed.
- Where there is flooding risk tillage should be done in a way that ensures field leveling using reversible plows.

**Mandatory:**
- In soils with a slope greater than 10% plowing must be performed towards the contours or diagonally, or create natural ridges along the contours and plowing in the diagonal.
- Uncultivated rows between the fields and the hedges, the natural vegetation of streams and the neighboring forests must be preserved.
- The maintenance of natural streams. Interventions concerning the rerouting of streams are made only after authorization by the competent service.

Crop rotation
The field should not be left bare during the winter when it is more vulnerable to erosion due to rain. In light soils it should be covered with vegetation during winter. Crop rotation is a good practice to achieve that.

Protecting water resources
Agriculture can not be exercised on lakes land revealed by the retreating waters of lakes and lagoons.

The uncontrolled use of water like overirrigation, flooding the neighboring fields and roads, the use of unsuitable or defective irrigation systems etc. must end.

In each irrigation should be applied the appropriate amount of water needed to saturate the soil in such depth as the depth of the root system. Deep infiltration and surface runoff can be reduced by proper control of a number of factors, such as:
- irrigation rate (avoid water losses, fix the delivery system)
- timing
- the soil slope
- the length of travel of water in the field
- the soil infiltration
the irrigation method

Farmers should comply with the irrigation practices for each crop (total water demands based on actual evapotranspiration, irrigation dose, time of irrigation, number of applications) for each irrigation system and for each soil type as determined by decision of the related services.

Irrigation systems
Surface irrigation
Surface irrigation is not proposed because it shows:
• high water consumption
• leaching of nutrients
• uneven watering

Where the field slope is more than 2-3% high water losses are observed through surface runoff. The application of surface irrigation may be necessary in special cases such as in saline soils or crops such as rice.

Sprinkler irrigation
With this system, water is applied to the entire field uniformly. Irrigation rate should be the same as the rate at which the soil absorbs the water to avoid runoff. Therefore the nozzle and the sprinklers should be adjusted accordingly.

Table 32. Average hourly soil infiltration.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Mean precipitation (mm/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sandy</td>
<td>50</td>
</tr>
<tr>
<td>light</td>
<td>25</td>
</tr>
<tr>
<td>medium</td>
<td>15</td>
</tr>
<tr>
<td>heavy</td>
<td>5</td>
</tr>
</tbody>
</table>

Avoid watering at noon 11am-3pm due to evaporation and when it is windy (over 5 degrees of the scale Beaufort) due to uneven watering. This system should be avoided when the quality of irrigation water is not good as salts from the irrigation remain on the plant leaves and stems.

Drip irrigation
Drip irrigation is the most efficient widely used irrigation system. Therefore it is recommended to be used when possible.

In general the farmers must:
• Prevent surface runoff or deep percolation
• Do not use surface irrigation (with ditches) in fields with a slope more than 3%

Management of native vegetation
The native vegetation, the residues of the previous crop or cover crops is best to cover the field surface during the winter especially in sloping fields. The benefits are:
• Protection of the soil structure from the rains
- Increase the ability of soil to absorb rainwater and reduce runoff
- It acts as thermal insulation mean during extreme temperatures
- It helps to minimize moisture losses due to evaporation
- Reduction of soil erosion and nutrient loss
- It assists in the development of soil microorganisms that help in soil fertility

**Management of crop residues**

The crop residues can offer protection from erosion and enrich the soil with organic matter. Burning of residues in environmentally sensitive areas, slopping areas and areas with organic soils, is forbidden.

Crop residues should be managed as follows:
- Pasturing of stubble and incorporation of the residues afterwards
- Direct incorporation in the soil
- Cutting, cover the soil with the remains (mulching) and incorporation into the soil during the next spring

**Handling of liquid waste**

For safe disposal of treated waste must:
- In slopping fields, disposal must be done in such quantity and with such method to exclude runoff
- Disposal shouldn’t take place during rainfall or when it is cold
- Liquid waste should provide to crops is when plants are in the proper vegetative stage
- The location of waste disposal should be at least 50 feet from surface waters

**Pig farms waste**

Pig waste is usually liquid and must be treated before disposal. The disposal can be done:
- In cultivated areas for fertilizing and enriching the soil with organic matter by direct integration or in soils with native vegetation by absorption and evaporation.

**Zones with intense problem of water balance deficit, with problems of exhaustion or salinization of groundwater aquifers**

The CGAP provide reduction in annual consumption of irrigation water of 5-10% depending on the size and rate of depletion with:
- Replacement of irrigation systems with more efficient and less water demanding ones
- Reduction of irrigation dose, measure and control of the consumption of irrigation water (using water flow meters)
- Replacement of irrigated crops by non irrigated
- Replacement of irrigated crops by less water consuming irrigated crops

**3.3 Codes of Good Agricultural Practices in Croatia**

In Croatia no codes of good agricultural practices are applied or have been adopted. Traditional practices are also not used.

Current water management legislation is being adjusted with the EU legislation. In order to implement the rules of good agricultural practice concerning the
management of agricultural production to make it less harmful for people, animals and plants, it is necessary to reinforce the system of control of the agricultural production concurrently with improving the technological equipment of agricultural producers. A transfer period and expert and financial assistance to agricultural producers is needed to facilitate their application of sustainable land and water resources management.

3.4 Codes of Good Agricultural Practices in Hungary

In Hungary irrigation always has to be managed parallel with flood protection, drainage control, namely good spatial water management should be implemented. Surface waters (inland waters) can be passed into diked rivers only through water pump installations. The danger and frequency of surface flooding is significant.

The idea of irrigation from surface water has been raised at the time when the regulation of river Tisza was planned. In case of sites that are more distant from the main canals, the irrigation water flows to the sites in irrigation canals/ main canals operated by Water Directory, Water Association or Local government. In some areas, the quantity or quality of surface water is not appropriate for irrigation. In these areas, irrigation water must be gained from underground water.

Most of the crops are irrigated with rain-like irrigation and the fruit trees are irrigated with dripping method. In the last decades, flooding irrigation also occurred but these days it is not typical in the region of Hajdúság.

Regulation on irrigation of 2010 includes that for irrigation surface waters must be used. If it is not possible, underground water can be used, primarily shallow groundwater. According to a new regulation aquifer beds can be used only for micro irrigation.

Hungarian laws dispose in general that in case of using water, best available techniques and the most efficient solution, the more purpose application and utilization solutions shall be favoured. The demand for the quantity and quality of water, the water-capability of the given area (surface/underground water), the existing users of water (who has already have permission for using water), the amount of water that must be left in the watercourse, the limit of fall of water level and the extent of tolerance of lack of water shall be taken into account.

Irrigation can only be realized where and when there is free /open or can be opened resources of water and environmental objectives and orders including in laws on protection of waters are not harmed. The water-settlement of the area must be resolved to the necessary extent before the irrigation starts and energy and water saving technologies must be applied that have the less loss of evaporation.

The use of underground water for irrigation only can be permitted when there is no opportunity for using surface water, at the same time – in order to be controlled – the fact that there is no opportunity for using surface water, must be found out by the water authority. In order to protect the quantity of good quality underground waters, shallow ground water can be used for irrigation and ground water from deeper beds and karstwater can only be used for micro irrigation. The amount of utilized water must be measured with normalized meter, this can reduce tendency of wastage.
In case of giving subsidy, the low pressure, low and medium intensity rain-like and micro irrigation equipments are preferred. These equipments can be operated in a water saving manner and sparing the soil and the plants. Further benefit is when the farmer who applies for subsidy, does not use underground waters only surface waters.

According to the practise of the last years, the farmers need permission for use of water only to that extent that is absolutely necessary for the given plants. Generally, the quantity of used surface water is only determined by technical evaluation that does not assist efficient utilization of water nor the efficient control on activity. The charge for service of water to be paid to the body that operates the canal and the expensive energy stimulate the farmers for sparing.

In livestock farming, the opened tenders based on EU and Hungarian funds (such as EMVA) ensure subsidy for developing technology (like water saving drinking systems) and modernizing the storage of manure (technical safety). In the milking houses, less water is used for cleaning and instead of washing dug disinfecting substances is used.

In the case of big poultry farms, we cannot expect great improvement, since the utilization of water is already controlled by computer. Since the unnecessary used water, whether used for drinking, or cleaning, would obstruct the establishment of appropriate conditions of animal health, this way they really use only the necessary amount of water.

3.5 Codes of Good Agricultural Practices in Serbia

In Serbia no codes of good agricultural practices are applied or have been adopted. Traditional practices are also not used.

3.6 Codes of Good Agricultural Practices in Romania

Agro-technical methods

- The seeding time must be chosen so that the soil water content and the amount of rainfall are at their optimum values;
- It is preferable to grow crops which require lower amounts of water;
- Measures must be applied in order to achieve an increased content of organic matter in the soil;
- Irrigation application scheduling must be performed so as to comply with the soil humidity content and with the real water demand of the cultivated crops;
- Weather stations can render long term meteorological forecasts.

Soil treatment

- Performance of the soil tillage works inside the optimum working interval, i.e. when the soil is damp, the furrow falls beneath the plough and the ploughing does not result in cobble-like or belt-like structures; in this state, soils, depending on their texture, may have a moisture content between 7 and 20%, with an optimum workable interval between 16 and 20%.
- Performance of ploughing immediately after harvesting of cereals, rapeseed or leguminous crops, at a depth of 8-10 cm, is capable of interrupting capillarity, of reducing water evaporation from the soil, of facilitating rainfall
infiltration and the condensation of water vapours coming from a larger depth. Thus, the water quantity adsorbed into the soil is 2-3 times higher, evaporation drops by approx. 8-10% and the vegetable debris are behaving like mulch strata.

• One must avoid to mobilize soil at depths higher than the recommended ones, both for the main tillage works, and for the preparation of the germination bed. Thus, ploughing at depths over 30 cm and preparation of the germination bed deeper than 10 cm, cannot be justified.
• On slopping land, one should avoid tillage at the slope direction, for the purpose of limiting water run-off and the erosion of the relevant soil. In hilly areas, on land with slope over 30%, tillage must perform along the direction of contour lines, as this can cut on water losses by up to 75%.
• Preparation of the germination bed during the sowing season, only throughout the sowing depth and employing only rotating active tools that avoid soil mass reversal; thus, soil preparation using the seed bed tiller and the rotating tine is much more efficient than the disk harrower which reverses the entire volume of processed soil, exposing it to the elements and facilitating the losing of water.
• In case of heavy textured soils (with high clay content) it is recommended to increase permeability of this layer through deep tillage (40 to 80 cm deep) that is also capable of improving the air and moisture regime of the soil;
• Such a deep ploughing should be executed every 4 to 6 years.

**Crop rotation-cover crops**

• Such tillage work must be performed along with other works that are designed to improve soil drainage capabilities. Thus, this till would prove more efficient in a crop rotation that includes hoeing and leguminous crops and which is accompanied by the spreading of 60-80 t/ha of manure.
• Adequate cropping patterns employed inside each farm, coupled with a crop structure that should include at least three groups of plants: cereals 33%, hoeing crops – technical plants 33%, leguminous crops 33%.

**Soil cover**

• Soil cover using different materials is capable of blocking water evaporation and additionally, depending on the mulch colour, can influence the soil’s thermal regime.

**Weed control**

• Efficient weed control should take place for each cultivated crop, in order to avoid water competition with the crop plants.

**3.7 Codes of Good Agricultural Practices in Moldova**

In Republic of Moldova there is not approved law concerning good agricultural practices. However, informative documents have been edited, like “farming property guide” which contains 21 agricultural practices.
Crop residues management
Crop residues from the previous year are let on the soil surface and tillage operations are reduced. This practice provides the advantages of improving the soil structure and increase organic matter content in soil while it saves time and energy.

Crop rotation
This application reduces costs for purchasing and applying pesticides by interrupting the natural growth cycle of insects, weeds.

Cover crops
Dense crops are sown in autumn in order to prevent nitrogen leaching and soil erosion in cold period of the year.

Cultivation of crops in strips
Including of annual legumes and perennial crops in an intercropping system fertilizer inputs are minimized.

Contour cultivation
In slopping fields crops are cultivated across the slope contour. This application reduces soil erosion and surface runoff. The same bebefits are accomplished when cultivating in Contour buffer strips

Slope control system
Construction of dams and dikes to prevent erosion from surface runoff.

Vegetative filter strips
Strips of vegetation that may include herbs, shrubs and trees can filter pollutants and prevent surface runoff.

Wetlands.
Floated areas such as ponds that serve as natural water filter.

4. Other good agricultural practices and studies
Extensive study on Good Practices has been performed in other research programs. Region of western Macedonia participated in Sustainable Hydro Assessment & Groundwater Recharge Projects (SHARP), a study of experiences and good practices in groundwater management. The good practices studied are:

- Dissemination in agriculture – decision support system for farmers. The DSS uses a set of points in order to evaluate the farm and find its distance from the Reference Farm. Land and soil, livestock, certification and quality protocols, crop type and land management techniques, irrigation, use of fertilizers etc are taken into consideration. DSS assist on the evaluation of the environmental conditions in a farm
- Groundwater monitoring and hydrogeological understanding.
- Development of groundwater monitoring database.
- Vulnerability maps.
- Tools for water management plants. Decision Support System (DSS) as a tool for the development of a Water Management Plan in the region. The system aims to
facilitate and optimize the decision-making process relating to the problems of land use, water management and environmental protection. The model includes a set of constraints related with Common Agricultural Policy (CAP), market, agronomical matters, labor and fertilizers. **CAP:** A large proportion of agricultural income depends upon CAP subsidies, and farmers cannot afford to ignore CAP regulations that affect most of the crops available for cultivation. For this reason, set-aside activity (SA) related to the subsidized crops are included. **Market and other constraints:** Express the market demand of the products in the area.

- Recharge of aquifers
- Ground and surface waters systematic monitoring
- Digital water book
- Assessment of the impact of climate changes
- Stormwater management

FAO has extensively investigated the use and adaptation of GAP. Several papers have been developed. According to FAO publications (Poisot et al., 2004) the concept of GAP was considered rather too wide and undefined. However, the basic aspects remain food safety, environmental protection, economic and social equity. Experts agreed that the concept of GAP should include the following aspects:

- **sustainability:** Good Agricultural Practices should be economically viable, environmentally sustainable, and socially acceptable
- **the focus should be on primary production, within a given incentive and institutional context**
- **take into account existing voluntary and/or mandatory codes of practices and guidelines in agriculture.**

Before initiating GAP activities at national or sub-national level, the following should be investigated:

- **existing GAP systems in use**
- **needs in terms of infrastructure and financing to support the transition period**
- **security for farmers as to return on investment, clarifying incentives for farmers**
- **cost of standard or technology compliance, understand other possible disincentives**
- **needs related to knowledge of appropriate technology components**

The principles of good farming are portrayed within 10 groups of practices (soil, water, crop and fodder production, crop protection, animal feed and livestock production, animal health and welfare, harvest and on-farm processing and storage, energy and waste management, human welfare, health and safety, and wildlife and landscape) (Poisot et al., 2004).

The codes of good agricultural practices include maximizing the infiltration of rain water on agricultural land and covering the soil as often as possible in order to avoid surface run-off while minimizing leaching to water tables. The maintenance of an adequate soil structure and the management of soil organic matter are important factors to achieve this. Efficient irrigation methods and technologies minimize losses in the supply and distribution of irrigation water by adapting the quantity and timing to the agronomic necessities and avoiding leaching and salinization. Water tables should thus be managed to prevent excessive rise or fall (Poisot et al., 2004).

Good agricultural practices are expected to (Poisot et al., 2004):
• Maximize water infiltration and minimize unproductive efflux of surface waters from watersheds.
• Manage ground and soil water by proper use or avoidance of drainage where required and by build-up of soil structure and soil organic matter.
• Avoid the contamination of water resources
• Adopt techniques to monitor crop and soil water status and prevent soil salinization.
• Avoid unproductive irrigation water losses and adopt water-saving measures and recycling where possible.
• Enhance the functioning of the water cycle to increase soil moisture storage and minimize runoff. This may include monitoring of water status, monitoring and proper use of irrigation water, establishing permanent cover, or maintaining or restoring wetlands as needed.
• Manage water tables to prevent excessive extraction or accumulation.
• Provide adequate, safe, clean watering points for livestock.
• Increase soil organic matter levels to maximize moisture retention and root penetration.

5. General suggestions for improvements

Using traditional practices and good agricultural practices among with the utilization of the recent technological developments and techniques will lead to optimization of agricultural production systems and minimization of inputs (agrochemicals and fertilizers) without reducing yield and quality with no economical impact to the farmers. On the contrary an economical benefit might appear due to reduction of the application costs (reduction of agrochemicals and fertilizers).

New more accurate agricultural machines have been developed. Sprayers with laser scanners, sonar or lidar that detect the tree canopy and are spraying straight on leafs minimizing the drifting. Other sprayers facilitated with camera recognizing the weeds, the sprayer nozzle sprays only one drop of herbicide directly on the weed leaf. Also, NDVI sensors are used to detect the green color of the weeds or plants, so that only the areas covered with plants are sprayed and the bare soil is not sprayed. These systems may provide up to 70% economization of inputs. NDVI sensor is also used on a real time nitrogen fertilizer application system which is mostly used on arable crops. The sensor is set at the front of the tractor and the variable rate sprayer at the back. As the tractor moves across the field, the sensor assesses how green or yellow the plant leafs are and gives a signal to the sprayer to increase or decrease the fertilizer accordingly.

New techniques and management strategies have been developed such as precision agriculture (PA) according to which the field is separated into management zones and each zone is treated accordingly. The final stage of implementation of PA is the variable rate application (VRA). Each zone produced in the previous stages receives the precise amount of input (irrigation, fertilization etc.) that is needed. VRA machinery has been developed to assist on this task.

The farmers should be encouraged to use more efficient and advanced systems to apply the inputs needed (irrigation system, fertilization system etc.). For example according to researches drip irrigation is a very efficient way to irrigate potato fields. Also sub-surface irrigation is a new irrigation system even more efficient than drip
irrigation. The drip irrigation network is installed 2-70 cm under soil surface supplying directly the root system of the plant with moisture while the surface remains dry (minimization of evapotranspiration). These systems are ideal to irrigate high value crops such as maize or potato. Additionally, drip irrigation system provides the benefit of applying fertilization among with irrigation simultaneously (fertigation). Using this system, fertilization can be applied very easily and inexpensively in the proper number of applications.

Additionally it would be useful to promote the use of small farm meteo stations to correctly detect meteorological data in order to calculate correct evapotranspiration and so planning in the best way the moments and the volumes of irrigation. Some more useful devices could be remote control of irrigation equipments including anemometers that can stop the machine in case of wind drift. Finally the apparatus for fertigation could complete the best use of irrigating devices keeping strong attention to nitrogen problems.

6. Strategic design for water conservation in the SEE area

In the current chapter we collected and reviewed all the available information from:

- Data collected from partners (questionnaires)
- Traditional practices and Good Agricultural Practices in the partner’s areas
- International practices found elsewhere
- Literature review

According to partner’s answers to questionnaires, reports and additional data gathered within the EUWATER project, the main tasks that need to be focused in order to enhance water conservation and decrease water consumption in the partner’s areas are:

- Improvement of Water Balance
- Improvement of irrigation efficiency
- Management and reuse of sewage – wastewater for irrigation

6.1 Improvement of water balance

The term Water Balance corresponds to the predictive methods which consider the plant physiology properties, calculating the real water needs in each crop growth stage, soil properties and climatic conditions in order to advise the farmers about the most appropriate irrigation timing and amount of irrigation water to apply. Water balance is essential for decision making on water management.

An improved water balance in the project areas can be achieved using certain management tools such as:

- Meteorological data monitoring
- Soil monitoring

In certain partners areas (Italy, Greece) small meteorological stations are being installed, mainly in big farms and high value crops that can afford the cost, in order to monitor the weather and microclimatic conditions in the farm. The main attributes that are being monitored using such stations are:
Precipitation
Wind direction and speed
Air humidity
Air temperature
Solar radiation

Using these data, irrigation may be customized according to the real needs and conditions in the farm. Recently several sensors that can be used as small meteorological stations have been developed reducing the cost of monitoring in field microclimatic conditions.

Apart from the above private systems, where the farm scale is small and cannot afford the cost of this technology, the weather properties may be monitored in local level by the local authorities (municipality or region).

Soil properties (Field Capacity, Permanent Wilting Point, soil texture, infiltration) are essential in order to perform irrigation programming. Therefore soil sampling and monitoring is very useful. In the cases where soil sampling on farm level is not feasible, several soil properties map have been developed in EUWATER project for the project areas. These maps are available on the EUWATER website and can be used from the agronomists or the farmers to calculate the irrigation schedule.

Additionally the implementation of an irrigation service, possibly via Web, would manage the water balance on the scientific basis by spreading the costs of a wide range of users.

At this point it should be noted that AUTH used the maps and database developed in WP3 to go one step further by developing a Decision Support System (DSS). The DSS is an important planning tool enabling the regional authorities to design optimal spatial development policies and protect the groundwater from the agricultural land use. It also supports production planning and water and fertilization management. From the results we can summarise that the DSS achieves to decrease both fertilizers use and water consumption. With the use of EU Water DSS we can achieve optimum crops plans in the pilot area combining different criteria taking in account the EU Water GIS maps of the pilot area. The Decision Support System (DSS) is a Computer system which includes models and a set of relational databases. EUWater DSS is simple step by step software which is based on the related GIS Maps created using LOS Indices developed for EU-Water project. The DSS is further used to simulate different scenarios and policies due to changes on different social, economic and environmental parameters (e.g. different levels of chemicals or water consumption per crop). The results from the implementation in Greece show that the DSS achieves the three main goals set by the model definition. An increase in Gross Margin achieved from (3.69% - 13.88%), a reduction of fertilizers use from (8.05% - 12.95%) and finally a reduction in labour use from (11.95% - 13.58%) depending on the scenarios.

The use of simulation models, using software to calculate irrigation programming according to real needs for each crop and each area and Decision Support Systems (DSS) may be vital. Several software programs have been developed to assist on irrigation scheduling. Some are free to be used by anyone providing a friendly and easy to use interface. Farmers and agronomists should be
aware of these programs and get informed or trained to use such tools. The local authorities may have an informative or training role on this task.

Also irrigation may be managed according to available soil moisture. Useful tools in order to monitor soil water content are the soil moisture sensors, tensiometers. Automated irrigation has started to be applied according to sensor readings. Possibly, the use of soil moisture sensors in combination with the weather station or weather data from local agencies would lead to optimized water balance.

**6.2 Improvement of irrigation efficiency**

An efficient irrigation provides water to plants based on the real needs in order to develop and achieve high yield. Additionally soil water content should maintain under field capacity avoiding leaching and preserving the overall water availability.

For a rational use of irrigation water the distribution method is significant. The proper use of irrigation facilities achieves the highest degree of efficiency in relation to the adopted method of distribution.

The parameters that have to be considered to choose the best irrigation method are: soil texture, soil chemical characteristics, slope, crop needs, water quantity and quality, environmental characteristics.

As mentioned in previous chapters, the different irrigation systems show significant differences in irrigation efficiency. The most efficient irrigation system is subsurface drip irrigation because water is applied directly in the root zone while the soil surface remains dry minimizing evapotranspiration. On the other hand it shows high installation costs and difficulties and therefore it may be used only for high value and perennial crops (trees, vines etc.). Drip irrigation is also highly efficient irrigation system; the installation cost is affordable especially in dynamic crops such as maize and it is being extensively used globally. Therefore it is recommended to be used when possible.

In general in order to maximize irrigation efficiency the farmers must:
- Prevent surface runoff or deep percolation
- Do not use surface irrigation (with ditches) in fields with a slope more than 3%
- Do not irrigate in the evening (11:00 – 15:00) due to high solar radiation (high evapotranspiration from soil surface)

Sprinkler irrigation is being extensively used in most of the partner’s areas. Also pivot systems are used in many cases. In these systems there are common management tactics that may lead to maximization of irrigation efficiency. Wind affects greatly the uniformity of water distribution minimizing the efficiency. Therefore when it is windy irrigation using these systems should not be performed. Installation of wind meters would assist on this task. Also, irrigation should not be performed in the evening (11:00 – 15:00) especially when temperature is high (summer) due to high evapotranspiration.

It is significant to keep the irrigation network and the equipment in good condition in order to maintain the maximum efficiency. Therefore frequent
inspections should be performed for possible leaks or damages and for evaluation of the general performance.

Old machineries for irrigation (especially in sprinkler) should be replaced by new ones (more efficient in water saving and energy saving solutions).

From the above mentioned, in order to minimize water consumption due to agricultural activities, the farmers should be enhanced to:
- Replace irrigation systems with more efficient and less water demanding ones
- Repair or upgrade the existing irrigation systems
- Substitute the old irrigation machinery with new more efficient

### 6.3 Management and reuse of sewage - wastewater for irrigation

One of the options for developing a ‘new water resource is the use of water that would otherwise go to ‘waste’. ‘Recycling is both technically and economically feasible, and can create significant quantities of useable water from sources such as run-off and treated effluent. Under certain conditions it is feasible to irrigate using treated wastewater. The origin of this water can be either form urban wastes or from livestock effluences (www.npsi.gov.au). The use of treated municipal wastewater is relatively low in Europe. It may become a significant source of water, particularly for the irrigation of crops, provided that guidelines and standards are adhered to. Treated urban wastewater provides a water source which is relatively unaffected by periods of drought or low rainfall. Additionally depending upon the level of treatment, it can be relatively nutrient rich, reducing the fertilization needs.

### 6.4 Enhance the adoption and application of CGAP

From the analysis of Codes of Good Agricultural Practices and traditional practices in the partner’s areas several practices were recognized to be commonly accepted in water preservation. These good practices are:

**Application of a series of tillage practices that ensure conservation of soil water**

The treated bare soil is vulnerable to erosion by wind or water. Therefore, treatment of soil must be limited as far as possible.

Soil treatments should take place at the right time with the appropriate equipment. Soil treatments should not be made during dry seasons.

Avoid deep tillage below 40 cm. Where deep tillage is needed, the soil should not be reversed.

Where there is flooding risk tillage should be done in a way that ensures field leveling using reversible plows.

On slopping land plowing must be performed towards the contours to limit water run-off and soil erosion.

**Crop rotation - Soil cover**

The field should not be left bare during the winter when it is more vulnerable to erosion due to rain. In light soils it should be covered with vegetation during winter. Crop rotation is a good practice to achieve that.

Soil cover using different materials is capable of blocking water evaporation.

The crop residues can offer protection from erosion and enrich the soil with organic matter by covering the soil with the remains.
Protecting water resources

The uncontrolled use of water like overirrigation, flooding the neighboring fields and roads, the use of unsuitable or defective irrigation systems etc. must end.

In each irrigation should be applied the appropriate amount of water needed to saturate the soil in such depth as the depth of the root system. Deep infiltration and surface runoff can be reduced by proper control of a number of factors, such as:

- irrigation rate (avoid water losses, fix the delivery system)
- timing
- the soil slope
- the length of travel of water in the field
- the soil infiltration
- the irrigation method

Management of native vegetation

The native vegetation, the residues of the previous crop or cover crops is best to cover the field surface during the winter especially in sloping fields. The benefits are:

- Protection of the soil structure from the rains
- Increase the ability of soil to absorb rainwater and reduce runoff
- It acts as thermal insulation mean during extreme temperatures
- It helps to minimize moisture losses due to evaporation
- Reduction of soil erosion and nutrient loss
- It assists in the development of soil microorganisms that help in soil fertility

Weed control

Efficient weed control should take place for each cultivated crop, in order to avoid water competition with the crop plants.

Management tactics

Additionally the CGAP provide reduction in annual consumption of irrigation water providing general management tactics:

- Replacement of irrigation systems with more efficient and less water demanding ones
- Reduction of irrigation rate, by measuring and controlling of the consumption of irrigation water (using water flow meters)
- Replacement of irrigated crops by non irrigated
- Replacement of irrigated crops by less water consuming irrigated crops
Chapter 4. Considerations on fertilization methods in order to reduce nitrates pollution

Premises and methodological approach

The part A.4 of the EU.WATER Transnational Strategy for the Integrated Water Management in Agriculture addresses the identification of alternative fertilization methods in order to reduce nitrates pollution. This survey starts from the analysis of the traditional codes of agricultural practices implemented in every partners’ areas and it considers many issues, and particularly, to identify some recommendations for a more sustainable and environmental friendly fertilization. Although these recommendations do not consist in radical changes in the local practices (otherwise the local adaptation plan could not be put in practice), they highlight feasible alternative fertilization methods.

The Province of Ferrara – leader of this activity - has initially merged the geological and environmental informative part (WP3 and in some detail also from the Pilot Actions, still in progress under WP5), with the agronomic information and codes of traditional agricultural practices, collected on site through interviews with the agronomists selected by each partner’s Committee, has developed a set of alternative fertilization methods devoted to prevent nitrates losses. Therefore, this hypothesis consists of an integrated evaluative approach, structured on the most peculiar local characteristics (that are very much representative for the SEE areas) and to be connected to the decision support system and the relative financial and normative packages (part that will be further finalized in the WP6). The expectation is the development of an integrated strategy to manage nitrogen fertilization in the application of the WFD and Nitrate Directive that fits not only the EU provisions but also the local agricultural practices, allowing the effective ownership of green-solutions by farmers.

Regarding the methodological approach, the present survey has been developed upon the following phases:

1. Exclusion of data previously collected by the partners by means of questionnaires and analyses. The objective is to compare the codes of good practices available in each of the 8 countries (and regions) involved in EU.WATER against the EU commitments reported in specific Directives and Regulations;

2. Sharing and discussion of previously collected information between partners’ agronomists through e-mail and skype to refine the analysis and define the aspects of nitrogen fertilization management. The process has started after the meeting held in Odessa, 12-14 October (plenary session and sessions between LP and all PP’s agronomists);

3. “Dedicated” site-visits in each partner’s area in order to tackle specific aspects directly with the agronomists and stakeholders (technicians and farmers). This allows to speed up the composition of the knowledge framework (related to codes of agricultural practices) and have an overall view of the main agronomic characteristics in the 8 selected areas. These areas are very much representative of...
the different environmental and social contexts of the SEE space, as they range from alluvial highly intensive agriculture, continental and extensive agriculture, up to Mediterranean agriculture.

4. data processing of the information collected in the project areas, highlighting the peculiarities and common aspects, with the aim to define a shared evaluative approach and a common strategy to manage nitrogen fertilization in the application of the Directive and in combination with the results achieved in WP3 and WP5;

5. use of the achieved results to address WP6, in interaction with ISPIF (leader of WP6) and IAE (co-leader of WP6), in order to make the economic part of EU.WATER project coherent with the agricultural model for managing nitrogen fertilization in the application of the Nitrate Directive.

1. The agronomic survey

The main issues investigated by the EU-Water project is the rationalization of water use in agriculture and the reduction of nitrogen loads and other pollutants, in line with the Water Framework Directive (Dir 2000/60/EC) and the European Directive on Nitrates (Dir 91/676/EEC). This has made necessary an agronomic survey among the project partners (PP).

The differences in terms of climate, with particular reference to rainfall, temperature, soil, livestock and its consequent management of effluents, determine differences in the cultivation techniques, such as processing, fertilization and irrigation.

Agronomic aspects more directly related to the risk of water pollution by nitrates from agricultural sources are summarized as follows: soil characteristics, land use (rotation and cover crops), soil processing, nitrogen fertilization and irrigation.

These questions are examined by each partner on the base of specific questionnaires related to each target areas.

Besides the aspects mentioned, there was a study on the application of codes of good agricultural practice and the impact of individual pilot projects (where they were made).

Finally, we tried to outline a range of good agricultural practices and their applicability and transferability in the target area.

1.1. Croatia

Soil Characteristics: The agricultural soils were classified based on a scale of fertility provided by the Partner (source: Environmental Protection Plan for the Region of Istria): – very fertile soils: designed for tree crops (vines, olives and some species of fruit), fertile soils: designed for extensive crops (cereals, industrial crops), horticultural crops (potatoes, cabbage, etc..) and the production of fodder, other cultivated soils: areas for the same crop of the previous ones but with less expectations in terms of yield because they are less fertile soils, other agricultural and forest soils: for grazing, wood production, etc. The soils included in the first two categories are largely classified under the so-called "red soils", which are extremely common in Istria; only a smaller extent of those soils belong to the so-called "brown land". 40% of cultivated soils have a thin surface layer that can be used (in some cases it reaches the outcrop of bedrock below). The total organic matter in farms
that use organic fertilizers, ranges from 1, 5% to 2%. The average nitrogen and phosphorus content of soils for agricultural activities are quite low. The same soils, however, are medium to well endow with potassium.

**Agricultural land use:** 50% of agricultural soil is used as **grazing**, 10% as **permanent grassland**, and 35% for the cultivation of **extensive crops** (wheat, corn and barley, mainly) and **horticultural crops** (potatoes, cabbage, tomatoes and onions). The remaining 3-4% is cultivated with **vines**, 1% with **olives** and 0.5% with **orchards**.

**Tillage:** The agricultural soils are predominantly “loose”, in some cases even “coarse” due to the presence of gravel and stones; then they are suitable for light processing. However, in some cases, it is necessary to grind the soil to make it cultivable, due to the high presence of rockiness.

**Fertilization:** The use of manure is limited to livestock farms and a real sale of livestock effluents does not exist. The manure is used mainly on corn, potato and, in minor way, on olive trees and vines. Organic fertilizers derived from industry (such as “stallatico” and compost) are generally used in the fertilization of tree crops. Synthetic nitrogen fertilizers are commonly distributed in autumn at soil tillage, even on crops, such as potato, with spring sowing. The total amount of nitrogen distributed on crops are, in some cases, especially for corn and potatoes, significantly excessive compared to the real needs.

**Irrigation:** In Istria there is large water availability: in the southern part of the region, water comes from very rich groundwater sources, while in the north there are some rivers of a certain importance. This water is not used due to lack of facilities for the derivation and distribution and due to the low incomes of most of the farms that prevent them from investing in irrigation systems. In general, great difficulties regard the transfer of new technology to the farms, probably due to the low incomes. Ultimately, about 1,5% of the cultivated area, in Istria, is irrigated.

**More information:** Code of Good Agricultural Practices are missing. There is a national program to protect the waters that have implications in the agricultural sector through the Rural Development Plan. Main attention is needed for pasture land where, due to the accumulation of manure on a permeable soil which increases the risk of nitrate losses to groundwater.

### 1.2. Greece

**Soil Characteristics:** The area of Kozani is characterized by soils that, in terms of textural, belong to the category of **medium-textured** soils, or francs. In this area are also very common soils with very high **clay** content. The average content of **organic matter** is 2.5%.

**Agricultural land use:** The most practiced crops are **corn**, **wheat**, **sunflower** and **sugar beet**. The average production of maize is from 10 to 17 T/ha, while is 7 T / ha for the wheat.
Tillage: In addition to traditional processes, applied especially to corn and beet crops, the techniques of minimum tillage are used too. In some case, these techniques are reduced only to the subsoiling. Normally, plowing is the technique normally used in the area, especially where soils are heavier (30 cm for wheat, 40 cm for corn).

Fertilization: For all crops are also anticipated significant quantities of nitrogen (up to 150 units/ha for maize and potato) in pre-sowing period. The total amount of nitrogen that is distributed seems to be excessive for some crops: on corn and potatoes crops are distributed up to 300 units / ha. The use of livestock manure is very limited mainly due to the low availability in the region. The levels of fertilization are exclusively determined on the basis of the theoretical requirements of crops.

Irrigation: The use of irrigation regards the spring sowing crops which the water is distributed on, mainly through drip systems due to the limited water availability. The quantities of return water reported are very high: 700 mm for potato and sugar beet, 1600 mm for maize.

More information: The Nitrates Directive came into force in Greece through Joint Ministerial Decree (JMD) 1190/133/1997 – “Terms and Measures for the Protection of Waters from Nitrates Pollution from agricultural Sources”. Designated vulnerable zones were incorporated into the Country’s legal framework. Seven action plans for NVZs were established. Each one provides detailed information about the situation in the area they refer. It also gives detailed guidelines about irrigation, fertilization management (types, rates and number of applications of fertilizers per crop), transportation and storage of fertilizers, livestock waste management. Code(s) of Good Agricultural Practice have been established to prevent and reduce the pollution of waters. It was established with the 85167/820/20-3-2000 Ministerial Decision, the ”Codes of Good Agricultural Practice for the protection of waters by nitrates pollution from farm origin” (Government Gazette B 477/6-4-2000). They include codes for the storage transport and application of nitrogen fertilizer, the quantity and time of application and land cover during the winter.

1.3. Hungary

Soil Characteristics: In the region of Debrecen predominant soils are chernozem, or blacks soils, characterized by humic layers, which often derive from abundant vegetal stabilized residues. Generally they are very fertile soils.

Agricultural land use: 30% of agricultural land is dedicated to corn, 15% to sunflower and 10% to wheat. A surface of about 2% is cultivated to sweet corn and, finally, 1% to green pea. The cattle farming is one of the most important agricultural activities for the target area (45% of agricultural GP comes from this sector) and the breeding of pigs, though still plays a significant role in the agricultural panorama, has been partially reduced due to several periods of crisis.
**Tillage:** Generally soil tillage starts with plowing, followed by grubbing or chiseling and then harrowing. In cases of dry season (i.e. autumn 2011) and high clay content in the soil, in many areas only grubbing is done then relying on winter rains and mechanical action of frost.

**Fertilization:** The still strong presence of breeding farms determines good availability of manure and slurry. According to the questionnaire filled by Hungarian Partners and to the agronomic survey conducted in the southern area of Debrecen, there is a widespread use of these organic matrices (manure above all), especially on maize and potatoes cultivations, where it is distributed by traditional manure spreading trucks. The sewage is distributed by tank trucks directly under the surface or, for some companies financed by government and European Community grants, by means of irrigation (pivot, lateral move, jackson). The obligation of burial is not applicable, even in vulnerable zones, in case the slurry derives from anaerobic digestion processes (e.g. biogas). In the target area, there are 679 registered farms: 50 of them are empty, 428 are considered large farms, and 73 are in possession of an IPPC permit. Within these 73 permits, 38 are related to pig farms, the remaining are referred to chickens and turkeys. Lagoons are allowed for the storage of slurry as long as the soil permeability is very low. In some cases the pig slurry is treated with additives (bioline, gulemax) added in the sub-grid. Some older lagoons, no more used for their purpose, are subject to environmental recovery initiatives and turned into wetlands with the planting of reed rhizomes. A safer storage technology sees the use of open lagoons with plastic insulation of the bottom and walls. They can be combined with a system of liquid / solid separation to reduce the volumes stored and to recover manure especially for deployment in the field after its correct maturation. Even in this country, especially for larger farms (no information about small farmers), concrete platform are used for the storage of manure: they are characterized by regular shapes and surrounded by retaining walls, with access from the side without wall through a ditch that collect leachate. The structure is usually dimensioned for 1 year storing. The distribution takes place primarily before plowing corn but also before wheat and barley and in these cases smaller quantities are applied.

The examination of some tables with the chemical characteristics of both liquid and solid digestate and cattle manure, provided by a visited farm, denotes a content in N equal to 0.39%. This value is in agreement with the Italian table average. This exam also denotes an important consideration that is common to the Italian situation and presumably to all the other PP situations: there is great variability not only on analytical techniques (and that could be easily managed with some common practices), but also on the nitrogen concentration in the manure and, even more, in the slurry. That depends on the sampling technique, storage time, type of farm housing, feeding diet, rainfall in case of open storage; in such situations the use of tables with mean values, although easy to manage at farm level, induces errors in calculation of nitrogen contents actually distributed on the field. A possible solution to this problem lays on timely regular analysis of the material to be distributed, and also on encoding methods of sampling and analytical methods. Only in this way it is possible to manage manure and slurry facing crops needs and environmental issues.
**Irrigation:** Some irrigation systems are recent, in good operating conditions and are usually fed by underground pressurized networks and deriving from surface water. As already said, some irrigation system can also be used for the distribution of sewage and/or fermented livestock slurry in which case the distribution does not take place from the nozzles of the top line but from a second lower distribution line. On the basis of agronomic experience the positive effect of irrigation on agricultural yields is undoubted and it leads to an average of 12 t/ha in the case of corn example. Some year, such as in 2011, when storm events meet crop requirements, irrigation is not required and, thanks to soil fertility, yields still stand to optimal levels. A characteristic feature is the permanence of the crop field (corn) well beyond the physiological limit of maturity: not fearing falls or cutting off, the crop is harvested with very low humidity (16-18%) even at the end of October.

**More information:** At the beginning of the implementation of Nitrates Directive, it has referred that specific action plans were not drawn up. To this purposes the state CGAP has been kept as “action plan”. Since the need to make specific fertilization plans was not foreseen, the Hungarian partner, in the context of its pilot action of the EU-W project (WP5), draw up patterns of more specific action plan which were integrated with two models of fertilization plans, both for the vulnerable zone and ordinary areas.

**1.4. Italy**

**Soil Characteristic:** The predominant soil textures in the province of Ferrara are silt loam and silty clay (68% of the territory), while peaty soils are less common (23% of the territory). The remaining 9% are sand and silty sand. The major part of the soils in the province of Rovigo is medium texture, deep, alkaline, with poor drainage.
Agricultural land use:

Table 33. Types of crops cultivated in Ferrara Province.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Surface (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter cereals</td>
<td>53.128</td>
</tr>
<tr>
<td>Maize (sillage/grain)</td>
<td>36.700</td>
</tr>
<tr>
<td>Annual forage crops</td>
<td>17.295</td>
</tr>
<tr>
<td>Energy plants</td>
<td>16.311</td>
</tr>
<tr>
<td>Fruit trees</td>
<td>14.500</td>
</tr>
<tr>
<td>Other</td>
<td>13.698</td>
</tr>
<tr>
<td>Rice</td>
<td>7.995</td>
</tr>
<tr>
<td>Beet</td>
<td>7.486</td>
</tr>
<tr>
<td>Tomato</td>
<td>7.133</td>
</tr>
<tr>
<td>Grain legumes</td>
<td>3.120</td>
</tr>
<tr>
<td>Gardening fruits</td>
<td>1.440</td>
</tr>
<tr>
<td>Vineyard</td>
<td>709</td>
</tr>
</tbody>
</table>

Table 34. Types of crops cultivated in Rovigo Province

<table>
<thead>
<tr>
<th>Crop</th>
<th>Surface (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize grain</td>
<td>51.664</td>
</tr>
<tr>
<td>Soybeans</td>
<td>22.354</td>
</tr>
<tr>
<td>Wheat</td>
<td>21.077</td>
</tr>
<tr>
<td>Not used land (tares)</td>
<td>15.763</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>5.388</td>
</tr>
<tr>
<td>Sugarbeet</td>
<td>4.203</td>
</tr>
<tr>
<td>Set aside</td>
<td>3.654</td>
</tr>
<tr>
<td>Durum Wheat</td>
<td>3.537</td>
</tr>
<tr>
<td>Fodder</td>
<td>2.335</td>
</tr>
<tr>
<td>Rice</td>
<td>1.808</td>
</tr>
<tr>
<td>Pear</td>
<td>1.362</td>
</tr>
<tr>
<td>Barley</td>
<td>1.264</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>1.21</td>
</tr>
<tr>
<td>Sunflowers (food and no food)</td>
<td>941</td>
</tr>
<tr>
<td>Set aside</td>
<td>510</td>
</tr>
</tbody>
</table>

Tillage: The presence of soils characterized by very different textures and the need to reduce production costs has led to the coexistence of a very wide range of soil tillage techniques. In addition to traditional processes, such as plowing followed by successive interventions of “seed bed preparation”, minimum tillage and no tillage techniques have spread. Even where the soil is plowed, working depth are reduced compared to the past in order to limit energy costs of the operation. This is due to various reasons, such as the need to correct the structure of compacted soils, to bury animal manure solids, and/or to reduce the charge of certain pathogens, etc.

Fertilization: most farms adopt a scientific basis for determining both quantities of fertilizers to be distributed and the most appropriate time for distribution. The spread of a more targeted use of fertilizers has been made possible by several
reasons, some of which are: the need to follow the rules of the Nitrates Directive (which are compulsory for all farmers in Rovigo and Ferrara provinces), the presence in the target area of qualified consulting and assistance services, the possibility to access databases on soil characteristics; and the availability of more and more sophisticated equipment for distributing.

Irrigation:

Table 35. Main irrigated crops and water needs

<table>
<thead>
<tr>
<th>Crop</th>
<th>Irrigation method</th>
<th>Irrigation amount (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit trees</td>
<td>drip irrigation - aspersion - irrigation on/under foliage - spray irrigation</td>
<td>600-700</td>
</tr>
<tr>
<td>Vineyard</td>
<td>flow irrigation - irrigation under foliage</td>
<td>550-650</td>
</tr>
<tr>
<td>Winter cereals</td>
<td>non-irrigated</td>
<td>350-400</td>
</tr>
<tr>
<td>Maize (sillage/grain)</td>
<td>Aspersion; lateral infiltration in sandy soils at risk of salinization</td>
<td>350-450/550-650</td>
</tr>
<tr>
<td>Rice</td>
<td>flood irrigation</td>
<td>1200-1500</td>
</tr>
<tr>
<td>Beet</td>
<td>Aspersion</td>
<td>600-700</td>
</tr>
<tr>
<td>Energy plants</td>
<td>Aspersion</td>
<td>600-700</td>
</tr>
<tr>
<td>Tomato</td>
<td>aspersion - drip irrigation - lateral infiltration</td>
<td>550-650</td>
</tr>
<tr>
<td>Grain legumes</td>
<td>aspersion - lateral infiltration</td>
<td>350-450</td>
</tr>
<tr>
<td>Annual forage crops</td>
<td>non-irrigated</td>
<td>400-500</td>
</tr>
<tr>
<td>Gardening fruits</td>
<td>aspersion - drip irrigation</td>
<td>400-600</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: 1 mm (on the surface of 1 hectare) is equal to 10 cubic meters

More information: Italy has adopted (by Ministerial Decree April 19, 1999) the Code of Good Agricultural Practices, which contains requirements, adoptable on a voluntary basis, relating to: crop rotation, tillage, plant nutrition, breeding farms.

Each region has also adopted Integrated Production Specifications, which have been inspired by the guidelines written at national level. The Specifications define a cultivation pattern for each crop. The main purpose is to produce agricultural products with as low as possible content of pesticides by following techniques and production more rational and respectful of the environment and operators.

Each Region has also renewed its Action Plan, which governs the management of nitrogen sources (including those of animal origin): in Veneto Region the latest Action Plan refers to 26/07/2011, to 28/10/2011 in Emilia -Romagna region.

Finally, it should be noted that, thanks to the Commission's Execution Decision of November 3, 2011, Italy (in particular Emilia Romagna, Lombardia, Piemonte and Veneto regions), was granted the Nitrates Directive Derogation that allows to raise the limit from 170 kg/Ha of nitrogen up to 250 kg/Ha under certain circumstances, and only for cattle and pig manure (chicken manure is excluded).
1.5. Moldova

**Soil Characteristics:** The arable land is 60% of the overall surface of the region. The dominant kind of soil is “chernozem” or black soils. **Agricultural land use:** Crop rotation is planned to reduce costs for purchasing and applying pesticides by interrupting the natural growth cycle of insects and weeds. The most common crops in the TA are: corn 1.800 Ha, wheat 3.000 Ha, vegetables 300-400 Ha, potatoes 280 Ha; it is referred also to greenhouses for 8 Ha.

**Tillage:** Several agronomic techniques are described in order to reduce erosion, leaching, water runoff. Among them the Partner refers to the following techniques. **Waste management plant:** vegetable crop residues from the previous year are left on the soil surface by reduced tillage operations to improve soil structure and organic matter content in the soil. **Rotation:** high density population crops are sown in autumn in order to stop water runoff, leaching of nitrogen from arable land and to prevent soil erosion in cold period of the year. Besides these aspects these cover crops prevent the erosion of the soil, add organic matter and improve soil structure. **Cultivation of crops in strips:** weeding crops are seeded on slopes and alternated with densely seeding perennial grasses and legumes. In this case there is also a reduction in the costs for fertilizers. **Contour cultivation:** agricultural crops are cultivated across the slope (contour) to reduce the erosion up to 50 % and stabilize productions. **Contour buffer strips:** the combination of grasses and legumes helps to reduce the speed of drainage and nutrient capture. **Establishment of degraded areas and Terrace culture system:** seeding perennial grasses or other vegetation are applied to stabilize highly eroded soil surface and improve the water quality. **Belt strips:** perennial belt strips are arranged around the field boundaries to prevent water, chemical and nutritive substance from running off. The strips also provide shelter for small animals and birds. **Protective forests:** rows of trees and shrubs are planted in alternating fields for protection from wind, snow and hydric soil erosion. **Fertilization:** Nutrition crop management is based on crop needs, soil and manure testing. Maximum allowed Nitrogen: corn 150 kg N/Ha, Wheat 140 kg N/Ha, Vegetables 150 kg N/Ha. Nitrogen applied: Corn 60 kg N/Ha, Wheat 60 kg N/Ha, Vegetables 60 kg N/Ha applied, in these three cultivation cases, as 90% of Nitrate ammonium in 2 o 3 times and generally localized among crop rows of corn and vegetables. This fertilizer is applied to seeder for wheat. There is no organic nitrogen available.

**Irrigation:** Irrigation is applied to vegetables, potatoes and greenhouses. Water is supplied by irrigation sprinklers on potatoes crops and by drip irrigation on other crops. The volume varies from 1000 mm (greenhouses) to 1200 mm for potatoes, up to 1600 mm for vegetables. The average coefficient of evapotranspiration in the growing season is 1.25 mm. The origin of the water is shallow. Its cost is calculated on consumption base. The balance sheets of water (irrigation management plans) are drawn based on the 50% -70% of the crops and they take into account climatic data, crop type, soil type, slope, irrigation infrastructure, higher-level irrigation plans and the WFD.

**More information:** In Republic of Moldova a Code of good agricultural practices is currently missing but there are many informative documents regarding this field,
such as “farming property guides”, which contains 21 agricultural practices. Some of them are listed below. **Pest:** field monitoring of insects, diseases and weeds (integrated pest control) is established and used to reduce damages to agricultural plants and environment, permitting to apply appropriate methods of pest control at the right time. **Manure storage:** constructions that protect water source from manure runoff by storing it until the appearance of favorable conditions. **Pasture rotation system:** pasture is devided into several parcels to ensure animal pasture rotation and improve vegetative layer and water quality. **Create pastures:** sowing perennial grasses and vegetables to reduce soil erosion and restore natural low productive pastures. **Vegetative filter strips:** strips of vegetation that may include herbs, shrubs and trees to filter pollutants and retain water leak. **Protection of small water courses:** protection of small water courses by stabilizing their banks, excluding animals pasture and creating accesses to vegetation buffer areas. **Wetlands:** flooded areas, such as ponds, that serve as natural water filter and provide fauna habitat. **Fauna habitat hill:** creating, maintaining and improving food sources and living environment for the fauna of the hill.

### 1.6. Romania

**Soil Characteristics:** The area of the region involved in the project (Arges Vedea-watersheds) has a very strong variability of soils in accordance with complex orography. In the central part of the region the most representative soils are chernozem, which is characterized, from the textural point of view, by the prevalence of clay, while along the plain of the Danube sandy texture soils are more frequent.

**Agricultural land use:** 50% of the total area of the region is destined to the cultivation of grains and horticultural crops, 10 to pasture, and 3% to meadow. Orchards and vineyards are really important (23,000 and 13,000 hectares) but the percentage does not represent more than 1,5% and 1% of the area.

**Tillage:** In the TA, plowing is frequently made with reversible plows bearing up to 4-5 mould-boards working 20-30 cm deep. Since the plows are not mould-boards equipped, crop residues (corn stalks) can be found on the soil surface. Burning of crop residues (corn stalks) is not widely practiced and, in any case, is subject to prior authorization. After plowing the “seed bed preparation” is made using disc harrows, aging teeth harrows, seldom rotary harrows and chisels combined with rollers for minimum tillage. Despite good soil refinement, sometimes
(like in autumn 2011) the crop emergency (wheat, rape) is very dissimilar due to both drought and moisture contents of the uneven surface of terrain. It is reported that the land is also managed by contractors who are paid about 50 €/Ha for plowing. This cost may be less if the farm provides the fuel. A state benefit (not-EU) on the fuel cost exists and it is about 1 Leu / liter of diesel up to a maximum of 40 l/ha, which means 9-10 €/Ha (1 Leu = about 23 cents €).

**Fertilization:** Since 1990 in the TA, but probably all over Romania, there are two farm realities: small farms (30-50% of farms have a maximum area of 3.5 hectares) with limited use of technical means including fertilizers, and large farms with the possibility of using large quantities. There is some form of land rent to reach larger farm size, approximately 100 hectares, and a very consistent percentage of land has been abandoned. In smaller farms the average amount of nitrogen spread per hectare does not exceed 60 units, in large farms it may exceed 200 units. Below an extract of fertilization practiced in large farms is reported along with the corresponding agricultural yields: **wheat:** 250 kg/Ha of complex fertilizer (20:20:0) + 200 kg/Ha ammonium nitrate + 4 kg/Ha foliar fertilizer; yields ranging from 4000 ÷ 6000 kg/Ha; **sunflower:** 250 kg/Ha of complex fertilizer (20:20:0) + 100 kg/Ha ammonium nitrate; yields ranging from 1700 ÷ 3000 kg/Ha; **corn:** 250 kg/Ha of complex fertilizer (20:20:0) + 200 kg/Ha ammonium nitrate + 4 kg/Ha foliar fertilizer; yields ranging from 4200 kg/Ha dry crop; 10000 kg/Ha under irrigation.

Some costs of fertilizers are summarized as follows: complex fertilizer (20:20:0): 500-600 €/Ton equal to a cost/Ha of 125-150 €/Ha, ammonium nitrate: 350 €/Ton equal to a cost/Ha of 70 €/Ha, foliar fertilizer (Nutrisol N=20%): 10 €/Kg equal to a cost/Ha of 40 €/Ha.

Finally a cost for spreading granular fertilizer of about 6 €/Ha is reported.

**Irrigation:** The increase in yield as a result of irrigation is reliable and demonstrated but the infrastructure is Soviet and today Irrigation Consortia, which manages it, wants the irrigation request to come from at least 20% of the farmers operating in each district. This results into restrictions in its effective application. The cost of irrigation is about 1200 Lei per 1000 cubic meters corresponding to 300 € for 1000 m$^3$ (0,3 €/m$^3$ or 3 €/mm). Generally wheat is not irrigated, corn receives from two irrigations for a total of 1200 m$^3$ up to 3 irrigation rounds with 1800 m$^3$/hectare in areas of sandy soils. In the southern part of the TA, there are pumping stations that derive water from the Danube (through water pipelines located in flood plains between the station itself and the river bed). Those stations drain and pump water that feeds the related water networks district.

**More information:** About the application of ND, ICPA is the national focal point for monitoring soil and crop in Nitrate Vulnerable Zones Aspects (NVZ). ICPA Developed the Code for Good Practice in Agriculture NVZ and the Code for Good Farming Practices. In several partner documents it is highlighted that the main source of risk of nitrate pollution of groundwater is represented by livestock effluents although there are not large breeding farms. There are small breeding farms, often close to villages, ranging between all species of livestock. In these cases there are not suitable storages for livestock effluents. A density calculations of how many animals can graze on pasture does not exist.
1.7 Serbia

Soil Characteristics: In the Pancevo area predominant soil (over 60%) is the chernozem, or “blacks soils”, characterized by humic and very fertile layer.

Agricultural land use: 50% of agricultural land is destined to maize, 13% to wheat and 13% to sunflower. Cultivation of sugar beet (3% of agricultural land) and vegetables (4%) have limited area.

Tillage: The use of minimum tillage involves at least 70% of the wheat cultivated area, while autumn plowing is the common technique for the spring sowing crops. Autumn process is common on all crops and this is dedicated also for burying the fertilizer distributed. Fertilization: Use of manure is very limited due to its scarce availability (few livestocks in the area). It is usually used by the farms that grow horticultural crops or before the planting of new orchards. Regarding the fertilization with chemical fertilizers it is common practice to anticipate significant quantities (60-80 units / ha) of nitrogen, usually by distributing complex fertilizer in fall during the preparation of the soil. This also occurs on spring sowing crops (corn, sunflower, sugar beet). The total quantities of nitrogen distributed on each crop are substantially comparable with the maximum quantity allowed by the Nitrates Directive (in the case of corn it does not exceed 200 units / ha). To underline that: the fertilization is quantified as a result of both soil analysis and interpretation by the technicians of the "Tamis" Institute in Pancevo; very high production can be achieved (up to 7 ton. of wheat and up to 10 ton. of maize) even using very limited amounts of fertilizer and without using the irrigation due to high "natural" fertility of the soils, the “chernozem”, which characterize all the plain of Vojvodina, from Belgrade to Hungary.

Irrigation: Despite the potential high availability of water, the irrigation is sporadically applied to very limited areas due to the scarcity of derivation facilities and the low income of most of the farms that prevents them from investing in irrigation systems.

More information: Code of Good Agricultural Practices is missing but the Institute "Tamis" is currently working to the diffusion of a "rational" cultivation system. With regard to potential pollution risks from nitrates it should be noted that: the quantities of nitrogen normally used are within the maximum limits allowed, for example, by the Nitrates Action Plans in Italy; the use of livestock effluents is extremely limited.

1.8. Ukraine

Soil Characteristics: The Odessa region is strongly characterized by the predominance of chernozem soils (blacks soils), extremely fertile, derived from vegetal stabilized deposits. Black soils have organic matter content that in the northern region reaches values above 6% and decreases down to the south due to drier climate conditions. From the textural point of view, these soils are characterized by the predominance of the finer component (from silt-clay to clay) although there are soils with also high percentage of sand. In general the soils of this
region are subjected to intense wind erosion.

**Agricultural land use:** 72% of land is mainly cultivated to grains (corn, wheat, barley, rice, sunflower) and horticultural crops. 15% is designated to pastures and meadows. 9% is covered with forests and 4% is orchard and vineyard.

**Tillage:** Not available.

**Fertilization:** Not available.

**Irrigation:** The economic difficulties of the last two decades have resulted in decrease in irrigated agricultural land, which, however, are mainly located in the southern region, where the climate is drier. Sprinkling irrigation is used but in many farms is still adopted the flood irrigation system.

**More information:** No mention is made to any Code of Good Agricultural Practices. The Partner refers to several situations of strong and diffuse nitrates pollution of groundwater due to the use of fertilizers agriculture (both because of their use and because of inappropriate storage locations and / or not suitable structures), nitrates of breeding farms, and solid waste landfills.

Considerations on Pilot Action: each partner completes this paragraph.

2. Common strategies to reduce water consumption and nitrate pollution

Starting from the prescriptions contained in some Codes of Good Agricultural Practice (mainly the Italian one) and the experiences coming from the Nitrate Project carried out in the province of Ferrara since 2007, it can be said that there are some agronomic choices that have a direct impact on the degree of risk of water pollution by nitrates from agricultural sources.

The most critical cultivation phases are: **crop rotations, tillage, nitrogen fertilization, cover crops, irrigation.**

2.1 **Crop rotations**

The crop rotation in the partner countries does not seem a critical factor in water pollution. The range of crops generally investigated and their seasonality seem to agree with this thesis. However, the crop rotation should be finalized to avoid mono-successions or succession of spring-summer crops that leave the soil devoid of vegetation cover during autumn and winter months when, due to the more abundant rains than in other periods of the year, it is reasonable to expect more intense phenomena of leaching of nitrogen present in the soil.

The possible landfill of residues of the previous crop is directly connected both to the type of crop rotation and the type of soil tillage. The landfill of cereal straw and other similar residues (i.e. stalks of maize, stems of rape, etc.) with low nitrogen content, as a result of degradation and humification processes occurring in these materials, determines a nitrogen removal from the soil solution. The nitrogen is then used by microorganisms that drive these processes and it is subtracted from
any leaching processes.

2.2 Tillage

The application of plowing is common, but in many cases the minimum tillage is made: for instance in drought climate patterns, loose textures or in preparation of the soil for the sowing of autumn-winter cereals.

The use of specific equipment for minimum tillage has been noted in several countries (PHOTO). Generally, the tillage has to take into account the priorities in order to be properly pursued. In general, a not-processed soil or a soil subjected to minimum tillage is characterized by a slower mineralization of organic matter and preserves, if properly structured, an abundant microporosity that ensures a more dynamic equilibrium of the water contained in it. Both factors play a positive action towards the reduction of nitrate leaching from soil to groundwater. Moreover, without vegetation cover the no-tillage favors the phenomena of surface runoff, which increases with the slope of the soil. Therefore, it would be appropriate to limit the traditional land preparation processes (especially plowing) to those situations of real need such as landfill of solid manures, such as need to re-establish a proper structure in difficult terrain, such as burying plant residues which are potential sources of pathogens (for example the Fusarium of wheat). Where slope is more than 30%, the most recent Italian action plans allow a maximum distribution of 50 kg N/ha and, if applied, a maximum of 35 tons/ha of livestock manure. If the slope concerns superficial water bodies, transverse bands of crops have to be seeded or other measures to reduce run-off of fertilizers have to be taken. Finally, the protection of water bodies is completed by buffer zones of at least 20 m, with crops planted across the slope (in this context the sowing are allowed in no-processed soil) with vegetation cover during the winter (Art. 5 PA 1150 / 11).

2.3 Fertilizers and fertilization techniques

With regard to the role played by the type of fertilizer used, the pilot action of the Province of Ferrara has shown that more or less stabilized organic matrices limit the risk of nitrate pollution thanks to the following two features: 1) the nitrogen contained in the matrices is gradually released into the environment and it responds better than synthetic fertilizers to the nutritional requirements of crops and, consequently, to their capacity to absorb nitrogen present in the soil; 2) the excess of nitrate nitrogen is reduced or canceled in the presence of high amounts of organic matter (especially in conditions of low oxygen).

The pilot action of the Province of Rovigo also has demonstrated that through the subsurface distribution of cattle sewage on corn it is possible to obtain crop yields very similar to those obtained with the chemical fertilization. With the added advantage that the "source" of the same nitrate (the manure) is applied to the soil when the root systems, in active absorption, provide the best possible retention.

With regard to synthetic nitrogen fertilizers, should be noted that they are often used among Partners without strict relation to their readiness: nitrate is much more "ready" for root absorption than ammonium nitrate than urea; so it is important to underline that in fertilization plans must be considered both the intrinsic characteristics of the fertilizer both the moment of its distribution which is directly related to its potential leaching: the more the distribution is done ahead of time
when the plant starts to absorb the nitrogen present in the soil, the greater the risk that this nitrogen can be transported to the level of groundwater.

In this context, the pre-plant fertilization (occurring before sowing) with nitrogen fertilizers should be limited as much as possible or should be avoided specially with nitrate-based fertilizers.

Finally, it highlights the need to evenly distribute the fertilizer, whether organic or chemical, on the whole cultivated area respecting the existing water bodies and keeping a proper distance from them.

The only exception may be the localized fertilization between the rows which, then, will be carried out at lower doses than those generally applied to the entire surface. In all cases, it is required to draw appropriate fertilization plans that consider at least the following aspects:

\[
\text{needs } N = \text{crop needs} - (\text{natural supplies of } N) + (\text{fixed assets and losses of } N)
\]

### 2.4 Irrigation

The role of irrigation is fundamental in determining the dynamics of nitrogen in the soil. The distribution of high volume of water can quickly determine the drag of nitrate from the upper layers to the aquifers, as a result of vertical movements, and to surface water, due to movements in the horizontal direction. The water distribution method is a top priority for a rational use and for achieving three objectives: to give water to plants based on their real needs, to maintain the water content of the soil under field capacity avoiding leaching and to preserve the overall water availability. The achievement of these objectives may be in conflict with requirements of some agronomical techniques, such as for example, the defense of the grasslands from frost in some livestock districts, or pedological features, such as the efficacy and relative easiness of application of lateral infiltration for irrigation in sandy soils. Apart from the exceptions, wherever there was a possibility it would be desirable:

- the use of predictive methods (water balance) which, considering the crop phases, soil and climatic conditions, advise the farmer about the most appropriate timing and amounts of water; the implementation of an irrigation service, possibly via Web, would manage the water balance on the scientific basis by spreading the costs of a wide range of users;
- where the service already exists (Italy), it would be useful to promote the use of small farm weather stations to correctly detect climate data at farm scale and correctly plan the moments and the volumes of irrigation; possibly, the weather station should be supplemented with the use of piezometers with a manual / digital reading for monitoring the subsurface aquifer; the use of detectors of the nitrate content in the soil would complement the information to set and better manage irrigation taking into account the needs of crops and reducing the nitrogen washout to a minimum;
- use of irrigation facilities able to achieve the highest degree of efficiency in relation to the adopted method of distribution; moreover a good irrigation practice has to pursue a high distribution efficiency which is strictly related to irrigation methods; the parameters that have to be considered to choose the best irrigation method are: soil texture, soil chemical characteristics, slope, crop needs, water
quantity and quality, environmental characteristics;

- abandonment of techniques and equipment to determine wastage of water resources or, if it is not possible, adoption of some important measures: for example, flood irrigation should be allowed only in deep soils, mainly clay soils, for crops with deep roots that require frequent irrigations. Moreover, when furrow irrigation is adopted the farmer has to be aware that the risk of nitrate percolation decreases: from the beginning of the furrow to the end, from sandy soils to clay soils, from shallow soils to deep soils, from superficial root crops to deep root crops, in very clay soils. In addition, long irrigation rounds are not advised because they can facilitate the formation of cracks and great losses of water and nutrients (becoming pollutants). In case of rain (sprinkler) irrigation, a very strict control has to be put on how to distribute sprinkler on the field, on rain intensity related to soil permeability, considering wind effect on sprinklers distribution diagram, to the effect of the crop on water soil distribution. In case of drip irrigation with fertilizers, the fertilizer injection has to be done not right at the beginning of the irrigation but only after having distributed at least 20-25% of the planned water amount; in the meantime it has to be considered that the fertilizer application must end when reaching the 80-90% of the planned water amount.

2.5 Cover crops

The risk of runoff also exists for the residual amounts of nitrogen present in the soil after harvest. In this case the “catch crops” could play a positive role, especially when, as in the case of wheat cultivated land, there is a real possibility that the soil remains uncultivated until the following spring.

3 Conclusions

Once having evidenced common characteristics among PP is not easy and therefore the search for common strategies has in itself the risk of defining very general techniques or procedures with limited or absent impact on the major aims of the project EU-Water, which are water saving and restraining nitrate pollution from agricultural sources.

With this premise, the first conclusions of the work done are summarized based on three phases:

- **Knowledge (technical and technology):** regarding all processes and experiences developed within the project EUW; they have identified critical points and provided possible solutions;

- **Policies:** once the most stringent problems and related solutions are identified, each partner can act at local/regional/national level on the existing policies to better adapt them to the EUW results;

- **Incentives:** the technical solutions provided in the first point, supported by the policy makers by adequate legislative measures, must be supported by appropriate financial incentives of local/regional/national and, above all, European origin like the Rural Development Plan.
3.1 Knowledge (technical and technology)

3.1.1 Vulnerability maps

The vulnerability maps drawn up by all PPs for their own Target Areas have allowed to divide the study territory in further and more significant gradients of vulnerability. The flat and sometimes insignificant limit of 170 kg/Ha of nitrogen applicable in Vulnerable Zones can be overcome permitting differentiated amount of application of nitrogen. Where maps show some areas with relative lower vulnerability, than some other areas, in the previous areas it will be asked to apply more than 170 kg/ha of nitrogen. On the opposite, in the areas of higher vulnerability, the limit of 170 kg/ha could be even decreased or just respected only if some techniques of leaching reduction (like sidedressing of sewage in corn) are put in place.

3.1.2 Partners’ Pilot actions

The pilot actions drawn up by EUW PPs are summarized as follows:

**Ferrara**: the leaching of nitrates in soils fertilized with manure (especially chicken manure) is lower than the one occurring in the same soil without organic fertilization. So fertilization with manure, especially in light soils, is useful to decrease nitrate pollution;

**Rovigo**: a prototype of coulter has been developed to localize cattle slurry between rows of corn (corn sidedressing), and agronomic trials were carried out showing that crop yields are quite comparable to chemical fertilization that brings the same amount of nitrogen;

**Hungary**: the fertilization, in particular organic, is always preceded by appropriate fertilization plans, here simulated in a DSS created both for vulnerable and non-vulnerable areas;

**Greece**: irrigation is led by a DSS that allows saving or at least has a greater efficiency of irrigation water also including considerations on leaching of nutrients towards the subsurface aquifer;

**Romania**: the Green Book will be used to summarize practical information and financial and technical incentives for environmentally friendly agriculture.

3.1.3 Agronomic Considerations

Examining the results of the pilot actions and considering the different agricultural realities of project Partners, it can be concluded that:

- the use of livestock manure properly matured and stored in appropriate containers is a resource that cannot and should not be dispersed, for several reasons:
  - it allows better capturing function of soil towards nitrates inducing minor leaching losses,
  - liquid cattle effluents (slurry), especially in corn sidedressing applications, show runoff and leaching almost close to zero, considering not only the absorption capacity of soil organic molecules but also plant uptake,
  - it permits a cost savings for the farmer;
- the use of chemical fertilizer must be made by considering not only the needs of the crop but also the intrinsic characteristics of the fertilizer, in particular the
speed of his transformations in the soil, in order to limit the amount of nitrate therein contained and subjected to leaching;

- the techniques and means of distribution play an important role in enabling a uniform distribution of fertilizer (organic or chemical) that will be applied to the soil/crop with adequate separation bands from surface water bodies;
- the distribution must be restricted or prohibited on soils saturated with water, ice, snow, before significant rainfall events, in the absence of cover crops;
- in certain situations, see the European authorization to Italy to raise the amount of nitrogen from 170 to 250 kg per hectare, the removal of the residues of the main crop (corn) is recommended;
- the use of fertilizer plans is a prerequisite needed to best calibrate the inputs of fertilizers in relation both to the needs of the crops and the pedo-climatic characteristics of the area;
- given the significant variability in the manure and slurry depending on storage time, animal diet, temperature and rainfall, etc., chemical analysis of livestock effluent are required at least once per year before land application;
- a common Partner procedure is required both during the sampling of the effluent mass and in the chemical analysis in order to have comparable data;
- for the same concepts of efficiency and greater respect of the environment, the use of water balance is a prerequisite if it is not existing already; where an irrigation service already operates, it is essential to replace the large-scale weather data with the farm scale data using farm weather stations that can be furthermore integrated with piezometers to monitor the water table level, which is often a not investigated variable in water balances;
- the use of instruments that detect the content of nitrate in the soil and that, coupled to the abovementioned instruments, can provide an additional element of assessment of actual nitrate concentration in the preparation of the water balance;
- some more useful devices could be remote control of irrigation equipments including anemometers that can stop the machine in case of wind drift; finally the apparatus for fertigation could complete the best use of irrigating equipment keeping strong attention to nitrogen problems.

3.2 Policies and related future actions

Once each Partner has focused on the major issues in the context of nitrate pollution from agriculture and irrigation management, with scientific data in its own possession and with operative proposals listed above, each Partner can act on local/regional/national policy makers to propose the necessary adjustments that must be understood not as a rejection of existing rules, but as a specific further scientific implementation.

In this sense, it might be useful to allow each administrative area (province, for example) to be more flexible about the limit of 170 kg/Ha of nitrogen.

This will be possible according to the knowledge acquired in the preparatory phase of EUW project dealing with techniques and procedures.
3.3 Incentives

Talking about incentives it is necessary to distinguish between Partner already members of the European Union and partner non-members yet. For the former it will be possible to allow the inclusion of a number of initiatives developed by EU-Water (corn sidedressing of the effluent, water balance management, construction of farm weather stations with dedicated software) into the Rural Development Plans especially in the next implementation period (2014-2021). In the meantime, it is possible to test large-scale validity of EUW postulates. For the other Partners it would be possible to indicate the specific sources of funding already available by the European Union or indicate hypothesis regarding new ones. Following this approach it will be possible not only to increase the spreading of techniques and technologies more environmental friendly but also, with the controls that follow the European funding, to monitor the exact extent of their application.
Chapter 5: Prioritization of methods/practices and development of the final TSIWMA as a guide of good practices to be further tailored for each area/country

Introduction

The aim of the current chapter is to compile the results of the two previous Chapters in a guide of good practices on water use and fertilization, giving specific suggestions to the farmers, and providing practical guidance to the partners for the adaptation of the TSIWMA into the local adaptation plans.

1. Total strategy plan for the SEE countries

EUWATER project has identified and developed a total common strategy that will lead to water scarcity deterioration and water quality conservation. This strategy is summarized in this chapter to become more comprehensible and widely applicable.

1.1 Common strategy for the integrated irrigation and fertilization management

In the framework of EUWATER project a common methodology was developed for all partners areas to assess the vulnerability of each area and propose specific management methods and tools to lead in water resource saving and prevention of water pollution from nitrates due to agriculture.

The total procedure is described in the following flowchart (Fig. 26). As shown in the flowchart, the first step for the procedure is the data collection. The information and data needed for the procedure are:

- Elevation
- Climate
- Soil characteristics
- Hydrogeology
- Land uses
- Crops data

After being collected, the data are processed to lead to the models that will be used to assess the vulnerability of the area being studied which is concentrated in several maps containing all the vital information. These maps are:

- Digital boundaries
- Digital data for land uses
- Digital elevation model (altitude above sea level, surface slope %)
- Digital soil type classes
- Digital data for agricultural field-sectors
- Digital data of surface waters (lakes, rivers etc.)
- Digital data for groundwater (waterwells, acquifers, drillings, depth of groundwater table below ground surface)
- Digital data for protected areas
- Digital climatic data (annual rainfall, annual mean temperature, annual potential evapotranspiration)
• Point pollution sources

All the above-mentioned digital models were used to calculate the vulnerability using the LOS indices and Relative Transit Time (TT), to export vulnerability maps which are the final output of the vulnerability assessment providing vital spatial information on which areas are more vulnerable to nitrates pollution and water leaching. The indices that were calculated and provided the vulnerable maps are:

- **LOS\text{-}P**: are the annual losses due to deep percolation beneath the root zone of the 30 cm (mm year\(^{-1}\))
- **LOS\text{-}R**: are the annual losses due to surface runoff (mm year\(^{-1}\))
- **LOSN\text{-}PN**: are the annual nitrogen losses due to deep percolation beneath the root zone of the 30 cm (kg ha\(^{-1}\) year\(^{-1}\))
- **LOSN\text{-}RN**: are the annual nitrogen losses due to surface runoff (kg ha\(^{-1}\) year\(^{-1}\))
- The sum of total losses of water and nitrogen are given by the following:
  \[
  (\text{LOS\text{-}PR}) = (\text{LOS\text{-}P}) + (\text{LOS\text{-}R})
  \]
  \[
  (\text{LOSN\text{-}PRN}) = (\text{LOSN\text{-}PN}) + (\text{LOSN\text{-}RN})
  \]
- **Relative Transit Time (TT)**: is the minimum relative transit time of losses from the soil surface to reach the groundwater table (days)

The results provide important information, with the vulnerability map suitable for use by local authorities and decision makers responsible for groundwater resource management and protection zoning. Vulnerability and sensitivity maps could be used for planning, policy, management and contamination assessment.

Further elaboration of the data can be performed to develop a Decision Support System (DSS) which will support the farmers and the decision makers on optimization of irrigation and fertilization, leading to a more sustainable and friendly to the environment agriculture.

Apart from the technical oriented tasks, the application of policy decisions in the areas must be reviewed. These tools are:
- The Codes of Good Agricultural Practices
- The traditional practices
- The Water Framework Directive
- The Nitrates Directive

Therefore a review and analysis of the situation in each partner’s area was performed on the policy and technical tasks. Additionally a detailed literature review was presented in an effort to identify new efficient technologies and international practices.
Figure 26. General flowchart of the common strategy for irrigation and fertilization management.

All the above information was analyzed to end up to the strategy actions which are divided in two main categories:

The common actions which can be adopted from all the partners
Individual actions adapted according to each partners area's situation and needs
2. Common actions which can be adopted from all the partners

In the EUWATER project two main priorities were followed:
- Water resource saving
- Prevention of water pollution from nitrates of agricultural origin

2.1 Common actions for water resource saving

The reduction of water consumption in agriculture is a crucial issue. The following measures and recommendations are proposed for sustainable water management in the SEE agricultural areas:

Technical aspects:

Soil management
- Enforcing a minimum tillage system to cut water losses from the soil. Avoid deep tillage below 40 cm. Where deep tillage is needed, the soil should not be reversed.
- Performing combined mechanical tillage (combo system) to be able to preserve soil moisture content.
- Performing specialized tillage, able to preserve moisture and block water losing from the soil (compartmented and continuous furrows, chisel and para-plough works that do not turn the soil furrows, etc.).
- Adopting agricultural techniques that achieve a protection of the soil in terms of preventing its settlement, the degradation of its structure and performing an efficient erosion control for the case of sloped and arable terrains.
- On slopping land plowing must be performed towards the contours to limit water run-off and soil erosion. Where there is flooding risk tillage should be done in a way that ensures field leveling using reversible plows.

Irrigation
- Water-saving techniques such as spray irrigation and drip irrigation should be preferred in order to decrease the groundwater quantities used for agriculture.
- New more efficient irrigation systems and management tactics (subsurface drip irrigation, variable rate irrigation, deficit irrigation, sensor irrigation etc.) should be tested and enhanced to be used.
- The use of simulation models and irrigation programming software must be introduced and applied on farm level by the farmers or the region (developing agencies to manage irrigation according to real needs on local level).
- Enhance/provide incentives to farmers to introduce meteorological stations and perform soil monitoring to efficiently calculate the real irrigation needs. This may be performed on regional level supported by each region.
- Developing a decision support system (DSS) providing valuable management decisions to the farmers.
- Applying micro-spray irrigation by means of mechanized installations, fitted with low pressure water spraying devices that apply water close to the soil surface.
- Do not irrigate during the 11:00 – 15:00 interval due to high solar radiation (high evapotranspiration from soil surface).
- Keep the irrigation network and the equipment in good condition in order to maintain the maximum efficiency. Frequent inspections should be performed for possible leaks or damages and for evaluation of the general performance. Replace irrigation systems with more efficient and less water demanding ones, repair or upgrade the existing irrigation systems and substitute the old irrigation machinery with new more efficient
- Utilization of the treated wastewater for irrigation purposes in order to decrease the groundwater abstraction. The use of reclaimed or recycled waste water for various non-potable uses has proved to be the most reliable of sources, like in most South East Europe (SEE) countries.
- Construction of small interception dams in the main torrents of the hilly region, aiming at the retardation of wintertime torrential flows and the increasing of the groundwater recharge. In addition, these dams would improve the water supplies for the agriculture requirements.
- Construction of water reservoirs and tanks to collect the rain water. This will reduce rainwater surface runoff, leaching and percolation and will provide water resources.

Crop management
- Selecting crop varieties that are able to make good use of the area’s climate potential and applying the crop rotation practice.
- The field should not be left bare during the winter when it is more vulnerable to erosion due to rain. In light soils it should be covered with vegetation during winter. Crop rotation is a good practice to achieve that. Also soil cover using different materials is capable of blocking water evaporation. The crop residues can offer protection from erosion and enrich the soil with organic matter by covering the soil with the remains.
- Integrated weed, pest and disease control must be performed by employing prophylactic means (soil’s solarization) as well as biological and mechanical means.

Policy aspects:
- Training courses should be organized in order to educate people in using methods to optimize water use.
- Reduction of groundwater abstraction should be applied in the areas that are affected by aquifer depletion.
- The low price of water, results in people not saving water; thus, effective measures must be taken to prevent the unconsiderable use of water, e.g. incentives for efficient water use.

2.2 Common actions for nitrates pollution deterioration
The most important measures to prevent nitrates pollution on fertilized agricultural land are as follows:
Technical aspects:

**Soil management**

- Prevention of physical degradation of soils (through processes such as destructuring, compaction, formation of hard-pan, erosion by water and by wind, performance of ploughing towards slope on sloping land, etc.) and also avoidance of poor management of agricultural land and irrational exploitation of forests.
- Avoiding excessive utilization of fertilizers, pesticides, especially on treated soils which are loose through numerous tillage works; the performance of tillage and soil treatment works must be performed in the right period.

**Fertilization**

- Applying rational fertilization which employs reduced amounts of fertilizers, applied in small doses (‘with the teaspoonful’ – fertigation).
- Enhance the adoption of fertigation method applied in accordance with the crop requirements.
- Using new efficient fertilization systems facilitated with sensors, or upgrading the existing ones.
- Selecting the water application timing so that crop plants suffer a slight water deficit (water in the soil at minimum limit value), making the applied water to be consumed intensively to prevent deep infiltration and surface runoff.
- The pre-plant fertilization (occurring before sowing) with nitrogen fertilizers should be limited as much as possible or should be avoided specially with nitrate-based fertilizers.
- Evenly distribute the fertilizer, whether it is organic or chemical. The use of new more efficient fertilizer distributors is essential.
- Draw appropriate fertilization plans that consider at least the following aspects:

  \[
  \text{needs } N = \text{crop needs} - \left(\text{natural supplies of N}\right) + \left(\text{fixed assets and losses of N}\right)
  \]

**Irrigation (prevent nitrate losses)**

- Adopting irrigation method that matches the soil’s physical characteristics and the terrain’s topography and is simultaneously compatible with the quality and quantity of available water and with the relevant crop’s requirements and local climate conditions.
- Furrow irrigation is forbidden on highly pervious soils, the recommended method is localized irrigation (drip or micro-spray irrigation).
- On fine to medium textured soils which show low infiltration rate and high water capacity different irrigation methods must be employed, correlated to the physical features of such soils and the crop specifications.
- Applying irrigation water by achieving high uniformity coefficients (80-90%), for the purpose of avoiding waterlogged or surface run-off spots.
- Avoiding irrigating using water that does not meet quality requirements (high content of nitrates or/and heavy metals), with high water application rates and on land situated in the proximity of watercourses; In situations like this a good
practice would be to replace the irrigated crop with non irrigated or less demanding until the water quality is restored.

**Crop management**

- Achieving crop plants with very well developed root systems, capable of exploring a significant volume of soil and thus easily extracting water and nutrients.
- The use of cover crops and crop rotation systems reduces the risk of runoff.

**Policy aspects:**

- Training courses should be organized in order to educate people in using methods to optimize fertilization.
- Extension of urban planning process by implementing water supply and sewerage infrastructure works, including water treatment stations equipped for at least two treatment stages (the mechanical and the biological one).
- Enforcing provisions of the Romanian and European legislation on reduction of nitrates pollution from agricultural and other sources.
- Application of the code of good agricultural practice especially in areas affected by nitrate pollution.
- Planning of surface water protection measures, such as domestic effluent disposal in torrents, as well as construction of proper landfills, which are environmentally compatible.
- Allow each administrative area (province, for example) to be more flexible about the limit of 170 kg/Ha of nitrogen.

### 2.3 Economical Tools to support the implementation of the actions

In order to enhance the farmers to adopt the abovementioned actions economical motivation in the form of subsidies should be determined by the local policy makers and stakeholders in each area.

More specifically the funding for the substitution of the old inefficient systems with new ones, the determination of subsidies for the farmers to obtain new technologically advanced tools to assist in irrigation scheduling such as meteorological stations, soil sensors and tensiometers, the determination of subsidies for the farmers to obtain new technologically advanced tools to assist in efficient fertilization.

Talking about incentives it is necessary to distinguish between Partner already members of the European Union and partner non-members yet. For the former it will be possible to allow the inclusion of a number of initiatives developed by EU-Water (corn sidedressing of the effluent, water balance management, construction of farm weather stations with dedicated software, application of DSS) into the Rural Development Plans especially in the next implementation period (2014-2021). In the meantime, it is possible to test large-scale validity of EUW postulates. For the other Partners it would be possible to indicate the specific sources of funding already available by the European Union or indicate hypothesis regarding new ones. Following this approach it will be possible not only to increase the spreading of techniques and technologies more environmental friendly but also, with the controls that follow the European funding, to monitor the exact extent of their application.
Additionally the farmers should be informed about the economical benefits they will have if applying these actions. According to the research results in many areas overirrigation and overfertilization using excessive irrigation water and fertilizers are applied. Therefore application of the proposed actions which will lead to maximization of irrigation and fertilization efficiency will reveal economical benefits to the farmers due to the reduction of the inputs (fertilizers, agrochemicals and irrigation costs).

3. Individual actions adapted according to each partners areas needs

Apart from the common actions that can be applied in all the partners’ areas according to the analysis of the situation there are additional individual actions or some of the common actions are more essential according to each partners areas needs and specifications.

3.1 Individual actions for water resource saving and fertilizer management in Italy

Both Rovigo and Ferrara are focusing on water balance improvement by monitoring meteorological and soil attribute and using pivot irrigation systems and lateral moves. On fertilization management, a very important task is the efficient use of manure to fertilize the fields.

3.2 Individual actions for water resource saving and fertilizer management in Greece

The DSS has already been developed and is being applied for Sarigkiol basin in the context of the EU WATER project in WP5 (pilot actions). According to preliminary results, it provides support to the farmers on production planning and water and fertilization management. The DSS will be free to use from the farmers via the EUWATER website. The DSS can potentially be used by any other region / area that can provide the necessary information for production planning and water/fertilization management.

For the Region of Western Macedonia, the most important issues proved to be the clear understanding and the improvement of water balance on the regional level as well as the improvement of irrigation and fertilization efficiency on the farm level.

In relation to the improvement of the water balance in the regional level, a study was conducted to record water drillings in the Sarigkiol area, and to monitor water flows. Planning for the continuation of the study at the regional level also took place, so that the Regional Authority acquires the necessary information to manage water balance on the regional level.

In relation to the farm level, assistance from the local agronomists was found to be especially important. This is because of the small size of individual farms in the region which does not allow individual small farmers to have a good understanding of the general conditions in the area. Hence, EU WATER actions will focus on training the local agronomists in relation to the results of the project, aiming at having agronomists supporting the farmers afterwards. Nevertheless, material for the
support of farmers will also be produced, containing simplified and shorter guidelines, and focusing on production planning issues.

3.3 Individual actions for water resource saving and fertilizer management in Ukraine

Improvement of water balance, in the case of Ukraine using data from meteorological and soil monitoring (especially in big farms) is important management issue.

3.4 Individual actions for water resource saving and fertilizer management in Croatia

Improvement of water balance, in the case of Croatia, performed and released by the Region, using data from meteorological and soil monitoring (especially in big farms) is important management issue. Additionally implementation of water caption and distribution network improvement is vital.

3.5 Individual actions for water resource saving and fertilizer management in Hungary

In Hungary as stated, better use of natural/rain water resources might be the key to a more sustainable agriculture.

Land preparation to favor retention at farm level and substitution of old machineries for sprinkler irrigation replaced by new ones (which are more efficient in water saving and energy saving solutions)

In orchards and fruit crops micro irrigation should be enhanced for using multipurpose irrigation (not only for water supply, but also for frost protection, colorization, as for apples, and conditioning).

Also, new fish ponds techniques need to perform for water saving.

3.6 Individual actions for water resource saving and fertilizer management in Serbia

Improvement of water balance, in the case of Serbia, performed and released by the Region, using data from meteorological and soil monitoring (especially in big farms) is important management issue. Additionally implementation of water caption and distribution network improvement is vital.

3.7 Individual actions for water resource saving and fertilizer management in Romania

In terms of measures aimed to ensure water saving, in Romania it is essential to perform rehabilitation/modernization of the irrigation water supply system (rehabilitation of supply channels and refurbishment of pumping stations serving those irrigation schemes situated within economically viable areas) and also to find those practical solutions capable of encouraging farmers (especially those committed to cultivating high value crops) to use locally adapted irrigating methods, employing mechanized (towed by tractor) sprinkler irrigation installations that are fitted with low pressure water spraying devices and to make use of any available
source of irrigation water (small existing reservoirs/ponds/rivers), thus eliminating long distribution canals and costly lift (re-lift) pumping stations.

Another solution is the use of furrow-diking techniques to store water accumulated from precipitations. In this respect priorities should also include:

- Adequate meteorological monitoring at regional level;
- Systematic checking of the soil moisture content (by gravimetric or other types of methods);
- Application of a system of tillage practices that are able to ensure conservation of water from precipitations.

Concerning the improvement of fertilizers’ management activities, priorities lie in the range of:

- Wherever possible, liquid animal wastes from neighboring livestock farms should be used to fertilize the appropriate crops;
- The already commenced program of constructing organic fertilizers’ storage platforms/tanks at commune/locality level should continue;
- The technologies for storage, treatment and application of animal wastes for crop fertilization purposes should be correctly employed, in accordance with provisions of the Code of Good Agricultural Practices (CGAP);
- The use of fertigation should be widely promoted among farmers;
- Farmers which apply provisions of the CGAP should be encouraged through a system of economic incentives;
- Monitoring of the numbers/species of livestock inside small and large agricultural exploitations;
- One should check how/if the provisions of the CGAP on fertilizers’ field application are observed;
- Any surplus of animal wastes which are not used for fertilization purposes inside the farm where they have been generated, should be made available for sending to another farm and this process has to be monitored;
- One has to check whether the fertilization plan is in place for each agricultural exploitation encompassing at least 10 ha and if each farm with at least 8 A.U livestock equivalent keeps a nutrients’ log (records);
- Nutrients’ monitoring has to be carried out in terms of pressure per hectare of agricultural land and pressure per hectare of pasture land;
- Nutrients’ monitoring has to be performed also in terms of pressure per hectare of agricultural land situated within buffer zones.

3.8 Individual actions for water resource saving and fertilizer management in Hungary and Moldova

In Moldova, management and reuse of sewage from households in agricultural areas was stated to be priority. The utilization of drip irrigation systems using the ideal irrigation scheduling (irrigation timing, water inputs etc.) is expected to improve the overall situation.

All the above solutions should be implemented as suggestions to the farmers and the local authorities responsible. All the involved parts have to be aware about
the economical and ecological benefits from the adoption of the implementation of the strategy and therefore be persuaded to adopt it.

Therefore seminars and schools need to take place in order to inform and train all the involved parts. In the framework of EUWATER project, several Local Implementation Networks (LINs) were developed as an effort to inform the parts involved with the agricultural sector in each partner’s areas. Additionally the local authorities should organize seminars to inform new farmers and agronomists and to follow the improvements and the new technologies.

**ABBREVIATIONS AND ACRONYMS**
- AS: agronomic survey
- CGAP: code of good agricultural practices
- EUW: EU-Water project
- Ha: hectares
- Kg: kilogram
- LIN: local implementation network
- N: nitrogen
- ND: nitrate directive
- Mm: millimeter, amount of irrigation water applied to 1 hectare; 1 mm = 10 cubic meters
- PP: all the partners
- TA: target area
- WFD: water frame directive
- WP1, WP..., WP6: work packages in the frame of EUW project
- LCWM: Lignite Center of Western Macedonia

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