IRRIGATION STRATEGY OF SERBIA

# SUPPORTING THE DEVELOPMENT OF AN IRRIGATION STRATEGY FOR SERBIA

## Brief on drainage systems

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## *Terms of Reference*

- Develop a brief and detailed presentation on drainage in the country, including statistical evidence on areas under drainage systems. The brief and ppt will include, among other, the following:
    - Institutional setting for drainage in the country, with qualitative description of the system's current performance and identification of needs for its rehabilitation and modernisation.
    - Analysis of how climate change is expected to affect the need for drainage in the period up to 2050.
    - Analysis of the financing of drainage and on how the funds received relate to the identified needs.
    - Analysis of the economics of drainage, according to the information available.
    - Overview of different kinds of drainage and point out new technologies that may be applicable in Serbia.

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# 1 Introduction

Aim of this brief is to present drainage in Serbia and prospects of irrigation development in the areas that are covered with drainage systems having in mind possibilities of multipurpose and multi criteria water management.

Agricultural land in Serbia is estimated to 4.68 million hectares. About 2.08 million ha (about 45% of agricultural land) are covered with drainage systems. Compared to irrigation systems there is obvious and huge difference. There are about 390 drainage systems with about 210 main and dozens of smaller drainage pump stations with cumulative capacity of 543 $m^3/s$ and 252 gravity outlets. There are about 24,000 km of drainage channels. Even though the extent of drainage systems with open channels is huge, pipe horizontal drainage systems are built on 62000 ha only.

The entire area of Serbia is divided into 7 water regions (Sava, Belgrade, Morava, Lower Danube, Srem, Backa and Banat and Kosovo and Metohija). Within broad regions there are reclamation areas operating in the previously described manner through a series of built smaller and larger systems for drainage. All land reclamation areas according to their characteristics and needs for regulating the water regime in the soil can be divided into 3 groups:

- reclamation areas of the lowland parts of river valleys, where most of the drainage systems (open canals) have been built and where in the future the reconstruction of the existing drainage network, construction of horizontal pipe drainage and land management will be required – these are the areas that are most intersting in terms of potential multipurpose usage: drainage and irrigation
- reclamation areas that include a small part of the lowland, and mostly hilly and mountainous areas with partially built drainage systems and where in further development it will be necessary to build new drainage systems and horizontal pipe drainage.
- reclamation areas of hilly and mountainous features, where drainage systems are built in small valleys, and the dominant problem is protection against erosion and torrential floods.

Extents of drainage within Water regions are shown in Table 1.

Table 1. Drained areas within Water regions (source: Strategy of water resources management in Serbia until 2034)

| Water Regions | Total area | Agricultural land | Agricultural land with drainage | Horizontal pipe drainage | Channels |
|---|---|---|---|---|---|
| | (ha) | (ha) | (ha) | (ha) | (km) |
| Bačka & Banat | 1.773.549 | 1.473.191 | 1.390.881 | 37.226 | 15.000 |
| Srem | 377.056 | 344.033 | 305.551 | 7.929 | 5071 |
| Beograd | 324.684 | 228.548 | 166.817 | 7.400 | 1900 |
| Lower Dunabe | 1.070.595 | 501.159 | 30.522 | 3.678 | 320 |
| Sava | 1.019.779 | 528.096 | 76.171 | 1.315 | 1250 |
| Morava | 3.181.602 | 1.424.762 | 43.930 | 4.460 | 597 |
| Total (without Kosovo & Metohija) | 7.747.265 | 4.499.789 | 2.013.872 | 62.008 | 24.138 |

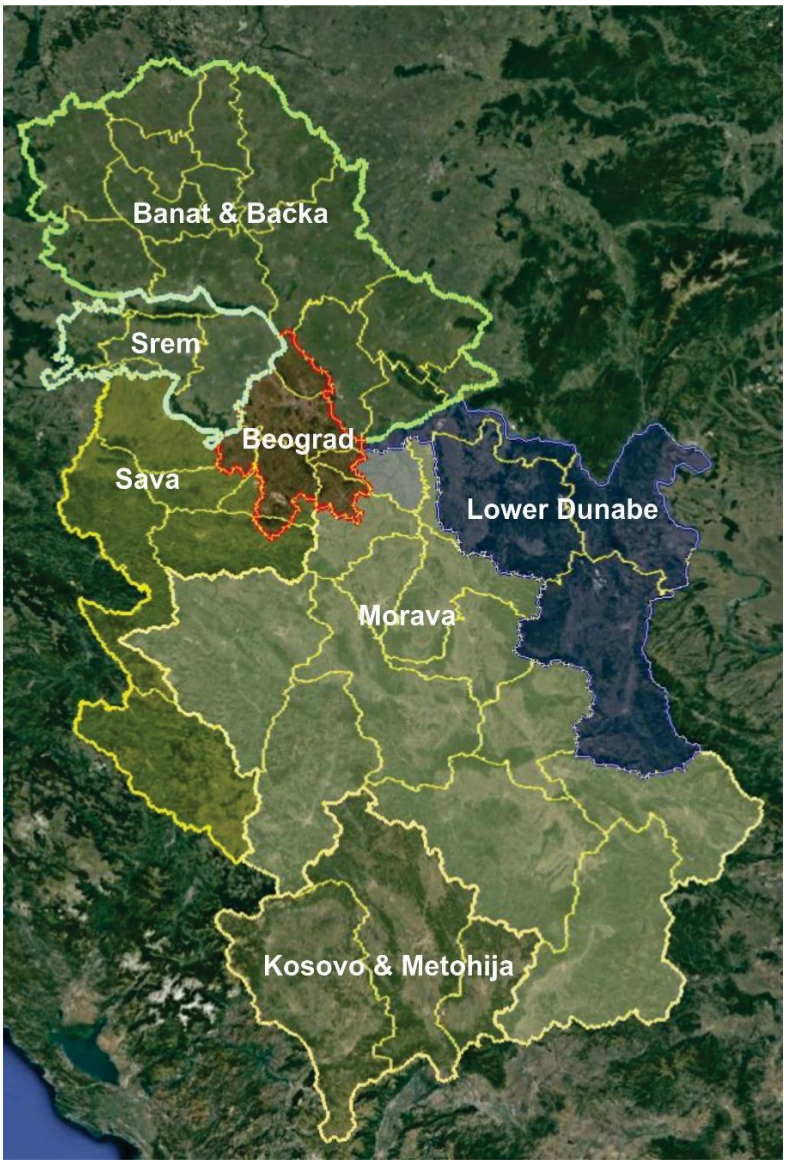


Figure 1. Teritory of Republic Serbia divided in Water regions

Classification of land according to drainage characteristics was performed in five drainage classes (in the sixth are lands outside the class). The I drainage class is characterized by very high risk of excess water and very weak drainage capacity, II drainage class high risk and poor drainage capacity, while in drainage class III, the threat is moderate - the soil drainage capacity is insufficient. Drainage is required to improve the characteristics of land for agricultural production on lands of I to III drainage class. On lands of IV drainage class, agricultural production takes place without major difficulties, if irrigation is not carried out, while otherwise the construction of a drainage system is required on these areas as well.

Distribution of drainage classes within Water regions is presented in the following table.

Table 2. Classification of land according to drainage characteristics within Water regions (source: Strategy of water resources management in Serbia until 2034)

| Drainage class | Water regions | | | | | | |
|---|---|---|---|---|---|---|---|
| | Bačka i Banat | Srem | Beograd | Sava | Morava | Donji Dunav | Total |
| I | 339.383 | 42.851 | 51.056 | 277.333 | 94.172 | 29.700 | 834.495 |
| II | 205.280 | 47.232 | 31.133 | 6.313 | 334.016 | 112.270 | 736.244 |
| III | 78.802 | 39.950 | 102.875 | 71.528 | 432.684 | 220.149 | 945.988 |
| *Sum I - III* | *623.465* | *130.033* | *185.064* | *355.174* | *860.872* | *362.119* | *2.516.727* |
| IV | 672.975 | 148.310 | 103.835 | 26.159 | 213.000 | 125.242 | 1.289.521 |
| V | 475.306 | 88.277 | 18.464 | 1.420 | 5.400 | 22.303 | 611.170 |
| Unclassified | 1.803 | 10.436 | 17.321 | 637.026 | 2.102.330 | 560.931 | 3.329.847 |
| Total | 1.773.549 | 377.056 | 324.684 | 1.019.779 | 3.181.602 | 1.070.595 | 7.747.265 |

It is clear that drainage is underdeveloped in all Water regions except: Bačka & Banat and Srem.

# 2 Main existing drainage systems

Locations of main drainage areas are shown on the following figure.

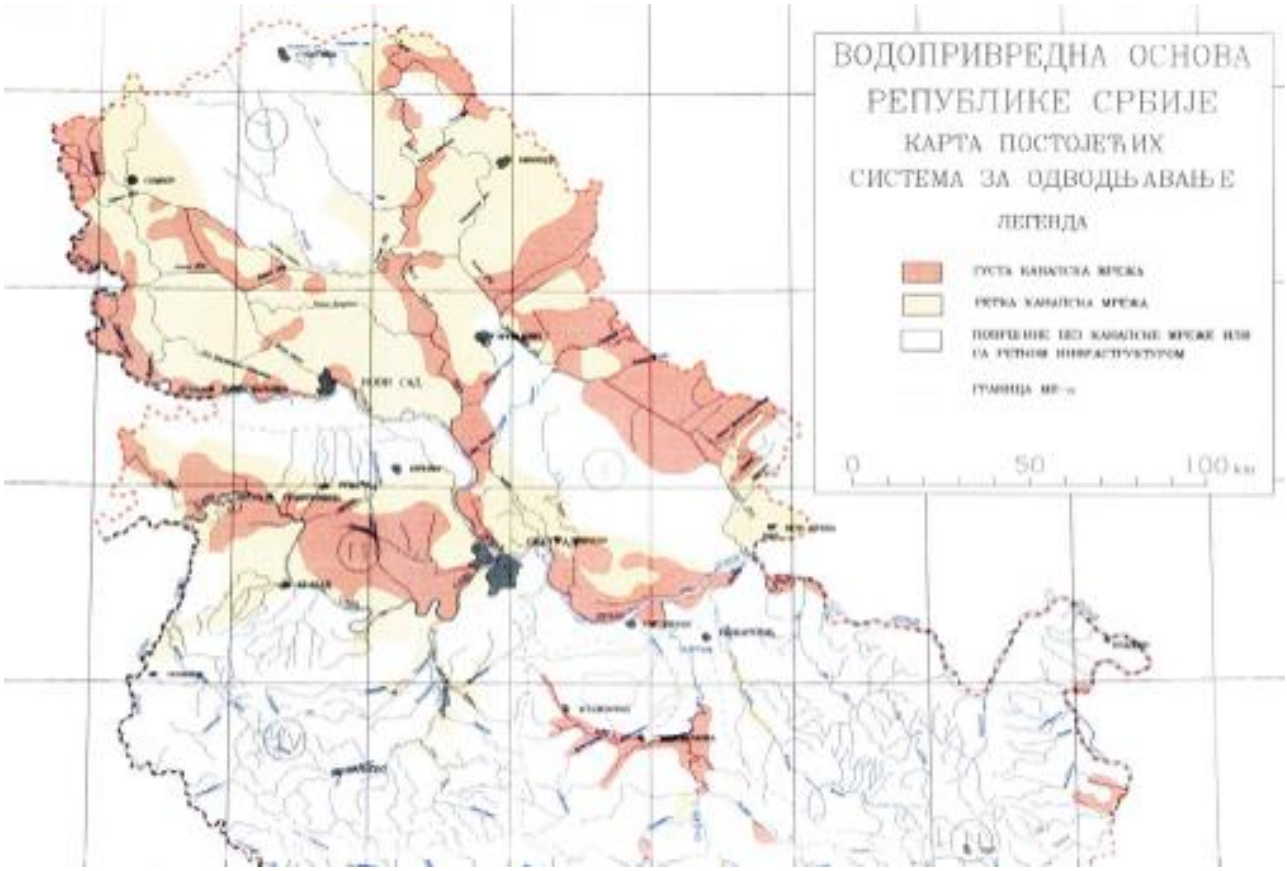


Figure 2. Spatial distribution of most important drainage areas (source: Water management master plan)

Most of built drainage systems are located in the water region Banat & Bačka where regional hydro system Dunav-Tisa-Dunav (HS DTD) is located.

The regional multi-purpose Hydrosystem "Danube-Tisa-Danube", mostly constructed after the Second World War (most of main water facility constructions were built before late seventies), uniquely, comprehensively, and complexly solves the problem of water management in Bačka & Banat and is one of the largest complex water management systems in Europe.

HS DTD is designed so that the network of main canals, with a dam on the Tisza river near Novi Becej and associated key water structures, connects the Danube with the Tisza in Bačka and the Tisza with the Danube in Banat. The hydro system connects, and partially or completely, includes large canals and cut watercourses in Bačka (Bajski kanal, Plazović, Mostonga, Krivaja, Jegrička and the old Veliki canal Bezdan-Bečej) and Banat (Zlatica, Stari and Plovni Begej, Tamiš, Brzava, Vršački kanal, Moravica and Karaš), changing their natural water regime. Thus, the basic canal network HS DTD cuts watercourses and connects them and together with detailed drainage canal network, forms a functionally indivisible whole - Hydrosystem DTD, which allows managing water regime in Bačka and Banat.

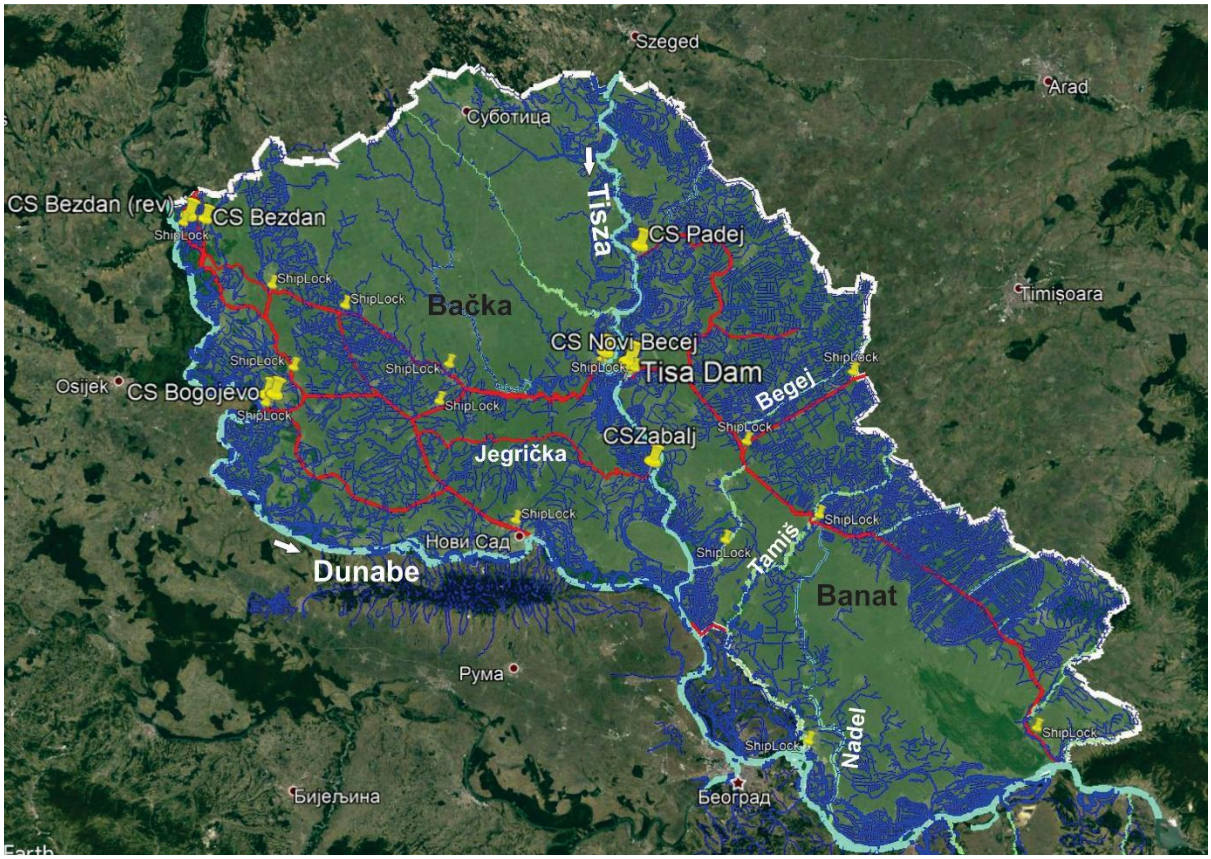


Figure 3. HS DTD system disposition with most main canals and most important hydrotechnical objects

The backbone of HS DTD is the Main Canal Network (OKM) with associated facilities and includes a network of main canals about 695 km long (with cut watercourses, a total of about 930 km), of which about 600 km are for water transport.

Table 3. Main canals in HS DTD network

| Name | Length [km] |
|---|---|
| Vrbas – Bezdan | 90 |
| Bečej – Bogojevo | 90 |
| Bač. Petrovac – Karavukovo | 52 |
| Novi Sad – Savino selo | 81 |
| Odžaci – Sombor | 13 |
| Ban. Palanka – N. Bečej | 147 |
| Kikindski kanal | 50 |
| Plovni Begej | 31 |
| Nadela | 81 |

The dam on the Tisza near Novi Becej, with seven spillways and a ship lock for ships up to 1,000 tons, was built in 1977 and is the largest hydraulic structure. By its construction and raising the water level of the Tisza upstream, gravitational water supply of the Banat part of HS DTD is enabled.

The following figure shows the general altitudes of main nodes in the system.

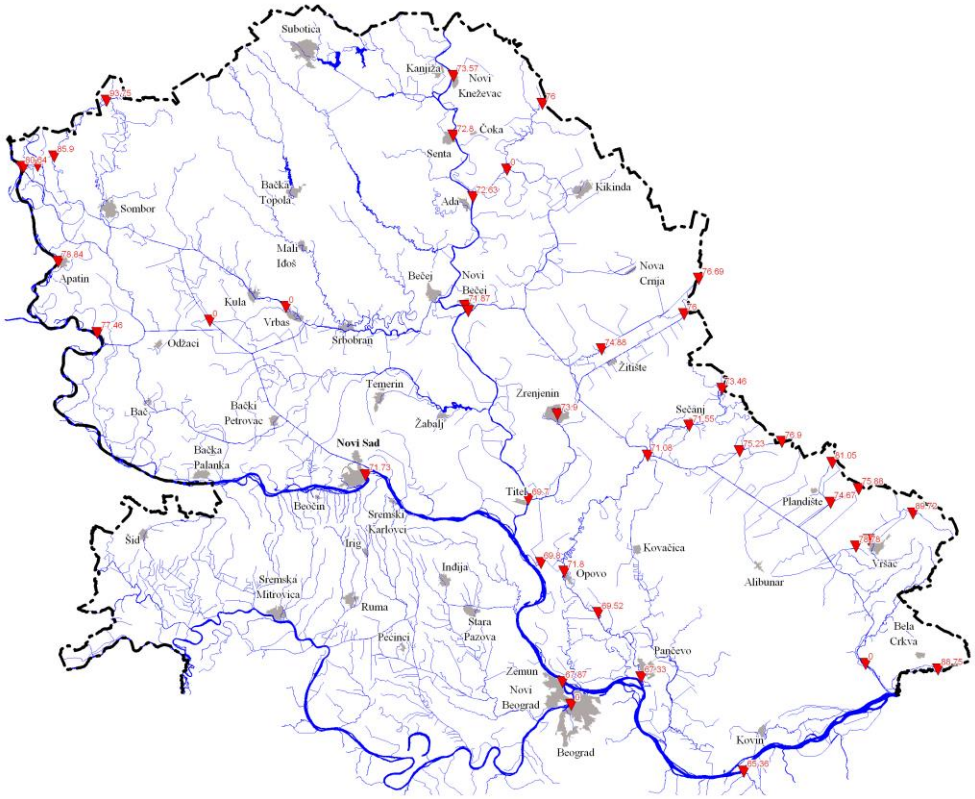


Figure 4. HS DTD system – spatial position and altitudes of main hydro nodes

The key water facilities of the DTD hydrosystem are: 25 water management hydro profiles, of which 3 are water intake with pump stations: "Bezdan", capacity 60 $m^3$/ s, "Novi Bečej", 120 $m^3$/s and "Padej", 20 $m^3$/s ; 17 are regulatory and five are safety water gates; five main pumping stations, two of which are reversible, for water intake and discharge ("Bezdan II", 12 $m^3$/s and "Bogojevo", 15 $m^3$/s), two are used for discharge of very large inland waters ("Žabalj", 16 $m^3$/s i "Bečej", 20 $m^3$/s) and one for water abstraction at very low water levels of the Danube ("Bezdan I", 6 $m^3$/s) and 17 ship locks, of which 12 are for 1,000 ton ships.

In addition to the above, in order to provide water management with rised water levels that are the consequence of the Danube rised water levels due to construction of the "Đerdap 1" dam, the water gates "Centa" and "Opovo" were built and hydro profile "Pancevo", that has water gate, pumping station and ship lock (Figure 5).

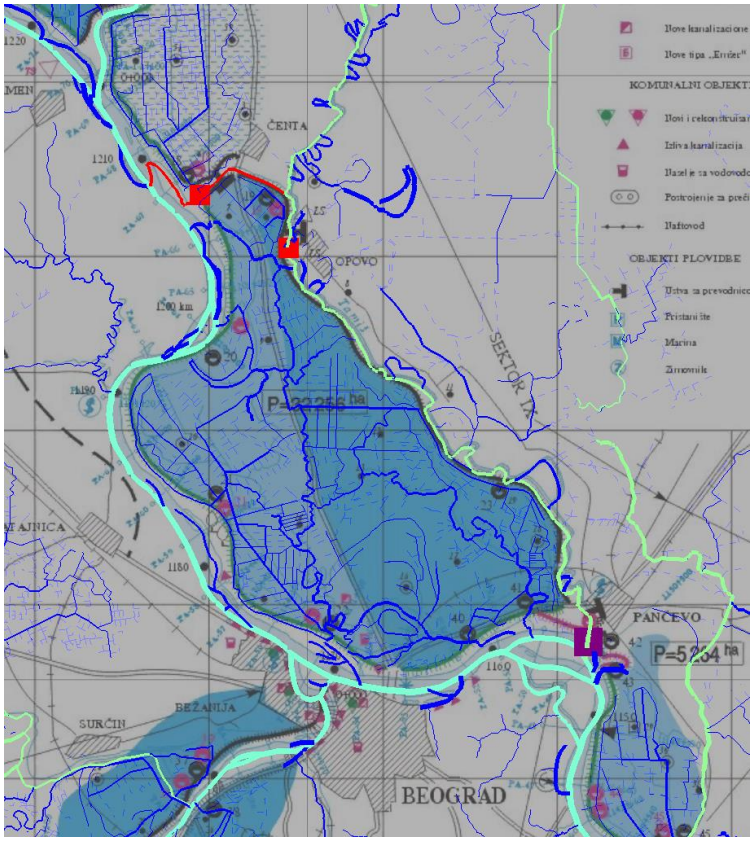


Figure 5. Position of water gates "Centa" and "Opovo" and hydro profile "Pancevo"

Through all main canals of HS DTD the water regime is regulated, with directed levels and water flow, which enables the reception and drainage of excess inland waters, reception and transfer of waters from cut watercourses, flood defense, irrigation, water supply of industrial facilities and fish ponds, navigation, tourism and recreation.

Detailed drainage canal networks are built in the most endangered soils in the alluvial plains of the Tisza, Begej and Tamiš. Overall density of the canal network is about 10-14 m/ha, with a drainage hydromodule between 1.0 and 1.6 l/s per ha. On the areas along the left banks of the Danube, the denisty is about 10.6 m/ha, with a hydromodule of 0.5 to 1.0 l/s per ha, while the canal network on the surfaces on lessivage terraces are with a hydromodule of 0.5 l/s per ha. Horizontal pipe drainage systems are bulit on about 37000 ha only, more in Banat and less in Bačka region. The whole drained area is divided in sub catchments ending up to about 200 drainage pump stations and/or gravity outlets.

HS DTD is designed as multipurpose system with the following goals: 1. Inland drainage from more than 1 milion ha of agricultural land, 2. Flood protection from cut water courses, 3. Irrigation, 4. Water supply for industry and fishponds, 4. Reception and conveyance of treated wastewater from industry and municipalities, 5. Navigation and 6. Tourism, sport and recreation.

In Banat region along the left bank of the Dunabe, downstream the Pančevo town, there are also drainage systems that are formaly not part of the HS DTD. They are built for drainage and transfer of inland water that is mainly caused with rised groundwater levels after the “Djerdap I” dam were bulit. Drainage systems covers the following regions: Pančevo-Ivanovo, Ivanovo, Ivanovo-Kovin, Kovin-Dubovac and most downstream Nera-Karaš where

HS DTD main canal Novi Bečej-Banatska Palanka confluence with Dunabe. Drainage systems in that region were mostly built during seventies, with more than 10 drainage pump stations having installed capacity of more than 30 $m^3/s$.

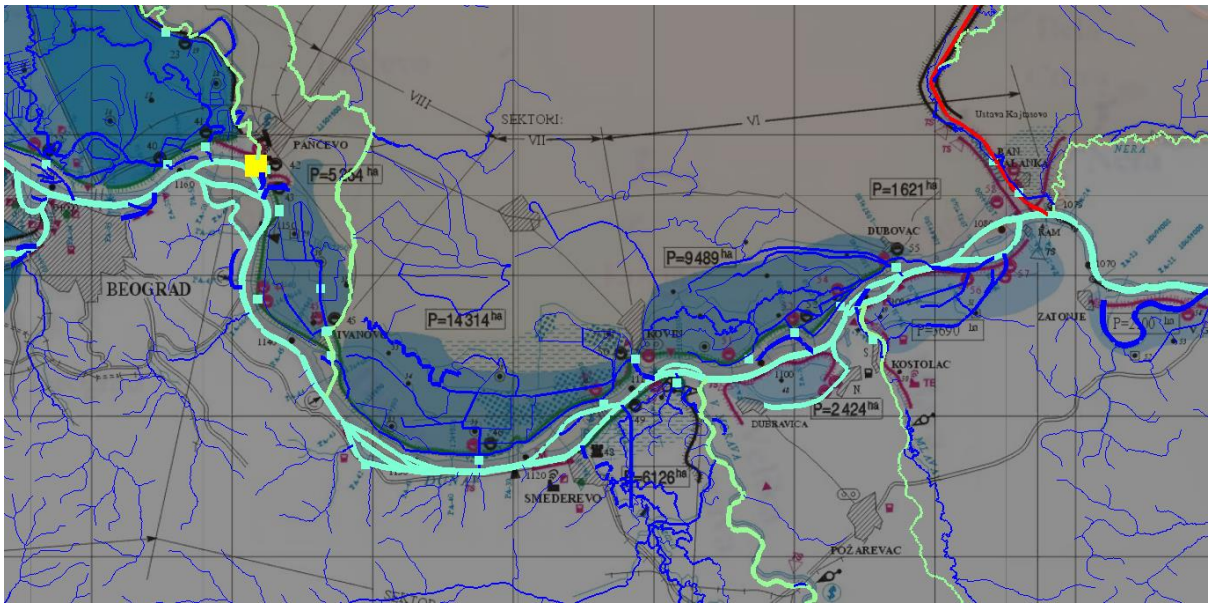


Figure 6. Drainage system in Bačka&Banat water region that are built for protection from rised water levels in Dunabe after the Djerdap I dam was built

Drainage systems in Water regions: Srem, Belgrade and Sava are predominantely located along the Sava river, except reclaimed area Pančevački rit, that is located on the left bank of Dunabe river, near Belgrade (Figure 7).

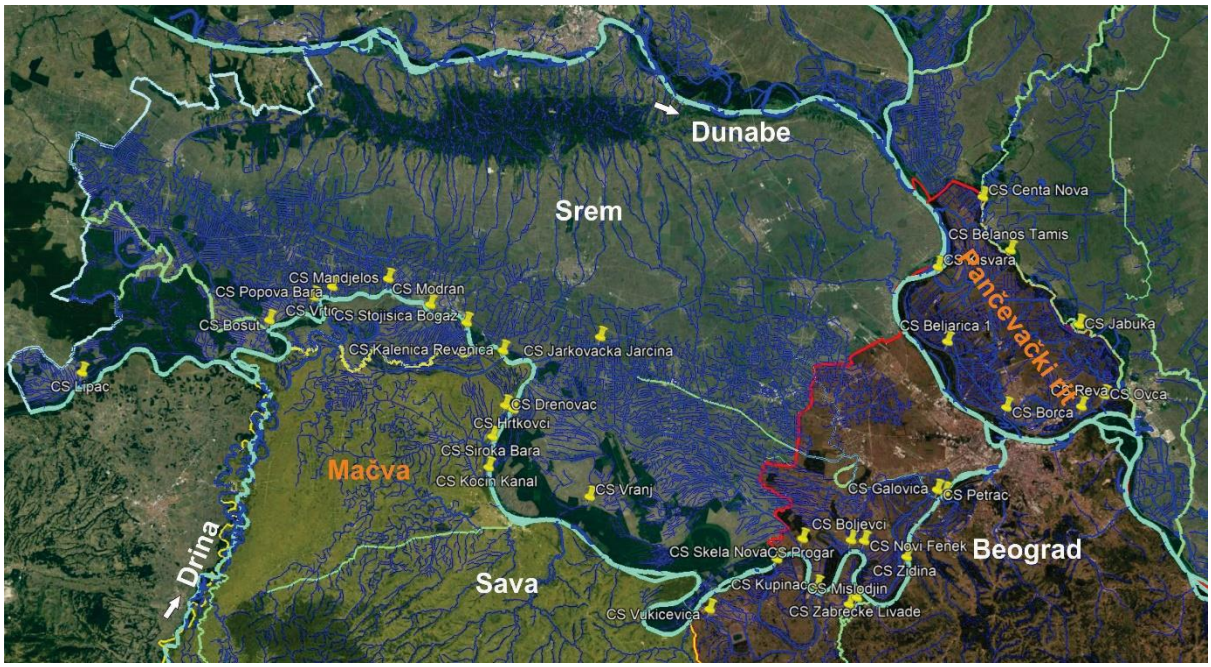


Figure 7. Main drainage system in water regions: Srem, Belgrade and Sava

Land reclamation area Srem covers the entire Srem water region and partly extends to Belgrade water region. The entire area is divided into 32 catchments and covers the whole area of about 353000 ha from which 253000 ha is agricultural land. There are only two catchments ("Patka" and "Golubinci-Stari Banovci") which drains into the Danube, while for all other basins the recipient is Sava. Drained waters from the area of 159,000 ha are gravitationally discharged into the Sava and the Danube, while other catchments (194,000 ha) are gravitationally drained to pumping stations and evacuated outside the protected area to the recipient Sava. There are 25 drainage pump stations located on the left bank of the river Sava. Total available capacity of pump stations is about 100 $m^3/s$. Most important pump stations with highest capacities are: CS Galovica and Petrac – 24 + 4 $m^3/s$, CS Bosut – 30 $m^3/s$ and CS Vrtić – 7.5 $m^3/s$.

The total length of the main canal network is about 465 km and the total length of the canal network in the reclamation area of Srem is 4,859 km, with a canal density of 13.6 m/ha.

According to the available technical documentation, the planned construction of horizontal pipe drainage covers significant reclamation areas, but it was built on only about 8,000 ha.

Part of the drainage systems are 13 reservoirs built on the south hills of the Fruška gora mounatain. Main purpose of these reservoirs are flood protection, but they are also used for fishery, turism and partly for irrigation of smaller orchard areas.

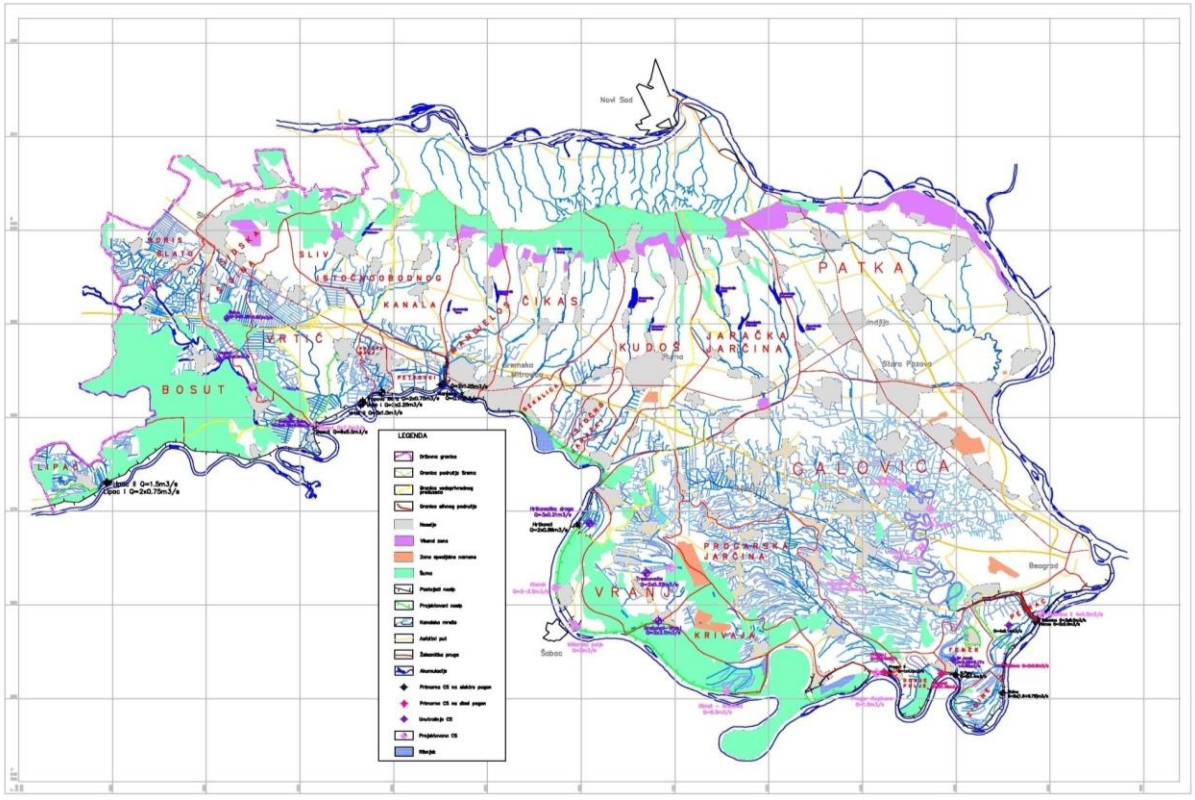


Figure 8. Catchments, flood protection reservoirs and land cover in Srem (source: *General design of irrigation in Srem – Institue J.Černi 2014.*)

In Belgrade water region, important land reclaimed area is Pančevački Rit. It is lowland area surrounded with rivers Dunabe, Tamiš and canal Karašac. The area of about 35000 ha is protected with leaves from flooding. Drainage system in Pancevacki rit is constructed for control of high groundwater level, due to groundwater infiltration from surrounding rivers and precipitation in wet periods of year. After the „Djerdap I“ dam was built, on average year, for the period of 6 months, water levels in rivers Dunabe and Tamiš are above terrain levels in the Pančevački rit region. For drainage purposes, the whole area is divided into 7 catchments with 7 drainage pump stations. For two of them the recipient is Tamiš and the rest are pumping water to Dunabe. Total installed capacity of drainage pump stations is about 23 $m^3/s$. The total length of canal network is about 750 km. Horizontal pipe drainage was built on the land that belongs to agricultural company Beograd (PKB) on the total area of about 6100 ha. Designed distance between drains is 20-30 m and about 200 km of canal drainage network serves as recipients for horizontal drainage pipes. Average density of drainage canal network is 23 m/ha.

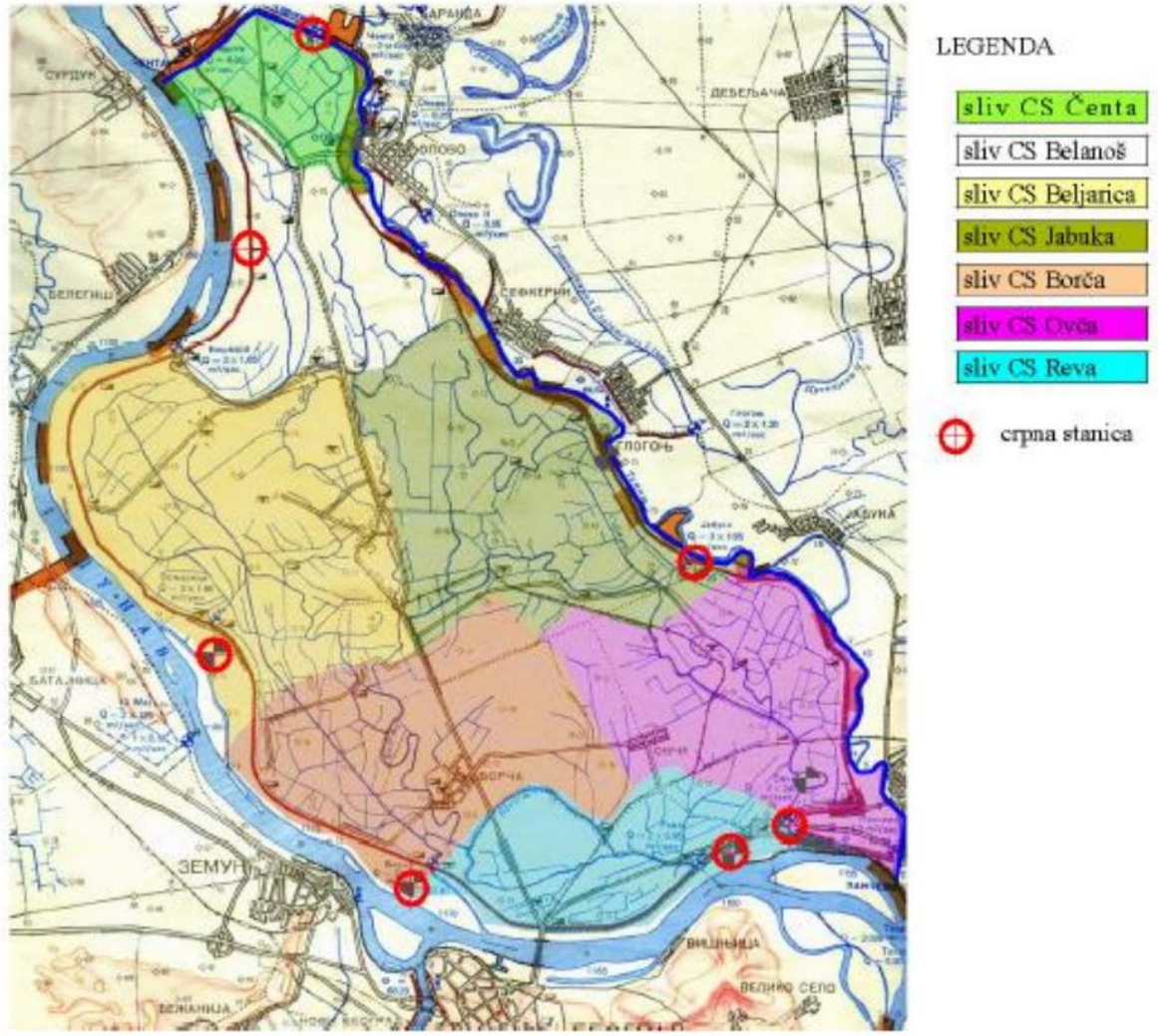


Figure 9. Catchments and drainage pump stations in the Pančevački rit region

In Sava water region, on the right bank of the river Sava, there is important amelioration area Mačva with developed drainage systems that extends on the reclaimed area of about 72500 ha. Area is located in the northwestern part of the Republic, surrounded with Sava river from the north and on the west by the Drina River. On the south there are hilly parts of the Cer Mountain and Mačva region is protected from torrential floods with Cer canal (COK). Rest of the region is protected from floods with levees built on the right bank of Drina and right bank of Sava.

Mačva region is divided in several catchments:

- Srednjemačvanski – with total area 28500 ha, length of canal network is 325 km and recipient for drained water is COK canal that ends up in Sava
- Donjomačvanski – total area is 11300 ha, length of canal network is 176 km and recipient is river Sava, water is transfered with drainage pump station with CS Kočin kanal with capacity 2 x 2 $m^3/s$ + 1 $m^3/s$
- Bitvanski – catchment area is 7500 ha, length of drainage canal network 193.5 km outlet is pump station CS Kalenića Revenica with capacity 3 x 2 $m^3/s$ and drained water is pumped to Sava
- Kalovički – catchment area is 6500 ha, length of drainage canal network is 121,5 km, pump station is Široka bara with capacity 3 x 2 $m^3/s$, recipient is Sava
- Drenovički – drained area is 1800 ha, length of canal network is 48 km, drainage pump station is Drenovac with capacity of 1 $m^3/s$ and recipient is Sava
- Zasavica – drained area 12600 ha, with pump station Modran with installed capacity of 5 $m^3/s$.
- Stojišića bogaz – area is 4300 ha with the pump station that has a same name and capacity of 4 $m^3/s$.

In total catchment areas that drains to Sava is 72500 ha, and much smaller part of total area (about 6500 ha) is naturally drained to Drina.

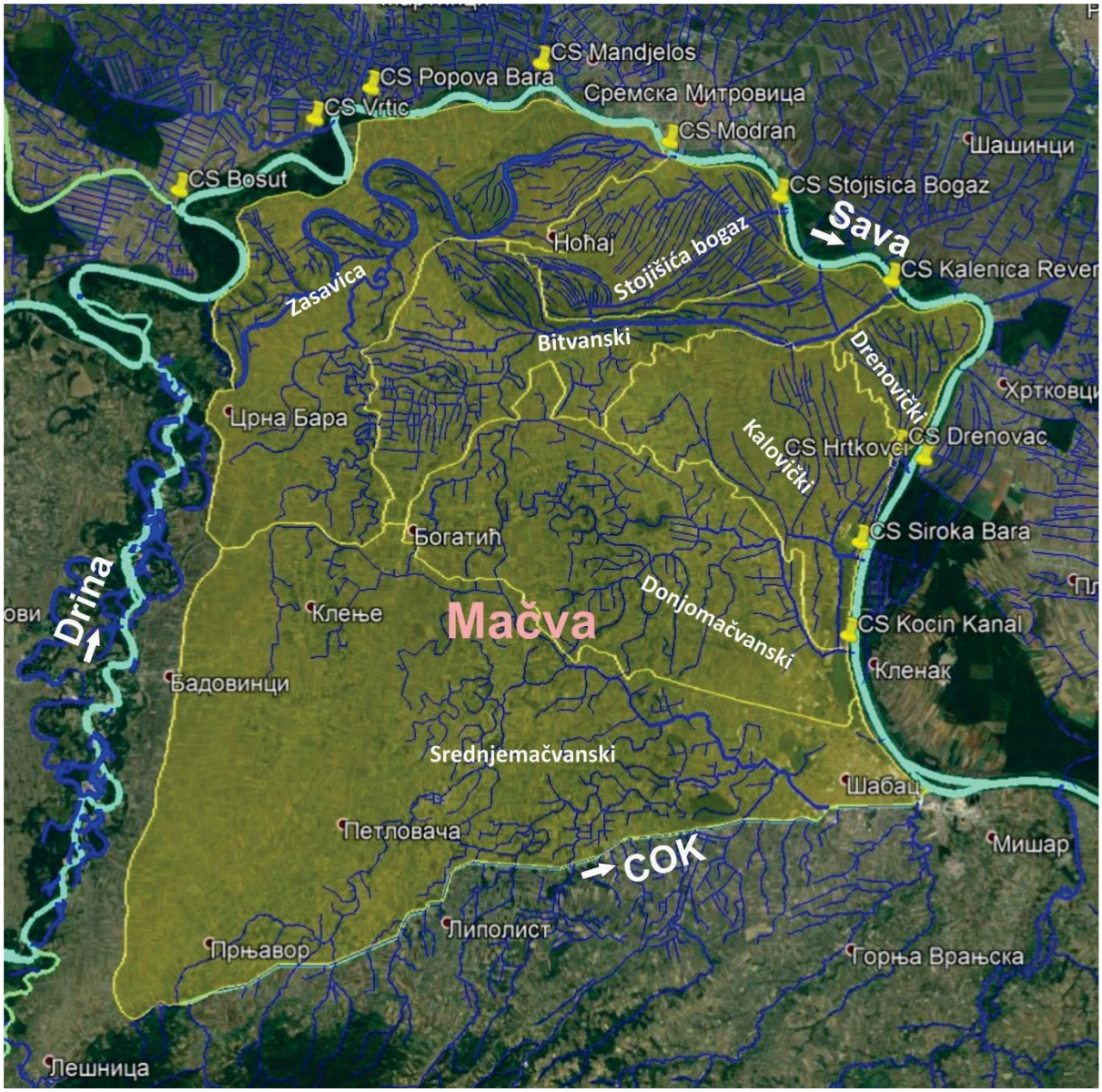

Figure 10. Catchments and drainage pump stations in the Mačva region

Previously described drained areas covers the majority of drainage systems in Serbia that has the highest potential to be used as multipurpose system, for drainage and irrigation.

# 3 Present state of drainage systems

Drainage systems generally do not provide an appropriate groundwater regime in all areas, meaning that levels of groundwater do not in some cases meet the required criteria for agricultural or urban areas.

Probably the most significant problem is lack of proper maintainance and reinvestment in hydrotechnical structures.

Once the drainage system with all the necessary facilities is built, it is necessary to manage it in an appropriate way and, above all, to maintain it. The term maintenance means complex

and regular application of certain measures that enable continuous efficient operation of all facilities in the drainage of excess water from a certain catchment area, in order to meet the prescribed criteria for establishing the optimal water regime of the land.

The maintenance of the drainage system in the last 25 years is unsatisfactory. Based on the analysis of system maintenance, it can be seen that in the past period, 25-70% of the required works were part of regular annual planing, and 25-50% were performed. When the ratio of necessary, planned and performed works is seen in time, it turns out that little has been done to maintain the system in prolonged period of time. It is estimated that due to that, their efficiency has been reduced significantly.

Pumping stations and the canal network are the most vunerable parts of the drainage system. Pumping stations require continuous and unavoidable maintenance and reinvestment, because their deterioration means that the entire system is not working. A longer period with lack of maintenance of the canal reduces the flow profile and thus prolongs the duration of drainage and increases risk of inland flooding.

Additonally, inadequate funcionality of drainage system is often the consequence of the fact that the system is only partialy built (usually without designed horizontal pipe drainage), or designed technical solutions were not proper. In many cases, systems with only a built-in canal network are not able to efficiently drain water from the surfaces between the canals at greater distances, especially on low terrains under soils of heavy mechanical composition. Therefore, the effects in agricultural production are below the levels that are achieved with the application of pipe drainage and agro-melioration interventions.

The existing density of the canal network is generally small and insufficient. On the most endangered lands of low areas in the alluvial plains of large watercourses, the density of the canal network is 7 - 30 m/ha with a drainage hydromodule of 0.5 - 1.5 l/s/ha. Given the need for efficient drainage of excess water, the existing channel density and hydromodules are insufficient except on surfaces with built-in pipe drainage.

After the construction of pipe drainage, although on relatively smaller areas, the existing capacities of pumping stations and their operating regime are not everywhere in line with the needs. In some cases, the pumps are outdated and of insufficient capacity, so the requirements for new facilities within the pumping stations are increasingly relevant.

In addition, problem is that there is increased use of canals as recipients of untreated used waters from settlements and industry, which limits the posibility of using drainage system for irrigation, because planned multipurpose usage sets much stricter criteria regarding the regime and quality of water in order to prevent secondary negative impact on land and plants.

The increasing use of irrigation in areas under drainage systems that are not functioning properly is a new additional factor that will affect soil moisture and groundwater level regime. Therefore, the changes that occur due to various influences on the built systems should be constantly monitored and protection measures should be implemented in a timely manner.

Due to reduced efficiency of existing drainage systems, the priority in future investments must be to gradually bring the system into the projected condition.

# 4 Sources of financing

Investment in construction and development of a drainage system is specific to each system and should be an integral part of the costs of complex land reclamation. The necessary funds can be provided from the following sources: earmarked funds from the budget of the Republic of Serbia, part of drainage water fee, funds of water users associations as own participation in investments, budget of local government units, investors own funds, bank loans.

The annual costs of regular maintenance and operation of the drainage system is provided from the drainage fee from the reclamation area or part of the reclamation area. The drainage fee is paid by all owners of agricultural, forest and construction land, in the reclamation area, according to the cadastral income, depending on the area and whether it is a legal entity or individual user. According to the Water Law, funds earned from drainage fees are used on amelioration area, or the part of the amelioration area where they are collected for financing the operation and maintenance works (Article 172).

Drainage fee is obviously based on the principle of solidarity, meaning that users that do not have problem with drainage, are also obliged to pay service.

The drainage fee is paid for the regulation of the water regime of the land in the reclamation area, by collecting excess water to the drainage systems, which are managed by the public water management company.

As previously stated, the main problem with functionality and efficiency of drainage systems is lack of proper maintainance that should be covered with drainage fees.

The following problems can be pointed out:

- Drainage fees must be calculated to cover the regular annual operation and maintatinance expenditures. Unfortunately, fees are very often political category and less than necessary for covering annual expenditures.
- There is problem with unsatisfactory collection rate of drainage fees, and it can be partly explained with: 1. The fact that fees are not collected by the water company that operates and mainatains the system and hence would be motivated to achive the highest possible collection rate, 2. Users do not understand what is the level of services that they are paying for (that is partly due to adopted solidarity principle);
- At the end, what is approved as annual expenditure for operation and maintainance and specially what is really going to be spent, depends on general availability of funds in the budget of the Republic of Serbia so planned expences were often cut in the past;

# 5 Conclusion

General overview of the state of drainage on the territory of the Republic of Serbia indicates that in the coming period the development of drainage should be directed in two directions:

- Proper operation & maintenance and moreover reinvestment in depreciated drainage systems in order to gradually bring the system into the projected condition

(recent estimate from public water company “Srbija vode” is that for modernisation of existing pump stations in regions Sava, Beograd and Morava, 32 milion EUR should be reinvested in following 5 years),
- Continuation of investment and construction to further improve efficiency and extend drainage systems.

In both cases, funding should be mainly provided from the drainage fee and from the budget of the Republic of Serbia.

Problems with the drainage fee, as an obvious main source of income, are as follows:

- funds from the collected drainage fees are insufficient for operation and maintenance of the drainage system;
- dissatisfaction of the owner/user of agricultural land with the services of water management companies for the drainage fee they pay;
- collection rate of drainage fees is insufficient;
- The drainage fee is insufficient for reinvestment and capital interventions

Based on certain and defined necessary annual funds for efficient and safe functioning of the drainage system, as well as defining all taxpayers in the system, the drainage fee per unit area (RSD/ha) should be determined as strictly economic category. Only in that way drainage fee will grow into a serious source of income necessary for operation, maintenance and reinvestment in the drainage system.

Adequate drainage fee should be used to improve the level of services of public water companies and only in this way will the trust of users be restored and the awareness of the importance of drainage in stable agricultural production be influenced.

Further development of drainage systems should be directed to multipurpose usage: drainage and irrigation. Minimal interventions in the form of construction of water gates for water retention in the canal network, having in mind the retention volume of the canal network, can enable its use for irrigation purposes. Water management issues must be considered at all times so that the aspect of drainage of the area would not be endangered due to the interest of irrigation.

Additionally, it should be considered that dual-purpose systems are sensitive to water pollution in the canal network because, self-purification cannot occur due to the low flow. Unfortunately, environmental awareness is very low. It is common for various types of waste to be disposed of in canals, and untreated wastewater from industrial plants and sewage systems of settlements is often poured into them, which very much limits the idea to use drainage systems for irrigation.

Obviously, proper functioning of drainage system and adequate water quality are prerequisities for further development, reconstruction and use of drainage system for irrigation purposes.