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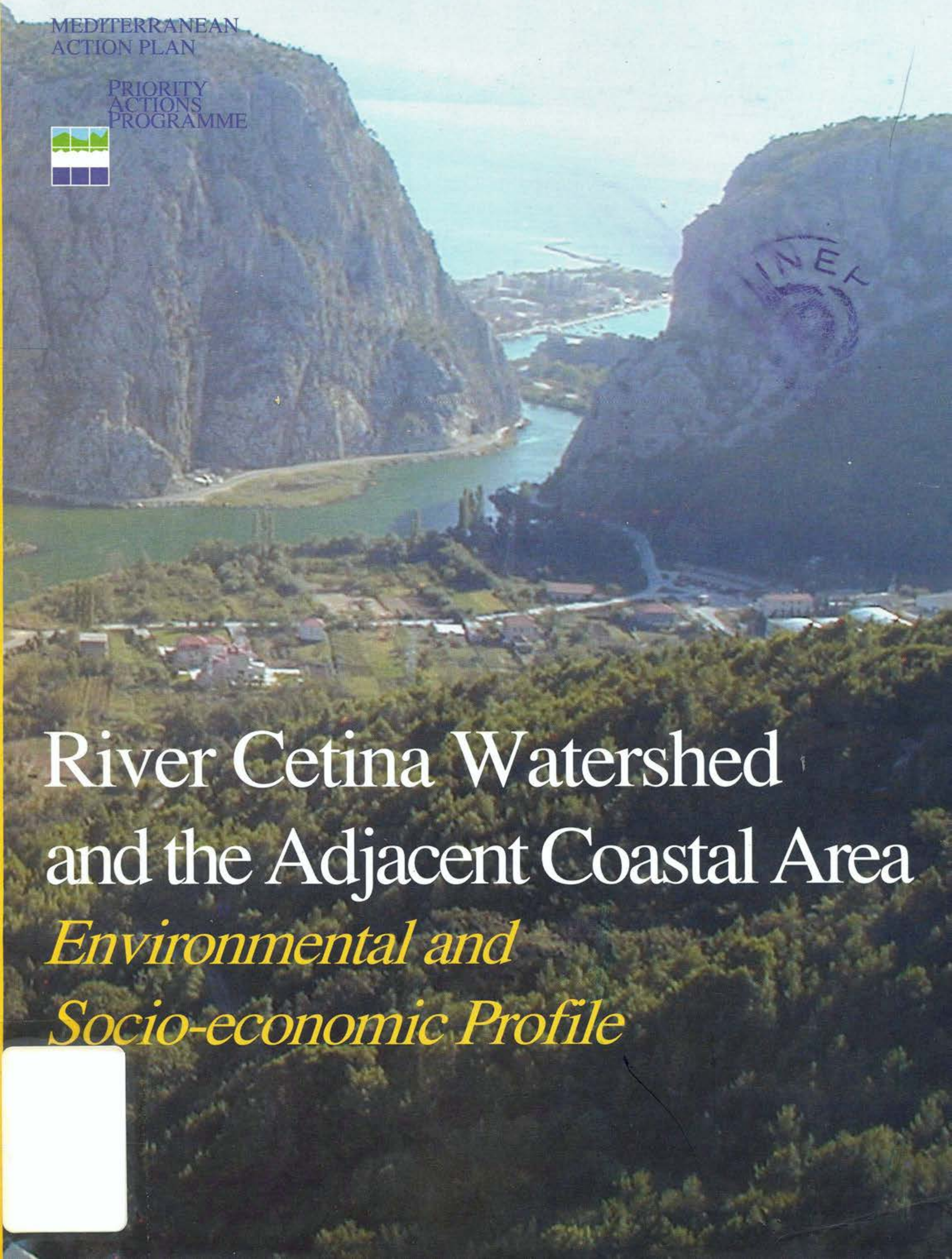

River Cetina Watershed and the Adjacent Coastal Area

Environmental and Socio-economic Profile

Note:

This document was prepared with the objective to demonstrate how the Integrated Coastal Area and River Basin Management (ICARM) approach could be applied in practice. The report was prepared by a team comprised of more than 20 experts from Croatia and Bosnia and Herzegovina. Working under the auspices of PAP/RAC, the team was guided by Ms. Maja Madiraca, Ms. Gordana Bubic, Mr. Jure Margeta and Mr. Ante Baric. Mr. Takehiro Nakamura (UNEP) and a PAP/RAC team (Mr. Ivica Trumbic, Mr. Harry Coccossis, Ms. Branka Baric, Mr. Slobodan Pavasovic and Mr. George Gavriil) provided additional expertise and technical support for the preparation of the document.

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ISBN 953-6429-34-9

Graphic Design: Mario Brzić

For bibliographic purposes this document may be cited as:
UNEP/MAP/PAP: *River Cetina Watershed and the Adjacent Coastal Area: Environmental and Socio-economic Profile.* Split, Priority Actions Programme, 2000.

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1. Introduction

1.1. Profile objectives

Development plans and plans for the protection of the environment, in particular those concerning enhancement of the use and protection of watersheds and their adjacent coastal areas, should be considered simultaneously. The protection of waters and the sea, either as an integral part of water management or as part of integrated land-use management, should follow the principles of an integrated planning, development and management of environment and space. An approach to the use and protection of the Cetina River watershed should also be integrated within this framework. It is important, therefore, that the impact of the respective operations on particular parts of the area as well as on broader elements are all evaluated.

Land and water resources of the Mediterranean region and in particular in karstic areas such as the Cetina watershed, are generally scarce and often subject to intensive and irrational utilisation. These impacts relate to land-use changes, concentration of population and human activities in certain parts of the area (near fertile fields and in the narrow coastal strip), environmental pollution, the over-utilisation and/or irrational uses of natural resources (freshwater and use for hydro-electrical purposes, mineral resources exploitation, etc.).

The interactive and functional relationships between the coastal and river basin areas have been accentuated by the growth of economic, urbanisation and tourism activities, changes within the infrastructure systems, and needs to supply coastal settlements and tourist facilities with fresh water, energy and food among other necessities. Such a complex web of interrelationships involving the mutual impacts of the coastal and river basin area, requires an extensive and systematic interdisciplinary analysis.

The general objectives of this study are as follows:

- To apply the principles of the "Conceptual Framework and Planning Guidelines for Integrated Coastal Area and River Basin Management" to issues concerning the Cetina basin and its adjacent coastal area;
- To investigate their interrelations (functional, socio-economic, natural, and others), as well as to clarify and quantify them;
- To provide support to the local administrative units and Split-Dalmatia county in the preparation of the integrated river basin and coastal area management strategy; and
- To develop the respective planning and managerial instruments in order to facilitate decision-making which is crucial to both the management and protection of the Cetina basin and its associated coastal area.

Specific objectives:

- To identify the major problems relating to the development of the Cetina basin and to establish and prioritise the means to their solution;
- To identify the basic conflicts in the Cetina basin and its associated coastal area, and to define their resolutions;
- To propose an institutional framework that would meet the need for the establishment of a long-term basin management system; and
- To create the preconditions for the achievement of regional and international co-operation in relation to management of the Cetina basin.

The basic principles of the integrated planning and management of the Cetina basin and the adjacent coastal area are the following:

- To respect the relationship between the river and coastal ecosystem;
- To limit the use of non-renewable nature resources, within the framework of the area's socio-economic development;
- To secure a multi-tiered system of co-ordination within the decision-making process (local/county/state/and international): and
- To ensure the participation of all interested parties in the decision-making process, and in particular that of the local population, in order to guarantee the most efficient management of the area.

The anticipated results of integrated planning and management of the Cetina basin and its associated coastal area, are constituted in the selection of the most adequate measures preventing possible conflicts inherent in land use. This could be primarily achieved by recognising the key relationship between the coastal area and the river basin (natural processes and processes of urbanisation), and by defining the key geographical and sectorial locations of important land users, aiming at adopting the concrete measures to be defined in this project.

1.2. Methodological approach

The methodological approach applied during the analysis of the socio-economic profile of the Cetina River, is based on the model of the integrated management of its basin and coastal area. The Cetina basin and its adjacent coastal area constitute a unique spatial, functional and natural whole. For this reason, any changes occurring in the use of upstream areas, also affect the coastal areas (and *vice versa*). Consequently, research on particular spatial phenomena of the area have analysed spatial-functional and natural relationships, respecting the administrative-territorial and political division of the area.

In accordance with the above, the researched area can be physically divided as follows:

- The narrow watershed area impacted by the Cetina hydrological regime, which we define as primary impact; and
- The wider watershed area defined in terms of the research subject, or secondary impact (this also includes the metropolitan area of Split).

In terms of integrated management, the area may be divided into two different spatial units:

- The rural, less populated and predominantly agricultural hinterland, with emphasised mountain massifs; and
- The urban and overpopulated coastal area with accentuated land-use conflicts.

Traditionally, the Cetina basin has been considered a complex, water supply area with additional hydro-electric power capacity. Its several other potentials, such as those relating to specific kinds of tourism, its nature, cultural-historical assets and biodiversity, to name but a few, have neither been largely researched nor adequately identified.

The methodological approach has been adopted by taking into account the existing data and expert evaluations that constitute the basis for the identification of certain issues and conflicts arising within the following general categories:

- Spatial/physical planning of the entire Cetina River basin and its adjacent coastal area;
- Management of particular areas within the river basin;
- Revitalisation and reconstruction of historical monuments and archaeological sites;
- Protection and enhancement of protected natural sites;

- Infrastructure systems;
- River and sea pollution;
- Water resource management;
- Revitalisation and rehabilitation of urban and rural areas; and
- Creation of a database.

1.3. Geographical position

Cetina is one of the most important rivers in the middle karstic coastal area of Croatia (Figure 1.1). Cetina's significance is reflected in the following facts:

a) the abundance of water used for:

- The water supply of the wider area, including,Vrlika, Sinj, Trilj, Omiš, Makarska; the islands of Brač, Šolta and Hvar, and as it has been anticipated, Vis island (in the near future);
- Agricultural activities, mainly irrigation; and
- Hydro-electric purposes.

b) the abundance of its natural beauty, such as scenic spots and opportunities for various uses of the river and its adjacent area

From its source to its mouth, Cetina spans almost 105 km, crossing an area that encompasses the counties of Split-Dalmatia and Šibenik-Knin, the locally managed towns of Vrlika, Sinj, Trilj and Omiš, and the municipalities of Kijevo, Civljane, Hrvace, Otok, Šestanovac, and Zadvarje.

The Cetina watershed is comprised of Bosnian and Croatian sections.

Its Bosnian section encompasses a large part of the county of Herzeg-Bosnia, that is to say, the municipalities of Livno, Tomislav Grad, Kupres, Glamoč and Grahovo, an area of approximately 2,440 km^2 of the total surface area, including its adjacent mountain massifs.

The total surface area of the Croatian section of the watershed, which is determined by a topographic dividing line, accounts for about 1,200 km^2, and includes the following:

- The upper part of the river course, extending to the Peruča dam;
- The middle part of the Cetina valley, to Trilj; and
- The lower part of the Cetina course up to its estuary, at the Adriatic Sea.

Historically, the significance of the Cetina watershed in terms of its geographical-transportation position, had been conditioned by the availability of trading routes and other important connections between the coast and the hinterland. The intensive development of the coastal area (and in particular of the metropolitan area of Split) had resulted in the socio-economic transformation of the entire watershed area.

The natural corridor, constituting the Cetina valley, is bisected by the following important transportation routes:

- The state road D1, crossing Split-Sinj-Vrlika and Knin, extending to Zagreb; and
- The road connecting Split-Trilj-Kamensko (the border crossing) – Tomislav Grad and Kupres, and further on to Sarajevo.

The area's extraordinary geographical-transportation position, at a natural crossroads, is the basic characteristic of the watershed's geographical position and the prerequisite for realising its economic potential.

Figure 1.1: Geographical position of the River Cetina watershed

The Cetina source is situated at the south-western slopes of the Dinara massifs, at an elevation of 382 m, in the farthest, north-western part of the Cetina field. From its source, in the vicinity of the Cetina Village, the river flows through the Cetina field, in a south-easterly direction, and enters the Peruča storage reservoir, located in the Koljan and Ribarnica fields. Downstream of the Peruča dam, Cetina passes through the Vrlika field, to Han, and further on, via the Sinj field to Trilj, where it flows into the Đale storage reservoir. From Đale, the river flows to the storage reservoir of Prančevići, where a part of its stream is directed via a supply tunnel to the Zakučac hydro-electric power plant. The main part of the Cetina continues its course further, through its natural canyon-like bed towards Zadvarje. At Zadvarje, the river suddenly changes its direction to the west, towards the town of Omiš, where it finally enters the Adriatic Sea.

The coastal area of the watershed embraces the area situated between the coast and the Mosor and Dinara mountains, including Omiš, as well as the eastern part of Biokovo. The western part of the hinterland (in relation to the Cetina mouth) is located between the coast and the northern slopes at a height of 300 m. The eastern part is relatively steeper, and takes in the pass of Vrulja and Biokovo, the highest mountain of the Dinaridi chain. Biokovo is the sole point within middle and broader Dalmatia, where high (up to 1,700 m), steep and craggy ridges closely approach the sea. The D8 state road (commonly referred to as "the Adriatic road"), with many of its sections crossing the centres of coastal settlements, establishes useful connections all along the coast.

The coastal sea includes a group of middle Dalmatian islands, of which Hvar is located to the south, Brač in the middle (facing the Cetina mouth and thus directly impacted upon by the watershed area), and Šolta which is situated in the most westerly part of the coastal sea. Vis is the most outstanding island in the open sea.

1.4. The geographical division of the area

For geographical purposes, the studied area can be divided into:

- The river watershed area; and
- The coastal area.

From an administrative and political point of view, the river watershed can be divided into two sections:

- The watershed section encompassing the territory of Bosnia and Herzegovina; and
- The section within the territory of Croatia.

The Croatian section of the watershed, including mountain massifs and important fields, encompasses the following spatial-physiognomic units:

a) The hinterland, i.e. the mountain massifs of Svilaja, Dinara and Kamešnica, and fertile fields;

b) The river mouth; and

c) The adjacent coastal area.

Given that the adjacent coastal area is directly impacted upon by Cetina, from a spatial-functional point of view, it can be divided into:

a) The coastal area, with Vrulja to its east, and the municipality of Podstrana as its western boundary; and

b) The sea surrounding the Brač Channel.

From a functional point of view (Figure 1.2), this area could be divided as follows:

- The narrower watershed area that is directly impacted upon by Cetina;
- The wider watershed/coastal area primarily functionally connected with the Cetina River watershed, including:
    - the Makarska riviera;
    - the islands of Brač, Hvar, Šolta and Vis; and
    - the metropolitan area of Split, including the hinterland area taking in the districts of Dicmo, Dugopolje and Klis.

1.5. Historical development

The historical circumstances and strategic development of this area, extending from Cetina's source by the foot of the Dinara mountain, to its mouth, near the town of Omiš, have largely been determined by the Cetina River. The Cetina valley embraces several geographical units with cultural and historical value, such as the upper and middle course of the river, stretching to the canyon-like Cetina bed downstream of Trilj, and the lower part of its estuary near Omiš, where the river enters the Adriatic Sea. The natural paths of Klis and Vrulja have been connecting the coastal area with certain Croatian towns, for centuries. At the crossing near Trilj, these natural routes have led to Imotski and Neretva, and via Kamensko and Prolog to Bosnia and Herzegovina. In addition, they have linked Knin, via the Una valley with the north, leading via Bukovica and Ravni Kotari, to Zadar and the western parts. The emergence and development of the settlements of both the upper and middle Cetina course have always been determined by these natural conditions.

Watershed borders

Part of the watershed in Bosnia and Herzegovina

Part of the watershed in Croatia:

- Hinterland

- Estuary

- Coastal area influenced by the river

- Brač Channel

- Wider area functionally related to the watershed

Figure 1.2: Geographical division of the River Cetina watershed

The Neolithic settlements, mainly traced besides the middle course of the river surrounding the Sinj field, testify that this area has been inhabited since pre-historical times. In the coastal section of the watershed, relics from that time have randomly been discovered, as the Palaeolithic, Neolithic and Bronze Ages have not been adequately researched.

The only evidence that this area had been inhabited in prehistory, remain its characteristic elevations. Because of its unfavourable climatic and hydrological conditions, the northern inaccessible part of the Biokovo hinterland, had been thinly populated even in pre-historical times. Better living conditions were to be had in certain arable parts of the mild south slopes, where the pioneer settlements had emerged and population concentration had firstly been registered as a social phenomenon.

With the emergence of the first ethnic (Illyrian) tribe communities during the Middle Bronze Age to the end of prehistory, cattle raising, which had previously been a major economic activity, was replaced by farming, thus diminishing the significance of the upper river course area. In the same period, owing to the extremely fertile Sinj field, as well as to the water supply from Cetina, several significant settlements emerged along the middle course of the river. The most common types of settlements were the "hill-forts" (fortified settlements at the top of the hill). Today, nearly a hundred of these settlements have been discovered along the upper and middle course of the river.

The beginning of the historical period was marked by a 150-year-long Dalmatian-Roman conflict, which had been so critical to the Romans, that they named the largest part of the newly occupied territory "Dalmatia", in honour of the Dalmatians' resistance. The establishment of Roman rule and its consequent hegemonic civilisation based its colonisation upon the optimal use of natural resources existing in the newly acquired province. The epigraphical monuments discovered, provide evidence of several Roman activities, such as the construction of a road system (connecting Salona with Narona, Sirmium and Servitium), as well as that of toll stations, bridges and aqueducts found in the ancient locations of Aequum, Osinium and Tilurium.

By introducing agricultural intensification, the Romans guided their citizens to systematic land ownership near larger arable areas. Very often, the land was occupied by monumental, residential and farm buildings (*vilae rusticae*). During this period, a number of older Dalmatian settlements had been reconstructed and several others emerged. Undoubtedly, the most important ancient centre in the Cetina basin was the 1st century colonial settlement (*Colonia Claudia Aequum*), located at the former town of Čitluk, which was erected during the reign of Claudius. Another ancient settlement, equally significant in terms of its surface area and historical value, was situated at Gradun, above the town of Trilj (ancient Tilurium).

With reference to the Croatian Middle Ages, the formation of the Republic of Poljica, mainly located in the fertile fields of the lower part of Cetina is especially interesting.

During the first decades of the 7th century, Slav and Avar settlers found the Cetina region socially and economically devastated. In this period, every aspect of the previously organised economy had almost been distinguished, and the natural economy was strengthened, while the decadence of urban living had been accentuated. During their first settlement phase, the Slavs only inhabited the area east of Cetina and north of the Sinj field.

In the 9th century, the entire Cetina region came under the jurisdiction of the first Croatian state community in Dalmatia, which was divided into eleven territorial units or counties. According to 10th century Byzantine sources, the upper and the middle course of the river had formed a single territorial unit, named "Cetina County" after the Cetina River.

During the 11th and 12th centuries, new territorial changes occurred within the previous county system. The Cetina region once again enjoyed a period of political stability and economic prosperity. Several significant archaeological sites, such as the church of St. Saviour in Vrlika with the oldest church tower in Croatian architecture, are indicative of this prosperity.

The downfall of the Croatian state, at the beginning of the 12th century, rendered the previous territorial division system weaker, while the new Hungarian-Croatian kings contributed to the impoverishment and decay inflicted on the land by the Croatian aristocracy. The aristocrats who remained politically faithful to the Hungarian crown were rewarded. The most significant privilege granted to the nobility, was the right to extend their land ownership. During this period, as the entire Cetina region was conceived of as a royal estate, it became the property of several Croatian aristocrats. Moreover, despite the changes relating to its ownership status that occurred between the 13th, 14 th and 15th centuries, the region's economic development continued. A number of archaeological sites, such as large late-Medieval cemeteries, suggest an extremely large population size.

After the decline of the Croatian dynasty, the coastal area continuously remained subject to foreign rule (the Croatian-Hungarian state, Venice, the Turkish Empire). It should be pointed out, however, that the Republic of Poljica remained independent throughout its entire history.

The various attempts at a Turkish occupation of the Cetina region towards the end of the 15th and at the beginning of the 16th centuries, caused a vast population migration from the Cetina to the northern Dalmatian and Slavonian areas. All the economic and political achievements of the late Middle Ages were interrupted by the change of rulers, partially restored only in the latter half of the 16th century, while the end of the Turkish occupation heralded a gradual revival.

The end of the Turkish and Venetian control of the Cetina region was characterised by new, significant population migrations. Under Turkish rule, the population fled and Catholics inhabited the abandoned areas of the Cetina's upper and middle course. After shifting the Venetian-Turkish border, firstly to the route crossing Zadvarje-Vrgorac-Sinj, and then further towards Imotski and Herzegovina, a flourishing coastal strip emerged under Venetian rule; several roads were constructed within the coastal area, while trade and agriculture flourished. A specific type of residential architecture, preserved until recently, was introduced. The two-storey stone houses featuring external staircases, typical of the Mediterranean region, were designed. The main characteristic of the architecture of the settlements was the grouping of houses around a common settlement square which was the junction of all the streets. In common with the dwellings of most hinterland settlements, these houses retained open courtyards, in itself, a particular feature of such settlements.

With the establishment of French rule, the situation remained unchanged. Important municipal and agrarian reforms undertaken by the French failed due to either their short duration or to the conformity of the Cetina region's inhabitants. During the short period of French rule, the completion of the coastal road and the construction of several bridges over the Cetina River, were initiated, aiming at the establishment of connective routes throughout the province. This was not achieved until the second period of Austrian rule, during which the construction of a coastal road leading from Split to Makarska, onto the Poljica road and penetrating further via the pass of Vrulja that connected the coastal area with the French hinterland road, was finally completed.

Important changes occurred in the Sinj and Cetina regions between the second half of the 19^{th} and the beginning of the 20^{th} centuries, during the second period of Austrian rule. The population size increased, while the middle class, tradesmen and landowners prevailed. This development was reflected in the overall appearance of Sinj and the Cetina region itself. In this first urban centre, public and administration building were erected, while sewage systems were designed and municipal parks created. In addition, existing roads were modernised and stone bridges were erected over the Cetina River. The aqueduct in Kosinac was complete by 1914.

During the 20^{th} century, two World Wars in addition to a number of unresolved social and political issues disrupted the area's period of bloom of the mid 19^{th} century. After the Second World War, intensive industrialisation processes within the coastal area resulted in a constant increase of the coastal population. These economically-motivated coast-bound migrations, caused a gradual degradation of the agricultural activities of the hinterland which has practically been abandoned.

It is during this period that the majority of hydro-electric power plants (HPPs) were erected along the river, and when most the efficient infrastructures including the Adriatic road, and water supply systems, to name but a few, were developed. At the start of the 1970's, tourism emerged as the most prosperous asset, encouraging the use of the coastline and the construction of residential homes, but simultaneously neglecting the hinterland.

Regretfully, a large part of this territory has been devastated during the recent war. The rehabilitation of this area, which has already started, should follow the cultural and economic principles of the past, respecting as much as possible the valuable natural resources of the area.

2. The basic natural characteristics of the Cetina River basin and its adjacent coastal area

2.1. Natural characteristics of the river basin and the coast

2.1.1. Climate

The river basin and its surrounding coastal area are characterised by two main distinctive climates: the Mediterranean and the continental climate. The Mediterranean climate of the coastal watershed is characterised by long, warm and dry summers, and mild and humid winters. The hinterland's continental climate is characterised by long and severe winters, as well as by warm and short summers, and humid springs and autumns.

Despite its small size, the geographical position of the Cetina River watershed is quite distinctive as it closely resembles the Adriatic Sea, from which it is divided by mountain chains higher than 1,500 m above sea level. This particular geographical position is quite significant for the climatic characteristics of the river basin. The penetration of humid air masses from the south west results in high levels of precipitation. As the watershed is mainly located in the continental part of the karstic Dinara mountain, it is the meeting point of influences deriving from both Mediterranean and continental climates. This often results in frequent changes of humid and dry, and warm or cold air masses constituting the complexity of this relatively small area's climatic characteristics.

The mean monthly and annual air temperatures recorded on two meteorological stations have been explicated in Table 2.1. The values obtained in station II are typical of the western part, being as it is, under the direct influence of a maritime Mediterranean climate, while those obtained in meteorological station VII typify the north-eastern part of the watershed, as it is influenced by a continental climate.

Table 2.1.
Mean monthly and annual air temperatures, measured at two meteorological stations in the watershed and in the coastal Split-Marjan area

Month	Meteorological station (see Figure 2.1)		
	II	VII	Split
January	-3.4	-4.3	7.6
February	3.8	-5.8	8.1
March	7.3	-0.7	10.3
April	11.4	5.0	13.8
May	15.7	8.7	18.7
June	21.0	13.2	22.6
July	23.6	15.1	25.5
August	23.3	15.8	25.0
September	18.8	13.2	21.5
October	13.5	5.8	16.9
November	8.7	1.4	12.3
December	5.0	-0.9	9.2
Year	**12.4**	**5.5**	**16.0**

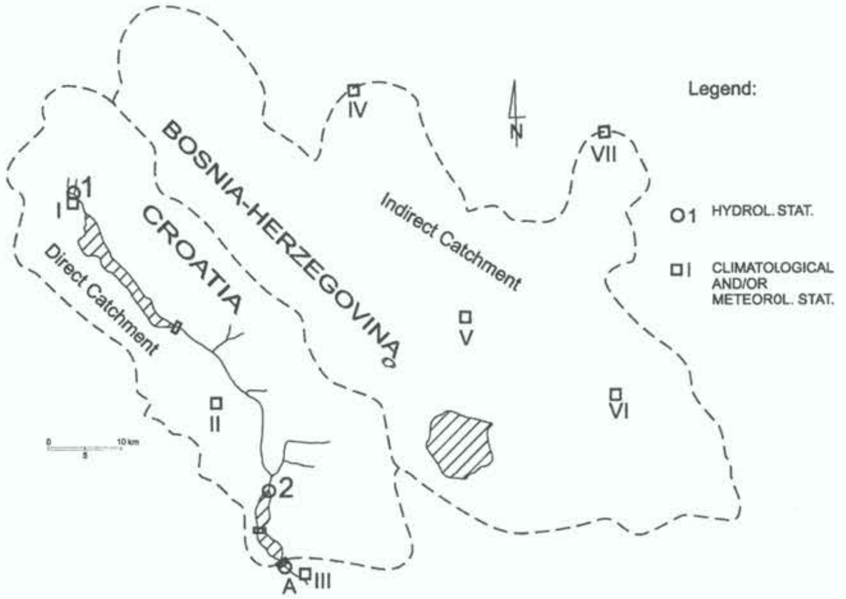

Figure 2.1: Hydrological and meteorological stations in the River Cetina watershed

It should be pointed out that although the distance between the meteorological stations is a mere 59 km, the difference in temperature regime is substantial. The mean seven-year temperature has decreased by up to 6.9°C. This, among other factors, has been caused by the area's elevation itself, which reaches approximately 882 m above sea level, the height at which the stations are located.

It can be generally maintained that the climate of the western, and in particular of the direct part of the Cetina watershed is partly maritime, retaining certain Mediterranean climate characteristics, with its warm and dry summers and mild and humid winters. The mountain chains included in the Dinara massifs, stretching towards the north west and south east, cause, to a large extent, the decrease of the direct influence of the Mediterranean climate, which is a characteristic of the Adriatic coast and the islands; the karstic fields in the Cetina basin are directly influenced by the continental climate.

The climate of the eastern karstic fields, in the direct Cetina watershed, is predominantly continental. Its influence increases at the far eastern parts of the Kupres field, where winters can be long and harsh, and summers cooler than usual. The influence of the maritime climate, especially during summer, is felt also in the Duvno field, which is located only about twenty kilometres to the south and is 250 m lower than the Kupres field. The climate in the vicinity of the Cetina source and the main body of the river is mostly influenced by orography. During the winter period, and sometimes in summer, the strong wind (*bora*) blows from the high mountains of the north east.

Table 2.2 shows that the average annual precipitation in the Cetina watershed is 1,380 mm. Generally, the warm part of the year is dry. Between June and August, the precipitation is approximately 17% p.a., while in the most humid period from October to December, annual precipitation reaches the 34% mark, i.e. twice as high as that of the summer. With reference to the winter air temperature, as during the colder periods, smaller losses through evapotranspiration have been registered. It is easy to understand why from October to December, the karstic fields are frequently flooded. These floods, depending on the precipitation regime, normally last from January to April, but they may be prolonged until May. It should be mentioned that the precipitation regime in the Cetina watershed is also affected by snow, which often covers the areas exceeding 500 m, i.e. 1,000 m above sea level.

Table 2.2.
Mean monthly and annual precipitation, measured at seven meteorological and/or hydrological stations (Figure 2.1)

	Number of station from Figure 2.1 including its height above sea level (in m)						
Month	**I (520)**	**II (308)**	**III (275)**	**IV (1031)**	**V (730)**	**VI (903)**	**VII (1190)**
January	75	116	181	121	88	106	80
February	99	104	161	124	95	115	85
March	106	112	140	122	103	123	88
April	82	89	129	105	82	94	89
May	93	88	83	110	93	107	105
June	93	91	81	103	87	92	108
July	58	65	55	68	52	56	62
August	75	82	70	77	72	80	87
September	101	85	94	115	90	83	96
October	124	151	152	152	145	150	130
November	105	134	234	148	128	153	110
December	120	156	258	194	134	146	109
Year	**1,131**	**1,273**	**1,638**	**1,439**	**1,169**	**1,305**	**1,149**

2.1.2. Relief

The basic relief contours of the Cetina watershed were created in the Tertiary period during the formation of the Dinara massifs. The mountain chain divides the watershed area into two basic high-altitude sections, the lower through which the river flows (250-550 m above sea level) and the higher area, east of Cetina, encompassing 2/3 of the watershed (800-1,200 m above sea level). The mountain massifs embrace both sections, with its peaks Dinara (1,830 m), Slime (1,830 m), Troglav (1,913 m) and Kamešnica (1,856 m above sea level). The western boundary of the direct river watershed is the mountain Svilaja (1,580 m above sea level), while its eastern boundary is the Dinara.

The atmospheric water's corrosion and the limestone's geological orogenesis created several karstic formations in the entire area, of which the most significant are the karstic fields. The largest of these, in the direct river watershed, are the following: Cetina-Pag (450-550 m height); Hrvace (300-350 m height); and the Sinj (290-320 m above sea level) fields. The largest fields in the remaining indirect watershed stretching to the territory of Bosnia and Herzegovina are: the Kupres field (1,000-1,200 m height); Glamoč (850-1,100 m height); Livno (700 m height) and the Duvno field (860 m above sea level). These are divided by lower or higher mountains, such as Hrbina (1,459 m), Slovinj (1,834 m) and Cincar (2,026 m) mountains, which divide the Glamoč field from that of Kupres. Additionally, the Staretina (1,633 m), Velika Golija (1,890 m) and Krug (1,249 m) divide the Glamoč and Livno fields. However, the relief contours indicate a constant high-altitude trend occurring from the coast towards the watershed margin. More specifically, it is a steeply accelerating trend, from the coast to the first plateau of the hinterland, and, thereafter, via the karstic fields towards the watershed margin. From the Sinj field, which is the last field of its watershed, Cetina falls suddenly downwards, from a height of approximately 300 m, into the sea.

As the above suggests, the relief of the entire watershed has been uniquely formed by several mountains, fields, and saddles. This condition creates the specific hydrological characteristics of Cetina's hydrological system formation.

The relief of the coastal area, whose form is rather diverse, is characterised by an extremely steep coast extending from the top of the coastal mountains to the Adriatic Sea. The exception is the relatively narrow coastal part, in the river mouth, and the flat western coast.

As mountain chains are embracing the coast, they aggravate connections between the coast and the hinterland. The most significant saddles are the following: Klis (350 m height), located between the coast and the direct watershed; Kamensko (700 m height) between the lower direct watershed and the eastern higher watershed; and Kupres (1,200 m height), situated at the eastern boundary of the watershed.

2.1.3. Geology and mineral resources

2.1.3.1. Geology

Litho-stratography

The Cetina River watershed was formed by carboniferous deposits, during the Tertiary, Jurassic and Cretaceous periods. Examples of Tertiary and Trias period deposits may partially be found here. A large part of the area, especially that prone to Cetina flooding, has been covered by Quarter sediments. The suitability of land for agricultural production depends on the characteristics of Quaternary deposits. Nevertheless, these deposits are insignificant for the watershed in hydrological terms.

Knowledge of the lithological characteristics of the rocks facilitates the analysis of the hydrological relations of the watershed.

Tertiary deposits (dolomite, limestone and slate) represent uncompleted barriers in the watershed. Jurassic sediments have been found in the form of carboniferous deposits that resemble marl and marl limestone. The greatest part of the watershed is made of limestone and Jurassic deposits which appear to be carboniferous rocks. The transition period from Jurassic to Cretaceous period is unbroken. According to their hydrological characteristics, Tertiary deposits could be divided into Palaeogene and Neogene deposits. While the Palaeogene, which are represented by limestone and marl clastites, do not constitute a barrier, the Neogene is a completed barrier formed of marl facies. It can be found in the Glamoč and Kupres fields, and especially in the Livno, Duvno and Sinj fields. Generally, the Neogene extends in the direction of the north west and the south east, following the reverse fissure in the northern outskirts of Livno field. It then continues further, after a small interruption, into the Duvno field. Neogene deposits are treated as a completed barrier that resembles portions of deposits in the Sinj field which are hydrologically divided into the north-eastern completed barrier and the western and southern incomplete barrier.

Quaternary deposits have been abundantly represented in every form. Terrain formed of loose particles can be found on the mountain slopes, while in the fields, the type and volume of Quaternary particles depend on the route of the particle and on the flooding regime of the Cetina River. Quaternary particles differ substantially from each other in terms of their volume. They are fairly insignificant from a geological and hydrological perspective, although of more interest from the viewpoint of agricultural production and mineral resources.

Tectonics

In addition to litho-stratography, the water division in the karst also depends on the structure of the rock mass and it is thus necessary that it is recognised as a crucial factor in the deeper understanding of hydrological phenomena. The formation of the wider area can be traced back to the beginnings of the Alpine orogenesis, when the entire watershed area suffered several strong tectonic movements. The first large fissure can be seen at the edge of the Glamoč field, extending along the margin of the Livno field towards the north west and the south east, north of Livno and Duvno and then towards Kongora. This watershed section is under the jurisdiction of the Republic of Bosnia and Herzegovina. In the same direction, a number of fissures, including several transversal ones, have been created, constituting a natural connective network, thus enabling the water to flow in these directions. The fissures have determined the current geo-tectonical and morphological state of the watershed, which is especially interesting in hydrological terms.

Fissures are not the only existing traces of orogenesis. Others have been discovered in the form of several sinclinals and anticlinals, which, much like fissures, stretch towards the direction of the north west and south east, designating a smaller inclination to the north-south that is akin to that of the reversal fissures.

2.1.3.2. Mineral resources

Mineral resources include several basically profitable materials. Primarily, limestone utilised in the production of concrete, in the construction industry. In the Cetina watershed, there are a number of quarries of different quality and size. In economic terms, there has been insufficient exploitation of decorative and construction stone. Sand and gravel are exploited in several locations in Sinj. Sand is also being exploited in the Brač Channel, between Stobreč and Omiš. In the Sinj field, some minor coal deposits can be found, within the Neogene lake deposits. Some coal (lignite) quantities are being exploited in the Duvno field, near Kongora, in the Livno field. These quantities are substantial and can, therefore, be utilised in a longer period of time.

2.1.4. Soil characteristics

The Cetina River watershed is mainly comprised of limestone and dolomite, forming the karstic area. Vegetation cover is scarce. This area, in which the natural habitat of pubescent oak and coniferous wood had previously flourished, is presently denuded and mainly covered by scarce maquis, and cannot, therefore, be used for agricultural production. In its northern part, certain species of trees can be found. Arable areas can be seen in the karstic fields that have been naturally flooded during rainy periods. Due to the extreme continental-mountainous climate, and despite their fertile soil, the Kupres and Glamoč fields remain inappropriate for intensive agriculture. This watershed section is mainly occupied by meadows and pastures, and is used seasonally, in the summer time, for the production of potato, cereals and other crops.

In the Livno field, we can see marshlands and peat-mosses. Part of the field is flooded over by the Buško lake waters. Prior to the construction of the Kazaginac and Podgradina dams, the lowest part of the field had mostly been a peat-moss one. Arable land can also be found in the Duvno field. The western watershed section, situated by the river source, is typically karstic; Quaternary deposits can be exclusively found in the Cetina valley, but as they are made of big grain, they are porous and almost arid. The most fertile part of the Vrlika field is flooded by waters from the Peruča reservoir. Only below the Peruča dam, in the Sinj field, more fertile soils of small-grain can be found. Their quality improves as we move downstream, where fertile soils covered by small grain are spreading over the area of Trilj. In the south-western part of the Sinj field, as well as in the area north of Sinj, there are important sand deposits. The fertile land reaches less than 20% of the total watershed surface, of which a part is permanently flooded by reservoir lakes. Along Cetina's course, in the area of Blato, a fertile zone exists. According to certain indicators, there had been a kind of natural dam downstream of the settlement, which has been recently destroyed by powerful water impacts. In the area behind this hypothetical partition, small-grain river deposits can presently be found forming a cliff in the settlement area, as well as a narrow fertile field along the river course.

The Cetina mouth was formed during the Quaternary river deposit. Today, its morphology has been completely changed by regulation works. Research drilling works, occurring at the exit of the river canyon, have uncovered thick Quaternary formations (more than 70 m). The contribution of Cetina's suspended deposits to the formation of the seabed surface in the Brač Channel has been substantial. The same deposits have also formed the beaches, extending through the wider area of Omiš. Further alterations in the river characteristics might question the river's additional contributions to the Brač Channel deposits, with all the anticipated consequences this phenomenon might have.

The lowest parts of the southern rocky slopes of the Mosor mountain are covered by flysh deposits. As these slopes are exposed to the sun, parts of them were used for agricultural production, by constructing underwall "barrows", and transforming the soil into steps. Underwalls can also be found in the hinterland of the Cetina watershed. However, since agricultural activities, in these inaccessible and arable areas (the only option is manual work and the use of digging machines) have been gradually abandoned, the underwalls began to crumble. If forest cover failed to appear at these locations simultaneously with the abandonment of agricultural production, the gradual crumbling of the underwall commenced, while erosion washed away the arable land.

The specificity of the structure of the coastal area relief has divided the entire coast into sections covered by different types of vegetation. The main coastal characteristic is the landscape itself, with its natural plant families that have been cultivated under anthropogenic influence. Instead of traditional agricultural crops, on the mild coastal slopes, Mediterranean vegetation (garrigue, maquis) with smaller complexes of Aleppo pine, predominates. Soil site class determination is the result of natural and anthropogenic influences in this area (Figure 2.2).

The first site class is represented by very fertile soils that could be easily cultivated by the application of the commonly used methods. This soil is deep and fertile. Due to the area's flat relief, there is barely any soil erosion. The latitude of the use of this class of soil for plants production is broad. Cultivation of this soil is not particularly problematic, neither in terms of humidity, alkalinity, salinity, climate, inclination, erosion or flooding, nor in those of soil porosity, water capacities, roots depth, soil nutrients condition or texture.

The second site class is characterised by soils which are easily cultivated. These soils are deep and fertile, which is typical of mild slopes that are moderately erosive, and only some of them can be slightly humid and alkalic, requiring more intensive fertilisation or minor drainage. By comparison to the first site class soil, whose cultivation does not entail any restrictions, this soil requires certain protection. Due to various pedogenetic factors, it may vary in chemical and physical aspects. Nevertheless, because of its production/application value, this type of soil belongs to the same site class.

The medium-quality soils, mainly the mild slope soils, belong to the third site class of soil. Generally, these soils can be shallower and less productive than the second-class soils. They are either too dry or too humid, and they can only be used with the additional application of melioration methods, which constitutes, in the first instance, high protection against erosion (terracing). In the case of over-humidity, these soils must be meticulously hydro-meliorated.

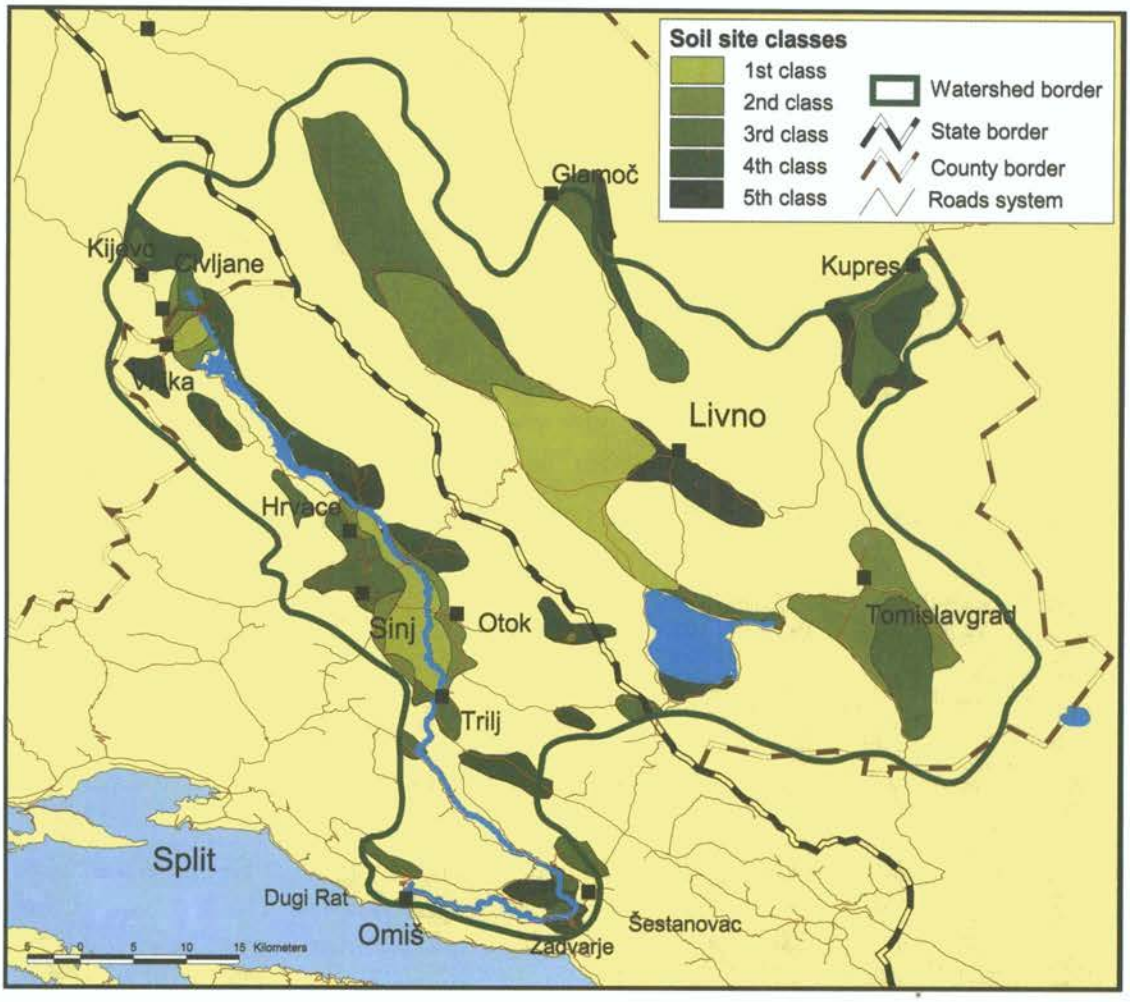

Figure 2.2: Suitability for agriculture

The fourth site class is represented by soils only suitable for limited cultivation, as these are extremely erosive. Within this area, these soils include terraced land with steep slopes, frequently shallow, rocky, and skeletal. Due to these considerable limitations, such soils should be carefully managed. The fourth site class soils are mainly used as pastures, and for either wine or fruit production.

The fifth site class includes soils of especially steep slopes of shallow pedological profile, stony soils, and soils subject to aridity. Due to erosion (mainly caused by water), this soil is degraded, containing only partially or completely eroded fertile layers. The soil profile is shallow and the surface is rocky rendering the use of even small agricultural machines impossible. Its cultivation requires the application of several radical measures, and, therefore, within the study area, the land remains largely abandoned. Pastures or agricultural areas of limited capacity have been terraced by agricultural crops, and some have been occupied by certain tree species.

2.2. Hydrology and hydrogeology

2.2.1. Water resources – hydrology

Cetina is a typical karstic water course with its watershed and riverbed formed in the area surrounding a deep Dinara karst. Because of this, and despite several previous investigations, it has been impossible to determine the size of the surface area or point out the exact watershed boundaries. A karstic terrain characteristic is that the underground dividing line does not coincide with that of the surface (orographic-topographic); moreover, the underground dividing line, may periodically vary depending on the level of groundwaters. As monitoring the groundwater in the karst can be a very costly and complicated process, useful data has been unavailable.

Various researchers have attempted to determine the boundaries and size of the surface of the Cetina watershed. Applying several methods, they have established that the surface area of the entire watershed to its mouth on the Adriatic Sea is from 3,700 to 4,300 km^2 of which the topographic watershed encompasses about 1,300 km^2 and the underground, about 2,700 km^2. The length of the Cetina River, from its source to its estuary, extends to 105 km. Its source is elevated at 382 m height, with an approximate riverbed drop of 0.3638 ‰. The Cetina riverbed is shown in Figure 2.3, which also designates the location of the storage reservoirs of its hydro-electric power plants (HPPs). Their main sources and their four control points (1, 2, 3 and A) are very important to hydrological analysis.

Within the above framework, it has been established that the first and simultaneously smallest HPP of Kraljevac was erected in 1912. The largest storage reservoir in Buško Blato, with a capacity of $831 \cdot 10^6$ m^3, accumulates water for the supply of the Orlovac HPP. The Zakučac HPP provides the greatest annual energy production. It should be mentioned, here, that the first supply tunnel connecting the Prančevići storage reservoir with the Zakučac HPP, was built in 1962, while the second in 1980. The construction and operation of these five HPPs have transformed the natural flow regime of both the Cetina watershed and the very riverbed.

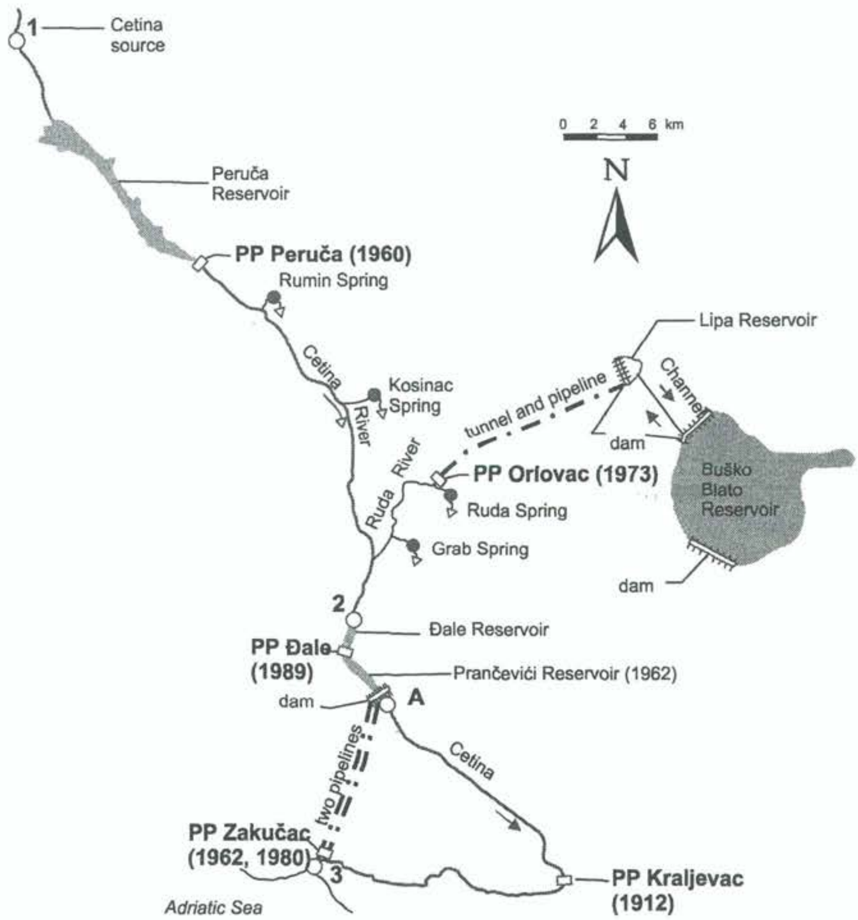

Figure 2.3: Hydrological system of the Cetina River

For this reason, the Cetina watershed has been frequently considered as two independent parts. The first is the upstream river flow that encompasses the section, extending from the river source (No. 1 in Figure 2.3) to the Prančevići dam (point A in Figure 2.3). Downstream of the Prančevići dam and up to the river mouth on the Adriatic Sea, Cetina's hydrological regime depends primarily on the quantity of water channelled via the two supply tunnels of the Zakučac HPP, as well as on the biological minimum (the ecologically acceptable flow), channelled through the basic outlet of the Prančevići dam. There is one more important natural difference between these two distinctive areas. Despite the fact that these parts are approximate, the watershed boundaries shown in the same Figure, clearly designate that there are two distinctive, subsequent watersheds. The right western part stretching along Cetina, has been called the "direct sub-watershed". It is often defined as a "topographic part of the watershed", as it has been determined by surface and morphological formations, that is, by connecting the mountain chain peaks whose heights are above 1,200 m; its highest peak reaches 1,869 m.

The left, eastern part of the watershed is termed an "indirect watershed" because its flow, towards either the direct part of the watershed or Cetina River, is diverted by several underground karstic channels, pits, cavities, holes, etc. In addition, the natural flow of this part has been disrupted by the construction of the Buško Blato storage reservoir, as well as by the Lipa compensation basin.

The indirect part of the Cetina watershed stretching up to the Prančevići dam, encompasses an area of roughly between 2,000 and 2,600 km^2, while the direct topographic part occupies about 1,200 km^2. The subsequent Cetina watershed, downstream of the Prančevići dam to the Cetina mouth, occupies approximately 500 km^2. It has been postulated that the surface topographic dividing line, nearly coincides with the underground hydrogeological dividing line in this part of the watershed. From a water resources management perspective, it is important to point out that almost the entire direct part of the watershed, extending up to the Prančevići dam, belongs to the territory of the Republic of Croatia, while the indirect watershed is mainly located in the territory of the Republic of Bosnia and Herzegovina.

Figure 2.4 contains all the underground connections of Cetina identified by using dye tracers. Along with the complexity of the interrelated underground connections of the Cetina watershed, the existence of several disputable interrelationships need to be taken into account.

Table 2.3 indicates the mean value of the river flow, recorded over a period of several years and presented in four sections. Section 1 encompasses the inflow of the entire river source zone. Section 2, includes the inflow of the eastern indirect watershed. The Section marked by the letter A, regulates the flow of waters from the Prančevići storage reservoir, referring to the situation after the completion of both supply tunnels of the Zakučac HPP. Section 3 indicates the mean river flow at its mouth, i.e. after the channelling of water through the two supply tunnels and the turbine of the Zakučac HPP, and after the join of the flow of the Cetina inter-watershed, from point A to the river estuary (point 3).

From the data presented in Table 2.3 we can conclude that the mean flow coefficient value for the Cetina watershed for the recorded period is between 0.627 (for the watershed surface area of 4,300 km^2) and 0.729 (for the watershed surface area of 3,700 km^2), having taken into account the adopted mean precipitation in the watershed of 1,380 mm p.a. So far it has been clear, that the Cetina watershed constitutes a rich water resource. However, it should be highlighted that the distribution of water quantities over the year is insufficient, given that in dry summer seasons, water quantities decrease substantially (Table 2.4).

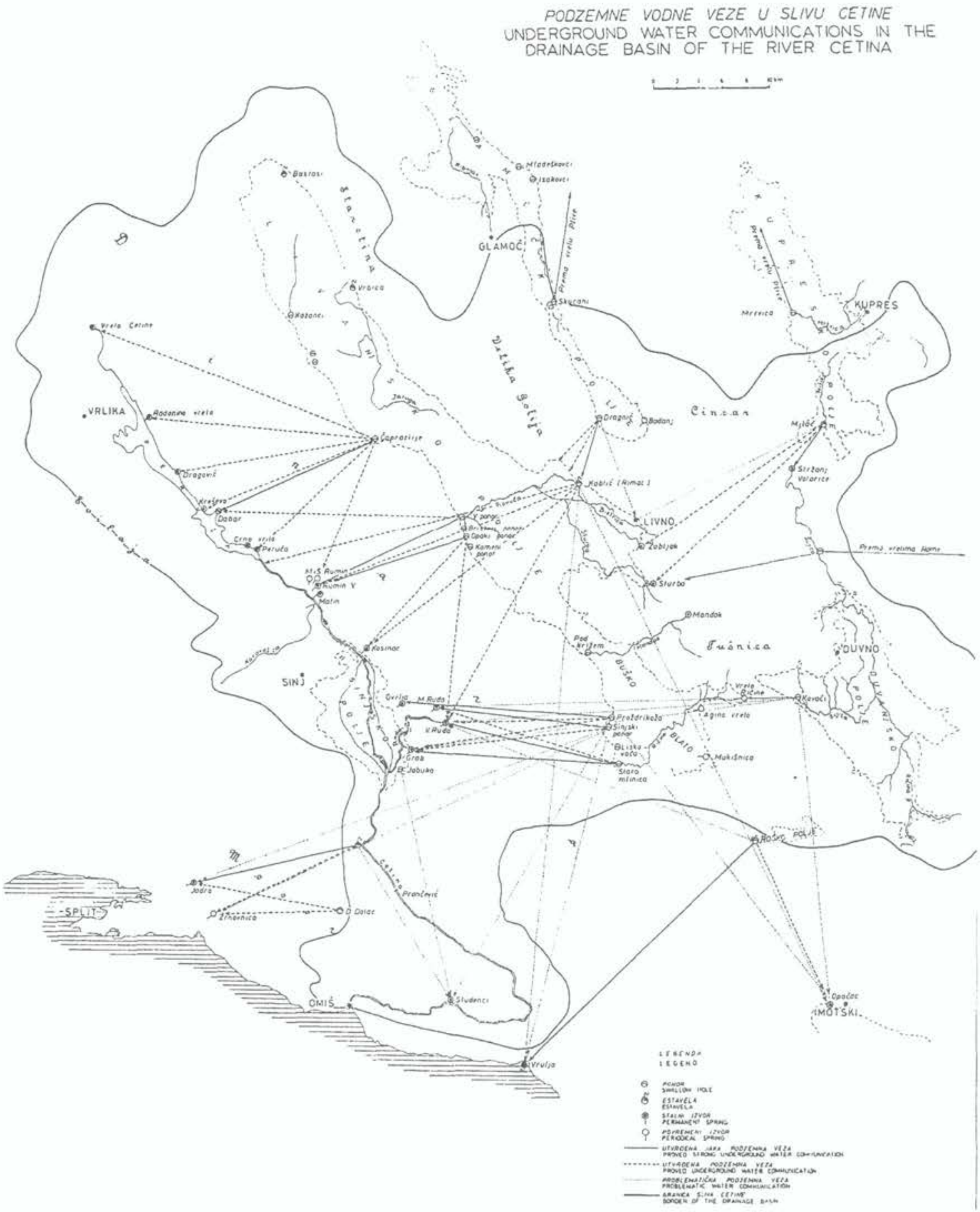

Figure 2.4: Underground waters in the watershed

Table 2.3.
The mean Cetina River flow capacity in four sections during the period spanning several years

Section No.	Location in Figures 2.1 and 2.2	Mean water flow capacity Q (m^3/s) through years	Note
1	1	12.5	1960 – 1998
2	2	104	1960 – 1998
3	A	8	1981 – today
4	3	118	1960 – 1998

However, it is true that the operation of storage reservoirs has improved, i.e. levelled the annual water flow regime. Namely, the Mlinica section is located downstream and Vinalić upstream of storage reservoirs. As it can be seen from the data presented in Table 2.4, the mean monthly river flow oscillation measured at Mlinica section is lower than the one measured at the upstream section. The impact of the Buško Blato storage reservoir has been very positive, increasing as it does, the relatively small flows of the left river bank sources of Rumin, Kosinac, Ruda and Grab. Their average minimum annual water quantities have been increased by 3 to 4 times compared to their original levels.

Table 2.4.
The mean monthly river flow capacity in two characteristic sections (m^3/s)

Section	Mean monthly river flow capacity												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Cetina – Vinalić 1947-90	15.3	15.0	15.2	19.4	15.4	9.6	5.0	3.4	4.9	8.7	15.8	20.3	12.3
Cetina – Mlinica 1947-93	132.9	133.5	122.6	123.6	101.3	77.7	54.5	50.4	55.7	74.6	117.6	146.4	99.2

As it is evident in Table 2.5, the underground Cetina water resources have an enormous capacity. However, it should also be pointed out that they have only been partially researched. The data in the same table reflects their dimensions. Table 2.5, also indicates the underground water values recorded in four deep piezometres perforated near the Prančevići storage reservoir. The maximum fluctuation amplitude of the underground water level, during this relatively short period of time, was recorded from 72.03 to 120.28 m, while the maximum groundwater level increased intensity was measured from 1.34 to 3.17 m/h, which is equivalent to an amount of 36 to 77 m/day. It should be stressed here that the maximum groundwater level decreased intensity may differ in homogeneity in accordance with different piezometres, ranging from 0.215 to 0.310 m/h.

Figure 2.4 designates that the direct connection between the Cetina waters and the Jadro source, has been determined by dye tracing. Given that the town of Split and its broader region have been supplied by high-quality water, originating in this karstic source, additional importance should be attributed to the Cetina waters, from the aspect of a wider regional water supply, as well as from that of water protection. It should be added, here, that the connections between the Cetina waters, diverting underground into the

Grabov mill and those originating in the Jadro river, have not been adequately researched. Moreover, the construction of the Prančevići and Buško Blato storage reservoirs seem to increase the water quantities of the Jadro and Žrnovnica sources. However, we must pinpoint that this latter postulation cannot be confirmed until the respective measurements have been completed and validated.

Table 2.5.
The River Cetina watershed groundwater levels measured at four piezometres

No. of piezometres	Max. level h_M (m a.s.l)	Min. level h_m (m a.s.l)	Range h_M-h_m (m)	Max. level increase intensity (m/h)	Max. level decrease intensity (m/h)
1	273.11	199.21	73.90	1.99	0.229
2	275.07	203.04	72.03	2.33	0.215
3	274.75	154.47	120.28	3.17	0.306
4	295.39	213.84	81.55	1.34	0.310

The average mean annual flow of the Cetina River into the Adriatic Sea is 118 m^3/s, coinciding with a water volume value of $3.72 \cdot 10^9 m^3$. This quantity flowing into the limited area of the Brač Channel is substantial. This fact alone reflects Cetina's importance in ecological terms for the coastal area. However, natural and human impacts on the flow, which can be enormous during the year, should also be considered. Apart from the Jadro source, several other larger (Žrnovnica), as well as a number of smaller sources can be found here in connection to Cetina.

2.2.2. Hydrogeology

In accordance with the hydrogeological division of the Dinara karst, the Cetina watershed can be mainly included in the middle strip, with only a smaller part in the Adriatic strip (Figure 2.5). The middle strip is characterised by a certain discord between its morphological and hydrogeological dividing lines. The surface flows have been exclusively formed in areas covered by impermeable rock layers. As karstic fields end at a point characterised by impermeable and permeable carboniferous rocks, river courses conclude in precipices. The only complete surface course with its estuary ending at the sea coast is Cetina River. The Adriatic strip is characterised by underground and coastal freshwater springs.

The largest part of the watershed, formed by porous limestone and dolomite does not feature any permanent surface flows. The prominent flood courses have been formed in gullies, exclusively after periods of heavy rain, while the flow of the other part of the watershed has been facilitated by the karstic surface's high water permeability, consisting as it does of limestone and dolomite.

In the Cetina watershed, there are several strips of complete barriers (the Lower Trias clastic deposits and thick Neogene deposits in karstic fields). In the coastal area, the completed barrier has been represented by Eocene flysh deposits.

The underground water flows upon limestone, through underground holes, canals and caves. Crucial to the flow's movement through limestone, is the secondary water permeability, which in the Dinara karst can be very unstable in terms of space, ground-plan and depth. It is also known that surfaces made of limestone and dolomite are overtly karstic. In analogy to the depth, the number of holes within the total volume of the rock mass decreases. Nevertheless, caves and cavities can often be found at even greater depths that may substantially affect the water flow direction in the karst.

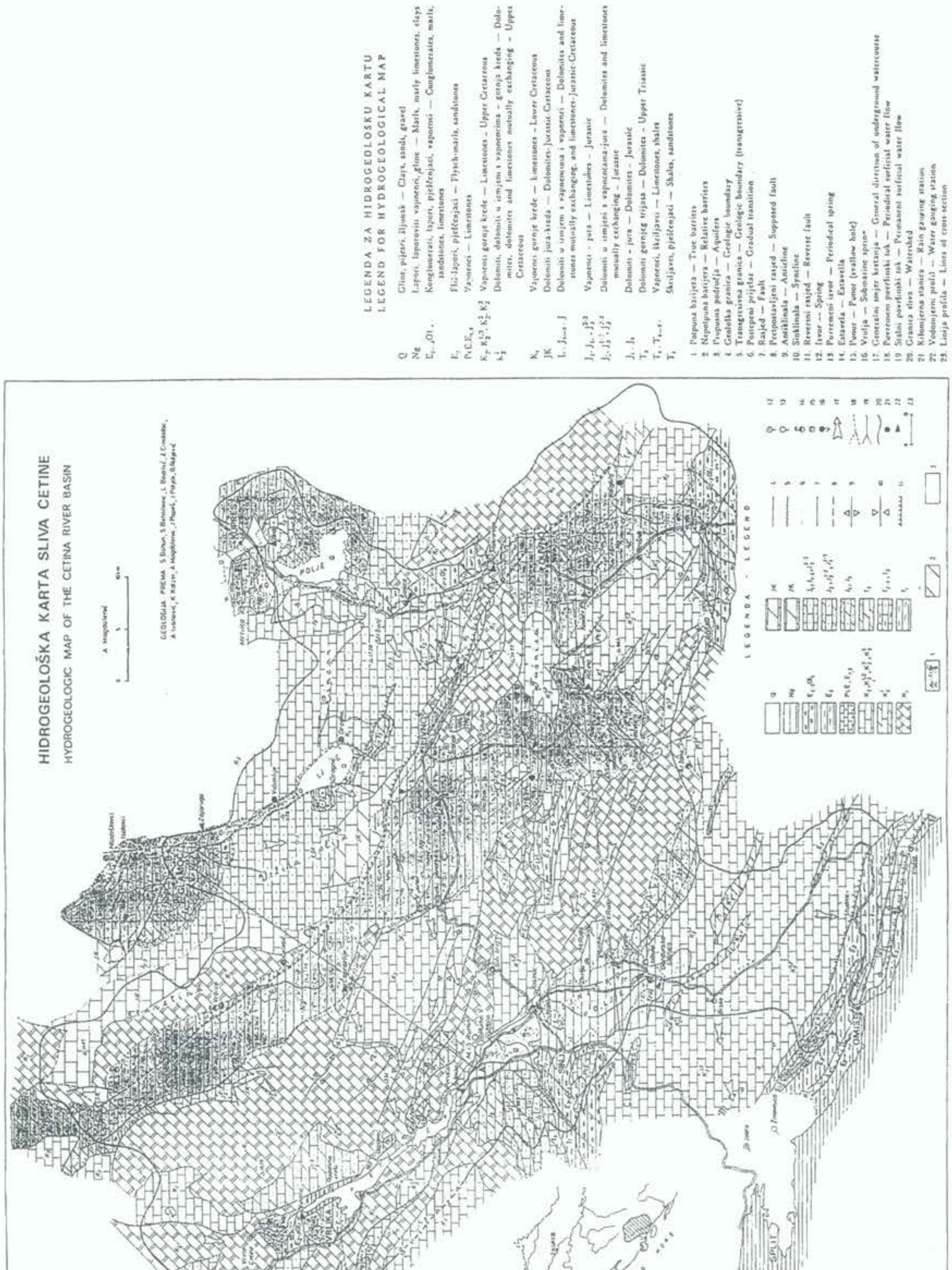

Figure 2.5: Hydrogeological map of the watershed

Research into Cetina underground waters has been undertaken within the framework of previous general research. Its methodological approaches have included the connection of the precipices and sources either by dye tracing or by using certain other route markers. The karstic fields in the Cetina watershed designate a plenitude of precipices, sources and estavelles. As the moving course of the underground flow remains unknown, its postulated speed has been roughly calculated by drawing a hypothetical straight line, connecting the two recording stations. The Cetina watershed research has been performed in the Kupres field, at its highest point above sea level, and through the Glamoč, Duvno and Livno fields to Buško Blato and the Sinj field. Dye tracing has been used in both lower fields' sources and the freshwater sources of Jadro and Žrnovnica, in addition to the underground springs of Vrulja.

Generally, it could be argued that the water moves from Glamoč and Kupres field towards the sources and estavelles surrounding the Livno field (Buško Blato and the outskirts of the middle part of Livno). From the Livno field and Buško Blato, the water gushes to the west, towards Cetina, and the sources near the north-eastern margin of the Sinj field. Attempts have been made for years, with little success, to halt the water flow in the precipices zone situated at the western edge of the Buško lake, in order to minimise water losses that have been occurring in the lake. Only the Sinj field is formed by an impermeable water barrier and surface water courses have been formed within it. Leaving the Sinj field near Trilj, Cetina enters into a canyon-like bed, which in its northern part is deeply cut by limestone originating in the Cretaceous Age. After a short turn to the west, the river enters into marl and sandstone flysh deposits. The limestone covering the bottom of the riverbed is obviously quite impermeable, as the water flow appears to be an open surface course. From Trilj to the Cetina mouth at its very bed near Bisko, a significant estavelle can be found in addition to a group of powerful sources, commonly called "Studenci".

The hydrogeological state of the watershed has been substantially altered by the completion of the infrastructure of the existing HPPs. Storage reservoirs have also been constructed in the Livno and Vrlika fields. The storage reservoir of Buško Blato has been connected, via a supply tunnel that crosses the Dinara mountain, to the Orlovac HPP.

From the Prančevići retention, Cetina waters are transferred to the Zakučac HPP by two supply tunnels passing through the Mosor mountain. Apart from changing the natural flow regime of Cetina, these operations have also caused drainage within the rocky massifs of the Dinara and Mosor mountains. The actual change of the hydrological conditions in these two mountains has not been yet determined, as the interest in water condition has diminished following the construction of the HPPs. The coastal population between Stobreč and Omiš have witnessed changes in the sources flow regime, appearing between the limestone and the Eocene flysh. Regretfully, any detailed research on these changes has yet to be performed. In the old village of Sumpetar, the appearance of a large, still-active landslide site at the coast, has been recorded after the completion of the Zakučac HPP. Moreover, the favourable impact of the existing storage reservoirs on the regulation of the annual flows of the Jadro and Žrnovnica sources, and in addition to the underground springs of Vrulja, included also in the Cetina watershed, has already been established.

2.3. Characteristics of the adjacent coastal area

2.3.1. Coastline characteristics

The coastal strip affected by the underground Cetina waters, extends from Vrulja, in the south east, to the Jadro river in the north west. Its length extends to approximately 30 km. The Cetina estuary is located in the middle part of this area.

The coast is relatively straight without open coves or bays. The most significant changes to the coastal strip have been linked to the river mouth. From Vrulja to the mouth, the coast is extremely steep. Smaller narrow plateaux can be found on the coast, creating beaches and open spaces that can be used for housing. The plateaux have been created by depositing of the eroded material from the slopes of the coastal hills. From the Cetina mouth to the town of Split, the coast levels out, owing to the sediment transferred by the river, as well as to the particular topography of the coastal strip. The flat surfaces west of the Cetina estuary narrow down as we move away from it. The largest plateaux can be found around the river mouth, in the area embracing the town of Omiš.

Within the researched area, the seabed can similarly be described. Steep coasts are followed by a steep seabed, creating depths of up to 70 m, relatively close to the coast (400 m from the coast). Around the river mouth and to the west of it, the seabed is shallow, extending from the coast towards the Brač Channel. A sea depth of approximately 45 m can be found at a distance of only 1 km from the coast.

The approximate width of the Brač Channel, in the area directly affected by the direct Cetina River reaches 7 km, while the channel depth is about 50-80 m. Considerable water quantities, containing organic and inorganic suspended matters, including dissolved matters, are constantly transferred by the Cetina River into the Brač Channel.

The entire coastal strip has experienced significant changes stemming from its intensive exploitation and urbanisation. More significant changes have occurred in the easily accessible areas, such as the flat terrain west of the river estuary, while the most radical changes have been registered in the Cetina mouth area, where the town of Omiš has been developed.

2.3.2. Coastal processes

2.3.2.1. The natural state of the Cetina River mouth

Flowing through its canyon down the slopes of the Mošnica and Dinara mountains above Omiš (Rat), prior to its entrance into the Adriatic, Cetina forms its wide estuary with several short and sinuous windings. Generally, the mouth extended in a south-westerly direction. During the rainy (winter) season, the entire mouth was rendered a marsh by high river flows. In the dry (summer) season, however, as flows remained low, the mouth remained above water level, even during high tide. The sediments formed in the river watershed by erosion processes were transferred by floods to the riverbed and to the sea. In the riverbed downstream of the Gubavica fall, a larger quantity of sediments were deposited, while gravel and sand were transferred to the sea. A larger quantity of gravel was deposited in Tisne Stine and Radman's Mlinice, while in the area within a distance of 3-4 km upstream of the mouth, in which the impact of the sea was stronger, smaller gravel quantities were deposited. Sand and fine particles were transferred by the Cetina River into the sea of the Brač Channel. In the geological past, the sea level was approximately 100 m lower, while the riverbed and its mouth were situated near the island of Vis. By raising the sea level, the river was inundated, while by slowing down the river course, the sediments were left upstream, thus forming the estuary. The sand deposits were transferred to the sea coast forming the shallows. Sediment deposits have reached areas in a west-south-westerly direction that are located at some distance from the sea, reflecting the direction of sediment movement under the influence of sea currents and waves.

The waves have mainly been created by winds from the 2nd quadrant, and so the sea currents have also been generated in a south-easterly to north-westerly direction. Under these circumstances, the sediment deposits have stretched along the coast over a length of approximately 3 km, to the peak in Dugi Rat, forming large shallows. The width of these shallows extends to nearly 350 m, while their length is approximately 1-2 m. The shallows reach a depth of approximately 40 m. Shallows considerably influence the generation of waves within the mouth area, while the estuary's short sinuous windings, overgrown with beach grass, decrease the impact of waves that enter the river mouth after breaking down in the shallows. Regulations of the river mouth changed considerably the natural correlations and processes.

2.3.2.2. Construction along the river and its impact on the state of the river mouth

The construction of the first phase of the Zakučac HPP substantially altered the Cetina flow regime. The deposits transferred by the river were halted by the Prančevići storage reservoir, while any deposits accumulating in the part of the watershed downstream of the dam, were left in the riverbed due to the extremely slow river flow in this section. With the river flow's increase (even in summer months), the hinterland side of the mouth, to the right, became permanently marshy.

The first river flow regulation works started in 1963 when the riverbed was refilled and cleaned up, downstream of the Omiš bridge. The material extracted was used to top up the right hinterland side. By way of this, the sand barriers in the mouth were eliminated, while the right hinterland side was permanently protected from flooding, except in cases of extremely high floods. These were the preconditions upon which the entire area's urbanisation emerged. The regulation line of the riverbed was determined and the construction of the coastal wall commenced at the left coast, downstream of the bridge, along a length of 287 m. This coastal part is now used for mooring. Shortly afterwards, the right coastal side was also appropriated for mooring. The coast was further developed, along a continuum extending 840 m downstream of the bridge, and a breakwater was constructed in the form of a stone dike at a distance of 1,115 m from the bridge. As the riverbed widened towards the sea, a funnel-shaped riverbed with mild banks was formed. The riverbed is now widely open to the south part of the seaside.

2.3.2.3. Difficulties related to regulation of the river mouth

Since the river mouth has been essentially altered – from a previously natural mouth with shallow tributaries overgrown with beach grass, into a funnel-shaped regular riverbed – the conditions of river and sea interactions have also been transformed. This change is mainly reflected in the generation of waves. In the Brač Channel, the generation of powerful waves are predominantly inflicted by "sirocco" (a south-easterly wind) affecting the coast and further, the Cetina estuary. As the wind changed to a south (*oštro*) and a south-westerly direction (*lebić*), the water level was raised at the mouth with unpleasant consequences for the town of Omiš. The town's road and sewage systems have become subject to flooding, demanding an additional river flow regulation as well as the reconstruction of the mouth.

Previously, the entire wave energy had almost been diminished by the shallow tributaries and the beach grass covering the river's natural mouth, and consequently the upstream part of the riverbed remained completely calm. These natural conditions cannot be reproduced by the present riverbed regulations. A similar situation has occurred in relation to sea currents that combine with river water under both natural and the presently regulated conditions of the riverbed. Regretfully, very little data exists on the sea currents in the vicinity of the river mouth. Knowledge on waves and sea currents at the mouth and its adjacent wider area is an essential prerequisite to any construction activities within the hinterland, especially for the management of and stabilisation of the seaside. Among other factors, the expansion of the riverbed towards the sea was caused by diverting the river waves away from the eastern seaside. These changes have also impacted on the environment with yet to be assessed repercussions.

2.3.2.4. Sediment transfer in the coastal area

The changes caused by the constructions on the Cetina riverbed and watershed have entirely altered the dynamics of sediment formation, transfer and deposit. In the hinterland, these changes have been reflected in the sediment deposit transferred into the sea, during long geological periods. As sediments have been constantly transferred away by river waves and sea currents, the river sediment deposit has been substantially decreased, demonstrating a severe deficit at the river mouth. This slow but steady process of deposit decrease will become more apparent in time. It is postulated that the bank in front of the mouth will gradually disappear and that the sea will permeate the land, generating more powerful currents in the riverbed, thus increasing the volume of waves within the entire river.

The dynamic balance of coastal and seabed deposits, including the ecosystem, has been additionally disturbed by sand extraction activities undertaken near Duće, Dugi Rat and Jesenice. Consequently, certain coastal parts have started to collapse, rendering parts of the Adriatic road dangerous.

Urbanisation, as well as the development of the coastal road, have also disturbed the natural regime of sediment deposit by floods to the coast. In several locations, the natural pebble beaches lack the natural minimum of sediment deposit, as enormous sediment quantities have been constantly transported by trucks to other beaches either from gravel yards or quarries. Furthermore, it is important to highlight that these operations have been performed without any prior research on deposit balancing or any other scientifically yielded data.

2.3.3. Oceanographic characteristics of the sea

In oceanographic terms, the Cetina mouth has not yet been researched in detail. Certain mouth parameters, therefore, remain undefined; these include the salinity intrusion length, flushing or mouth residence time, deposition rate of river-borne sediment, the supply of nutritious salts and other ions according to the theoretical dilution line and the occurrence of maximal turbidity.

Drawing upon the existing data, however, certain classifications of the Cetina mouth can be made. According to its length, the river mouth can be classified by its smaller estuaries. Due to relatively low tidal oscillations (up to 0.5 m), large horizontal eddies (particular tidal residues) are absent, while the process of vertical diffusion in the mouth is mainly dependent on the shear pressure. Taking into account the existing hydrological analyses of the outer part of the mouth, and the broader area of the Brač Channel, which have established the appearance of substantial halocline quantities in the vertical column, at a depth of 5 to 10 m (especially accentuated in winter and spring), the Cetina mouth can be described as a strongly stratified or salt-wedged type of estuary.

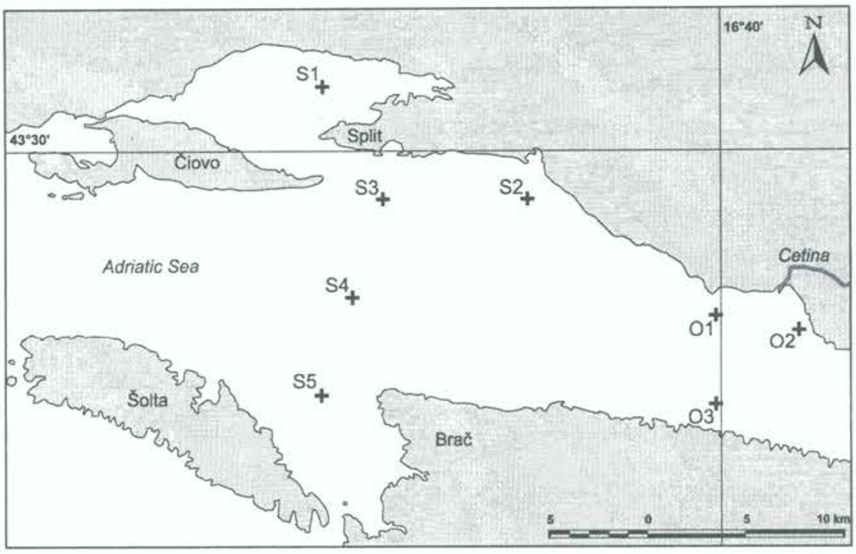

Figure 2.6: Wider coastal area with earmarked oceanographic research stations

The results of certain detailed, multidisciplinary research on the Brač Channel were evaluated in September 1990 (Figure 2.6). By April 1991, several significant oceanographic characteristics, crucial to the assessment of Cetina's impact on the Brač Channel, had been obtained. These can be summarised as follows:

- The current field in the channel implies the existence of surface currents in an east-west direction, with the compensation of the seabed current in the opposite direction. Cetina's impact on the sea currents has not been established. However, the long-term collected data on the vertical division of physical-chemical parameters, confirms the existence of such currents, and it can be concluded that the river's impact on the Brač Channel is evident only west of the Cetina mouth.
- The mean Channel water mass exchange period, recorded by three different methods, is 68 days, which is fairly positive in relation to wastewater discharges in the channel.
- The high sea transparency and the low light extinction coefficient in the outer portion of the river mouth indicate an insignificant deposition rate of river-borne sediment in the sea; this is a characteristic of karstic rivers and has been anticipated in this particular case due to the existence of several dams which created storage reservoirs retaining larger quantities of suspended matter.
- The vertical and horizontal division of nutritious salts within the water column suggests an increased nitrite and orthosilicate concentration in the surface layer of the sea, as measured at the stations of the outer part of the mouth. This is the result of the transfer of river sediment, which dissolves soil minerals in the entire mouth. The situation is similar to that of other rivers in this area. The absence of ammonia and orthophosphate concentrations indicate that the impact of urban wastewaters on the Cetina River remains insignificant.
- The range of maximal and minimal oxygen saturation degree values confirmed that eutrophication did not occur in either the river mouth, or the Brač Channel.

The latest monthly research results of the type that have been recorded at the S4 and O1 stations since 1998, confirm the previous results.

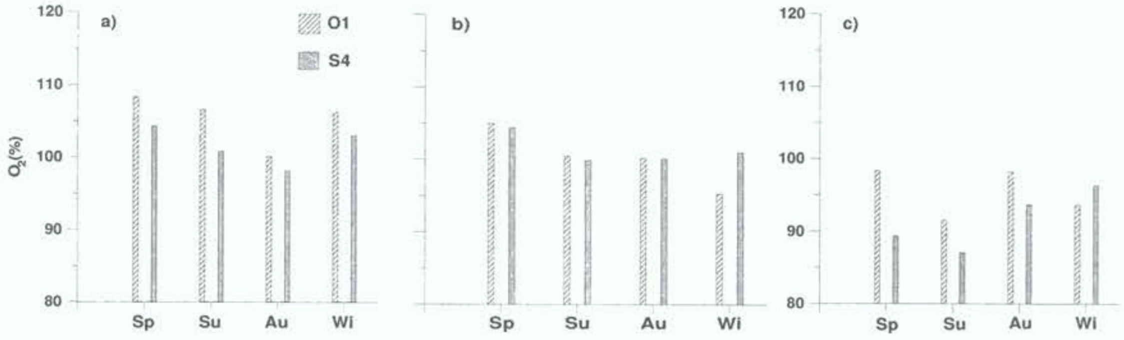

Figure 2.7: Mean oxygen saturation degree values in: (a) surface; (b) middle; and (c) sea-bed layer during spring (Sp), summer (Su), autumn (Au) and winter (Wi) as registered at stations O1 and O4

The oxygen saturation degree at the channel area near the mouth differs slightly from that measured in the area of Split (Figure 2.7). The slightly higher values registered at the surface layer of the mouth area can be explained by the intensification of primary production, which is a consequence of the transfer of nutritious salts by the Cetina River, while the lower values recorded in the area of Split, could be justified by the intensification of the dissolution of micro-biological organic matter. The mean oxygen saturation values registered in the surface layer are between 98% and 108%, while those registered in the seabed layer are between 87% and 98%.

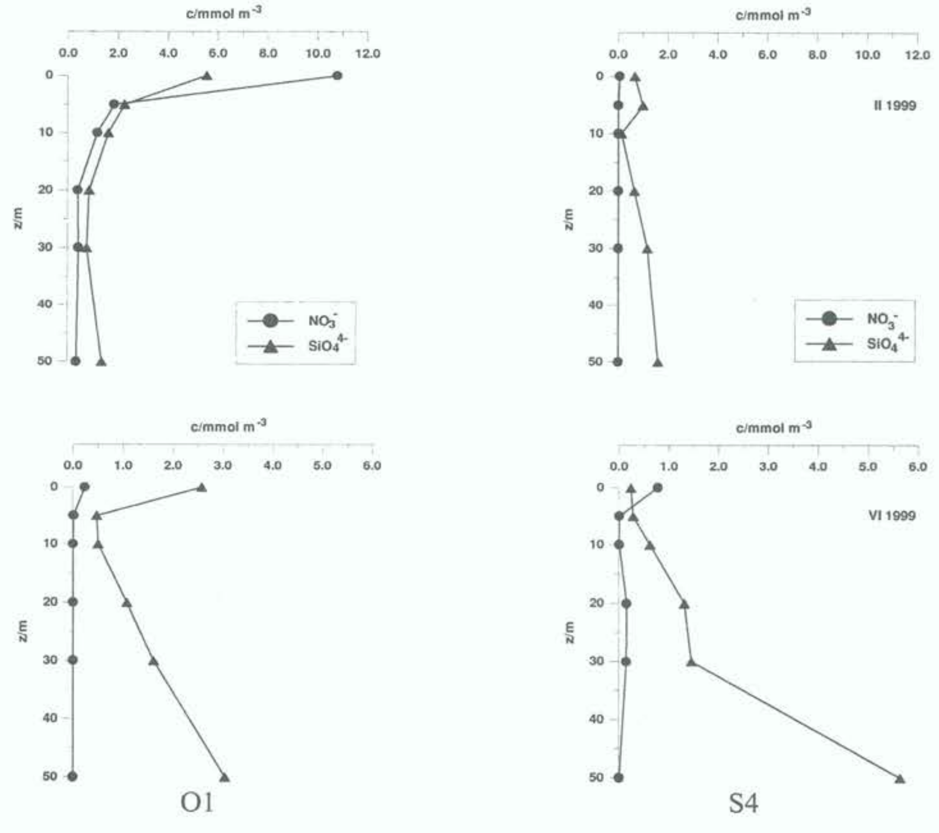

Figure 2.8: Vertical division of nitrate and orthosilicate concentration as registered at stations O1 and S4 in particular seasons

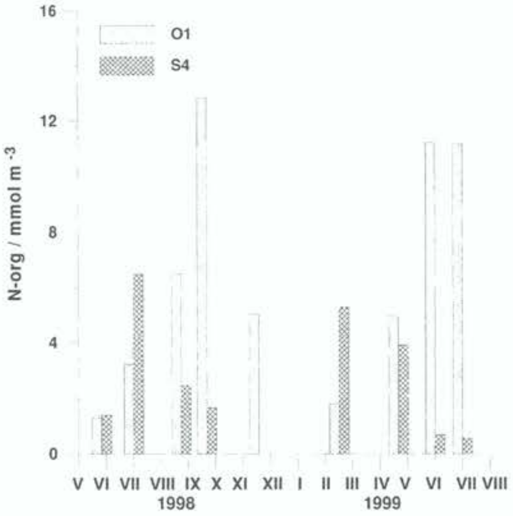

Figure 2.9: Concentration changes of the organically bonded nitrate in the surface layer as registered at stations O1 and S4

The Cetina's impact on the Brač Channel is minor. This can be confirmed by the maximum nitrate and orthosilicate concentrations registered at the O1 station which have been validated throughout 1998, except in August. The lower rate concentrations appearing occasionally have been registered at the S4 station (Figure 2.8). While the surface maximal concentrations have been caused by nutrition salts transferred by the river, the maximal seabed concentrations have been caused by the bacterial decomposition of organic matter, as registered at the S4 station (Figure 2.9).

Nutrition salts transferred by the river also generate an increase of the local primary production reflected in the increased concentration of the organically bonded nitrate at the surface layer, as recorded at the O1 station during the calendar's warmer seasons.

It can be concluded that the Cetina River is an important source of nitrate and orthosilicate concentrations appearing at the surface layer of the Brač Channel at the River mouth. Although from the point of view of energy less favourable than ammonia, nitrate is an important source of nitrogen needed for the development of bacterial and phytoplankton population, while orthosilicate is indispensable for the construction of the silicium plate of diatoms. By their building into the organisms, the "river" nitrate and orthosilicate concentrations enter the cycles of nutrition salts circulation in the sea what can be seen from the organic ammonia concentration. As already mentioned before, the negative consequences of eutrophication, which could be caused by the increased nitrate concentrations, are not known.

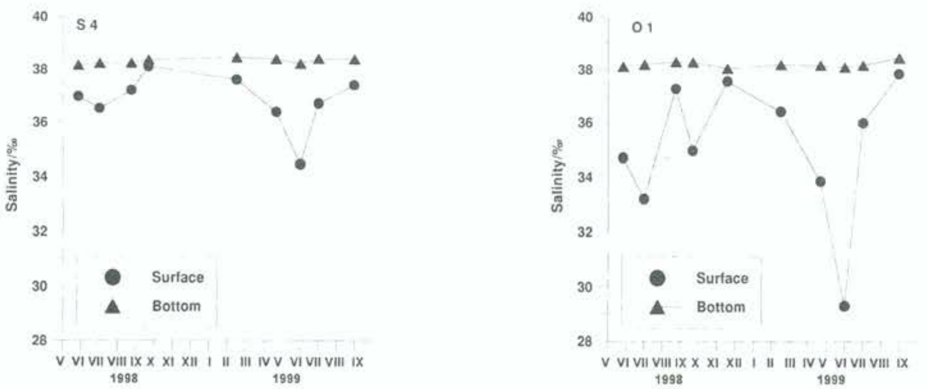

Figure 2.10: Salinity fluctuations in the surface and sea-bed layer during the period 1998-1999 as registered at stations O1 and O4

It is interesting to note that the greatest decrease of salinity in the surface layer as recorded in June 1999, does not coincide with the highest nitrate and orthosilicate concentrations. The highest values were recorded in February and May of 1999 (Figure 2.10). We may, therefore, conclude that there is no simplistic correlation between salinity (i.e. the transfer of clear water) and nitrate, and orthosilicate concentrations within the surface layer of the Brač Channel. This can better be explained by a sudden transfer of water lacking in nutrient salts, into the riverbed, causing the dissolution of pristine nutrition salts that cluster in the river.

3. Institutional and legal framework

3.1. Administrative – political borders

As we have already mentioned, for administrative and political purposes the entire Cetina River watershed and its adjacent coastal area can be divided into two distinctive sections, the "indirect" and the "direct", as these sections belong to two different states (Figure 3.1). The main part of the "indirect" Cetina watershed is located in the territory of the Federation of Bosnia and Herzegovina, while the "direct" watershed and its adjacent coastal area (i.e. the river mouth, the seaside and the islands) are located in the territory of the Republic of Croatia.

3.1.1. Federation of Bosnia and Herzegovina

Within the Federation of Bosnia and Herzegovina, the "indirect" Cetina watershed is included in the county of Herzeg-Bosnia, that embraces an area of 5,209 km^2 and comprises the following six municipalities: Tomislav Grad, Kupres, Livno, Glamoč, Bosansko Grahovo and Drvar. The "indirect" watershed border does not correspond to that of the Herzeg-Bosnia county. More specifically, this section's border is narrower, encompassing nearly the entire municipality of Livno, a larger part of the municipality of Tomislav Grad, as well as certain parts of the municipalities of Kupres, Glamoč and Bosansko Grahovo (Table 3.1). The municipality of Drvar is outside the "indirect" watershed section.

Table 3.1.
Size of municipalities in the County of Herzeg-Bosnia

Municipality	Size (km^2)	Number of inhabitants in 1991
1. Tomislav Grad	967	30,009
2. Livno	994	40,600
3. Glamoč	1,096	12,593
4. Kupres	622	9,618
5. Bosansko Grahovo	780	8,311
Total	**4,459**	**101,131**

3.1.2. Republic of Croatia

The section of the river's "direct" watershed is typified by its morphology. Its wider adjacent area and the entire river flow are located in the Republic of Croatia, within the county of Split–Dalmatia. A smaller part of the upper watershed forms part of the county of Šibenik–Knin. In the county of Šibenik–Knin, the watershed occupies the municipalities of Civljane and Kijevo, while the county of Split–Dalmatia includes the following municipalities: Hrvace, Otok, Šestanovac, Zadvarje and Dugi Rat, as well as the towns of Vrlika, Sinj, Trilj and Omiš. The wider adjacent area of the "direct" watershed section includes the municipalities of Brela, Baška Voda, Tučepi, Podgora, Gradac, Makarska, as well as the islands of Brač, Šolta, Hvar and Vis. With the exception of the island of Šolta, which represents one municipality, the islands are administratively divided into several municipalities and towns (Brač 8, Hvar 4 and Vis 2 municipalities – see Table 3.2).

Figure 3.1: Administrative-political division of the region

Table 3.2.
Size of the towns and municipalities in the counties of Šibenik–Knin and Split–Dalmatia included in the Cetina River watershed

Towns and Municipalities	Size (km^2)	Inhabitants No. in 1991
County of Šibenik–Knin		
1. Kijevo	76.5	1,261
2. Civljane	83.0	1,672
Total County of Šibenik–Knin	**159.5**	**2,933**
County of Split–Dalmatia		
1. Vrlika	243.0	5,621
2. Hrvace	209.0	5,296
3. Sinj	198.0	26,411
4. Otok	95.0	6,574
5. Trilj	264.0	13,894
6. Šestanovac	91.0	3,318
7. Zadvarje	15.0	292
8. Omiš	261.5	15,630
9. Dugi Rat	11.5	6,544
10. Podstrana	12.2	5,240
11. Donja Brela	26.7	1,684
12. Baška Voda	25.6	2,173
13. Makarska	37.8	11,958
14. Tučepi	22.0	1,760
15. Podgora	54.4	2,687
16. Gradac	92.5	2,567
Island of Brač	***394.5***	***13,824***
17. Sutivan	21.8	641
18. Supetar	29.8	3,324
19. Milna	34.7	1,118
20. Nerežišće	79.0	1,013
21. Postira	46.8	1,495
22. Pučišća	106.2	2,393
23. Selca	53.4	2,333
24. Bol	22.8	1,507
Island of Šolta	***57.9***	***1,448***
25. Šolta	57.9	1,448
Island of Hvar	***300.3***	***11,459***
26. Hvar	62.8	4,002
27. Starigrad	54.2	2,884
28. Jelsa	108.8	3,802
29. Sućuraj	74.5	771
Island of Vis	***90.3***	***4,354***
30. Vis	51.3	2,106
31. Komiža	39.0	2,248
Total County of Split–Dalmatia	**2,502.2**	**142,734**

3.2. Laws and regulations

With reference to legislation, the current political situation has resulted in differences to the status of the Republic of Croatia, and the Federation of Bosnia and Herzegovina. While the Republic of Croatia, despite the recent war, has been systematically developing its legislation, the BiH has yet to complete legislation in every field. More significantly, laws have been adopted to date at both the national and local levels. The enforcement of the legislation relating to the Law on Waters and the Environment is implemented by the administrative and legislative bodies of both the "Assembly of the

Federation of Bosnia and Herzegovina" and "the Assembly of the County of Herzeg-Bosnia" under the auspices of the governments of the Federation and of the County.

Covering the researched area within the Federation of Bosnia and Herzegovina, the following laws are currently in force:

1. Law on Waters (Official Gazette of the Federation Bosnia and Herzegovina, No. 18/98);
2. Law on Land-Use Planning (National Gazette of the County of Herzeg-Bosnia, No. 14/98);
3. Law on Agricultural Land (National Gazette of the County of Herzeg-Bosnia, No. 10/98);
4. Law on Forests (National Gazette of the County of Herzeg-Bosnia, No. 18/98); and
5. Law on Construction (National Gazette of the County of Herzeg-Bosnia, No. 14/98).

Legally endowed by the legislation on waters, the public enterprise of the Adriatic Sea Watersheds' Area, in Mostar, has a remit to manage and regulate the Cetina watershed, dealing with issues and conflicts relating to water supply applications, water quality control and protection against flooding, among others.

In the following chapter, attention is given to legislation affecting the management structure of the various resources of the Republic of Croatia.

3.2.1. Legislation and the water management structure in the Republic of Croatia

In the Republic of Croatia, water management is governed by a number of laws, which have been significantly amended over recent years in line with European Union legislation. It is safe to say that all legislative prerequisites relating to water management have already been secured in accordance with the principles of sustainable development.

3.2.1.1. Laws and regulations relating to water management

The Law on Waters (National Gazette 107/95) represents the basic legislation tackling water management. This legislation covers the following areas: the legal status of waters and water assets; the operation of water management (water uses, water protection, regulation of water flows and other waters, and protection against the harmful effects of water); ways of organising and implementing tasks and duties relating to water management; the prescribed conditions for undertaking water management related activities; authorities and duties of state and local administrative bodies. Furthermore, it refers to certain other important aspects and issues relating to water management. According to this legislation, certain conditions prescribed by other specific legislation, such as that on navigation, fisheries, health and the protection of nature, have to be applied in order for it to effectively cover water management.

Another important piece of legislation is the Law on Water Management Financing (National Gazette 107/95, 19/96 and 88/98). Based on the relevant Law on Waters, this legislation defines the appropriate financial sources for the implementation of activities relating to water management; more specifically, it determines rates and amounts, monitors individual liabilities and payments, and delineates certain issues relating to both the realisation and utilisation of financial resources. These include: water usage fees; water protection fees; sand and pebble exploitation fees; watershed fees; the local self-managed units' budgets, and other minor sources of funding.

One of the most significant pieces of legislation is the National Plan for Protection Against Flooding (National Gazette 8/97, 32/97 and 43/98). This plan defines the regions, sectors, water flow sections and protective constructions and equipment relating to flood protection. It also prescribes the specific water levels beyond which protection against floods, and against ice formation in some regions, intervenes. It determines the legal and physical persons under obligation to prevent floods and ice formation, as well as the measures needed in all protection stages. It also covers communication systems, data collection and information techniques.

In the field of water protection, the key law is the National Plan for Water Protection (National Gazette 8/99). This plan generally aims to protect the waters and the sea. More specifically, it provides legislation against pollution deriving from the hinterland and the islands. This plan includes useful research and water quality analysis and covers water classification (definition of the desired standard of water in the water flow and its sections, and of other waters, as well as parts of the sea polluted as a result of certain hinterland activities). In addition, it prescribes: water classifications that determine the particular water type in accordance with measures laid down by water regulation; measures for water protection and measures applicable to irregular and sudden water pollution episodes; plans for the construction of wastewater treatment structures and facilities; plan fund-sourcing and provides a list of physical and legal persons in charge of the plan's implementation, determining their jurisdictions and responsibilities.

3.2.1.2. Water management, organisations and jurisdictions

According to the Law on Waters, the Croatian Waters organisation has been formed to be legally responsible for all water management activities over the entire Croatian territory. Its jurisdiction includes the following:

- The surface and underground hinterland waters, including the river mouths flowing into the sea, as well as the channels connected with the sea up to the border of the Croatian Waters jurisdiction;
- The mineral and thermal waters, with the exception of those from which mineral raw materials can be extracted, as well as those generating accumulated heat that can be utilised for energy production. These cases have been regulated by the respective mining legislation;
- The drinking water sources within the national territory; and
- Coastal sea waters in need of protection against pollution deriving from the mainland and the islands.

Watershed areas, encompassing one large, or more watersheds of minor flows, fall within the jurisdiction of the Croatian Waters. The management of these areas has been tailored to safeguard the complexity of the plethora of water-related issues.

The Dalmatian watersheds are comprised of eight separate entities, one of which is the Cetina watershed. The Cetina water management headquarters are located in the branch office of Croatian Waters.

3.2.2. Legislation and the coastal sea management structure

The management of the coast and the coastal sea is governed by the Maritime Code (National Gazette 17/94, 74/94), which is the first complex maritime law. This code dictates the legal interrelationships within the field of maritime navigation. It determines the surface and underwater sea area of Croatia, prescribes safety regulations for navigation within Croatian jurisdiction, and defines, among other things, the regime of the coastal zone management.

Part of the coastal zone (the seabed, the marine and its adjacent coastal parts) can be utilised via the issue of permits. Each permit is prescribed in accordance with the rights of the Republic of Croatia. A number of subsequent legal regulations have been adopted in line with the Maritime Code for the delineation of particular aspects of the management and use of the coastal zone and the sea.

The Law on Sea Ports (National Gazette 108/95 and 6/96) determines among other factors, the division of sea ports, any activities undertaken in the port, and overall port arrangement regulations. Ports are divided in accordance with their usage into public and specific use. According to their size and commercial importance, the public ports are classed as ports of international commercial interest, ports of county or local interest, while the ports of special purposes can be of importance for the county and the State, as well.

3.2.3. Legislation and land-use planning in the Republic of Croatia

Plans relating to land-use are governed by the Law on Land-Use Planning (National Gazette 30/94, 68/98 and 35/99). The main principles of this law are reflected in its call for a balanced approach to development, as well as to environmental protection, ensuring the conformity of space users' interests. In practice, the latter can often be antagonistic to economic development and that of infrastructure. However, this legislation is still incomplete, as it omits, for instance, regulations governing the use of building land within urban areas.

The legislation prescribes the enactment of land-use plans, at three levels: state, county, and town and municipality levels. At the level of the Republic of Croatia, a land-use strategy has been adopted (1997), defining the long-term objectives of land-use planning, in accordance with the overall economic, social and cultural development, providing the basic guidelines for land-use planning. At the county level, land-use planning, which has yet to be enacted, determines the scope of overall land-use planning, respecting the particularities and limitations of narrower land-use units. All operations of relevance to the state of the county have been tackled by the plan. Additionally, the implementation of land-use plans that encompass valuable and protected natural landscapes (national and nature parks) has been agreed upon at this level. The core plan governing towns and municipalities is the physical (structural) plan.

In principle, towns and municipalities are legally obliged to manage the spaces under their jurisdiction for the purpose of public welfare whilst observing existing legislation. For this reason, municipal plans must be harmonised with those of the wider area (county, state). Towns and municipalities establish public enterprises or issue permits to legal persons for the implementation of specific public interest activities (water supply; wastewater discharge; the collection, transportation and disposal of solid waste; municipal lighting; the maintenance and construction of public transportation areas; the upkeep of cemeteries; etc.).

Land-use planning and management have been tackled by a number of specific legal regulations, of which the most significant are the following:

- Law on Agricultural Land (National Gazette 54/94, 48/95, 19/98 and 105/99);
- Law on Forests (National Gazette 52/90, 6/91, 61/91, 14/93, 26/93, 76/93);
- Law on Environmental Protection (National Gazette 82/94, 128/99);
- Law on the Protection of Nature (National Gazette 30/94, 72/94);
- Law on the Protection and Preservation of Cultural Assets (National Gazette 69/99);
- Law on Islands (National Gazette 34/99);
- Law on Sea Fisheries (National Gazette 74/94, 57/96);;
- Law on Public Roads (National Gazette 100/96, 76/98);
- Law on Sea Ports (National Gazette 108/95, 6/96);
- Law on Electrical Power Industry (National Gazette 31/90, 47/90, 61/91 178/94);
- Law on Mining (National Gazette 93/95);
- Law on Cemeteries (National Gazette 19/98); and
- Law on Development (National Gazette 52/99, 75/99).

3.3. The existing database

The Cetina watershed is a complex natural and socio-economic system requiring that each stakeholder has access to vast and varying information. In addition to the traditional sources of information, the Geographic Information System (GIS) increasingly appears to be one of the methods permitting efficient utilisation of a comprehensive information base.

For the preparation of this document, all the available information on planning and management of the Cetina watershed has either been registered or compiled. During data collection, the main difficulty was the fact that the Cetina watershed extends over two states with very different priorities and systems of legislation. Consequently, the activities were restricted to the compilation of the already existing data.

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For the preparation of this document, most of the available information on planning and management of the Cetina watershed has either been registered or compiled. In that endeavour, the main difficulty was the fact that the Cetina watershed extends over two states with very different priorities and systems of legislation and, consequently, systems of data collection, storage and distribution. The collected or registered information was divided into a number of thematic categories: maps, protected areas, environmental protection, physical characteristics of the area, infrastructure systems, economy, land use, social infrastructure, and demography,

a) The Republic of Croatia (County of Split-Dalmatia)

Besides a vast number of sources that could be found in a number of state and county scientific institutions and government offices, the County Physical Planning Institute has started to build the GIS data base. The main impetus for building the database has been the preparation of the county's Physical Plan. It is expected that the plan will be adopted in the second half of 2001. By that time, the GIS data base will be completed and fully utilised for the plan's preparation and implementation.

The GIS data base consists of a number of base maps. Scanned geo-coded maps are in the scale 1:100,000 and 25,000. The digitised maps are the following:

- 1:100,000 (only particular indispensable layers, Data format shp.);
- 1: 25,000 (the entire map contents utilise dwg. format, Data format dwg.); and
- Borders of states, counties, municipalities and settlements (Data format shp.).

According to the existing legislation, the inventories for protected areas and individual objects under protection have been prepared as follows:

- Protected parts of nature (Data format shp.);
- Protected cultural monuments and historical units (Data format shp.); and
- Sanitary protection areas of water sources and water intakes (Data format shp.).

In the field of environmental protection very little has been done. However, although the polluters' inventory has not yet been fully prepared, the data on pollution discharges has been collected, while the study on the proposal for the location of solid waste disposal operations (Data format shp.) has entered the adoption stage.

The base of physical characteristics includes the following:

- The agricultural area of the county has been evaluated and categorised in five classes; it has also been divided into the following five categories identified according to their prevailing crops: plough-field, orchard, vineyard, olive-grove and pasture (Data format shp.);
- The data base on county's forest area has not yet been completed; the data relating to the managed parts of the area has been obtained by the Croatian Forests, and that referring to other, non-managed parts has been taken from the base map 1:25,000 (Data format shp.);
- Hydro-meliorated land (Data format shp.); and
- Land exposed to erosion risk (Data format shp.).

The base on infrastructure systems comprise the following:

- The existing and planned state, municipal and local road network (Data format shp.);
- The hydro-electric power plants (HPPs) and distribution system (Data format shp.);
- Telecommunication systems (Data format shp.);
- Water-supply systems: captures, water intakes and waterworks (Data format shp.);
- Airports (Data format shp.); and
- Harbours, ports, marinas (Data format shp.).

The basic economic indicators have been compiled and divided by former municipalities (Data format shp.). This was necessary in order to maintain the temporality of the statistical data.

The existing municipal and county land-use plans were used as sources. According to these documents, the data base on land uses is divided into the following six categories: areas relating to settlement uses; tourism and recreational areas outside settlements; areas for commercial use; areas for specialised use; areas for agricultural use; and areas for transport use (Data format shp.).

The demographic data obtained from the 1981 and 1991 censuses have been categorised by settlements and municipalities, and features information on population, households, language, qualification, religion (Data format shp.).

The social infrastructure refers to the registers of the following institutions:

- Health institutions;
- Welfare institutions;
- Pre-school institutions, elementary and secondary schools; and
- Academic and other advanced educational institutions conferring degrees in various faculties.

b) Bosnia and Herzegovina

GIS data relating to Bosnia and Herzegovina can be obtained from the GEOdata enterprise in Zagreb, on a CD. The maps are presented on a 1:300,000 scale, and in ARC/INFO coverage format.

This atlas covers information relating to rivers (both major and minor), lakes, six categories of roads, railways, ground-plans for larger settlements with demographic data (1948-1991), settlement centres, including demographic data (1991), as well as state and municipal borders (1991) with demographic data (1971). In addition, it provides the IFOR zones, the Dayton borders, and scanned and geo-coded maps on a scale of 1:300,000. Scanned maps of the entire area are also available on TM 25,000 and TM 50,000 scales.

4. Detailed analysis of major socio-economic and environmental conditions

4.1. Population

4.1.1. Population dynamics

In 1981, the size of the population of the Herzeg-Bosnia county and its adjacent watershed area reached 104,354, that is, 55% of the entire Cetina watershed population. The population size of the watershed section within the jurisdiction of the Republic of Croatia totalled 85,939, accounted for 45% of the entire watershed population. In the same year, the population total had been 190,293. In the period 1981-1991, the total population number increased for 1.3% (Table 4.1). In 1991, the population size of the watershed section totalled 192,884 of which 101,131 or 53% in the Bosnian, and 91,753 or 47%, in the Croatian part of the watershed (Table 4.2).

Table 4.1.
Population movements in the Cetina River watershed

Area		Number of inhab. in 1981	Number of inhab. in 1991	Index 91/81
County of Split-Dalmatia				
	Omiš	14,886	15,630	105.0
	Sinj	24,119	26,411	109.5
	Trilj	13,363	13,894	104.0
	Vrlika	6,028	5,621	93.2
	Municipalitiy of Dugi Rat	4,890	6,544	133.8
	Municipalitiy of Podstrana	2,901	5,240	180.6
	Municipalitiy of Hrvace	6,190	5,296	85.6
	Municipalitiy of Otok	6,214	6,574	105.8
	Municipalitiy of Šestanovac	3,783	3,318	87.7
	Municipalitiy of Zadvarje	294	292	99.3
	Total County	**82,668**	**88,820**	**107.4**
County of Šibenik-Knin				
	Municipalitiy of Kijevo	1,330	1,261	94.8
	Municipalitiy of Civljane	1,941	1,672	86.1
	Total County	**3,271**	**2,933**	**89.7**
Total		**85,939**	**91,753**	**106.8**
County of Herzeg-Bosnia				
	Municipalitiy of Livno	40,438	40,600	100.4
	Municipalitiy of Tomislav Grad	30,666	30,009	97.9
	Municipalitiy of Bosansko Grahovo	9,032	8,311	92.0
	Municipalitiy of Glamoč	14,120	12,593	89.2
	Municipalitiy of Kupres	10,098	9,618	95.2
	Total County	**104,354**	**101,131**	**96.9**
Total watershed		**190,293**	**192,884**	**101.4**

Source: 1981 and 1991 Censuses

Table 4.2.
Number of inhabitants in the Republic of Croatia functionally linked with the Cetina River in 1991

Area	Number of inhabitants in 1991
Makarska riviera	22,829
Island of Brač	13,595
Island of Hvar	11,459
Island of Šolta	1,448
Hinterland (Dicmo, Dugopolje, Klis)	10,265
Island of Vis (in the perspective)	4,354
Total	**63,950**

Source: 1991 Census

Until 1991, the stable movement of the entire watershed population had been recorded. However, movements are influenced by the increase in the number of inhabitants in medium-sized settlements. These settlements are located near the fertile Sinj field and near the coastal area (Figure 4.1).

The most significant disruption to population and developmental activities caused by human intervention, occurred during the 1991-1995 war period. Considering the nature of this disruption, a greater than usual effort should be made to reconstitute normal conditions. It has been estimated that less than 70,800 inhabitants are currently living in the territory of the County of Herzeg-Bosnia, i.e. 25% less than in 1991.

The recent hostilities in the Croatian part of the watershed are also responsible for the decrease of its population size, as the greater part of this territory had been directly exposed to war (i.e. the entire Šibenik-Knin county, the municipalities of Split-Dalmatia county: Vrlika, Hrvace, Sinj and Otok). Fortunately, the living conditions in these devastated areas have currently stabilised. According to certain estimates, in 1999, the entire watershed population size fell to 157,000, representing reductions of 17% and 18% on the counts made in 1981 and 1991, respectively.

With reference to the total number of inhabitants, it should be noted that nearly 64,000 people occupying the coastal area and the islands have been supplied with water from the Cetina River. Therefore, they also constitute the population of the Cetina River area.

At the Bosnian watershed section, the age structure of the population has been fairly uneven. In 1998, 21.5% of its total population was aged below 14, 63.3% was aged between 15 and 64, while 15.2% of the population was aged 64 or over. The ageing process has gradually reached disturbing dimensions, especially in the municipality of Bosansko Grahovo.

The age structure in the Croatian watershed section varies substantially according to particular areas. Specifically, the coastal population is more active by comparison to that of the hinterland and the islands, which have been caught up in processes of ageing and depopulation. According to data obtained in 1991, the proportion of the population aged over 60 in the Sinj area was higher than 14% of its total population, while it was 12% in the coastal area, and 18% in the islands.

Figure 4.1: Population number fluctuation according to administrative units

Regarding future population movements within both the Croatian and Herzeg-Bosnian watersheds, it is anticipated that they will be primarily affected by economic restructuring activities as well as by the development of economic activities in the wider area, that are likely to feature specific investments complemented by revitalisation programmes, aiming at retaining the existing population through the provision of acceptable living standards. In the future, population movements will also be differentiated, respecting the natural and social inherited characteristics imposed by the particularities of the different watershed sections, as well as by the consequences of war which will continue to affect both the structure and the movement of the population, especially in the Herzeg-Bosnian watershed section.

As the entire watershed area, with the exception of central settlements and the coastal part, represents an active emigration area, a consistent decrease in the size of the population is bound to occur. However, the steady increase of the total number of inhabitants in the watershed area indicates the strong impact of the dynamics of the demographic changes in the coastal area and central settlements located along the river. In the hinterland, the population increase is only likely to occur in the Sinj, Trilj and Otok areas, while in the coastal zone, it will be manifested in the areas of Omiš, Dugi Rat and Podstrana, where economic resources such as infrastructure, and fertile land are substantial.

The selective migration from both the Herzeg-Bosnian watershed section and part of the Croatian hilly/mountainous region reduces in particular the proportion of younger, and thus more fertile individuals, which impacts negatively on the already skewed age structure and the reproductive capacities of the areas' populations. For these reasons, and because of the differentiated nature of population movements, the number of inhabitants in the Cetina watershed, at the beginning of the third millennium will at best reach the 1991 level.

4.1.2. Population distribution

Population dynamics has been altered within particular spatial units (Table 4.3, Figure 4.2). Positive fluctuations are mainly recorded in the central settlements located near fertile fields (Sinj, Trilj, Otok) along Cetina, and in the narrow coastal strip (Omiš, Dugi Rat and Podstrana). Almost 80% of the population residing in the Croatian watershed section has been concentrated in these areas.

In the Herzeg-Bosnian watershed section, only 24% of the population are urban-dwellers indicating the dispersed pattern of settlement distribution which features a large number of small rural settlements. By comparison, the Croatian watershed is characterised by larger settlement sizes, which are concentrated to such an extent that in 1991 almost 36% of inhabitants had been registered in central settlements (Figure 4.3).

Table 4.3.
Population distribution as per spatial units

Croatian part of watershed	No. of inhabitants 1991	Share (%)
Hinterland:	64,339	71
- hill/mountain part	3,000	5
- near the river course	61,339	95
The coastal area	27,414	29
Total	**91,753**	**100**

Source: 1991 Census

Figure 4.2: The spatial population distribution

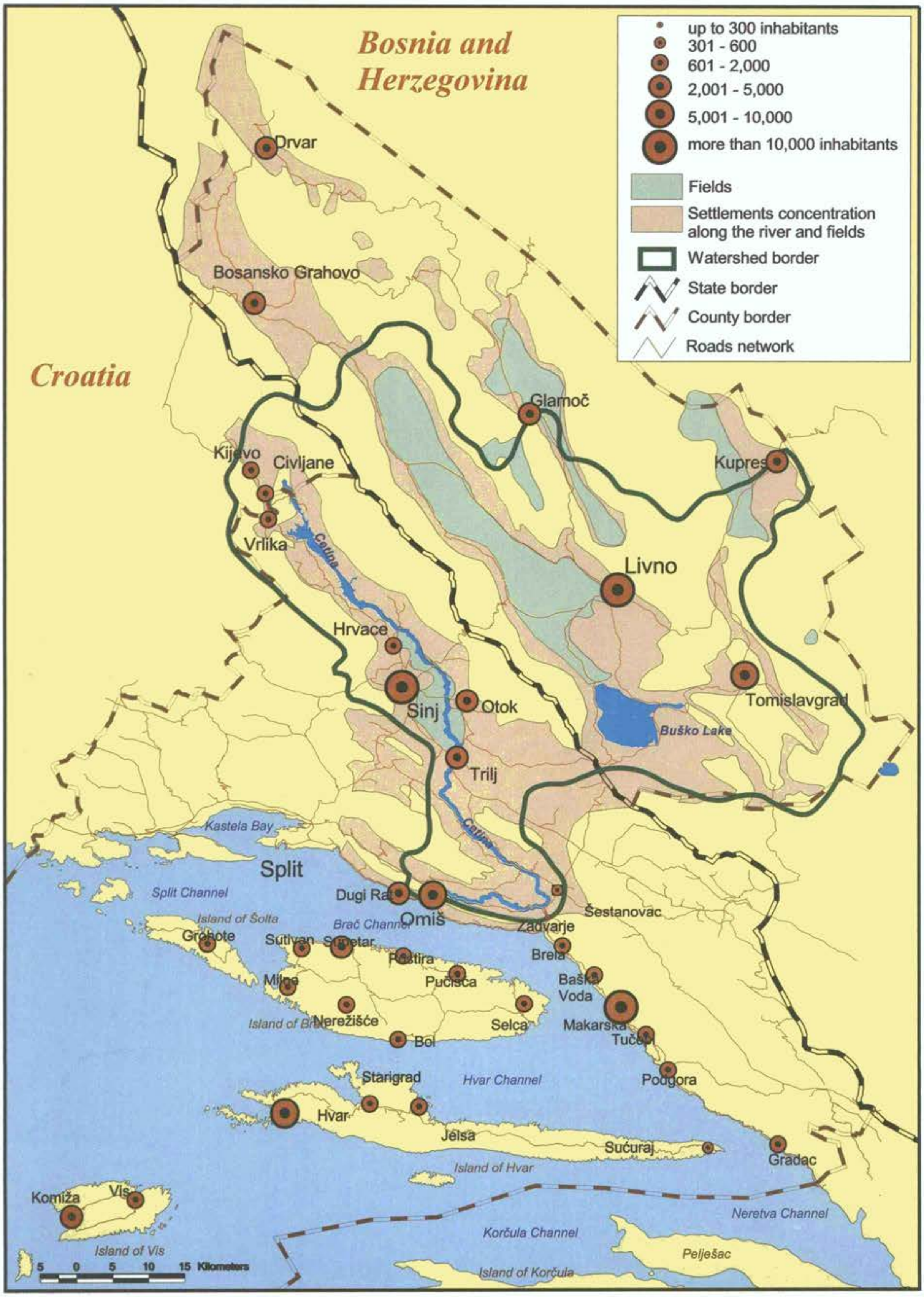

Figure 4.3: Population in towns and municipalities in 1991

In 1991, the approximate population density in the Croatian part of the watershed was equivalent to 56.9 inhabitants per km^2 (84.3 inhabitants per km^2 in the Republic of Croatia) while in the Herzeg-Bosnian part, it was only 22.6 per km^2 (Figure 4.4). Taking into account the spatial population distribution in the watershed area, and respecting its geographical and specific spatial units, it can be concluded that the population density in the Croatian watershed section has been extremely differentiated. Furthermore, respecting the natural and social inherited differences with reference to demographic fluctuations, population distribution, and demographic structures, which have largely been affected by recent hostilities, we may suggest the following basic starting points relating to the further demographic development of the watershed:

- The area has been demographically differentiated and, taking into account the inherited characteristics it will probably remain so in the future;
- Any efforts aiming at the improvement of the demographic fluctuations and structure, such as investments, revitalisation programmes for hilly/mountain areas, the introduction of favourable taxes and other measures should be undertaken at the state, regional and local level, in order to develop environmentally-sound economic activity programmes (agricultural production, industries using cleaner production techniques, small industrial production units, farms, specific forms of the development of tourism, etc.). These programmes should also respect and encourage indigenous forms of economic activity that are part of the historical legacy, while enriching them with "upgrades" from the contemporary era;
- Within the framework of development plans, the entire watershed area must be considered as an integrated natural and economic entity, in order for it to enhance coastal tourism activities with other complementary economic activities; and
- The prerequisite for the stabilisation of demographic fluctuations is the establishment of a quality transportation network within the area and of well developed infrastructure (i.e. adequate water supply systems, wastewater disposal and irrigation systems, in addition to social infrastructures).

4.2. The area's economy

4.2.1. Major economic activities

The economic structure of the continental part of the watershed (i.e. the Herzeg-Bosnian and Croatian part) differs significantly from that of the coastal area. In the upper part of the watershed, the dominant economic activities have been those relating to industry, mining, electrical supply, trade, catering and agricultural production; the share of other economic sectors has been marginal. In the coastal area, the dominant economic activities have constituted industry, trade and tourism.

4.2.1.1. The economic structure of the Herzeg-Bosnian part of the watershed

In terms of the economic structure of the Herzeg-Bosnian watershed section, the shares of industry, mining, trade and transportation are predominant. Generally, these economic sectors account for more than 80% of the entire area's economy. The sector of industry includes the manufacturing of plastics, synthetic leather, construction material, sewn timber, high-tech cables, and textiles. The majority of production activities were concentrated in the municipalities of Tomislav Grad and Livno, as these were the most developed towns in this underdeveloped area.

Before the war, the number of people employed in industry totalled 11,000, while today, according to official data, the sum only stands at approximately 3,500. Moreover, according to the existing data, the number of people seeking employment stands at 5,426.

Figure 4.4: Population density according to administrative units

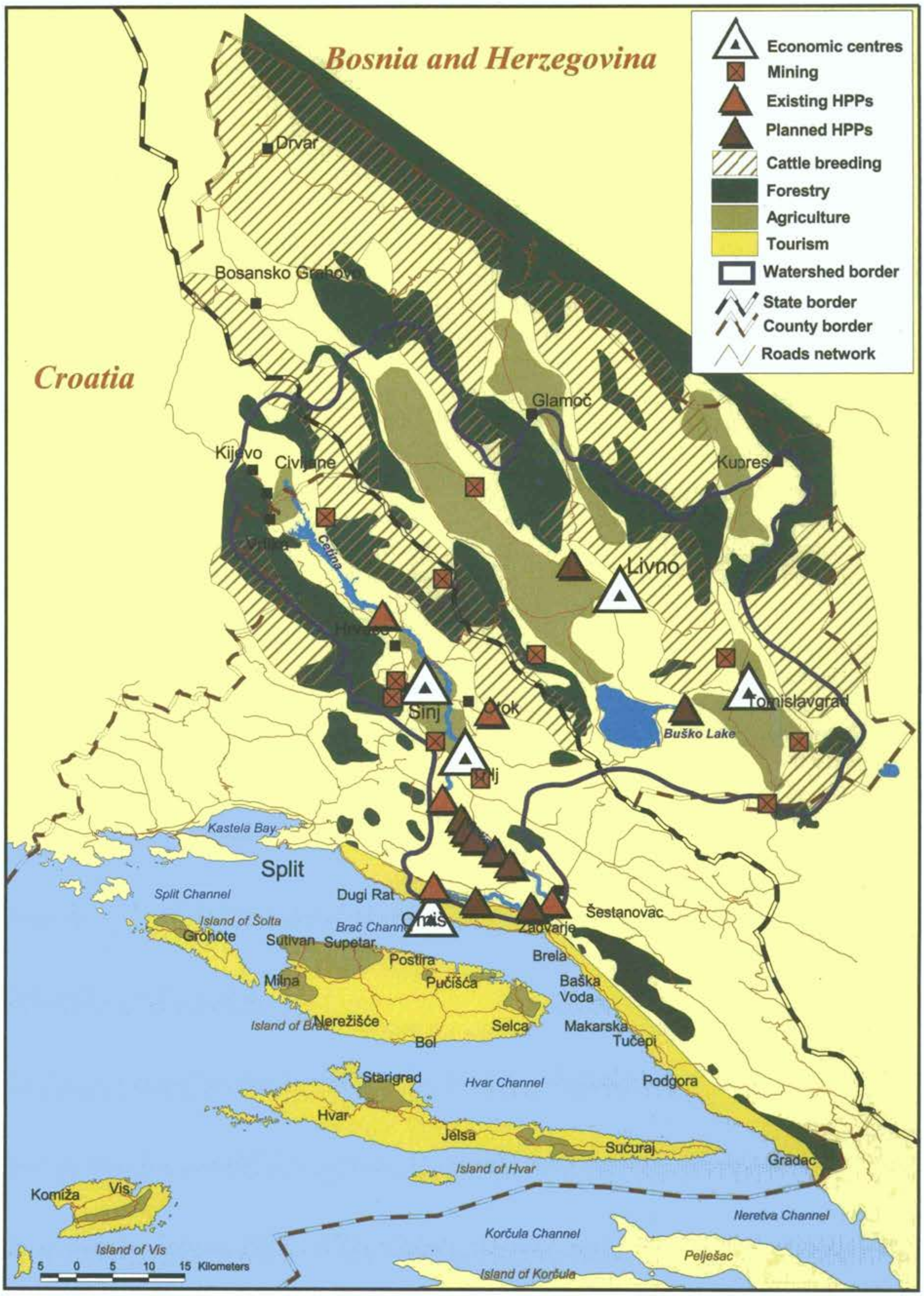

Figure 4.5: Main economic centres and dominant economic activities

Due to factors, such as the wartime destruction and the slow transition process, most of the companies have either closed down or are functioning at a reduced capacity. As the reconstruction process undertaken by larger companies (which simultaneously represent the largest pollution sources), has been relatively slow, their completion remains uncertain. Before the 1991 hostilities, the level of economic development could be indicated with particular reference to the number of registered enterprises, which totalled 40 in Livno, 21 in Tomislav Grad, 17 in Kupres, 23 in Glamoč, and 20 in Bosansko Grahovo.

The Herzeg-Bosnian county is rich in natural resources: forests cover about 182,630 ha, accounting for approximately 13% of forested areas in the Federation; vast complexes of agricultural land occupy about 305,612 ha, accounting for 25% of the entire Federation; meadows occupy 69,229 ha; 45,865 ha, meanwhile, is arable land. In addition, this part is rich in mineral deposits such as lignite (production of 650,000,000 t), dark coal, bauxite, etc. The lignite deposits in the Livno and Duvno fields constitute the basis for the production of electricity, complemented by the imminent operation of the Livno thermo-electrical plant, with a planned capacity of 2·300 MW.

The irrational and intensive exploitation of natural resources might result in the radical degradation of the environment. Coal exploitation could endanger agricultural production, while water exploitation for hydro-electric purposes may destroy chunks of arable land. The completion of the 2nd phase of the Orlovac hydro-electric plant, as well as that of the thermo-electric plant and the mines in Livno, will degrade the larger area.

Coal exploitation in the Livno basin was one of the first such exploitations in Bosnia and Herzegovina. However, research on these resources remains insufficient. The Livno and Duvno fields contain lignite and dark coal deposits. Coal is presently exploited in the Livno area. More specifically, dark coal is exploited in Tušnica, while lignite is processed in Prolog, Čelebić, the Eminovo Village and Vučipolje. Despite the above-mentioned natural resources, this county was considered underdeveloped during the pre-war period mainly because of the insufficient and inadequate utilisation of its development potential.

Infrastructure systems are also underdeveloped. The density of the road network (i.e. 23 km/100 km^2 with worn-out bituminous-covered surfaces). The electricity-supply system is either insufficient (110 kW) or incapacitated (35 kW or even 10 kW). The entire water-supply system is characterised by its low degree of population coverage, while the water pumping systems are completely incapacitated. This situation is compounded by total absence of wastewater systems.

As if it had not been difficult enough before the war, the situation has deteriorated because of the recent war. Four municipalities had been directly impacted upon by war operations (Kupres, Glamoč, Grahovo and Drvar) while another two (Livno and Tomislav Grad) have been partially affected. The final range and severity of the war's destructive consequences have not yet been assessed. It has already been made clear however, that the devastation is enormous and that comprehensive international support is required for the restoration and reconstitution of these areas.

Additionally, the extensive destruction of housing units should also be mentioned. The proportion of destroyed dwellings in relation to the previously-existing housing stock totals are as follows:

- The total number of family houses stood at 31,000 of which 7,600 or 24.5% have been destroyed; and
- The total number of flats was 3,850 of which 951 or 24.7% were destroyed.

Apart from the reconstruction of the destroyed dwellings, economy revitalisation represents another prerequisite for future progress, as it has been made clear that the area's very survival depends on its economic development. The area's current economic situation is extremely problematic. The majority of companies operate at less than normal capacity (below 50%), and are plagued by chronic financial problems.

The county's strategy currently involves it in trying to:

- Rejuvenate agricultural production and encourage the development of a single-family type of farming. The Herzeg-Bosnian county area is ecologically appropriate and favourable for the production of organic produce;
- Encourage the development of specific types of tourism (excursions, hunting, winter tourism), endeavouring to enrich the current economic structure;
- Facilitate the rational use of natural and mineral resources and to harmonise their exploitation with prescribed environmental protection requirements;
- Further intensify the development of neglected agricultural production and cattle raising, as well as every kind of service activity; and
- Identify activities that are complementary to tourism already developed in the coastal region, and enable them to form the basis for development.

4.2.1.2. The economic structure of the Croatian part of the watershed

The economic development of the hinterland had been characterised by consistent industrial development and a steady decline of agricultural activities. Today, despite its undeveloped character, the hinterland industry remains one of the most resourceful economic sectors within the structure of the entire economy. However, the shortcomings inherent in the one-dimensional development of this leading economic sector have been manifested, especially during the crisis, in the economy as a whole. In 1991, the share of industry within the total economy was above 60%. Energy production, transportation and trade, as well as the construction industry represented large-scale economic sectors. Moreover, textile, chemical, and building material industries had also been predominant in the pre-war industrial structure.

With reference to the textile industry, "Dalmatinka" remains a promising industry despite the current crisis. Before the war, it provided more than 2,500 jobs. Its future development, however, depends on the incorporation of substantial technological changes in order for it to update its production techniques and remain competitive. "Cetinka", manufacturing plastic materials in Trilj and Vrlika, had also been significant in terms of its employment role, providing 1,000 jobs. The construction materials industry is another once-prosperous economic sector that is presently incapacitated.

Economy of the coastal area consists of 60% of industrial production and the rest is the trade, tourism, textile ("Galeb" textile factory located in Omiš) and processing of aluminium ("Omial" – Omiš, and "Dalmacija" – Dugi Rat). Tourism, which had previously flourished, is now only developed in the coastal zone of the watershed (Table 4.4). The majority of opportunities for the development of tourism are concentrated in the coastal area and especially in the hinterland and the islands, which are functionally connected to the watershed, as they have been supplied with water from the Cetina River. It is expected that further tourism development, boosted by investments, will continue to support family-type accommodation units of small-scale capacity such as private accommodation, apartments, family apartments and boarding-houses, while the number of hotels will not be increased.

Table 4.4.
Number and structure of tourism capacities in 1999

Spatial units	No. of beds in 1999		
	Private accommodation	Hotels	Camps (accomod. units)
Area of Sinj	20	180	-
Area of Omiš	5,128	*	223
Makarska riviera	23,400	8,000	436
Island of Brač	7,660	3,900	690
Island of Hvar	9,131	5,400	483
Island of Šolta		628	-
Island of Vis	1,171	586	-
Total	**46,510**	**18,694**	**1,832**

* The tourist settlement of Brzet used to provide 194 beds, although these are not currently available

Source: Department of tourism, County of Split-Dalmatia (1999)

Natural resources have so far been inadequately utilised. Taking into account the availability of certain considerable natural resources (agricultural and other areas covered by forests), it is clear that the Sinj area's development capacity has so far been insufficiently explored, despite the fact that its location, between the coastal agricultural sector and the hinterland favours this particular type of development.

Agricultural development had previously been interlinked to family-type farming, occupying almost the entire arable land (98%). This type of farming has been directed towards specialised activities undertaken on smaller properties. Today, the infrastructure development capacity of agricultural areas is minor, especially in terms of property acquisition. The number of individuals engaging in agricultural production is diminishing, while agricultural collectives, or other combined endeavours through which farmers can pool their resources, are almost non-existent. Another specific obstacle relating to agricultural production is the absence of the planned commercial exploitation and distribution of agricultural products on the market.

Statistics compiled in 1992, indicate that the sum of agricultural land in the Croatian part of the Cetina watershed encompasses 98,995 ha. The most valuable arable land (plough land, orchards, vineyards and meadows) does not occupy more than 23,788 ha. The rest of the land has been mainly utilised as a karstic grassland (Table 4.5), for the cultivation of maize, wheat and potato. The utilisation of the arable land in the Bosnian watershed section has been relatively more productive (Table 4.6).

Table 4.5.
Usage of agricultural land in the Croatian part of the Cetina watershed (in ha)

Area	Usage of agricultural land					
	Pasture	Plough land	Vineyard	Meadow	Orchard	Total
Sinj	57,872	15,713	540	1,905	30	**76,060**
Omiš	17,335	4,631	760	99	110	**22,935**
Total	**75,207**	**20,344**	**1,300**	**2,004**	**140**	**98,995**

Source: Annual statistics (1992)

Table 4.6.
Usage of agricultural land in the Bosnian part of the Cetina watershed (in ha)

Area	Usage of agricultural land		
	Pasture	Plough land	Total
Kupres	4,500	3,000	**7,500**
Livno	48,177	31,256	**79,433**
Tomislav Grad	48,178	23,467	**71,645**
Glamoč	17,000	13,000	**30,000**
Total	**117,855**	**70,723**	**188,578**

Source: Annual statistics (1992)

Crops are mainly produced in the Sinj, Vrlika, Hrvace, Livno, Duvno, Glamoč and Kupres karstic fields. Their production is restricted to cereals (wheat and barley in Sinj and Vrlika), maize and potato, as well as that of small-scale fodder, while other crops have been neglected. In many cases, crop production represents the most meaningful agricultural activity. This area, however, is typified by extremely extensive characteristics inducing often low yields (wheat about 2 t/ha, maize 1 t/ha, barley 1.5 t/ha, lucerne 1.3 t/ha of hay). The distribution of precipitation during the period of vegetation can be unfavourable even for the production of crops. The production of maize is limited as a result of summer droughts. In the past few years, certain changes to the production structure of Sinj and Vrlika aiming to increase the share of vegetable production (cabbage, paprika, watermelon, and apple), have been registered.

The structure of the area's livestock production has been determined by those of crop production and plant cover, as well as by land structure itself. Some fields such as Pag, Glamoč and Kupres, are now exclusively utilised for grazing and hay production. Cattle breeding constitutes a resourceful activity in areas where natural conditions have not favoured the production of crops, as in the case of large karstic meadows that can only be used for grazing. The rearing of cows for their meat is intensified in the Vrlika, Hrvace and Sinj fields, upstream of Cetina, as well as in the Livno, Duvno, Kupres and Glamoč fields in the Bosnian watershed section, while in other parts it has been neglected. In karstic pastures, the breeding of sheep constitutes another substantial production area. Goat breeding is represented in the mountainous parts of the watershed. Poultry husbandry remains a small-scale activity as it merely covers individual consumption needs (eggs and meat).

During the 1995-1997 hostilities, in the areas of Vrlika, Kupres and Hrvace, the number of cattle, and the respective milk sales decreased considerably. The number of cattle and especially the sum of lactiferous bovines has recently increased, suggesting the start of a new upward trend. However, as the milk industry can only meet a third of the local demand, milk production remains insufficient.

Aquaculture represents a small-scale activity in the Cetina watershed. Trout production has decreased, despite its long tradition and the conditions favourable to its development. The largest farm with a production capacity of 250 tons of trout, and 3,500,000 processed pieces, is located in the Ruda river, a Cetina tributary.

Forest exploitation for firewood supply has been carried out in a haphazard manner. Intensive forest exploitation and unregulated felling have been the main causes of forest degradation. Moreover, as it is only elevated forests that can produce high- quality wood and given that these represent a mere 2.7% of the total forested areas, it is clear that forest exploitation constitutes an insignificant economic asset, depending as it does, on the accessibility of these areas.

The utilisation of wood will be developed in the following three directions:

- Use of wood originating in meliorated low forests;
- Organisation of trees spacing and fertilisation felling; and
- The exploitation of beech wood in the Svilaja mountain area.

The soil erosion testifying to the irrational manner of forest exploitation must be remedied by afforestation measures.

Mineral exploitation activities occur mainly in the Sinj area, and revolve around the exploitation of construction materials such as stone, clay, and gypsum. As many exploitation sites have not been restored after their use, their surrounding landscapes remain degraded and ecologically threatened.

4.2.2. Employment

The recent war in tandem with the slow process of transition, have negatively impacted upon employment. The comparison between the pre-war and the current employment-related statistics reflects the dimensions of this impact (Table 4.7 and 4.8).

Before the war, a substantial number of companies had been employing a large number of workers, while today only a few of these companies are still operating. The data refers to the total number and structure of employed workers in 1998 and 1999, respectively. In 1999, the number of employees accounts for 11,053, i.e. only 12% of the total population.

4.2.3. Major economic centres

The most important centres of the Cetina watershed within the territory of the Herzeg-Bosnia county, are the towns of Livno and Tomislav Grad, while the towns of Sinj, Trilj and the Omiš-Dugi Rat conurbation represent the most significant centres of the Croatian watershed section. With reference to their population size, economic growth and employment rate, these urban centres are expected to emerge as the leading lights of the area's future development.

Table 4.7.
Number of employees in 1998 in the coastal part of the watershed

Sectors	Number of employees
Industry	2,873
Agricultural production	25
Forestry	8
Water supply economy	52
Construction economy	198
Traffic and transportation	102
Trade	239
Catering and tourism	149
Handcrafts	727
Housing-communal services	55
Financial and other services	85
Economy	**4,513**
Education and culture	391
Health and social services	215
Administration	90
Non-economic services	**696**
Total	**5,209**

Table 4.8.
Number of employees in 1999 in the area of Sinj (hinterland)

Sector	Number of employees
Agriculture, hunting and forestry	90
Fishery	-
Mining	45
Manufacturing industry	1,613
Electricity, gas and water supply	393
Construction industry	565
Trade	1,058
Hotels and restaurants	110
Transportation, warehousing and delivery	302
Financial transactions	67
Real estate transactions	27
Public administration	230
Education	843
Health protection service	468
Other services	33
Total	**5,844**

However, given the present economic situation and the extended period needed to economically reconstitute the area, these major economic centres do not attract people as much as they did previously. Any future development of the area will rest upon a polycentric approach to development and on the dispersal of economic activities and the social infrastructure in the rural settlements, while the major economic centres will continue to constitute the leading forces for the growth of this area.

4.3. Land, river and sea use

4.3.1. Urban and rural development

The main characteristic of the development of the wider Cetina watershed is the emergence of several important urban centres, such as Split, Sinj, Omiš and Makarska (Figure 4.6). Another basic characteristic of the development of the settlements is the steady growth of larger centres and the constant decline of smaller, rural settlements whose population had been mostly engaged in agricultural production and cattle breeding. Generally, the larger coastal settlements indicate a rapid growth tendency, while the small villages of the coast, progress less rapidly.

The impact of Split as a regional centre located beyond the narrower Cetina watershed area, extends in both the researched, as well as in the broader area to cover the entire territory of Dalmatia. Its impact as a prominent centre, extends to the neighbouring domain of Bosnia and Herzegovina. More specifically, it strongly affects the urban area embracing the vicinity between Trogir and Kaštela, and from Solin to Omiš, and Makarska, in particular. In this way, a unique urban continuum has been established, taking in the narrow coastal zone and its roads. The town of Split with more than 200,000 inhabitants is by far the largest town in the broader Cetina area.

The urban system of Sinj encompasses the settlements scattered around the fields, including Vrlika to the north-west and Trilj to the south-east with 60,000 people distributed over five settlements of approximately 800 inhabitants each. Sinj has the largest population size (11,378).

Figure 4.6: Settlements network in the River Cetina watershed

The urban system of Omiš embraces the narrow coastal strip, stretching to the coastal area of Split and Makarska. This coastal strip which includes the Cetina estuary is the most densely developed coastal zone. It is characterised by a number of conflicts revolving around the utilisation of land, which threaten to devastate the coast. In addition, the part of the hinterland beyond the Sinj area, gravitates towards Omiš.

The remaining smaller settlements that can be classified as rural ones, are typically comprised of several villages located in the wider area, and largely dependent on the marginal agricultural resources provided by the karst. Their gradual disintegration indicates that these watershed sections have not benefited from the urban hubs in the surrounding area. The structure of the smaller settlements at a distance from the coastal settlements and the fields has been transformed from traditional agrarian to a type of exclusively urbanised residential structure. These changes have been less accentuated in the territory of the Federation of Bosnia and Herzegovina.

The inhabitants of the narrow part of the river watershed that includes the Cetina estuary and the coastal strip, are distributed over 138 settlements of approximately 848 residents each (Table 4.9). Only Makarska, Sinj, Omiš and Podstrana are inhabited by more than 5,000 inhabitants. Small settlements of up to 500 inhabitants, making up 16.4% of the total population of the researched area, predominate here. The majority of people are based in settlements with between 500 and 1,000 inhabitants, which collectively make up 20.8% of the area's total population.

Generally, the population size of small settlements tends to decrease. This tendency is explained by vast population migrations from smaller settlements either to larger centres – with the latter reflecting this tendency in their increased population numbers – or to certain other attractive areas. The larger settlements indicate a constant increase of population, as well as an improvement of both their infrastructures and urban services, which clearly justifies their attractiveness.

The wider Cetina watershed area contains parts of the Federation of Bosnia and Herzegovina, with its centres and settlements concentrated in the vicinity surrounded by the large fields of Tomislav Grad, Livno, Kupres, Glamoč and Bosansko Grahovo. Although nearly twice the size of narrow Croatian counterpart, this watershed section is inhabited by less people, while it is characterised by more settlements. The average Bosnian settlement size is also two times smaller than the Croatian (432 inhabitants). This area is characterised by consistent growth in the settlements, many containing more than 2,000 inhabitants and a corresponding decrease in the number of smaller settlements. More than 78% of the Bosnian settlements are inhabited by less than 500 residents, thus reflecting the area's rural character (Table 4.10).

Table 4.9.
Number and size of settlements in 1991 in the narrower part of the Cetina River watershed

Settlements size	Number of settlements		Number of inhabitants in settlements			
	1981	1991	No. 1981	No. 1991	% 1981	% 1991
more than 10,001	-	2	-	23,121	-	19.76
5,001 – 10,000	2	2	18,053	11,319	16.47	9.67
2,001 – 5,000	7	7	22,646	20,022	20.66	17.11
1,001 – 2,000	18	14	24,327	19,022	22.19	16.26
501 – 1,000	36	35	25,270	24,303	23.05	20.77
less than 500	75	78	19,318	19,209	17.62	16.42
Total	**138**	**138**	**109,614**	**116,996**	**100.0**	**100.0**

Table 4.10.
Number and size of settlements in 1991 in the wider territory of the Cetina watershed in the Federation of Bosnia and Herzegovina

Settlements size	Number of settlements		Number of inhabitants in settlements			
	1981	1991	No. 1981	No. 1991	% 1981	% 1991
more than 10,001	-	1	-	10,080		9.97
5,001 – 10,000	1	1	9,002	5,012	8.63	4.96
2,001 – 5,000	2	3	8,008	9,067	7.67	8.97
1,001 – 2,000	12	8	16,001	10,253	15.33	10.14
501 – 1,000	44	37	30,839	27,467	29.55	27.16
less than 500	174	183	40,504	39,252	38.81	38.81
Total	**233**	**233**	**104,354**	**101,131**	**100.0**	**100.0**

It is interesting to compare the population sizes of different settlements within the Federation of Bosnia and Herzegovina. Here, 66% of the population is distributed in settlements with less than 1,000 inhabitants, while the respective percentage with reference to Croatia drops to 37% of the total Croatian population.

Whereas 29% of the Croatian population lives in settlements with more than 5,000 inhabitants, the relevant percentage for the Federation of Bosnia and Herzegovina is 15%. Furthermore, Croatian settlements, by comparison to their Bosnian counterparts, are characterised by constant and rapid changes to their population numbers: more specifically, Croatian settlement populations are declining rapidly as increasing numbers relocate to Croatian urban centres.

With the exception of certain larger towns, such as Sinj, Makarska, Omiš and Livno, the structure of urban settlements in the area is generally undeveloped. In many of these settlements, the share of the residential area exceeds 80% of the total settlement area.

It is clear that in the past, large numbers of people were employed in centres outside their area of residence and thus the daily migration from the hinterland to the coastal areas (Split) was substantial. The current decrease in the number of the daily migrations reflects the increase of unemployment.

The islands are caught in similar processes. The larger island coastal settlements show a certain growth tendency whereas the rural settlements situated in the hinterland, are experiencing an overall population decrease. These fluctuations are modified by tourism and to a lesser extent, in accordance with their proximity to the vicinity of Split. For instance, a more extensive settlement development pattern has been noted on the island of Brač, a pattern which is not mirrored on other islands located at a greater distance from the coast.

Settlement development is, among other factors, limited by the absence of well-developed infrastructures, especially with reference to wastewater disposal systems, as well as municipal and other solid waste disposal systems. As their road network also remains undeveloped, convenient state roads are frequently treated as settlement roads, providing direct access to private houses. The Adriatic road is one of these.

Coastal settlements, and those around Sinj and Livno, are showing growth tendencies, while the remaining experience the population decrease. During wartime, the settlements located north-west of Sinj had to be evacuated and were eventually destroyed. Although their restoration is underway, the fact that a proportion of the displaced population is not likely to return to their homes in tandem with a number of other negative factors relating to the population structure, will eventually slow down the area's economic growth rate.

Any future settlement development pattern can only be consolidated by diminishing the differences in size between settlements. Split with about 200,000 inhabitants is the largest settlement in the narrower watershed area. The next group of settlements that are about 20 times smaller than Split are the towns of Solin (12,575), Sinj (11,378), (Makarska 11,743), Trogir (10,266), and Livno (10,080). Omiš (6,079) follows, then Trilj (2,118), Vrlika (1,334), and finally the other settlements with less than 1,000 inhabitants each. This doesn't fit the principles of rank-size rule. Moreover, measures should be adopted to speed up the development of the Sinj, Trilj and Vrlika secondary cities, and the Bosnian ones of Livno, Tomislav Grad and Glamoč, as well as to encourage the growth of the smaller settlements around the fields and along the coast.

If the former urbanisation pattern tendencies in the Cetina watershed and the adjacent coastal area continue, the coastal settlements will experience the further population growth as a result of the accelerated development of tourism, while the reduced share of the primary sector will intensify stagnation in the hinterland, further decreasing its population size. Changes are also expected to occur in the smaller settlements (whose population size has been steadily diminishing) such as the hinterland settlements and those located in the Croatian watershed section. Similar processes are anticipated for the territory of the Federation of Bosnia and Herzegovina. These changes would be accentuated by the present difficulties in crossing the borders, which would reduce the coastal population size, and will intensify population migration from the smaller settlements to urban centres in the Federation, such as Livno and Tomislav Grad.

4.3.2. Urbanisation along the coast

The coastal strip, within the influence area of Cetina, is part of a relatively developed metropolitan area of Split. With the completion of the Adriatic road, and the development of tourism, this area has been under the way of important changes, often occurring in a spontaneous and thus haphazard manner.

The major part of the coast includes a narrow zone delimited by high mountain chains. Only in certain places, such as the Cetina estuary, or in the stretch between Omiš and Dugi Rat does the coast widen, as it penetrates into the land (i.e. the riverbed and the mouth surface area). On the narrow coastal strip along the road, several settlements have emerged on a seemingly infinite row. Very frequently, the entire population of the settlements located on hills and other elevated areas, had to move either towards the coast, where work opportunities were provided by tourism, or to the nearest towns such as Omiš, Split, Makarska, and Dugi Rat. The role of the Adriatic state road (D8) has also been significant in facilitating communications while simultaneously functioning as the sole direct connection between settlements and other individual units. Unfortunately, as the road has been extended all along the sea, with some of its sections nearly reaching the sea, the beauty of the seaside has been irretrievably lost and recreational activities have declined, while access to the sea itself has became impossible.

The settlements from Split to Makarska have spread along the coast, covering the narrow coastal strip. Larger towns, such as Omiš, Makarska and Dugi Rat have gradually established urban functions, including also the gravitation area. In these centres, industrial constructions, hotels and other tourist accommodation, as well as public buildings and services continue to spring up.

Sea transport routes have almost been replaced by road transport routes. The coastal settlements are now provided with marinas, while a section of the Cetina mouth (near the bridge of Omiš) is partially utilised as mooring for leisure boats.

On several coastal locations, tourist activities have been intensified as the emergence of several hotels testifies (the Lav hotel, hotels in Omiš and Makarska). This rapid development has also been reflected in the emergence of various types of private accommodation.

Regretfully, as the above development (which mainly refers to residential development) has been implemented in an irrational and thus unplanned way, the normal functioning of settlements has been disrupted, while the urban area has been experiencing a range of problems. Given that the infrastructure development is drawn upon the existing pattern, the construction activities remain enormously expensive, especially due to its complexity. As a rule, wastewater and solid waste disposal systems are absent. Moreover, the number and distribution of transformer stations remains insufficient and cannot provide the required supply of electricity; consequently, the area's electrical supply is so low, that the area is subject to frequent electricity supply interruptions and power cuts. The road network is also inadequately developed, while the national road often represents the sole safe transportation option. Parking lots and certain seaside facilities, that would boost tourism and recreational activities generally, are also absent.

Furthermore, settlements (or certain parts of them) have expanded so close to the sea, that the size of the coastal parts, utilised for bathing and recreational areas, has exceeded the legally prescribed limits of a minimum access to the coastal public property. By way of this, an obvious and unique tourist asset and perhaps the main magnet for tourists has been lost. As the coastal strip continues to diminish, either due to the construction of the national road or to that of housing and other accommodation units, the impact on many settlements has been multi-faceted. In an effort to return parts of the coast to public use, intensive filling up and construction of marinas and of open spaces has been initiated within the settlements. Unfortunately, these operations have often been undertaken irresponsibly and thus have been left incomplete. For many settlements outside the urban zones, access to the coast becomes difficult, due to the density of housing and other accommodation units. Often, the constructions built on the coast, do not meet the required standards and also fall short in terms of functional and aesthetic value.

In order to preserve the coast, it is essential to establish a strategy for the rehabilitation of the degraded coastal zones, as well as to prevent any further construction within the remaining unoccupied coastal parts. Developmental activities relating to tourism should be diverted towards the hinterland, in order to prevent further degradation resulting from assorted public usage, including recreational activities. By means of new legislation regulating transportation, the state road should also be relocated deeper inland in order to diminish the coastal traffic density, and thus traffic pollution, enlarging at the same time, the size of settlement spaces for public use.

4.3.3. Land-use patterns

Arable lands, forests, settlements and other spaces constitute the main land-use categories (Table 4.11, Figure 4.7). According to statistical indicators, the entire agricultural land in the Cetina watershed, encompasses 304,048 ha, of which about 38% are occupying the narrower watershed area. The most valuable arable land, such as plough, orchards, vineyards and meadows account for 32% of the total of agricultural areas (97,309 ha), while the remaining land contains karstic, and frequently mountain pastures.

Table 4.11.
Agricultural land use in the Cetina River watershed (in ha)

Municipality (former)	Agricultural land-use		
	Pasture	Arable land	Total
Sinj	57,872	18,188	76,060
Omiš	17,335	5,600	21,966
Makarska	14,646	2,798	17,444
Total narrower watershed area	**89,853**	**26,586**	**115,470**
Kupres	4,500	3,000	7,500
Livno	48,177	31,256	79,433
Tomislav Grad	48,178	23,467	71,645
Glamoč	17,000	13,000	30,000
Total Bosnia and Herzegovina	**117,855**	**70,723**	**188,578**
Total	**207,708**	**97,309**	**304,048**

The agricultural land encompasses the area of the "direct" and wider Cetina watershed, while in the coastal area, almost no agricultural land is presently in use. In the coastal area, the terrace-type of land use appears frequently, despite the fact that the land has been abandoned and overgrown by pine-wood and evergreen. Due to its specific terrain characteristics, the terraces have gradually collapsed, giving back to the terrain its former shape of a slope.

Agricultural production is mainly represented in the karstic fields of Sinj, Vrlika, Livno, Duvno, Glamoč and Kupres. It is based on the production of cereals and potatoes, and to a lesser extent, on that of fodder, while any other agricultural production has been neglected. Furthermore, agricultural production, plant cover and land structure have also conditioned the structure of the livestock. Pag, Glamoč and Kupres fields are now exclusively utilised for grazing and hay production. Cattle breeding is particularly resourceful in areas where the natural conditions have not favoured the production of any crops, that is in large karstic meadows, that can only be used for grazing.

The agricultural land of the watershed differs significantly from that of the coastal area. The hinterland is characterised by large fields, surrounded by arable land, as well as by hilly/mountainous areas covered with pastures. On the coast, arable land is scarce. Luckily, the coastal climate favours the production of certain Mediterranean crops. Coastal arable zones should, therefore, be preserved and protected from certain dangers, such as fire.

The forests of the "direct" watershed and on the coast possess no direct economic value, given that less than 3% can actually be utilised for the production of high quality wood, while almost half of them occupy rocky terrains. By contrast, the "indirect" watershed section is rich in forests. The area's share of high (economic) forests, favours the large-scale production of high-quality wood.

Settlements have been developed in areas around fertile fields and roads, as well as along the coast. The traditional, rural settlements are the most common place (accounting for 70% of the settlement total, with population size below 500). In analogy to their distance from urban centres and the coast, their population size decreases. As a general rule, however, settlements with a population size of below 500, tend to further decrease regardless of their location.

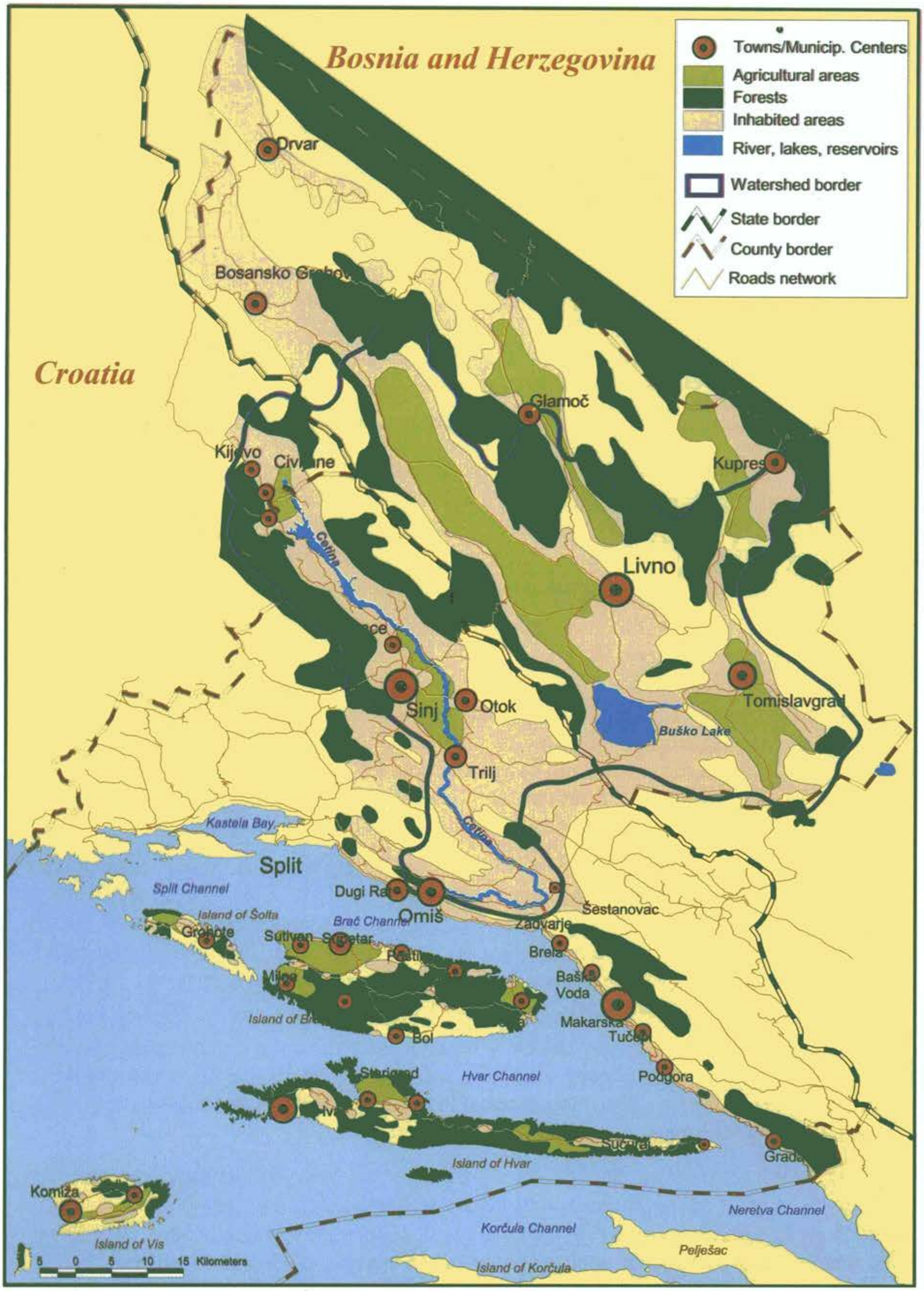

Figure 4.7: Land-use pattern in the River Cetina watershed

In the territory of the Federation of Bosnia and Herzegovina, an average settlement's population size is 432 inhabitants, while the respective size for those located in the Croatian "direct" watershed area is 850 inhabitants. In the Bosnian part of the watershed, there are only two towns with more than 5,000 inhabitants (accounting for 14.9% of the total Bosnian population) and 220 settlements with less than 1,000 inhabitants (accounting for 66% of the Bosnian population). The flourishing urban centres of Livno and Tomislav Grad have been formed around fields and near roads, while the smaller urban settlements are located further up in hilly/mountainous areas.

The Croatian urban development pattern differs from that of the Bosnian one. Although the Croatian rural settlements with population size up to 1,000 are dominant, they merely account for 37% of the Croatian population (81% of these settlements have less than 1,000 inhabitants). Their size is characterised by a consistent decrease, as their rural population has been migrating to larger centres, to the coast and other prosperous areas. In the "direct" watershed, the important urban centres have emerged around the Sinj field and along Cetina, stretching from Sinj to Vrlika (Cetina's source). This area has also favoured the development of centres with complex structures, such as residential zones, industrial, recreational and other areas.

As we have already mentioned in 4.3.2, the coastal urban areas stretch in a continuum, especially those between Omiš and Split. Here, Makarska constitutes a significant tourism asset, Dugi Rat an industrial, while the town of Omiš combines tourist and industrial potentials. Conclusively, the coastal strip has been urbanised to a greater extent by comparison to the rest of the coast. The settlements between Omiš and Split, that appear to form an urban continuum, possess neither green nor any other buffer zones. Only at some places, the buffer zones have been developed as the result of existence of natural barriers, such as Vrulja.

4.3.4. Sea use

Historically, the sea has always represented a significant asset to the coastal population, providing them with food, construction material, as well as with a natural, waste discharge outlet. Sea transportation of goods and people was the sole method of communication with the neighbouring areas.

The importance of Cetina's connection with the sea can best be reflected in the fact that the construction of the first HPP on Cetina (HPP Zakučac), was followed by the additional construction of the first large building of this area, which is the carbide and ferroalloy factory of Dugi Rat. By means of the operation of the Zakučac HPP, Cetina's energy potential was harnessed for the factory's large-scale production operation, whose products were exported world-wide. The sea transportation routes have also facilitated the transportation of both raw materials and manufactured products.

On the island of Brač, fishing has been a prosperous economic activity for its northern towns of Postira and Pučišća, which have produced and exported nearly 22,000 tons of salt pilchards. The sand-miners of Krilo Jesenice, utilising a fleet of wooden ships, once exclusively supplied the entire area of middle Dalmatia with construction sand, which was extracted at the Cetina estuary.

Today, the situation regarding sea use has changed. Summertime tourism has gained great economic importance, based on the use by the coastal strip (marine and terrestrial) as a bathing area and for various off-shore recreational activities.

The importance of sea transport routes has diminished both for the mainland and on the northern part of the island of Brač, as roads have become preferred for their speed and convenience, for the transport of people and products. The sea, however, still constitutes a significant means of communication between the island of Brač and the mainland.

As fishing activities on the island have been insufficient to meet its consumption needs, the sardine factory of Postira is forced to import fish from other areas. Species fished on the island merely meet the demand of locals and tourists.

The population growth along the narrow coastal strip during the last 40 years, which was triggered by the completion of the coastal road, and the availability of family-type accommodation units, has threatened the sea through wastewater pollution. A number of underground urban wastewater discharges were constructed, unfortunately, without treatment facilities.

4.3.5. River use

4.3.5.1. Former regulation and development of water uses in the Cetina watershed

Cetina possesses a substantial water and energy supply potential. Despite the fact that the majority of its waters originate in karstic springs, the river constitutes a potent flow, characterised by powerful and rapid fluctuations with a total river inclination of 382 m, from its source to its estuary. Cetina's most important uses relate to hydro-electric applications, which have long been recognised as the river's most resourceful potential. In addition to the regulation of its utilisation and the constructions required for its hydro-electric exploitation, several other measures have been undertaken to ensure the water supply of the broader area, including agricultural irrigation and the prevention of flooding. Furthermore, Cetina and its tributaries are the recipients of all wastewater generated in the watershed. To a lesser extent, Cetina is used for fish farming. Until recently, tourism by the river had been a marginal area; however, its future development has been planned, focusing on the river's natural assets and fishing, rowing and sailing in its storage reservoirs, as well as rafting in the lower part of the Cetina canyon.

The most significant hydro-electric stations have already been completed (Table 4.12). The construction of their first phase had started by the end of 19th century.

By 1912, the first phase of the Kraljevac hydro-electric power plant has been completed. This was the largest HPP in Dalmatia at the time. Its second phase was completed in 1932. The second phase of constructions in the Cetina watershed started after the Second World War.

Table 4.12.
Characteristics of the existing hydro-electric power plants (HPPs)

No.	HPP Name	Beginning of operation	Installed power (MW)	Installed flow capacity (m^2/h)	Average energy production (GWh/year)	Useful stor. res. volume ($10^6 m^3$)
1.	Kraljevac	1912	59.7	70	33	0.1
2.	Peruča	1960	45	120	123	578
3.	Zakučac	1961	468	220	1,300	6.8
4.	Orlovac	1974	237	70	497	831
5.	Đale	1989	40.8	220	158	3.7
Total			**850.5**	**700**	**2,111**	**1,419.6**

In 1960, the storage reservoir and HPP in Peruča were constructed as a multi-purpose dam plant, given that in addition to its electricity generation function, it has impacted positively on Cetina's hydrological regime, by reducing flood wave generation, as well as by improving water discharge from the protected surface area of the Sinj field. Furthermore, the accumulated water in its storage reservoir facilitated the establishment of an irrigation system, as well as the water supply to both populations and industry.

The additional construction of the storage reservoir and the Peruča HPP enabled the regulation of the Cetina's water level, whilst harnessing its energy to the needs of the Kraljevac HPP located downstream of the river, and from 1961 onwards, to those of the Zakučac HPP, and for HPP Đale from 1989. With the operation of the Zakučac HPP, the hydro-electric utilisation of the Cetina River was continued in its downstream segment with the largest existing river inclination. The first phase of the Zakučac HPP started its regular operation in 1961, and its second phase, in 1981. In addition to its energy potential, the Zakučac HPP had also been recognised for its water supply capacity. This fact justifies its significance as a multi-purpose project.

With reference to water resources management, the biggest project undertaken within the entire watershed, is the construction of the Orlovac HPP, in the territory of Bosnia and Herzegovina. This HPP's system comprises of subsequent systems for the collection, transfer and the accumulation of water at the outskirts of the Livno field, as well as of utilisation systems at its fall in the Sinj field. This system was completed in 1974. By means of the Orlovac HPP and its storage reservoir in Buško Blato, Cetina's level has been completely stabilised to such a degree that almost no overflow is currently registered either in its Prančevići dam, or in its downstream river flow section, which is technologically adjusted respecting the biological minimum.

Apart from the above multi-purpose stations, the river's energy potential has been utilised in the area between the Sinj field and the Prančevići storage reservoir by the Đale HPP since 1989, when its regular operation started. The main characteristics of the HPPs are given in Table 4.14, while their schematic survey is shown in Figure 4.8.

4.3.5.2. Future plans for the development and energy use of the waters of the Cetina watershed

Given that the most strategic locations for the hydro-electric applications of Cetina have already been occupied, the future activities will mainly be directed towards water management issues and less to the significance of the HPPs as energy producers (Figure 4.8). The aspect of energy will only provide support to water management and to utilisation of the watershed. In the Republic of Bosnia and Herzegovina all the planned HPPs in the wider watershed are located in karstic fields. The remaining water potential can be harnessed in the future operation of storage reservoirs for water accumulation in the north-western part of the Livno field, which would be utilised in the Orlovac HPP. The construction of channels is expected to supply the Čaprazlije retention with water, as well as to transfer water into the HPP Orlovac from the Lusnić pumping station.

The water exploitation in Glamoč field has been facilitated by the creation of the smaller storage reservoirs of Hozići and Buleklagija, which are located in the upstream flows within the Glamoč field. In this way, partially levelled flows are carried by regulated flows and channels to the lowest level of the field, where the construction of the Pučine winter retention, which will be used temporarily, is scheduled. More specifically, during the vegetation period, water would be released from the retention so that the land obtained could be used for agriculture.

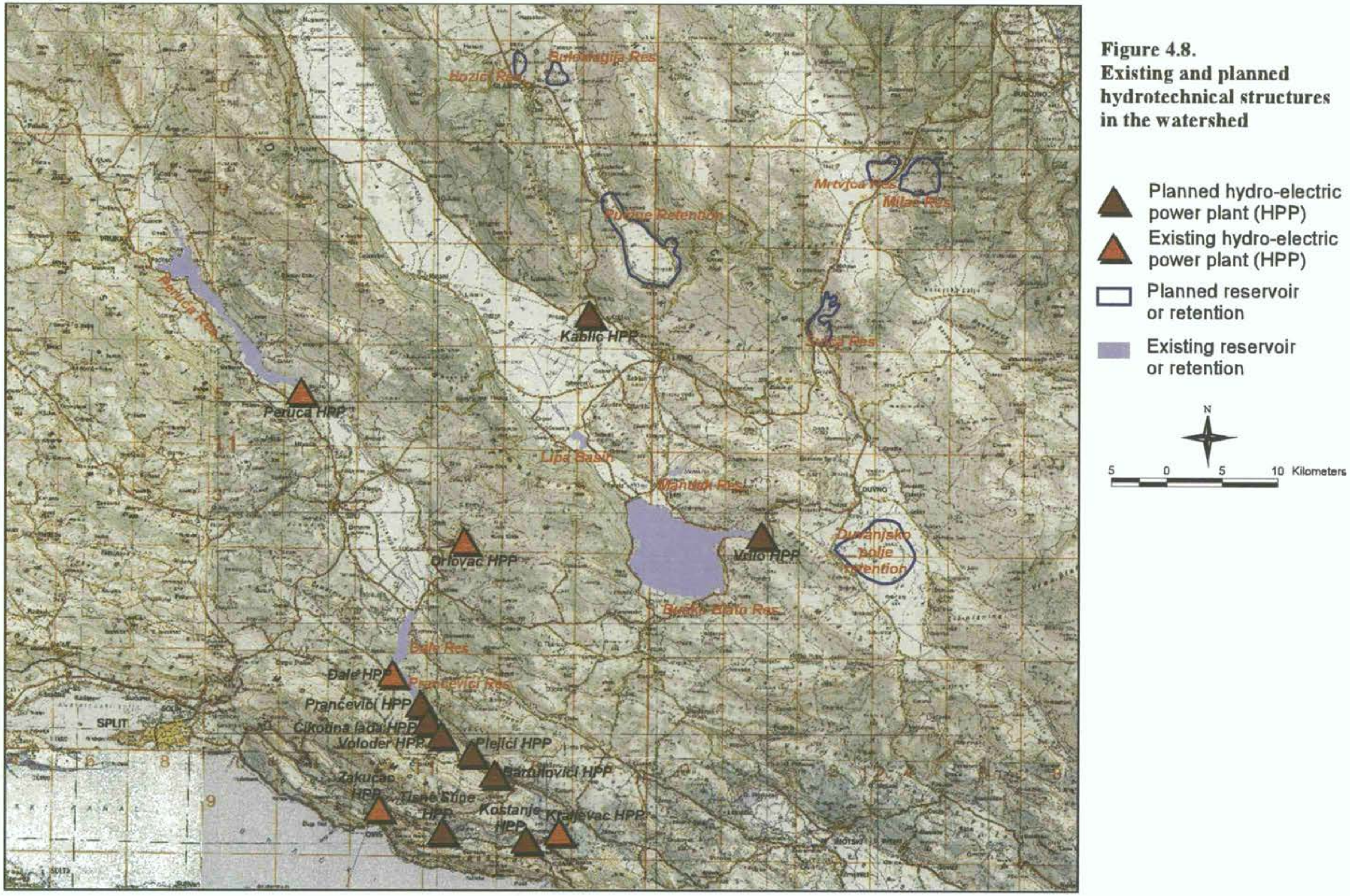

Figure 4.8.
Existing and planned hydrotechnical structures in the watershed

The water stored in Pučine would be transferred by pressure pipes to Kablić HPP in the Livno field. This development would facilitate the transfer of approximately 4 m^3/s of water from the wider Una river watershed into the wider Cetina watershed, in order to enable the future operation of the Orlovac HPP in Livno field.

The planned water exploitation in the Kupres and Duvno fields, would decrease the inflow and pressure of water in the lower horizons of the Duvno field. This could be achieved by creating storage reservoirs in the Mrtvica, Milač, Kupres and Šujica fields. The water regulated by these reservoirs would then be stored in the temporary winter retention in the Duvno field, from which it could be transferred via a tunnel and by pressure pipes to the Vrilo HPP, and further on to the Buško Blato storage reservoir. Furthermore, the water elevation between the fields of Kupres and Duvno would be utilised in the Stržanj HPP.

Apart from the energy applications of the concentrated water inclination in the Kupres field, a well conceived hydro-electric utilisation of the wider Cetina watershed would provide the basic solutions to problems arising in relation to the area's water management. The creation of storage reservoirs, the use of temporary winter depositories, the completion of a channel system, as well as that of a water flow regulation, would level karstic fields' flows, directing their transfer from higher to lower horizons.

Conclusively, the completion of the above planned HPPs represents a multi-purpose project: it would prevent floods, resolve problems relating to water transfer, whilst improving the irrigation system of agricultural land. Furthermore, an additional construction of well-planned water intakes would satisfy water supply needs.

4.3.6. Technical systems

4.3.6.1. An overview of the existing hydro-electric power plants in the Cetina watershed

The Kraljevac HPP

The Kraljevac HPP was the first to be erected on the Cetina River, and is located 21 km upstream of the river estuary. It is a derivation HPP, 110 m high, with a total installed flow of 70 m^3/s and total installed power of 59.7 MW. The installation of an aggregate of biological minimum has secured the rational exploitation of waters, whilst increasing the generation of electrical energy. After the construction of the Zakučac HPP, and especially after that of the Orlovac HPP, the operation of the Kraljevac HPP proceeded, based on waters of biological minimum and on its own inter-inflow, significantly decreasing its production. In the past ten years, its average annual production has been only 33 GWh.

The Peruča HPP

The Peruča HPP is a dam plant constructed upon Cetina 14 km upstream of Sinj, possessing a storage reservoir that facilitates the seasonal water regulation. After the attempt to demolish the dam, during the recent war, the entire installation has been repaired by erecting a complementary construction in order to increase the volume of its storage reservoir. The HPP's installed flow capacity is now 120 m^3/s, while its average annual power production is 123 GWh. The total volume of the storage reservoir is 570 mil. m^3, which enables the full seasonal levelling of the flow capacity.

The Zakučac HPP

The Zakučac HPP is a derivation plant that possess the most high flow and energy production capacity within the entire Cetina watershed. Its installed flow capacity is 220 m^3/s, that of its energy production reaches 486 MW, while its annual production is 1,550 GWh.

The small Prančevići storage reservoir, with a total volume of 6.9 mil. m^3 and useful volume of 4.4 mil. m^3 covers the daily inflow levelling required for the operation of this HPP.

The Orlovac HPP

The Orlovac HPP system includes water collection, transfer and reception systems at the horizon of the Livno field in Bosnia and Herzegovina, while the hydro-electric production is performed in the machine room of the Orlovac HPP, in Croatia. The machine room of the Orlovac HPP is situated by the village Ruda, downstream of the Mala Ruda spring. It includes three aggregates with Francis turbines and generators. The total installed flow capacity of these turbines is 70 m^3/s, while the total installed capacity of this HPP reaches 237 MW. The gross elevation is 403.7 m and the constructive elevation of the turbine is 380 m. Its average annual production is about 497 GWh. The operation of the Buško Blato storage reservoir facilitates the reception and regulation of flows. Its total volume of 800 mil. m^3 ensures the long-term elevation of the inflow. Caused by the area's karstic characteristics, as well as by the large lake surface, enormous underground water losses appear. These losses supply underground waters of the River Cetina.

The Đale HPP

The last HPP constructed within the entire Cetina HPP system is the dam HPP of Đale. The Đale HPP was erected on the river at a distance of 5.8 km downstream of the Trilj bridge, in the profile of Beksetine mills. The inflow levelling and the increase of the elevation at the profile of this HPP had been ensured by the creation of storage reservoirs in the Cetina bed, with a total volume reaching 3.7 mil. m^3 and use volume of 2.95 mil. m^3. This HPP utilises the operation waters of the Orlovac and Peruča HPPs, in addition to the natural inflows of the Cetina River downstream of the Peruča dam and the turbines of the Orlovac HPP. The plant's hydro-electric potential is utilised at the elevation extending from the Sinj field to Prančevići basin. Its installed flow capacity reaches 220 m^3/s, while its power capacity is 40.8 MW. Its average annual production over the past 10 years has been 106 GWh.

4.3.6.2. Basic characteristics of the planned constructions in the Cetina River watershed

a) The wider Cetina River watershed in Bosnia and Herzegovina

Annex to the Orlovac HPP system

The basic conceptual solution of hydro-electric energy production system of the Orlovac HPP involves the construction of storage reservoirs, the use of temporary winter retentions, the construction of channels and intakes, and the regulation of water flows, as well as the elevation of karstic fields' waters, and their regulated transfer from higher to lower horizons, resulting in energetic exploitation of elevation of some 400 m between the Livno and Sinj fields. Its main part has already been completed, with the exception of the part located north-westerly of the Livno field. The collection and water transport channels, the retention Čaprazlije and the Lusnić pumping station remain still to be completed. The completion of this part of the Orlovac HPP system, would increase the average annual energy production in the existing HPP facilities.

The Kablić HPP

This HPP could utilise the waters of the smaller storage reservoirs in the upstream flows of the Glamoč field, namely Hozići and Buleklagija, which are transferred to the Pučine retention, by regulated water flows and through channels. From the Pučine depository, the flows would be transferred further on, through a supply tunnel and pressure pipes to the Kablić HPP.

The Vrilo HPP

This could utilise the waters of the storage reservoirs in Kupres field, namely Milač and Mrtvica, as well as those of the Šujica river, in the Šujica field (i.e. the Šujica storage reservoir), in addition to the Duvno field winter retention.

The construction of channels and the water flow regulation in the reservoirs of Milač, Mrtvica and Šujica would ensure the transfer of waters between the storage reservoirs; from the Duvno field retention, the flow would be transferred by a supply tunnel and pressure pipes to the Vrilo HPP (Table 4.13).

Table 4.13.
Overview of the planned hydro-electric power plants in the territory of Bosnia and Herzegovina

Pos.	HPP Name	Installed power (MW)	Installed flow capacity (m^2/s)	Average energy production (GWh/yr)	Gross /incl. (m)
1.	Kablić	20	15	67	160
2.	Vrilo	48	40	120	140
	Total	**68**	**55**	**187**	

b) The narrower Cetina River watershed (Table 4.14)

The Small Peruča HPP – biological minimum

The exploitation of the biological hydro-potential minimum that is released from the Peruča storage reservoir with volume of 6 m^3/s, as it does not include the main aggregates, implies the additional installation of a biological minimum aggregate.

The Small Prančevići HPP – biological minimum

The biological minimum of the Cetina section downstream of the Prančevići dam, has been so far discharged via a special 600 mm pipe, and reaches 3-4 m^3/s, depending on the retardation point of the Prančevići reservoir. The satisfactory biological minimum prescribed by water management regulations (8 m^3/s), would be ensured by the basic discharge or overflow. By means of a small HPP, which could be erected on the left bank of Cetina, as well as of a water intake, at the Prančevići dam, the biological minimum could be utilised.

HPP on Rumin

By increasing the existing level for 4-5 m on the water flow Rumin Veliki, upstream from the existing water mills, the use of water surplus over the mill consumption would be used in the HPP Rumin, on the left bank. Water derivation – pipeline to turbine room is relatively short.

HPP on Ruda Velika I

A construction of a partition, upstream of the waterfall situated approximately 260 m of the spring, and with retardation to the Ruda spring level, would eventually facilitate water utilisation within a relatively short derivation in the turbines on the left bank near the waterfall.

HPP on Ruda Velika II

Another construction of a low partition, 800 m downstream of that planned for Ruda Velika I, with a maximum retardation to the lower water level of the Ruda Velika I

HPP, would ensure that the water would be transferred to the turbines of the Ruda Velika II HPP with shorter derivation.

The Čikotina Lađa HPP

The planned location of the small Čikotina Lađa HPP is by the bridge, 1.5 km downstream of the Prančevići dam, near the abandoned water mill. By construction of the lower level dam and by widening, as well as by reconstruction of the existing supply channel of approximately 300 m to the former water mill at the bridge at the left Cetina bank, water flow capacity could be used from the biological minimum to the installed flow capacity.

The Plejići HPP

The small Plejići HPP could be located at about 1 km downstream of the Plejići water mill, at the ending of the Cetina canyon. A storage reservoir would be created by constructing a 15-20 m high dam. This is programmed as a dam plant with eventually a short derivation. Due to the inaccessibility typifying the terrain, a single elevation concentration is suggested instead of several constructs with lower elevations. The use of biological minimum and other waters is possible up to its installed flow capacity, including the use of the storage reservoir.

The Bartulovići HPP

Its location is scheduled upstream of the village Bartulovići, at the exit of the canyon. Its conception is similar to that of Plejići HPP, with a turbine room at the left river bank.

The Tisne Stine HPP

The location of the Tisne Stine HPP is scheduled upstream of Radman's Mlinice. In the natural, narrow part of the canyon of Tisne Stine, a dam of 20-25 m height could be erected. Its maximum retardation would be limited by the existing water supply system in the Studenci spring. It could either be a dam or a short derivation plant, erected on the left river bank. Foreseen is the use of biological minimum waters of the River Cetina, the spring Studenci and the inter-watershed downstream of Prančevići dam, as well as of overflow waters from Prančevići dam up to the installed flow capacity (Table 4.14).

Table 4.14.
Overview of the planned hydro-electric power plants (HPPs) in the Republic of Croatia

No.	HPP Name	Installed power (MW)	Installed flow capacity (m^3/s)	Average energy production (GWh/yr)	Gross incl. (m)
1.	Peruča – bio. min.	3	5	2,600	23-57
2.	Prančevići – bio. min.	10.74	8		24
3.	Rumin	2	10	400	
4.	Ruda Velika I	8-10	15-20	1,200-1,600	10
5.	Ruda Velika II	3	15-20	380-480	2.5-3
6.	Čikotina Lađa	1.5-2.5	6-8	190-320	4-5
7.	Plejići	5-8	15-20	600-1,150	15
8.	Tisne Stine	10-15	12	3,000-4,000	25
	Total	**41.24-54.24**	**86-123**		

4.3.6.3. Transportation

Territory of Croatia

Within the entire Cetina watershed, it is only the road infrastructure that has been fully developed and integrated in the county and state road networks (Figure 4.9). In that area, the state road D1 (extending from Split via Knin to Zagreb), and the part of the road crossing Bosnia and Herzegovina from Tomislav Grad via Livno (including one subsequent route towards Glamoč and Banja Luka, as well as one extending to Bosansko Grahovo, Bihać, and Zagreb) represent the most useful road routes along the river. They also constitute the most significant connections between the coastal area and the hinterland, as well as between the coastal area and the entire country and Europe. These roads stretching in parallel to the river flow, are crossed by several transversal roads of local use. The most significant of these subsequent roads is the one extending from Sinj and Trilj in the direction of Livno and Kupres, and further on, towards the mainland of Bosnia and Herzegovina. The second important road is the Adriatic coast road, stretching along the coast, from Dubrovnik to Rijeka, and further on towards Europe. The watershed road network is relatively well developed providing all settlements with the essential, solid connections.

As there has been pressure for the construction of additional main roads, it is anticipated that the road network will be further developed. The construction of several new roads has been already programmed (Figure 4.10).

In accordance with the strategic development relating to transportation, new roads will also replace the old ones in order to satisfy the newly emerging requirements. This refers specifically to the scheduling of a road leading from Bihać to Mostar, crossing the valley of Livno, as well as to a road stretching from Knin towards Split, and along the foot of Svilaja mountain. In the hinterland, the new Adriatic highway is programmed to be developed parallel to the coast, crossing Cetina at Bisko (Figure 4.9).

Territory of Bosnia and Herzegovina

With reference to the territory of Bosnia and Herzegovina, two major routes should be mentioned: the connecting route of central Bosnia, leading to Kupres via Livno, and further on to Trilj in Croatia, as well as another transversal route connecting Mostar with Bihać – and via Tomislav Grad, Livno and Grahovo – with Zagreb. The traffic density of both routes remains relatively low.

4.3.6.4. Wastewater treatment plants – present and planned

Territory of Croatia

The major point sources of municipal wastewater pollution in the Cetina river are the towns of Sinj, Trilj and Vrlika. The suggested schedule of wastewater treatment plants for the Cetina watershed is as follows:

- Trilj biological wastewater treatment plant:
    - I phase 3,500 EP – constructed;
    - II phase 7,000 EP;
- Sinj mechanical biological wastewater treatment plant – the construction preparations are presently at the following stage:
    - I phase 15,000 EP (I level of wastewater treatment);
    - II phase 30,000 EP;
- Vrlika biological wastewater treatment plant:
    - I phase 3,225 EP;
    - II phase 3,452 EP;
- Omiš submarine outfall and the mechanical wastewater treatment plant: 32,000 EP (the outlet has been constructed).

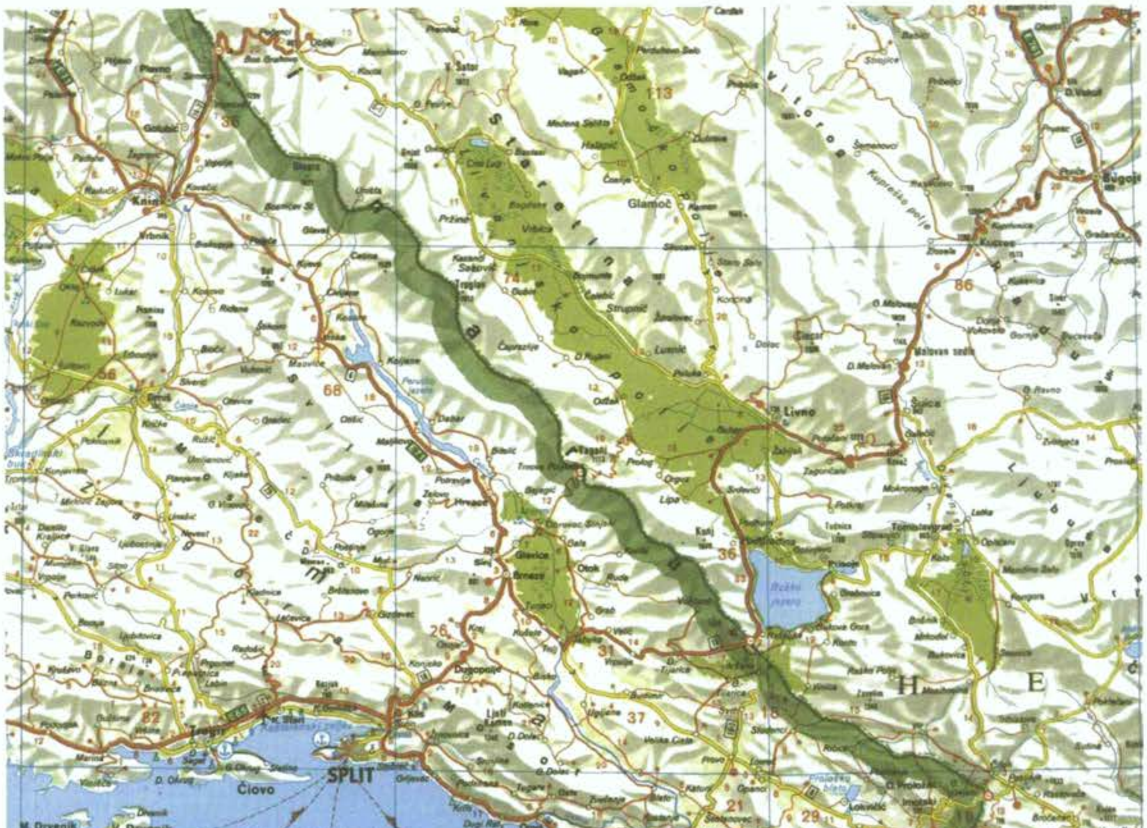

Figure 4.9: The road network and other parts of the traffic system of Croatia and Bosnia and Herzegovina

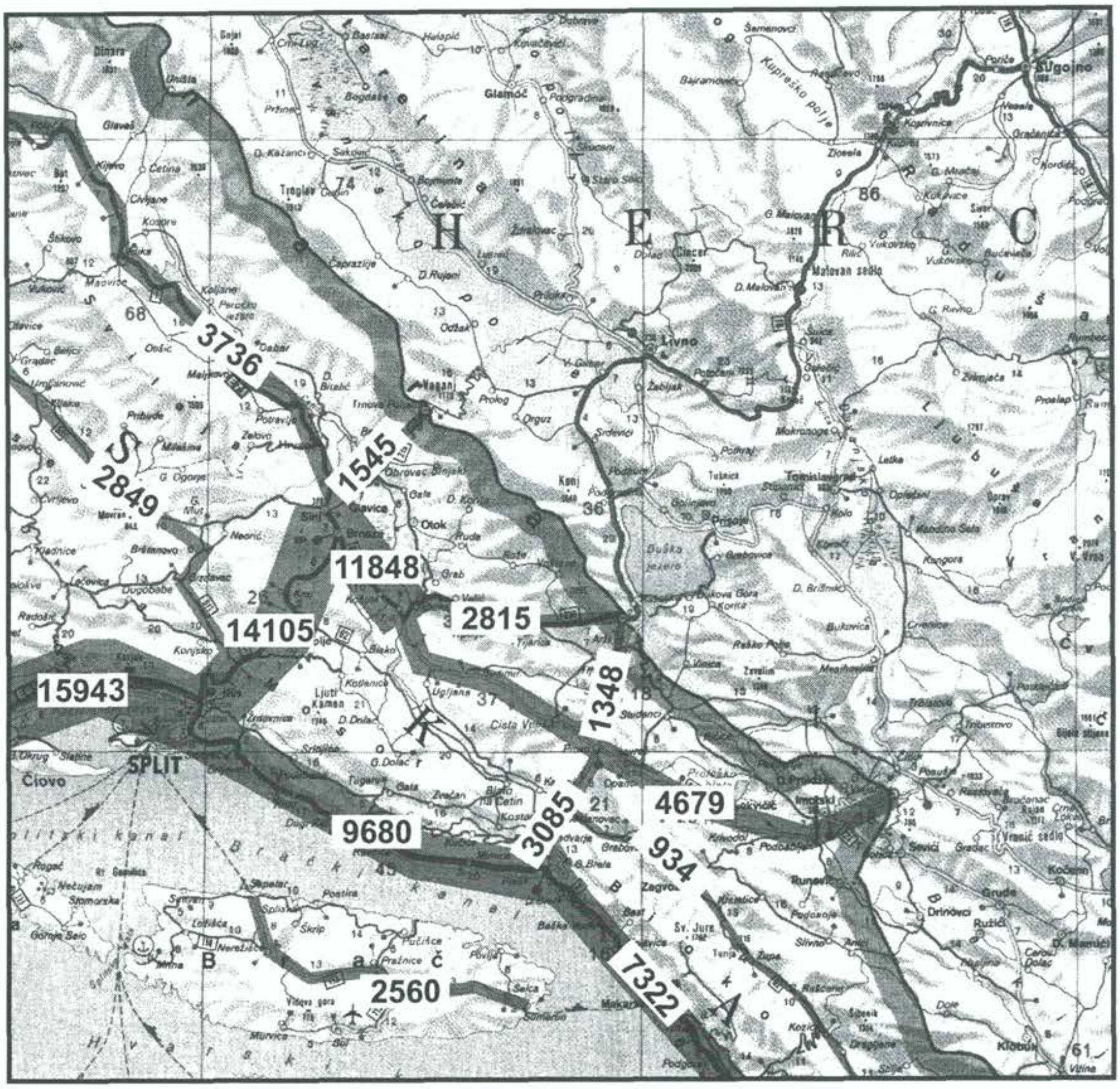

Figure 4.10: View of the annual traffic density in a section of the watershed that belongs to Croatia

Territory of Bosnia and Herzegovina

The larger towns of this area, such as Grahovo, Livno, Tomislav Grad and Kupres possess neither a complete sewage system, nor any other kind of wastewater treatment system. All wastewater has been discharged directly and without any prior treatment into the Cetina watershed, and while both sewage and wastewater treatment systems have already been scheduled, they are yet to be implemented.

4.3.6.5. Water supply

Territory of Croatia

Water from the Cetina River is utilised for the water supply of the Omiš region and also serves the islands of Brač, Šolta, and Hvar, while it is anticipated that it will supply the island of Vis, as well as the Makarska riviera, in the future. As an alternative option, it is also possible that the Omiš – Brač – Hvar supply system could partially supply Split, from the section between Gata – Srinjine. From a hydro-geological perspective, the fact that Cetina is connected to the Jadro river source, implies that the quality of the Jadro waters, which supply the town of Split, depend upon the quality of the Cetina waters themselves. It is also important to know that the Cetina River remains the only alternative option for the supply of Split.

Several water supply systems have been operating, supplying almost every settlement in the area, whilst meeting the needs of more than 90% of the area's total population (Figure 4.11). In the following paragraphs, the basic characteristics of these supply systems will be analysed with particular reference to the settlements located along and thus supplied by Cetina. These are the systems of Vrlika, Kijevo and Maovica (water intake from the Vuković spring), Sinj (Kosinac and Ruda) and the supply system of the Omiš hinterland. The largest systems are those of Makarska, as well as the regional systems of Omiš, Brač, Hvar, Šolta and Vis.

The Kijevo, Vrlika and Maovice water supply systems

The above locations are supplied by the water intake of the Vuković spring, which is one of the Cetina sources. The Vuković spring, which is located next to the water intake at an elevation point of 376 m above sea level, possesses two pump systems, of which one is used to supply the Kijevo area (27.68 l/s), while the other is utilised for that of the town of Vrlika and of the Maovica Village (approx. 38 l/s).

The Šilovka water supply system

The construction of this system had started prior to the recent hostilities in Croatia, based on the utilisation of the Šilovka spring, which is located next to Cetina, at the foot of the Peruča storage reservoir. The system is relatively simple with two pressure pipelines connecting the Šilovka pumping station with the river banks. It supplies all settlements within the area extending from the Peruča dam to the town of Sinj.

The water supply system of the Sinj and Omiš hinterland

The system supplying Sinj constitutes the largest water supply system in the Cetina watershed. Its capacity covers an area of 116,000 ha, supplying approximately 60,000 consumers with water. In addition to Sinj and Trilj, this system also covers the needs of the hinterland towns of Solin and Kaštela. The construction of an additional supply system for the settlements situated along the middle flow of the Cetina River has been initiated in the Omiš hinterland. The water is transferred from the Kosinac and Ruda sources. The intake of water from Kosinac is ca. 95 l/s, while the main axis of the system, the Ruda water intake, provides with 240 l/s. In accordance with the anticipated future requirements, the extracted water quantities from Ruda water intake should be increased to 500 l/s (the min. capacity of this water intake is 800 l/s).

The water supply system for settlements near the middle Cetina River flow

This system is based upon the previously described water supply system of Sinj, via the Strmendolac pumping station, i.e. the water reservoir of Marasovići. This system is programmed to supply the settlements along the middle Cetina flow, i.e. those under the administration of the town of Omiš.

The water supply system for settlements near the lower Cetina River flow

This system supplies the Kostanje Village on the Cetina River's right bank and the Kučiće settlement on its left one. Water is supplied by the Studenac spring, which is located next to the riverbed, on its right bank. The system's capacity reaches 15 l/s.

Regional waterline of Omiš-Brač-Hvar-Šolta-Vis

The regional waterline of Omiš-Brač-Hvar-Šolta-Vis (Figure 4.11) covers the needs of 53,272 inhabitants (according to the 1991 census). The system has yet to be completed and thus does not include the island of Vis and parts of the island of Hvar. The current annual water supply of the entire system approximates 6,000,000 m^3, by comparison to the period before 1990, when it exceeded 8,000,000 m^3.

The basic waterline characteristic is the large discrepancy of consumption during the year. The differential ratio between the winter and summer consumption can reach up to 1:10. During the maximal consumption period, its present supply capacity of 500 l/s is exceeded, and therefore, the upgrading of its capacity is scheduled for the future. Apart from upgrading the capacity of the waterline on the islands of Brač, Hvar and Šolta, an extension of the system to the island of Vis, has also been planned and is to be implemented in several phases.

The water intake is situated in the Zakučac HPP. Given that this (surface) water needs to be treated to reach required drinking water standards, it is first transferred to the Zagrad treatment system, located 230 m above sea level. The system's present capacity is 3·210 = 630 l/s while plans exist to up this capacity to 5·210 = 1,050 l/s. Between this treatment system and the coastal zone of Priko, a pipeline has been constructed with lines supplying the western and eastern parts of Omiš and the island of Brač. In the island's Trstena Bay, four submarine pipelines, each 8,100 m in length, have been installed (170 mm, 2·202 mm and 400 mm). All waters gravitate from the land without having to be re-pumped, accumulating within Brač's central storage reservoir at a volume of 2·2,000 m^3, and with a lower elevation point of 146 m above sea level. Three major pipelines branch out from this water reservoir:

- Eastern sub-system – Brač water reservoir – Sumartin Village;
- Western sub-system – Brač water reservoir – Milna Village with branch pipeline to the island of Šolta; and
- Southern sub-system – Brač water reservoir – Bol Village with a branch to the island of Hvar.

Along the major waterlines, i.e. from the branch pipelines to the settlements, water reservoirs have been constructed to level the daily consumption and to ensure the operation of adequate pressure within the settlement supply network.

The current capacity of the Brač supply system has been based on the previous needs and respective development. The postulated capacity of its submarine pipelines and the proposed capacity distribution for consumption are as follows: Brač 210 l/s; Hvar and Vis 143 l/s, and Šolta 27 l/s.

The Makarska waterline

The existing water intake of the Makarska waterline is located in the glide chamber of the Kraljevac HPP. The water is transferred into the chamber from the Cetina riverbed via the tunnel of Dupci (1,200 m in length) to the Zadvarje treatment system where the water is treated. This waterline (pipeline) supplies the entire coastal area from Dupci to Gradac, as well as Hvar island. Its capacity is 400 l/s, while its planned capacity is anticipated to be 500-600 l/s. All smaller settlements not yet connected to supply systems, utilise rainwater; in the summer period they are supplied by water tankers.

Figure 4.11: Water supply systems and other objects of infrastructure in the Split-Dalmatia County connected with the River Cetina

Territory of Bosnia and Herzegovina

The area's larger settlements are all served by supply systems, while the smaller settlements rely on local springs and rainwater.

The Livno waterline

This constitutes the largest regional system, supplying the entire Livno region and its surrounding settlements, by utilising the water of certain water intakes, namely the Bistrica and Strube springs and the Mandek reservoir. Current daily water consumption stands at nearly 150 l/s. The surface waters from the storage reservoir are adequately treated, while its underground waters are merely disinfected. There are plans to extend this system to cover the entire Livno field.

The Tomislav Grad waterline

Tomislav Grad has its own water supply system drawing from the Ostrožac water intake. The present water consumption stands at approximately 50 l/s. As these quantities are insufficient, new water intakes are scheduled for construction in Šujica river source area, with a capacity of approx. 30 l/s. The Tomislav Grad system, remains a relatively small regional system, supplying the majority of settlements in the municipality, and Tomislav Grad itself. This municipality is also supplied by several other minor systems that cover the needs of smaller settlements, such as: Kongora, Mesihovim, Crvenice, and others.

The Grahovo waterline

Grahovo is equipped with a smaller, autonomous supply system utilising the waters of a nearby spring. Its capacity is approximately 30 l/s.

4.3.6.6. Irrigation

Territory of Croatia

Despite the fact that Cetina crosses the middle of the Sinj field, with a minimum flow capacity of 4.5 m^3, irrigation provision has been unsatisfactory. From 1998 onwards, however, an improvised irrigation system was implemented by opening the irrigation channels and discharging water from the Cetina River into the network, and thus successfully irrigating 2,000 ha by infiltration.

Territory of Bosnia and Herzegovina

In this area, irrigation systems have remained undeveloped, despite the fact that a comprehensive developmental strategy had been prepared for the Livno field which would facilitate a sufficient supply of water from the Brezine reservoir as well as from the existing storage reservoirs and channels. Although the area's annual precipitation rate is high, rainfall quantities are low during the vegetation period, so that the lack of humidity in the summer period can be felt. Field irrigation in this area mainly draws on the local water resources. The areas that are candidates for irrigation, occupy 20,000 ha within Ždralovac, Čaprazlije, the central part of the Livno field, and in the Serdjevac and Bijelo field.

4.3.6.7. Melioration works

Territory of Croatia

In this part of the Cetina watershed, melioration activities are only possible in some karstic fields through which the river flows. The largest field is that of Sinj with

6,900 ha, with a net melioration surface of 4,050 ha. The Sinj field melioration system has been simultaneously developed with a flood protection system. Works relating to land consolidation, drainage channel systems and the road network have all been completed, while two dams and two water pump stations for inner water drainage have been constructed (Trilj and Vedrine). As this system, however, has never yielded the anticipated results, its reconstruction is necessary. To that end, the reconstruction of water pump stations and dams has already been concluded, while works on a complementary drainage system and road network, as well as an additional water pump station must be implemented in due course.

The situation with reference to other important fields is as follows:

- In the Hrvace field, with a 1,054 ha surface, flood protection and melioration drainage systems have yet to be completed. However, a preliminary schedule for the melioration of the hinterland parts of the right bank, covering a total of 1,291 ha, has already been prepared.
- In the Cetina – Pag field, encompassing an area of 850 ha, flood protection and melioration drainage systems also remain incomplete, while a preliminary design for the melioration of the right bank hinterland area of 540 ha has already been prepared.
- Similarly, the Vrlika field that encompasses an area of 620 ha still lacks the required flood protection and melioration drainage systems. An area of 400 ha should be meliorated. The field is partially crossed by a neglected network of channels and is flooded on an annual basis. The technical documentation relating to the necessary drainage system has now been completed.

Territory of Bosnia and Herzegovina

The need for drainage is acutely felt in the Livno and Duvno fields, which are regularly flooded at the end of the winter due to the effects of the sudden melting of snow and the enormous quantities of rain. During this period, the natural drainage routes are incapacitated and the fields are flooded.

In order to improve this situation and to utilise waters for hydro-electric purposes, especially in the Orlovac HPP, comprehensive melioration works have been scheduled for implementation in both the Duvno and Livno fields. A large portion of the required work has been carried out and certain parts of the field have already been meliorated. The central part of the Livno field encompassing 2,900 ha, and 1,070 ha in the area of Ždralovac, as well as the Čvrsnica farm in the Duvno field, all remain unmeliorated. A further development of the Orlovac HPP system, would facilitate the melioration works in certain parts of the Livno and Duvno fields.

4.3.6.8. Flood protection

The narrow Cetina watershed

Active flood protection measures in the narrower river watershed area commenced in 1939, after the Trilj strait was constructed. Prior to these works, the Sinj field was periodically flooded due to the great inflow of water unleashed by the direct and indirect watershed, as well as to the river's low flow rate, from the Sinj field into the Trilj strait. Sediments were transferred to the Trilj strait by strong floods. These increased the quantities of flood waters through greater run-off and prolonged the duration of the flooding. These initial melioration works benefited the Sinj field, facilitating the future application of more effective solutions with regards to flood protection and water drainage systems.

After these initial interventions, and within the framework of the melioration of the Sinj field, specific regulations for the Cetina and Ruda rivers were introduced, which were followed by the construction of embankments with a total length of 28 km.

After 1950, work on river regulation mostly dealt with the partial cleaning of the riverbed and the construction of four channels at melioration locations. These operations resolved previous problems relating to the flow rate of flood waters and ensured the stability of the river banks. These operations aimed to guarantee flood protection over a 100 year period, allowing for a maximum flow rate of 417 m^3/s at the entrance to the Sinj field and 725 m^3/s through the Trilj strait.

By means of the completion of the Peruča HPP in 1959, a storage reservoir was developed upstream of the Hrvace field enabling the seasonal regulation of inflows, thus substantially increasing the degree of protection against flooding. Similar regulation works relating to the cleaning and deepening of the Cetina bed were performed – across a total length of 1 km downstream of the dam – aiming to both decrease the level of the lower waters of the Peruča HPP and to increase the installed elevation of the plant.

In the section crossing the Hrvace field, no regulation works have so far been undertaken, except the preparation of the respective projects. Within this preliminary framework, the riverbed would be partially regulated, mainly by the installation of embankments with a maximum flow rate of $Q = 280\ m^3/s$ that would be in accordance with the natural conditions of the Cetina regime. The current flow rate is approx. 65 m^3/s, which implies that the Hrvace field is regularly flooded.

Wider River Cetina watershed

As we have already mentioned, the wider part of the Cetina watershed is located in the territory of Bosnia and Herzegovina. Flood protection has been planned here, generally in the form of storage reservoirs or of small-scale regulation works on the riverbed. With reference to the protection of particular fields from flooding, the following activities have been envisaged:

- All flows in the Livno field would be entirely controlled by creating open channels for a regulated collection of the surface waters in the Čaprazlije retention, within the north-western part of the field, and furthermore, by transferring these from the Lusnić water intake into the central part of the existing Orlovac HPP system.
- For the regulation and hydro-electric exploitation of the Šujica flow in the Duvno and Kupres fields, the building of storage reservoirs at Mrtvica, Milač, Šujica and the Duvno field have been scheduled. Additional regulation-related works are currently scheduled for the bed of the Šujica river.
- Similarly, the water regime of the Glamoč field will be stabilised by the construction of additional storage reservoirs in Hozići and Buleklagija, as well as the natural winter depository at Pučine, which will supply the anticipated Kablić HPP to be located in the central part of Livno field and the Orlovac HPP, following the completion of the channels.

4.3.7. Major pressure points

The following pressure points should be the focus of a well-developed strategy that should immediately be initiated:

a) Impacts on water resources through:
   - the use for the production of hydro-power; and
   - the use as a recipient of wastewaters.
b) Exploitation of mineral resources.
c) Exploitation of living organisms.
d) Urbanisation processes (changes in land use) referring to:
   - degradation of the mouth area;
   - over-building on the coastal strip;
   - landscape degradation; and
   - the uneven distribution of the population.
e) Complex geo-political interrelations; and
f) Transition and reconstruction processes.

4.3.7.1. Impacts on water resources

The hydro-electric utilisation of the Cetina waters is very profitable due to the favourable natural elevation of the watershed. This fact led to the construction of the existing large hydro-electric power plants and to the scheduling of several others. The reservoirs of the HPPs have completely altered the natural regime of the river flow resulting in monthly and annual flow regulation, which in turn triggers the decrease of flows in winter and their increase in summer. The current hydrological regime of the river remains far from natural, while the impacts of these changes on the watershed as well as on the coastal ecosystems have yet to be assessed. The use of the Cetina River as a recipient for wastewaters and generator of hydro-electric power has had a detrimental effect on the watershed regions and the entire coastal area.

Cetina's waters are mainly used to supply all parts of the watershed, in both Bosnia and Herzegovina, and Croatia, especially the wider coastal area and the central Dalmatian islands. Its waters are utilised both directly – by an intake from Cetina (the supply system of Makarska, and the regional system of Omiš-Brač-Hvar-Šolta-Vis) – and indirectly, by the numerous Karstic springs of the watershed (Ruda, Kosinac, Bistrica, etc.) and those beyond it (Jadro, Žrnovnica).

Given that only a few of the small and medium-size settlements and industries of the watershed possess sewage and water waste treatment systems, the pollution originating there is directly discharged into the Cetina watershed. To make matters worse, the pollution originating in diffuse sources (agriculture, transport, solid waste disposals, etc.) rapidly mixes with the ground and surface waters of the watershed. Due to the particular karstic hydro-geological characteristics and the great elevation variations of the watershed, the pollution is quickly transferred, maintaining its composition, into the downstream springs of Cetina and its tributaries. This further implies that the systematically increased pollution concentrations impact significantly upon all the downstream supply networks, especially upon the three largest supply systems of Makarska, Omiš-Brač-Hvar-Šolta-Vis, and Jadro serving approximately 500,000 locals in addition to the estimated 200,000 tourists during for summer season. It has been clearly recognised that in the territory of Bosnia and Herzegovina, the pollution concentration decreases as we move towards the upstream, more elevated parts of the watershed. Thus, the need to radically reduce the discharge of pollutants into the watershed from all sources, remains of the utmost importance.

The negative consequences of the use of hydro-electric applications have been reflected in the following:

- The disturbed water regime (summer, winter, daily regime);
- Landscape degradation;
- The groundwater level rise (the Sinj field);
- Landslides (on the coast);
- Drainage of the lower courses behind the Prančevići dam; and
- Changes in the biocenosis and to habitats; Cetina no longer constitutes a natural water course because it has neither a logical flow regime, nor a natural distribution of flora and fauna.

The benefits of hydro-electric applications are the following:

- Economic growth (exploitation profits), serving as stimulants to development;
- Flood protection and irrigation;
- Higher minimum flows of the coastal sources (Jadro and Žrnovnica); and
- Safer water intakes.

The negative effects relating to the utilisation of the Cetina water resources as wastewater recipients are the following:

- The pollution of the river, water supply sources, river mouth and the coastal sea;
- Threats to the quality of water supplying the wider region, which could endanger the health of population and tourists;
- Threats to ecosystem's biodiversity; and
- The degradation of nature and of the landscape which diminishes the area's attractiveness to tourists and recreational users.

The positive effects refer to the instant dilution of the upstream area's wastewaters.

In order to resolve the contradictions entailed in the application of the river and sea waters as wastewater recipients, it is necessary to schedule the construction of several wastewater treatment systems for all the relatively larger settlements of the watershed. This should be complemented by a comprehensive long-term strategy for the protection of waters against all sources of pollution, observing the watershed's particular karstic characteristics.

4.3.7.2. The exploitation of mineral resources

The unplanned exploitation of mineral resources, and especially of mineral raw materials, such as calcareous tufa, gypsum, clay and coal to name but a few, have led to landscape degradation and environmental devastation. The reserves have not yet been explored although large potential zones of exploitation have already been identified. With reference to the majority of these zones, however, conflicting land-use interests have also been identified. The abandoned exploitation zones have not been adequately treated, thus constituting a potential danger to local populations whilst causing soil erosion.

The positive economic effects of the exploitation of mineral raw materials are often short-term, while an overall assessment of this exploitation has established that it has been more harmful than beneficial. Conclusively, a rational utilisation of these resources is necessary and should include the following measures:

- A recuperation of the abandoned exploitation zones; and
- The creation of new exploitation zones based exclusively on meticulous and thorough research as well as on the preparation of environmental impact assessment studies.

4.3.7.3. The exploitation of living organisms

The exploitation of living organisms has been accelerated in both river and marine areas. The unregulated and ever increasing fishing activities of recent years have depleted fish stocks in the Brač Channel by 50%. Fish stocks in the river are significantly reduced by pollution and development. The river's hydro-electric exploitation has disturbed the specific landscape characteristics of the upper, central and lower flows of the river and thus the living conditions (degradation of the fish fund). A specific problem has been posed by the introduction of allochthonous fauna which threaten the survival of the existing autochthonous species. As the economic benefits of such irrational exploitation have been insignificant, the preparation of a new programme striving for a rational exploitation of river and maritime species based on detailed studies and analyses and aiming to primarily protect these living natural resources, in particular in the newly constructed accumulations, is imperative.

4.3.7.4. Urbanisation processes (changes in land use)

The processes of urbanisation have altered traditional land use. Development activities and the majority of the population have been concentrated in the narrow coastal strip, leaving the hilly/mountainous area almost completely deserted. The movement of the population towards the coast and the larger towns by the river has affected the demographic structure of the area to such a degree that the coastal population is currently characterised by an increased proportion of young people, by contrast to the hinterland which is caught in a process of demographic ageing. This negative tendency further implies the dependence of the older on the younger population, as well as negatively impacting on the economic standards (trends) of the entire area.

The greatest tangible impacts and changes can be witnessed at the Cetina mouth, which is the contact point between the ecosystems of the river basin and of the coastal area. The area in the vicinity of the river mouth is the largest, fertile flat area of the wider coastal belt, rich in water. Since most of the coastal area is very steep, lacks water and thus remains a bad candidate for intensive urbanisation, the river mouth zone represents the most appropriate place for the emergence of settlements; this explains the fact that the largest settlement, namely the town of Omiš, had emerged here. It goes without saying that the town's development had been also favoured by the specific ecological and socio-economic characteristics of the Cetina mouth. The population in this vicinity has grown immensely and in a seawards direction. The intensive processes of urbanisation have totally destroyed all the ecological features and values of the mouth, leaving no traces of its original natural state. This negative tendency persists as the area continues to attract migrants who sustain the constant changes to the Cetina mouth and its adjacent coastal area.

In addition to the emergence of dwellings, industries and tourist accommodation facilities, the existing lack of space has also contributed to the current uncontrolled and haphazard density of the coast (Dugi Rat, Podstrana); these parameters have affected the coastline to such an extent that its natural shape has been totally altered. In this way valuable natural spaces have been irreversibly lost, while, given that the clay materials have been washed away over time by the forces of precipitation, winds and waves, the ecological effects have been especially harmful (degradation of coastal habitats).

Furthermore, on part of the coast, the original landscape has been fully degraded not only by irrational and unsystematic building, but also due by the desertion of agricultural land located on the gentle slopes. This land is currently overgrown by maquis and garigue, making it vulnerable to fires, especially during summer.

4.3.7.5. Geo-political relations

As has already been mentioned, the unique natural ecosystem of the watershed, spreading over the territories under the jurisdiction of two countries, poses certain management-related problems. An agreement relating to its common management has not been yet established, nor have any other bilateral agreements been defined regarding the ways of tackling the management of the system. This lack of a comprehensive approach to the organisation and protection of this highly sensitive environment should be overcome as soon as possible through the preparation of a comprehensive management plan, and an integrated plan for the organisation and protection of the watershed.

4.3.7.6. Transition and reconstruction

The entire area is presently in a transitionary phase. The general problems faced by countries in transition (changes in ownership structure, introduction of market mechanisms, etc.) have been further accentuated in this area as it has been partially devastated during the recent war. Apart from the negative ecological consequences of the war (destroyed forests and other natural resources), the area's economic development has been arrested, while the negative demographic trends have become more profound.

In this context, the watershed currently requires a new development strategy that would mobilise all the forces at its disposal (international, national, regional and local) in order to lay new foundations for the area's future growth and prosperity. It has been clear that it would be impossible to achieve these goals by merely dealing with problem categories (electric power production, water resources organisation, protection and use, urbanisation, economy) individually/sectorally. A holistic and interdisciplinary approach must be adopted that will serve as the basis upon which a comprehensive system of legislation as well as the necessary bilateral agreements involving concerned neighbouring countries and other actors, will be established.

4.4. Environmental situation

4.4.1. Major river ecosystems and habitats

In the flowing waters, the water mass movement from the river's source to its mouth, causes a variability of environmental impacts in a horizontal direction. Due to this fact, a variety of species have developed, dependant on the substrate type and the flow speed. The statistical analysis of the caenotic structure of fauna and flora, indicate three different zones within the flowing waters: the upper, the middle and the bottom zone with characteristic communities of plankton, benthos (phytobenthos and zoobenthos) and nektons.

The plankton community is generally insignificantly developed, especially in zones characterised by a rapid water flow.

The natural fish food in rivers consists of organisms living on the riverbed, while their development depends on primary organic production. Biological research on Cetina waters has, therefore, been complemented by the analysis of the qualitative and quantitative structure of its phytozoobenthos communities.

Knowledge on the qualitative and quantitative system of individual biocenosis is not only significant to an evaluation of the bioproductivity of flowing water, but also to the assessment of water quality, as particular plant and living organisms constitute important natural water quality indicators.

4.4.1.1. Phytobenthos

The Cetina Riverbed is mainly rocky, and only partially covered with gravel and sand. It is covered by micro-phytobenthos, whose qualitative composition is diverse, primarily depending on the physical-chemical conditions of the water. The micro-phytobenthos community of Cetina includes the representatives of five systematic groups: *Cyanophyta, Pyrrophyta, Chrysophyta, Cholophyta and Rhodophyta*. The representatives of *Chrysophyta,* which are predominant, have been included in the *Diatomeae* class that forms 59% of the species. The representatives of other systematic groups are less prevalent: *Cyanophyta* 21%, *Chlophyta* 18%, *Pyrrophyta* 1% and *Rhodophyta* 1% of the species of the micro-phytobenthos community.

The *Diatomeae* class is the most common, represented by *Diatoma vulgare, Diatoma vulgare var. capitulum, Synedra ulna, Gomphonema olivaceum, Gomphonema olivaceium var. calcareum, Stauroneis anceps,* and *Cymbella, Navicla, Nitzschia* species categories. The characteristic representatives of *Cyanophyta* in the micro-phytobenthos community found in the River Cetina are the *Nostoc verrusosum, Gomphosphaeria lacustris, Rivularia hematites,* which belong to the *Oscillatoria* and *Phormidium* species.

The species of *Chlorophyta* are also well represented, while the most frequent species are *Cladophora glomerata, Ulothrix sp., Mougeotia sp., Zygnema sp., Spirogyra sp.* as well as certain categories of *Pediastrum, Scenedesmus* and *Cosmarium* species.

Pyrrophyta and *Rhodphyta* are represented only individually in the micro-phytobenthos community.

The rocky surface is often covered by mnium, i.e. the *Cinclidotus aqualicus* and *Fontinalis antipyretica* species.

With reference to the higher water plants found in the upper and middle flow of the Cetina River, the most common are the species of *Berula angustifolia, Potamogeton natans, Potamogeton crispus*, those of *Ranunculus* as well as the various marsh grasses, such as *Juncus sp., Scirpus sp.,* and others. In the lower Cetina flow, higher water vegetation remains relatively undeveloped, and with the exceptions of the above-mentioned species, the representatives of *Miriophyllum* and *Ceratophyllum* species are absent.

The Cetina's water quality has been determined by the indicative plant community species, according to the Liebmann saprobic system. Researches carried out over certain periods of time (1977/78 and 1982/83) have shown that with reference to the micro-phytobenthos community prevalent are the algae, which constitute the indicators of the beta-mesosaprobic and oligosaprobic waters, although occasionally, the species indicating the alpha-mesosaprobic degree of pollution, can be found in some places.

On the basis of its biological indicators, it can be concluded that Cetina belongs to the I-II site class. Additional research undertaken in 1998/99, has shown a higher degree of water pollution within the lower Cetina flow. Changes have been manifested by the presence of nitrophile species, spreading along the entire lower flow. The species of *Cladophoraceae* family are predominant, while the dominant communities are represented by *Ulva rigida, U. fasciata* and *Enteromorpha prolifera* species.

4.4.1.2. Zoobenthos

Since the natural fish food consists of the fauna of the riverbed, knowledge on the qualitative and quantitative composition of the macro-zoobenthos community is essential for the definition of bioproductivity within the studied river flow. With reference to the macro-zoobenthos community inhabiting the parts of Cetina under analysis, the representatives of the following groups have been found: *Turbellaria, Mollusca* (*Gastropoda* and *Bivalvia*), *Oligochaeta, Hirudinea, Crustacea (Amphihoda* and *Isopoda*) and *Insecta (Odonata, Ephemeroptera, Plecoptera, Trichoptera, Coleoptera* and *Diptera*). Both the composition and density of this community in the entire river flow depend on several environmental factors, more specifically on the physical-chemical characteristics, seasonal and daily changes of the water regime, the bed and banks structure, as well as on the water quality, i.e. on the water flow loads.

The most significant fauna development has been established in habitats covered by mnium and algae, as well as in the silty river-bed covered by macro-phyto vegetation, while the unoccupied stony and sandy base is less developed. It can be concluded, that in the researched sections of Cetina there are differences in the quantity of macro-fauna, which are conditioned by the different biotope structure.

According to the analyses undertaken in all research stations, the most represented groups are the species of *Amphipoda* and those of *Rivulogammaris konjicenzis*, while other groups are not evenly represented in the findings of all research stations. The *Ephemeroptera* and *Plecoptera* larva prevail in the upper rather than in the middle or lower Cetina flow, while the group of *Isopoda* has been found only in the upper and lower section of the river. Other groups are more or less evenly represented within all three researched sections of Cetina.

The average values of macro-fauna biomass established during the research have as follows: in the upper Cetina flow, the biomass has been recorded to be 23.50 g/m^2; in the middle flow, it has been varying from 11.83 g/m^2 to 24.30 g/m^2, while in the lower flow, the biomass of macroscopic invertebrates was from 5.67 g/m^2 to 23.15 g/m^2. With regards to natural fish food production, no differences have been established between the upper, middle and lower River Cetina flow (or the three river sections under investigation).

Certain stations in the middle and lower Cetina flow where the habitat structure is not so diverse, constitute the exception. On the basis of the above-mentioned data, that is relevant to the establishment of the quantity of natural fish food and Cetina waters can be categorised as medium to rich fishing waters (according to German standard).

4.4.1.3. Ichthyofauna

The qualitative and quantitative structure of the Cetina flow has been determined by the analysis of the living population of the river. The quantitative structure of its upper course, extending from its source to the Peruča storage reservoir, is characterised by six fish species that belong to the families of *Salmonidae, Cyprinidae* and *Cobitidae* (Table 4.15). The *Cyprinidae* family, which is represented by four species, is prevalent with 74.05%; in relation to the entire ichthyomass it accounts for 59.74%. Within this family, the Illyrian chub (*Leuciscus illyricus,* Heck et Kn.) is the least represented; however, it remains predominant within the ichthyomass, due to the larger habitus.

Table 4.15.
Allochthonous and introduced fish species in the upper River Cetina flow

Fish species	Introduced fish species
Family: SALMONIDAE	
Brook trout (*Salmo trutta m. fario*, L.)	
Lake trout (*Salmo trutta m. lacustris*, L.)	
California trout (*Oncorhynchus mykiss*)	+
White-fish (*Coregonus peled*, Gmelin)	+
White-fish (*Coregonus laveratus maraena*, Bloch)	+
Family: THYMALIDAE	
Grayling (*Thymalus thymalus* L.)	
Family: CYIPRINIDAE	
Primorski blistavac (*Leuciscus souffia muticellus*, Bonaparte)	
Cetina ukliva (*Leuciscus ukliva*, Heckel)	
Strugač (*Leuciscus svalizze*, Heck et Kn.)	
Illyrian chub (*Leuciscus illyricus*, Heck et Kn.)	
Oštrulj (*Aulopyge hugeli*, Heckel)	
Babuška (*Carassius auratus gibelio*, Bloch)	+
Carp (*Cyprinus carpio*, L.)	+
Family: COBITIDAE	
Cetina vijun (*Cobitis taenia dalmatina*, Karaman)	

The brook trout (*Salmo trutta m. lacustris L.*) is present in larger numbers and more represented in the ichthyomass, by comparison to the Illyrian chub. The larger numbers of the *Cetina ukliva* (*Leuciscus ukliva*, Heckel), the *primorski blistavac* (*Leuciscus souffis muticellus,* Bonaparte) and *strugač* (*Leuciscus svalizze vallize*, Heck et Kn.) can be probably explained by the larger habitus, which renders them insignificant to the fishing industry. Therefore, their numbers have been regulated either by natural mortality or by predators. Despite their sufficient numbers, the *Cetina vijun* (*Cobitis taenia dalmatina*, Karaman) constitute only 2.13% of the entire ichthyomass.

Owing to the continuity of living organisms in the hinterland waters of the Adriatic watershed from the Tertiary period to date, as well as to the interrelations between the watershed and the south-western Bosnian karstic fields, Cetina has been characterised by a very particular ichthyofauna that includes a vast number of endemic fish species. Part of the ichthyomass has been introduced both for nourishment purposes and for the enrichment of the icthiomass structure with species attracting anglers. The introduction of certain allocthonous species can be dangerous because they could be undesirable and especially threatening to the autochthonous population and could, therefore, reduce the biodiversity and its distinctive quality. The most prominent example for the Cetina is a kind of *babuška* (*Carssius auratus gibelio*, Bloch, 1983), which was probably created by the introduction of carp, and poses a potential threat to the autochthonous species.

Fifteen species of ichthyofauna have been registered in the Cetina and its storage reservoirs; these belong to the following families: *Salmonidae, Thymalidae, Cyprinidae, Cobitidae and Angullidae.*

Out of six fish species introduced both deliberately and accidentally (*babuška*), the following have been accommodated: grayling (*Thymalus thymalus, L.),* carp (*Cyprinus carpio*, L.) and *babuška* (*Carassius auratus gibelio*, Bloch). Despite the fact that they have been characterised by a vast and rapid growth, certain other species have not thrived and have, therefore, been seen as failing to accommodate to the new environment.

In addition to the above introduced species, the autochthonous species of dentex (*Salmo dentex*) have also disappeared from Cetina. These species together with the brook trout had once been the predominant Salmonidae species of Cetina.

The ichthyofauna in storage reservoir Peruča has been defined by four species: the brook and lake trout, the Illyrian chub and the *Cetina ukliva*. This area is literally dominated by the *Cyprinidae* family reaching the 99.51%, and the 98.55% of the entire ichthyomass. Predominant also is the Illyrian chub with 29.89 PCs/ha and 7.01 kg/ha. The lake trout with 0.16 PCs/ha is poorly represented, while the brook trout has almost died out. The evaluated population density rate of 46.93 PCs/ha is quite low compared to that of the upper flow. This rate is characterised by an average ichthyomass of 7.30 kg/ha. The storage reservoir Peruča has the lowest species density rate.

By comparison to the Peruča storage reservoir, the middle Cetina flow indicates the highest population density rate, which is characterised by eight species. Prevalent is the *Salmonidae* family (brook trout) with 275.66 PCs/ha, and 29.59 kg/ha. These values have been the highest for this species in the entire Cetina flow. The Illyrian chub with 42.06 PCs/ha occupies second place within the ichthyo-population total. The biotope diversity of the area and its underground connections with its neighbouring karstic flows, as well as the regulated and unregulated introductions, have evenly contributed to breeding resulting in the appearance of certain species which cannot be found in the upper flow. Their upstream migration has been physically prevented by the Peruča HPP. The planned introduced species, grayling and carp, have completely adapted to this environment, breeding and occupying their own space within the biotope. Owing to underground connections, the endemic species of *oštrulj* can also be found here. While this species has been numerous, nevertheless it reaches only the 0.07 kg/ha of the entire ichthyomass; this is because of its especially smaller average mass by comparison to that of the Buško Blato. The average population density rate in this part accounts for 383.08 PCs/ha with the relevant ichthyomass of 41.5 PCs/ha.

In the upper part of the lower river section, the population density rate is the lowest within the entire River Cetina flow (with the exception of the Peruča storage reservoir) with five species belonging to the following families: *Salmonidae, Thymalidae, Cyprinidae and Cobitidae.* A significant space within the ichthyo-population of this area is occupied by the broom trout with 60.85% of the entire ichthyomass, and 30.05% of total number. The Illyrian chub, which is numerically better represented than the broom trout, remains twice as lower in the entire ichthyomass. The average population density is almost the same as that of the middle Cetina flow, accounting for 386.02 PCs/ha; however, the ichthyomass load by water surface unit is quite low, accounting for only 17.6 kg/ha.

From the analysis of the population density and the relevant ichthyomass in the Cetina, with the exception of the storage reservoirs of Peruča and Prančevići and the lower brackish section, it can be concluded that Cetina is inhabited by the following nine fish species: the brook trout, grayling, the Illyrian chub, the *Cetina ukliva*, the *primorski blistavac, strugač,* carp, *oštrulj* and the *Cetina vijun*. Predominant in number and ichthyomass remains the brook trout with 195.98 PCs/ha and 8.20 kg/ha, which with the addition of certain other physical-chemical and biological parameters, categorise the Cetina waters as a specific Salmonide type of water. The Illyrian chub with 129.07 PCs/ha and ichthyomass of 6.69 kg/ha is the second significant species within the Cetina ichthyomass. With reference to the remaining autochthonous species, the *primorski blistavac,* the *Cetina ukliva, strugač* and the *Cetina vijun* are equally significant.

The average population density in the researched area accounts for 751.80 PCs/ha with ichthyomass of 32.73 kg/ha. With the addition of the autochthonous species inhabiting the storage reservoirs, such as the European eel and a type of lake trout, as well as the representatives of *Blenniidae, Pleuronectidae, Mugilidae* and *Sparidae* family inhabiting the brackish river section, the population density has been increased.

As anglers from Omiš had argued, the introduction of *babuška* (*Carassius auratus gibelio,* Bloch, 1783), in addition to the numbers of the autochthonous species, has been a mistake, because it has multiplied extensively within the lower river section.

The high hydro-electric potential of Cetina changes its biotope characteristics. Its storage reservoirs slow down its flow, increase the water temperature and alter the structure of flora and fauna, rendering the limnophylic species predominant. This simultaneously prevents upstream and downstream migration; to make things worse, connections between the river and the karstic underground are to a certain extent lost. For these reasons, it is also anticipated that the Salmonide characteristics of Cetina will be gradually changed.

4.4.1.4. Other water animals

The Cetina watershed is populated by several different water animals. The most prevalent and significant of these species as well as their representation rate is explicated in Table 4.16.

Table 4.16.
The most important and prevalent water animals and their presence in the Cetina River watershed

Species	Latin name	Presence
Small green frog	*Rana esculenta*	+++
Big green frog	*Rana ridibunda*	++
Meadow brown frog	*Rana temporaria*	+
Ring snake	*Natrix natrix*	++
Brook lamper	*Lampetra planeri*	+
Newt	*Triturus vulgaris*	++
Cray fish	*Astacus astacus*	++
European (pond) tortoise	*Emys oribicularis*	++
Freshwater mussel	*Anadonla cygnea*	++++

Key: + represented individually; ++ poorly represented; +++ well represented; ++++ very well represented

4.4.2. Major coastal ecosystems

4.4.2.1. Phytoplankton

In September 1990, the quality composition of the phytoplankton community of the Brač Channel showed a large species diversity. The largest number of organisms in general and of species in particular, had been registered near the coastal stations (i.e. Stobreč, Postira and the one located 1 km away from Dugi Rat).

The prevailing group of organisms within the mycroplankton community was the diathomeia (*Rhizosolenia alata f. gracillima* and *Tr. imbricata var. shrubsolei*), while within the nanoplankton category the kokolithoforine (*Calyptrosphaera spp., Pomntosphaera spp., Syracosphaera pulchra, Coccolithus pelagicus)* had been the most represented. The "dinoflagellati" and the "microflagellata" categories had both indicated an equally lesser presence in this region; the latter's participation in the phytoplankton community has not been analysed in detail. The vertical division of the phytoplankton has confirmed the expected results of the prevalence of diatomeias on the surface and kokolithoforines in the deeper layers.

Taking into account the analysis results of the division of the phytoplankton biomass (chlorophyll **a**) and the qualitative composition of the phytoplankton, we can conclude that during the period of favourable dynamics in the major part of the Brač Channel, the negative impact of surface eutrophication has been minimised.

The qualitative analysis of the phytoplankton community implemented in April 1991, had established that the Brač Channel indicates an extremely high diversity of phytoplankton species. In qualitative terms, the diatomeia constitute a substantially dominant group category. In the upper layers, the most important ones are certain species of the genus *Chaetocores,* while in bottom layers, larger number from the genus *Nitzschia* and *Navicula* has been found. The micro-plankton component has been very well represented within the entire region, which is typically characterised by equal representations of centric and pennant types. In every station – with the exception of the station offshore of the town's port – in terms of the nanoplankton component of the phytoplankton community, the kokolithoforine is prevalent, designating a very high diversity of species. The station near Dugi Rat had registered an increased number of diatomeia, which is usually typical of brackish waters, and which is undoubtedly conditioned by Cetina.

The extreme diversity and richness found in the composition of the phytoplankton community constitutes a still healthy indicator for phytoplankton community. This has also been reflected in the lack of surface blossoming of the phytoplankton. In accordance with the above, we can conclude that the Brač Channel region has not been significantly affected by wastewaters originating in the towns and settlements. The research analysis undertaken over the spring period, which is the regular phytoplankton blooming period, had found extremely high values of the chlorophyll biomass, reaching between 0.35-1.74 chlorophyll **a** m^{-3}. The vertical division of the chlorophyll **a,** within the entire region was found to be (in equilibrium) fairly balanced, indicating an intensive vertical mixture (mixing). The highest values of the chlorophyll **a**, that have been caused by the blooming of the benthos diatomeia, have mainly been found in the bottom layers of the seawater. The horizontal division has also shown a very interesting pattern. Although it must be pointed out that within this period the entire region under analysis has been very productive, it can nevertheless be divided into three sections, according to the variety of the chlorophyll **a** concentration rates. The highest productivity has been obtained from the Split Channel, a slightly lesser one from stations located closer to the shore, while the smallest productivity rate has been shown in the central and southern parts of the Brač Channel.

The comparison between the above results obtained from the Brač Channel and those from Kaštela Bay (a typical eutrophication area) as well as from the open sea near the island of Vis, can clearly establish that in terms of a high productivity level, the region between the Brač and Split Channels more closely resembles Kaštela Bay than the open sea. By contrast, the autumn period analyses (periods of stratification) had established that the Brač Channel waters resembled those of the open sea.

4.4.2.2. Benhtos communities

Phytobenthos

Until recently, there have been neither detailed analyses nor any research conducted on the benthos communities of the Cetina mouth region, with the exception of some existing data on the region of the Brač Channel. Drawing upon the existing data, an attempt has been made to delineate the picture of the present situation of the benthos communities, in order to define the volume and the intensity of the changes caused by sea pollution. The resultant analysis of the benthos flora can be very well used as a pollution indicator for a particular region. The numerical (expressed in percentage) presence of the three main systematic algae groups (*Chlorophyta, Phaeophyta, Rhodophyta)* is especially useful for the assessment of both the level and volume of pollution.

The floristic analysis of one sample of the benthos flora, which was undertaken in September 1990 on four transects in the Brač Channel, as well as on several stations, had established that there has been a total of 228 taxons (types, sub-types, varieties, forms and stages) of benthos algae (*Rhodophyta* – red algae; *Phaeophyta* – brown algae and *Chlorophyta* – green algae), two types of sea blossom (*Posidonia oceanica* and *Cymodocea nodos),* as well as three dominant types of the genus *Rivularia* (*Cyanophyta*) a relatively undefined group category. The taxons were allocated to three partitions, 27 rows, 49 families, 120 genus, 187 types and 41 forms lesser to the species. (Table 4.17).

Table 4.17.
Presence of benthos algae and sea meadows in the researched localities (Split, Stobreč, Brač) expressed in number and percentage

Taxonomic groups	Split		Stobreč		Brač	
	No.	%	No.	%	No.	%
Rhodophyta	59	68.6	87	64.0	107	63.3
Phaeophyta	10	11.6	27	19.9	39	23.1
Chlorophyta	17	19.8	22	16.2	23	13.6
Total	86		136		169	
Cyanophyta	1		1		2	
Angiospermae	2		1		2	
Total	**89**		**138**		**173**	
R/P	**5.9**		**3.2**		**2.7**	

The members of the Rhodophyta (red algae) categories have been prevalent in number and percentage. Significantly less represented have been the members of Phaeophyta (brown algae), i.e. Chlorophyta (green algae). The number of taxons differ considerably for particular transects, with the largest having been found in the least polluted area, in the transect of Brač. The smallest number of taxons had been registered within the area of Split that has been greatly affected by urban wastewaters.

A more detailed analysis of the researched benthos flora structure had established that both the higher systematic groups and the particularly lower systematic group members of certain individual categories (especially families and genera) are numerically as well as relatively (by percentage) unevenly represented within specific researched transects. In the Stobreč transect, a lesser number of nytrophile types has been forming communities that are rather unevenly developed, with a smaller density. This emergence constitutes sufficient evidence that the composition of the benthos algae communities has been definitely altered by organic pollution. The disappearance of the autochthonous types of algae, from the rigid rocky shores at the surface, a phenomenon that has been registered even in much deeper zones, had been the effect of chemical pollution, which is generally a consequence of wastewater emissions from larger urban centres. The benthos algae communities of the Stobreč transect (in close approximation to Omiš and influenced by the Žrnovnica and Cetina Rivers, and especially the surface ones in the medio-littoral and upper infra-littoral bionomic level, have shown a decrease of their intensity and volume. Nevertheless, the group diversity remains very high in this transect compared to that of Split (an additional 50 types have been registered here). Apart from these, another nine types of the Cystoseira genus have been discovered here. Changes have also been reflected in the presence of nytrophile types that have been variously spreading over rocky surfaces. From the above data we can plausibly conclude that the communities of the Stobreč transect have been mildly polluted by sewage discharges originating from several outlets meeting the very surface of the sea. A similar diagnosis is to be expected with reference to the Omiš region (Cetina mouth). The present condition of the algae communities illustrates well the level of sea pollution. The presence of the nytrophile types within the composition of the main group categories have shown a smaller or greater level of eutrophication that is analogical to that of sea pollution.

Zoobenhtos

In the Split (Zvončac), Stobreč (the southern side) and Brač (the northern side) transects a quantitative and qualitative analysis of the composition of the zoological component of the bionomic levels of the supra-littoral, medio-littoral and infra-littoral, reaching to approximately 30 m depth, has been conducted.

The analysis of the summarised fauna material (macro-zoobenthos composition) determined 160 types that belong to the following systematic categories: Porifera (31), Cnidaria (7), Annelida (5), Arthropoda (20), Mollusca (76), Tentaculata (1), Echinodermata (15) and Tunicata (5). The data on the determined types per groups (in number and percentage) is shown in Table 4.18.

Table 4.18.
Presence of macro-zoobenthos types in systematic categories in the particular analysed transects

	Split	Stobreč	Brač
Porifera	8	7	20
Cnidaria	5	3	7
Annelida	5	5	5
Arthropoda	9	8	12
Mollusca	37	44	40
Tentaculata	1	1	1
Echinodermata	7	6	8
Tunicata	4	1	4
Total	**76**	**75**	**97**

From the analysed results, we may conclude that in both quantitative and qualitative terms, the transect on the northern side of Brač island has been dominant (96), with the Split-Zvončac (76) and Stobreč (75) transects to be nearly similar. These differences in the systems can be explained both as the result of the partially different system and the declination of the sea bottom, as well as that inflicted by the town's wastewaters on the livestock in the analysed region. This negative effect has been especially visible in the poor zoological composition of the medio-littoral and upper part of the infra-littoral level in the region of Split, i.e. the Stobreč transect where the flora and fauna have been gradually altered. Given that the mussel *Mytiluy galloprovincialis* is a medio-littoral family species that resists high concentrations of suspended material and simultaneously one that tends to increase its kind and biomass within conditions of growing pollution, it constitutes an additional indicator of the sea quality of the section in which it has been found. Moreover, the sample from the Split region has been rich in representatives of grown nytrophile algae, which also implies increased levels of mainly organic sea pollution.

The quality of the coastal waters in the proximity of large urban and industrial centres has been also reflected on the composition of the zoological component of the littoral biocenosis. The impact here is severe: the number of group categories decreases; the number of individual species and the biomass of one type increases and gradually one type starts prevailing. This situation worsens the more the littoral biocenosis comes under the direct influence of the town's general and industrial pollution sources, as is the case in the analysed area of Split and especially in Stobreč. The situation could potentially be the same in the Omiš region.

4.4.2.3. Major habitats

The biological research has identified nine biocenoses spreading from the supra-littoral to the upper part of the circa-littoral. With reference to firm substrate, the following biocenoses had been developed: supra-littoral rocks biocenosis, upper rocks of the medio-littoral type biocenosis, that of the lower rocks of the medio-littoral, the biocenosis of photophyle algae, and percoralligen which is a type of the coralligen biocenosis. With reference to moving grounds (sand and mud) the following biocenoses had been registered: Biocenosis of meadows *Posidonia oceanica*, biocenosis of muddy sands, biocenosis of terrigen mud and enclaves of coralligen biocenosis.

The biocenosis of the supra-littoral rocks is widely spread, but not identically well developed throughout. In the Split port, for example, some typical types such as *Chthamalus depresus* are absent, and this situation could be attributed to local sea pollution.

The biocenosis of the upper and lower rocks of the medio-littoral is developed in the entire region, but significantly changed in regions with localised pollution, such as the Split port. They lack some characteristics of plant and animal species (from the algae *Lithophyllum incrustans, L. Tortuosum*; of the animal species *Actinia equina* and *Patella Lusitanica*). Along with the changed communities some nytrophile types have penetrated that are characteristic of eutrophised and more polluted waters (*algae Enteromorpha compressa, Blidiniga minima, Enteromorpha intestinalis* and of the animal species *Lithophaga lithophaga, Mytilus galoprovincialis*) which form certain layers in the more degraded parts.

The biocenosis of photophilic algae has been particularly well developed on the hard and well illuminated rocky shores, as well as on large blocks of rocks. In the more polluted parts of the sea, such as the sea within the vicinity of the port of Split, significant alterations have been registered that indicate the gradual disappearance of certain plant and animal species together with the evidence of the appearance of other more hardy species of a mainly nytrophile character that have been replacing them (*Dictyota dichomata d. implexa, Pterocladia capillacea, Ulva rigida, E. intestinalis, Gigratina acicularis* – of the algae and of the animals especially *Balanus amphitrite, B. eburneus, Mytilus galloprovincialis*). The majority of these species characterise less or more polluted waters.

The biocenosis of *Posidonia oceanica* (*Cymodocea modosa and Zostera marina*) meadows has been developed at certain locations. In the polluted regions, it has been gradually diminishing, which is reflected in the distribution and division of the communities, i.e. decrease of the surface it grows upon, as it is the case outside the Split port. Here, a large number of commercially exploitable fish have been registered, such as species belonging to the family of *Labridae, Sparidae (Dentex dentex* – dentex), *Diplodus puntazzo* – charp snouted sparus, *Diplodus annularis* – annular git head), types of the family *Centracanthidae* (*Spicara smaris* – picarel, *Spicara maena* – blotched picarel), *Gobiidae*, *Serranidae*, *Blennidae*, *Pomacentridae (Chromis chromis* – damselfish), *Mullidae (Mullus barbatus* – red mullet, *Mulus surmuletus* – striped surmullet), and *Syngnathidae* families. In the communities of the types: *Cymodocea nadosa* and *Zostera marina* that have been found in the Split and Omiš regions, the infiltration of some nytrophile elements had been registered (*Olva rigida*), in addition to the disappearance of the *Zostera marina* family.

The biocenosis of the terrigen mud has been formed on muddy grounds. In some vicinities, such as that of the port of Split, only facies (stages) of sessile forms with certain particular species (such as *Sternapis scutata, Cucumaria elongata, tichopus regalis* and *Phallusia mammilata* and of the fish *Pagellus erythrinus)* of this biocenosis had been recorded.

The coralligen biocenosis has been formed on both the smaller accumulations of biogene, strengthened ground and at greater depths. In the polluted regions, the algae species of *Udotea petiolata, Halimeda tuna, Vidalia volubis* as well as the *Serpula vermicularis, Microcosmos sulcatus* and *Frondipora verrucosa* animal species have been found to be decreasing.

In the benthos community of the deeper littoral – the community of clay ground, and in the shallow coastal areas and channels (including the Brač Channel), biocenosis appears in the form of facies *Nephrops norvegicus – Thenea muricata (Turittela profunda*).

In the Brač Channel, the community of clay grounds is prevalent (zoocenosis *Turritella profunda*). This type of community is typical of the particular texture of the ground sediment found in the shallow, coastal region, which has been encouraged by the absence of strong demersal currents or is due to the protection of the coast against the impact of waves. This probably explains why the group category of clay (type of community) of the channel regions of the central Adriatic, has been found in shallow rather than in deeper waters, matching similar finds in related literature. The lower distribution level is 79 m. The strong seasonal fluctuations of salinity registered can be explained by the load of the coastal rivers into the sea (Cetina, Žrnovnica and many other fresh water springs). In the Brač Channel, the dominant species of particular group categories are the following:

- Gastropoda*: Turritella communis;*
- Lamellibranchiata*: Anomia ephippium;*
- Echinodermata*: Stichopus regalis, Astropecten irregularis;*
- Ascidiacea*: Ascidia mentula, Phallusia mamillata, Bortyllus schlosseri, Ciona intestinalis;*
- Crustacea*: Galathea sp., Portunus depurator, Macropodia longirostris;* and
- Cephalopoda*: Alloteuthis media, Sepia elegans, Alloteuthis subulata.*

4.4.2.4. Rare species and protected areas (spawning, nursery and recruitment areas)

Rare sea organisms have not been adequately researched, and this can be reflected in their relative absence from available existing sources. In addition, none of the locations in the Brač Channel has been protected. As it is essential to protect the spawning locations, as well as the areas inhabited by the young generations of fish species, we will be focusing on this issue here.

The first research of the spawning regions and the growth of juvenile sea organisms is linked to that of anchovy ecology (*Sardina pilchardus*, Walb) within which, among others, the Brač Channel's research and analysis had been performed. In the wider research area (Trogir and Kaštela bay, the Split and Brač Channel, and the coastal waters of the central and open Adriatic) eggs, larva, post-larva and 68 other fish species have been registered, which were parts of 60 species, i.e. 32 families. It has been concluded that there are certain local differences within the composition of larva populations; more specifically, in the Brač Channel, 43 species have been found, which constitutes 63% of the total number of the recorded species, while in the neighbouring Split Channel only 26 species were recorded, reaching only 38% of their total population size.

The horizontal distribution of the larva and post-larva stages of the fish has reflected the impact of the open sea on the channel areas in the central Adriatic region. The largest number of species had been found in the open central Adriatic region, a figure which gradually decreased in more protected coastal seas. The impact of the open sea on the channel areas, that is to say its movement from the first to the second region has been reflected in the emergence of the post larva stages of those species in the channel region. When adult, they move out to the deeper parts of the open Adriatic, like for instance the *Maurolicus muelleri* – boreal pearl-side and *Argentina sphyraena* – lesser silver smelt.

With reference to the seasonal distribution of larva stages, these species that together with the anchovy are alongside the plankton community and constitute the main commercial species of the Brač Channel deserve our particular attention, given that they are particularly vulnerable as their juvenile population has been threatened both by possible competitors and predators. The larva stages of the anchovies usually emerge between October and April, while that of the other fish, during the entire year, reaching their peak between May and October. The umbrella group category of "other fish" includes the larva of anchovy, which is an insignificant competitor to the sardine larva category, as these two species are complementary in terms of their appearance. The intensity of the sardine spawning differs in various locations and in the range of spawning seasons; this can be determined by an analysis of the distribution and density of their eggs and the anchovy larva. With reference to spawning, the character of the population can be determined, by the analysis of the diameter of the plankton sardine eggs, as well as by their richness. In the Brač Channel, the sardine recruit spawners population can be found, which spawns in spring. The analysis of the distribution of the longitudinal composition of the larva population and the post larva stages mean that the directions in which it is transported with the sea currents can be determined. The sardine larva and post larva are mainly transferred from their spawning area towards the two opposite shores of the Adriatic. This dispersal in the distribution of the post larva in several directions can be explained as the result of the incoming currents that pass parallel to the Croatian coast moving in a north-westerly direction, as well as by the temporary transversal currents moving towards the Italian coast. This movement – transfer of the sardine larva, is visible even in closed regions. In the Brač Channel, it has been apparent that the inflow of the plankton stages of the sardine stemming from the Hvar Channel is stronger than that coming from the open sea via the Split Channel. With reference to their hydrographic elements, a difference in the distribution of the plankton stages of the sardine between the channel area and the coastal open sea of the Adriatic has been recorded. This difference, reflected in the appearance of the plankton stages of the sardine in the channels and coastal waters of the open, central Adriatic in relation to temperatures and salinity, supports strongly the perspective that charts the appearance of recruited population of sardine in the central Dalmatian channel area, which could be presumed by drawing a comparison of the eggs' diameters, in the relevant (respective) areas.

Later research on the ichthyo-plankton and Split Channel was undertaken in 1990 and 1991 over a two-month period (September and April). Given that this research had been implemented in the middle of September, the spawning season for anchovies and other species, as well as that of the sardine and other species preferring colder months for their spawning preparations, the species found were relatively few (14). The analysis concluded that the sardine eggs and larva dominated in number and percentage of the plankton stages of the total species sample. This was followed by the anchovy eggs, the larva of brown comber (*Serranus hepatus*), various goby *(Gobius spp.),*those of anchovy and, for the first time, by those of giant sardine (*Sardinella aurita*).

During the course of 1990 research, the development stages of the *Oblada melanura* (saddled bream), *Sardinella aurita* (giant sardine) species had been recorded along with certain others belonging to the *Labridae* family. In terms of commercial exploitation, the saddled bream is the most important. It should be pinpointed that these species had not been recorded by earlier research.

The spatial division analysis of the total number of fish eggs established that the major concentration had occurred around Stobreč and that the size of this population had gradually been decreased in the areas towards Omiš, the northern shore of Brač and towards the Split Channel. The spatial distribution of the number of fish larva had been completely different. Here the concentration centres varied in the area just offshore of Split, that at the entrance to the Split Channel and the area at the end of the Split Channel between Čiovo, Šolta and Drvenik. The larva in the region offshore of Split, had most probably been transferred by the current flowing along the northern coast of the island of Brač, from Omiš towards the Split Channel, most likely from the centre of the greatest concentration of eggs in the Stobreč area. Meanwhile, the centres of the larva concentration in the Split Channel entrance had most probably been transferred by incoming currents through the Split Channel entrance as well as through the passage between Šolta and Drvenik in the open sea area.

Drawing a comparison between the spatial distribution of the total number of larva and eggs and that of anchovy, which is especially dominant in terms of population size, it becomes clear that the concentration point registered near Stobreč has been a consequence of the region's intensive anchovy spawning and that its eggs and larva have been directed, by currents, towards Split. The population size of anchovy eggs and larva had reached higher values at the exit of the Split Channel, appearing to be the result of its intensified spawning, in this particular area. However, the form of the isolines of anchovy eggs and larva distribution leads us to the conclusion that the point of the species' intensified spawning is more likely to be located outside the area of research, either in the Marina bay or further to the west, towards Ploče peak. The low value of the diversity index (0.44 and 1.61) had shown a relative stability of the ichthyo-plankton composition, which can best be explained by the fact that in the Adriatic the ichthyo-plankton is generally very sparse in September. The spatial distribution of the diversity index yields a better illustration than does the distribution of the number of species or the fish larva, that the composition of the ichthyo-plankton from the northern coast of Brač and Šolta towards the mainland becomes increasingly monotonous. In the regions along the north coast of Brač, in the eastern part of the researched region, at the far western end of the Split Channel and especially in the area north of the Split Channel entrance, an increase in the diversity index is caused by the penetration of surface waters from channels that are closer to the open sea or from the open sea in the region between Šolta and Drvenik. Based on the analysis of the distribution of the developmental stages of fish, it can be concluded that during the period when the plankton material was collected, these were the most prolific, but also the poorest in species along the northern coast of the Brač Channel, in the region between Omiš and Split. If we were to find an identical situation throughout the year, it could offer proof of growing eutrophication in the above-mentioned region.

During 1998 and 1999, qualitative and quantitative research was carried out (six times annually) of the ichthyo-plankton of fish fry and other sea organisms on the stations by the Stobreč-Žrnovnica mouth and Duće Glava – the Cetina mouth – Omiš. The preliminary results of this research are presented in Table 4.19. Along with these two dominant species: the sardine and anchovy, the major appearance of plankton stages of spicarel – *Spicara smaris* has been registered, but could also be expected because the Brač Channel region is the spawning ground of this economically very important fish. Also, a larger number of plankton stages of the striped bream – *Lthognathus mormyrus* was found. This is another economically important type of fish, whose presence can be explained by the existence of very favourable, muddy/sandy ground conditions necessary for the spawning of this fish. Based on the analysis of the plankton stages found in the vicinity of these stations, we can conclude that these regions are relatively rich in plankton stages, housing the spawning centres and feeding grounds of a range of the area's economically crucial fish species particularly sardine, spicarel, striped bream, red mullet and smelt.

In Table 4.20 the following data are given: number of caught species, individuals, index of richness and diversity index for the stations at the mouths of the Žrnovnica and Cetina Rivers. From the analysis of the registered species, we can conclude that these regions are relatively rich in quantities (i.e. as nurseries and feeding ground for fishery). Their concentration analysis for the Žrnovnica mouth had been as follows: *Mullus surmuletus* – striped surmullet (N=529, 29.2%), *Atherina hepsetus* – smelt (N=309, 17.02%), *Mullus barbatus* – red mullet (N=307, 16.9%), *Diplodus annularis* – annular git head (N=185, 10.2%) and *Lithognathus mormyrus* – striped bream (N=98, 5.4%). The relatively high index values of the richness and diversity indicate that the researched areas are relatively rich in biological diversity. At the research stations, stages of certain commercially exploitable species have been recorded (striped bream, dentex, white sea bream, striped surmullet, red mullet) designating the regions under analysis to be valuable to their breeding and feeding requirements.

Table 4.19.
Number of larva per species found at the stations on Duće Glava – the Cetina mouth – Omiš and Stobreč – the Žrnovnica mouth (1998-1999)

Species	Duće Glava – Cetina mouth – Omiš		Stobreč – Žrnovnica mouth	
	No. of individuals	%	No. of individuals	%
Sardina pilchardus	222	19.8	288	32.8
Engraulis encrasicolus	100	9.0	152	17.3
Spicara smaris	133	11.9	99	11.3
Serranus hepatus	55	4.9	72	8.2
Lithognathus mormyrus	128	11.5	44	5.0
Cepola rubescens	49	4.4	40	4.6
Atherina boyeri	-	-	29	3.3
Atherina hepsetus	-	-	25	2.9
Atherina spp.	22	2.0		
Diplodus annularis	56	5.0	25	2.9
Mullus barbatus	33	3.0	19	2.2
Mulus surmuletes	33	3.0	-	-
Liza aurata	22	2.0	-	-
Merluccius merluccius	15	1.3	-	-
Gobius spp.	9	0.8	-	-
Microchirus variegatus	9	0.8	-	-
Belone belone gracilis	9	0.8	-	-
Argentina spyraena	5	0.4	-	-
Coris julis	10	0.9	19	2.2
Gadiculus argenteus argenteus	20	1.8	15	1.7
Calliyonimus pusillus	30	2.7	10	1.1
Boops boops	18	1.6	9	1.0
Oblada melanura	18	1.6	7	0.8
Pomatochistus marmoratus	44	3.9	5	0.6
Arnoglossus laterna	-	-	5	0.6
Sardinella aurita	10	0.9	4	0.5
Labridae	33	3.0	4	0.5
Sygnathus spp.	-	-	1	0.1
Lichia amia	-	-	1	0.1
Diplodus vulgaris	-	-	1	0.1
Diplodus annularis	56	5.0	1	0.1
Sarpa salpa	-	-	1	0.1
Diplodus puntazzo	-	-	1	0.1
Undetermined	33	3.0	-	-
Total	**1.116**	**100**	**877**	**100**

Table 4.20.
Number of species, individuals, index of richness and index of diversity (fish fry) at the stations on the Žrnovnica mouth and the Cetina mouth

	Žrnovnica mouth	Cetina mouth
Number of species (S)	26	36
Number of individuals (N)	1.724	1.815
Index of richness (D)	3.355	4.664
Index of diversity (H')	1.981	2.221

4.4.3. Protected areas

4.4.3.1. Protected natural areas

To date, only the Cetina canyon (Figure 4.12) encompassing the few last kilometres of the River flow before part of the river mouth, is covered by environmental protection legislation. This particular area constitutes a significant geo-morphological phenomenon in terms of landscape value. As the prescribed legislation has been relatively liberal, it permits a wide range of human activities. In accordance with the particularities of the landscape and the availability of connection routes, as well as the existing protection legislation, certain tourism, recreational and traditional agricultural activities have been undertaken. Human settlements remain to a large extent uncontrolled, although further construction is not permitted. It is anticipated that future management will resolve the severe conflicts of the area.

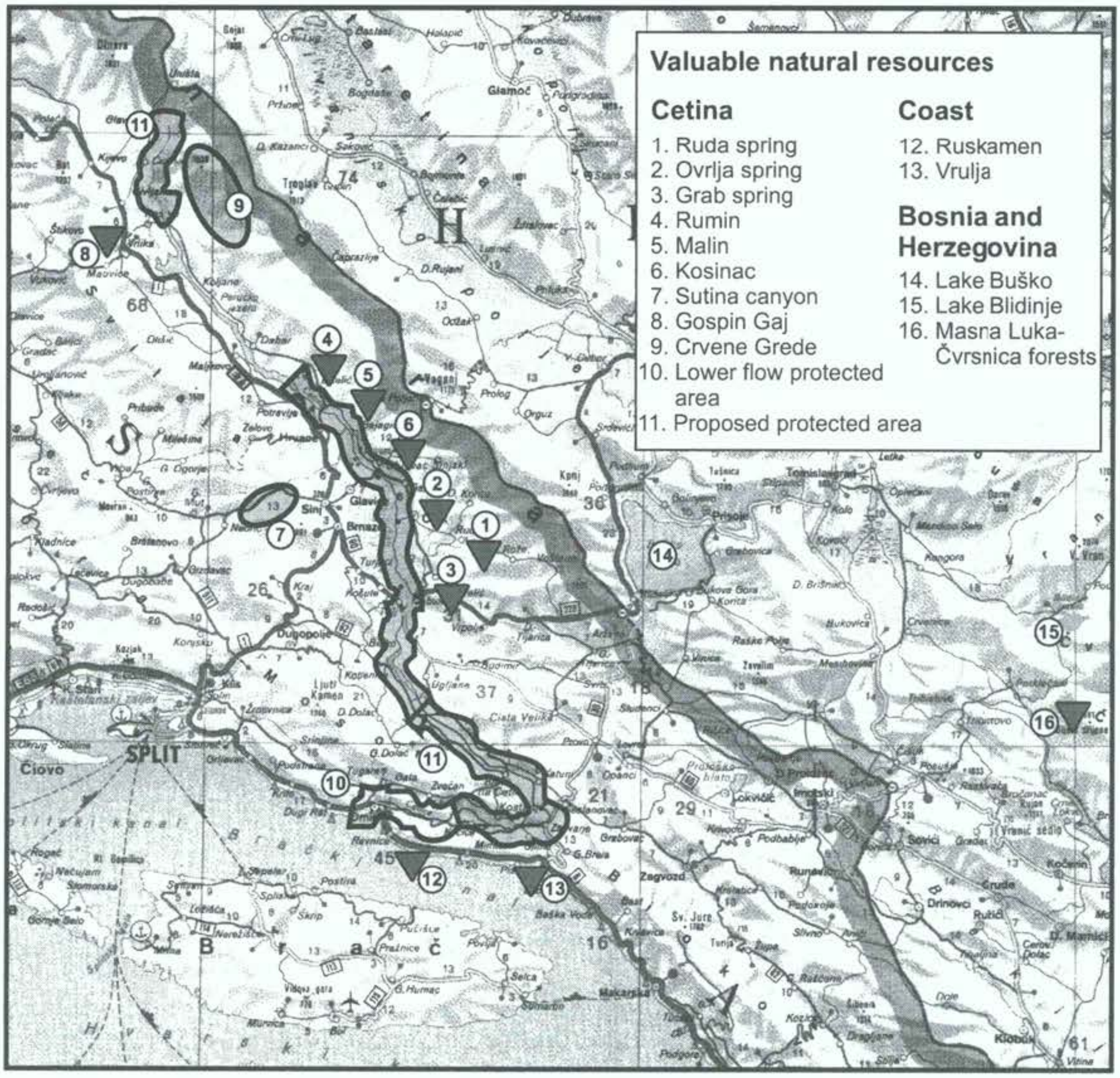

Figure 4.12: Valuable natural resources

From the perspective of future protection strategies, the following parts of the wider Cetina region possess a greater natural value: Malin, Rumin, Ovrlja, Kosinac, Grab, Ruda and Sutina; the upper flow from the source to the Peruča lake; the area of Crvene Grede in the Dinara mountain; Gospin gaj near Vrlika and part of the lower flow, upstream of the currently protected area. The streams of Malin, Rumin, Ovrlja, Kosinac, Grab, Ruda and Sutina constitute the main Cetina tributaries. These not only possess landscape value but in certain cases their value acquires an additional cultural value due to the prevailing examples of traditional indigenous architecture (historical water mills, etc.) harmonising with the existing landscape. Besides the waterline of the town of Sinj, the location of Kosinac possesses horticultural and historical elements. The wider Sutina area, features forested areas and boasts a stream that partially forms a very interesting canyon constituting another scenic landmark. Ovrlja is an interesting hydro-geological phenomenon – a spring on the very top of the hill. Malin, Rumin, Grab and Ruda with their springs and upper flows are very interesting in geological terms, and together with Kosinac and Sutina must be included in the category of protected landscapes, while Ovrlja and certain parts of Kosinac should be included as natural monuments of park architecture.

The upper Cetina flow, upstream of the Peruča lake, undoubtedly possesses great landscape value, and should, therefore, be included in the protection category. With reference to this unique area, two different levels of protection should be identified. Part of the area close to the source (the Pag field), is a marshy area, that periodically floods. Its habitats are among the most endangered as well as the richest in variety and biomass in Europe; this fact alone, makes imperative the area's inclusion within the protection category.

Furthermore, this particular area has been registered as home to the sole existing colony of the redshunk *Tringa totanus* in Croatia. The action plan tackling the protection of this species has already been included in the first priority category of the Strategic Action Plan for the Protection of Biological and Landscape Diversity, of the Republic of Croatia. The area also constitutes a significant hunting ground of a rare and endangered long-legged bat (*Myotis capaccinii*). Any disruptions to the natural appearance of this marshy area, however minor, could be devastating.

Certain parts of this area should be protected and utilised as highly controlled hunting areas. All major construction activities should be banned throughout the area, while the borders should be redefined by way of the exclusion of human settlements. Given that the area's existing human settlements are insignificant and largely deserted or demolished, they are not likely to pose large pressures for future development. To the extent that their development is unavoidable, it should be directed towards the hilly slopes and away from the fields. Traditional agricultural activities, as well as mowing and cattle grazing, should be permitted in certain fields, while within the strictly prohibited parts of the marshy area, the current mowing and grazing activities should be gradually curbed. The Crvene Grede, the very steep, almost vertical rocks on the Dinara mountain slopes, constitute potential nesting locations for very rare birds of prey and should be protected from any disturbances. The mountainous, rocky area above the Crvene Grede is the sole nesting area of the mountain lark bird *(Eremophilla alpestris*), in Croatia. For this reason, this area should be included in the special reserve category.

The main characteristic of this region is that the rocky grazing grounds have actually been created by anthropogenic intervention. Forests, bushes – the natural vegetation climax of this region, had already been destroyed by ancient times, by either the unplanned instances of exploitation or by fires. Later on, the meadows were mainly used for sheep grazing. In more recent eras, the farms have been gradually decreasing, and after the recent hostilities, have almost disappeared. For this reason, these meadows constitute an additional endangered biotope, as they have been gradually turning into bush land. Such a change would result in the extinction of many species, including the mountain lark. The protective measures for this region operate against a backdrop of the area's potential for economic exploitation. In this sense, farming as the sole practical and appropriate economic activity, must be revived, as soon as possible, simultaneously saving the meadow biotope. With reference to Crvene Grede, their inhabiting bird species should not be disturbed during their breeding season. As Crvene Grede and the meadows are relatively inaccessible and of minor interest to economic endeavours, neither conflicts of interest, nor any other problems should be expected here.

Gospin gaj near the town of Vrlika possess an aesthetic value, as a beautiful forestry complex within an area where forests are scarce. Within the borders of Gospin gaj the Vrlika fountain is a cultural monument. Gospin gaj should be included either in the landscape or in the park forest protection categories, while any further human activities should be prohibited.

The already protected Cetina canyon area should be extended upstream, to include the Gubavica waterfall. Despite the fact that such an extension would only include a few settlements, it would nevertheless be enriched by valuable landscapes and certain interesting geo-morphological phenomena. The revival of the down-at-heel state of traditional agriculture on certain slopes, would enrich the existing landscape. This is a permissible development. The river banks, however, should remain intact.

Drawing a dividing line between protection measures and the needs of human communities, it is advisable to avoid any anthropogenic effects on the environment in order to diminish the chances of possible conflicts. It would also be advisable to include the surrounding areas within development plans as zones where intensive development activities should be prohibited, in order to obtain more protection zones of different categories.

All the proposed protection categories, according to the Croatian Law on the Protection of Nature, are under the jurisdiction of the Split-Dalmatia County's local authority as well as that of the Croatian Ministry of the Environmental Protection and Physical Planning, which determine the areas and the protection measures respectively.

With reference to the Bosnia and Herzegovina territory, the following areas are especially valuable in terms of structure, content and beauty:

- Blidinje lake with surroundings (82.4 ha);
- The forest region Masna Luka on the Čvrsnica mountain (100 ha); and
- Buško lake with surroundings (558.0 ha).

The Blidinje lake originates in the glacial period, while Buško Blato constitutes a Continental Mediterranean Sea remnant. The Blidinje lake, the Buško lake complex, parts of the Vrana mountain, as well as the Čvrsnica and Midena mountains should all be developed to become recreational and tourism assets.

In the relatively well preserved environment of Cetina and its surroundings, additional reasons could probably be found to support the protection of individual locations. This quest should be undertaken by future scientific research. With reference to this area, we must focus our attention on the river fauna and its tributaries, as we can find interesting endemic species, typical of other karstic waters.

Generally, it is necessary to preserve the landscape diversity of the entire Cetina watershed. A favourable aspect to this endeavour is the fact that a substantial part of the river flow remains uninhabited and inaccessible, while the fields and the river mouth are still under stronger anthropogenic influence. In order to preserve the natural characteristics of these parts, the fields should neither be meliorated nor cultivated.

Ecologically, the edges of the fields and the borders between larger ploughed surfaces are of particular importance and should be planted with groups of trees and bushes.

Of particular importance is the prevention of the introduction of allochthonous plant and animal species that endanger the existing biodiversity regime. The most striking example can be drawn with reference to the harmful effects of the introduction of carp (*Cyprinus carpio*) into all the waters of the Adriatic watershed, including the Cetina basin. This species has been introduced for recreational purposes. In order to avoid similar mistakes in the future, it is essential to analyse the biotope situation with regard to the introduction of allochthonous species so that a project on an eventual reversal of the damages could be prepared.

Any planned interventions relating to wastewater disposal, in the wider Cetina region, should be regulated, in order to protect the extremely sensitive ecosystems of its underground and surface waters.

The larger protected areas should be extended to include the upper part of the river flow, upstream of the Peruča lake, and the already protected part of the lower flow. The latter should be expanded towards the upstream area, and its protection plan should embrace the mountainous locations of Crvene Grede and Sutina, that possess a minor economic growth potential. In the middle flow, the smaller, but nevertheless characteristic locations along the edges of the fields should also be protected. These can be referred as "protection points" at least in the part which remains significant according to economic, settlement organisation and transportation perspectives.

There are two general goals and two basic aspects relating to this task. The goals include:

- the protection of biological and landscape diversity, which could be achieved by the protection of certain locations in accordance with protection categories, and by implementing the existing legislation measures prescribed by the Law on the Protection of Nature; and
- the protection of the entire region by the application of sustainable development principles on settlement, transportation, economic, and other developmental future activities.

4.4.3.2. Cultural heritage

The Cetina valley has always been of central importance to the survival (life) of central Dalmatia and its neighbouring regions of Bosnia and Herzegovina. On the Dinara and Svilaja mountains, as well as on the numerous hills of the region, a large number of prehistorical mounds, cemeteries and fortifications have been discovered. The tumultuous history of the area can be witnessed in the numerous monuments originating in the Illyrian period (fortifications, mounds and protection walls), Roman period (Roman monuments, early Christian monuments, roads and aqueducts) as well as in the Medieval period (early Croatian churches, early Croatian cemeteries, fortifications, mills, etc.). This historical legacy includes numerous cultural monuments along the coast and in the Cetina watershed from entire urban centres (such as Omiš, Makarska and Livno), fortifications, secular, holly and military buildings, to infrastructure, bridges, roads, water supply systems, etc. (Figure 4.13).

Figure 4.13: Architectural heritage

The protection of this cultural heritage, which is the sole remaining tangible evidence of our civilisation, being an imperative, poses limitations with reference to certain land-use applications. More specifically, no landscape alteration either relating to water regulation, infrastructure development or any other activity, should be allowed to threaten the integrity of the monuments or historical areas, but should rather contribute to the maintenance of the area's cultural heritage.

The rich architectural heritage, which can be traced back to prehistoric times, has not been fully researched and evaluated. The cultural heritage has been better researched in the territory of Croatia, especially on the coast and in the vicinity of the Cetina estuary. The cultural monuments on the territory of the Federation of Bosnia and Herzegovina, having been inadequately researched, are less preserved. During the recent hostilities, several cultural monuments, including religious sites, were severely damaged, especially in Bosnia and Herzegovina and in the part of Croatia (the north-eastern part of the Cetina River watershed).

A characteristic of the prehistoric period was the appearance of the first human communities in caves, followed by forts and mounds on elevated topographical sites. One of the oldest settlements of Palaeolithic hunters was discovered in the "Gospodska pećina" cave by the Milaš spring of the Cetina River. The first prehistoric settlements appeared as early as the later stone age. Those settlements emerged on elevations embracing the karstic fields and valleys. In the bronze and iron ages, they became the prevailing type of settlement, offering good strategic positions and establishing visual contacts among settlements. This system primarily served a defence function, especially around the area inhabited by the Illyrian tribes of Delmati. The settlements appeared by each field, along the course of the Cetina River, and in the coastal area.

At present, only a few remnants of the Greek period exist in this area; these are primarily linked to the Greek colonies of Epetion, Tragurion, Salona and Narona. After many years of war and their eventual victory over Delmati, the Romans established a province here, re-establishing the capital in Salona. The most important Roman centre in the Cetina area was the colony of Aequum and the military campus of Tilurium-Gardun above the present-day town of Trilj. The Romans built several towns, forts and military camps, such as Osinium (Sinj), Oneum (Omiš) and Burnum, to name but a few. They built roads connecting the capital of the province, Salona, with Narona and Sirmium, as well as aqueducts. In the fields, outside the towns, they built agricultural estates (*villae rusticae*) for rich landowners (Livno, wider area of Cetina, coast). Some of the Roman land allotment is still reflected in the current land-use patterns.

Cetina had constituted the external border of the Roman colony, during the Avar and Slavic intrusions in the first half of the 7th century. In addition, there are also several important religious monuments originating in the Middle Ages, such as the church and cemetery of St. Saviour by Vrlika, the church of St. Peter in Omiš, the convent of St. Peter in Sumpetar-Jesenice, as well as numerous cemeteries in the wider watershed area. The Medieval communities had been densely structured for defence purposes. In strategic defensive positions, several feudal fortifications were built (the burgs of Sinj, Omiš and Duvno, the burg of Burag in Livno, the forts of Čačvina, Glavaš, Prozor, Travnik, Nutjak, etc.). The religious architectural heritage of the wider Cetina watershed mainly originates in the 18th and 19th centuries, but in part of Central Poljica area and in Omiš, several Medieval churches can also be found.

The Turkish invasion also significantly enriched the area's cultural heritage. Monuments from that period on the territory of Bosnia and Herzegovina (the mosques of Livno Glavica, Balaguša and Begluk, with their adjacent living quarters, and necropoles from the Turkish period) have been preserved to a large extent; regretfully, part of that heritage has been either damaged or destroyed during the recent hostilities.

With the exception of the urban centres of Vrlika, Sinj, Omiš, Makarska, Livno and Tomislav Grad, the wider area of the Cetina watershed is characterised by smaller settlements of a rural nature. The great majority of the urban centres have been built on several historical sites, preserving parts or fragments from the earlier periods. As a rule, they demonstrate a well defined and consistent Medieval core, with certain additional constructions originating in the beginning of the 20th century.

The selection of sites for rural settlements has been determined by the morphology of the terrain and by its suitability for the survival of men and domestic animals. The important criteria within this selection process have been those of water availability, land fertility and the stipulations that locations face the sun and are protected from winds. The villages have been dispersed, scattered in several hamlets, usually emerging along field borders or on hill and mountain slopes. Today, these areas suffer from depopulation, with the exception of the villages near the large urban centres and along the main roads. The division of large, traditionally constructed houses, once belonging to extended families, marked the era of the division of agricultural estates and the appearance of ones of a diminishing size. In terms of its typology, traditional architecture belongs to the Karstic-Adriatic zone, or, in a broader sense, to the Mediterranean-Balkan zones, as it is characterised by the utilisation of stone as its main construction material.

Due to the length of the river and the plenitude of its numerous tributaries, the significance of bridges over Cetina has been recognised since ancient times. Apart from the ancient bridges over Peruča, and the one over Cetina, 300 m downstream from Trilj (*Pons Tiluri*), there had always been several available means serving as crossing points (where Ruda flows into Cetina, Čikotina Lađa near the Prančevići dam, Priko at the mouth of Cetina in Omiš). In the late 19th century, several stone bridges were constructed, such as the Pavić bridge near Podgrađe, the bridge at Panj between Rumin and Bitelić, and the ones over the Kosinac stream, by Gala and Grab. Mills were also important to agriculture, and their number exceeded the 250 located along Cetina and its tributaries alone. The most significant ones have been erected on Cetina under the site of Gardun and the Medieval fort of Nutjak. Regretfully, the oldest of those was destroyed when the accumulation lake (storage reservoir) for the Đale HPP was created.

The most important archaeological research was undertaken on the occasion of large hydrological interventions which altered the river's natural appearance at its upper and central flows, such as the melioration of the Sinj field, and the construction of the Peruča and Đale HPPs.

The protection of the cultural heritage is regulated by specific legislation, and in Croatia it is systematically implemented under the jurisdiction of the Ministry of Culture. In the territory of the Federation of Bosnia and Herzegovina, the recent hostilities posed serious obstacles to the systematic implementation of the existing protection measures and the adoption of new, complementary regulations.

Conclusively, the protection of architectural and other cultural heritage has been closely interlinked to that of the environment and of natural phenomena. More specifically, man-made monuments and the environment often constitute unique monuments, such as the Pločasti (the flag-stone) bridge, the Vuković bridge at the spring of Cetina, as well as the bridges and mills near Obrovac, the fort of Čačvina, Tisne Stine and the fort of Visuć, and the mouth of Cetina in Omiš, to name but a few.

4.4.4. Vegetation of the Cetina watershed

4.4.4.1. Vegetation features

Characteristics of the forest vegetation are shown in Figure 4.14.

Steno-Mediterranean forests of the Aleppo pine (Pinus halepensis)

a) Forests of Aleppo pine with heath (*Erico-Pinetum halepensis*, Krause et al. 1963)

Generally, whereas Aleppo pine (*Pinus halepensis*) grows on a dolomite lithological basis and in a xerothermic climate, heath (*Erica manipuliflora*) flourishes in the underlying shrub layer, that in addition to flora composition, provides these communities with a special appearance. The sub-spontaneous Aleppo pine forests of the coastal slopes of the Biokovo mountain and those of the Hell Islands near Hvar, can be included in this forest category, which is especially vulnerable to fires.

b) Forests of Aleppo pine and holm oak (*Querco ilicis-Pinetum halepensis*, Loisel 1971)

Mixed forests of Aleppo pine and bigger or smaller proportions of holm oak (*Quercus ilex*) are widespread all over the Mediterranean, where, in the xerothermic climate, they occupy micro-climatically more humid habitats. On the Croatian coast, such forests cover comparatively large areas, especially on the island of Hvar. This is the most important type of Aleppo pine forest in Croatia. Within the flora structure of the forests of Aleppo pine and holm oak, it is significant that the holm oak makes a prominent underlying community in the form of high bushes or low trees, but after the pines have been cut, they do not grow into an overlaying community, as the abundant pine shoots grow to regenerate the overlaying pine layer. In the area of holm oak forests, the Aleppo pine can follow a similar flora pattern, but over time, the elements of holm oak forest create a thick underlying community that gradually grows into a climazonal holm oak forest. On the northern coast of the Brač island, Aleppo pine culture has been established. Due to a string of anthropogenic influences, these cannot develop into natural communities. By halting the anthropogenic influence, these would develop into forests of Aleppo pine and holm oak (*Querco ilicis-Pinetum halepensis*, Loisel 1971).

Eu-Mediterranean and hemi-Mediterranean evergreen forests of holm oak, and Mediterranean forests of Dalmatian pine

a) Pure forests of holm oak and myrtle (*Myrto-Quercetum ilicis*, /H-ić/ Trinajstić 1985)

The pure holm oak forests and maquis are exclusively comprised of evergreen elements, without any deciduous ones. Of all forms of holm oak forest and maquis on the Croatian coast, the ones mixed with myrtle constitute the most thermophilous community, developing wherever the ecological conditions are favourable, which primarily relates to winter temperature variations. In the flora composition, the most prominent are myrtle (*Myrtus communis*), juniper (*Juniperus phoenicea*), mastic tree (*Pistacia lentiscus*), honeysuckle (*Lonicera implexa*), and rough bindweed (*Smilax aspera*). The layer of herbaceous plants is practically absent, since the thick overlaying layers produce too much shade, leaving the ground covered by a mere layer of leaf litter.

b) Mixed holm oak and flowering ash forests and maquis (*Orno-Quercetum ilicis*, H-ić /1956/1958)

Mixed holm oak, flowering ash forests and maquis are widespread over the entire northern Mediterranean region. With reference to Croatia, it is mostly maquis that prevails. In the composition of flora, among the evergreen elements, those less sensitive to low temperatures have become more developed, as has been the case with the holm oak (*Quercus ilex*), the jasmine box (*Phyllirea latifolia*), and the strawberry tree (*Arbutus unedo*), as well as with those species requiring higher humidity, such as laurestine (*Viburnum tinus*). Among the herbaceous plants, the most prominent ones are cyclamen (*Cyclamen repandum*), asparagus (*Asparagus acutifolius*), and butcher's-broom (*Ruscus aculeatus*), while the most common vines are rough bindweed (*Smilax aspera*) and vitaceae (*Clematis flammula*). The group composed of deciduous elements is dominated by flowering ash (*Fraxinus ornus*). The forests of holm oak and flowering ash, wherever they have survived, are an especially beautiful ornament, reflecting their Mediterranean origin and thus justifying their classification as Eu-Mediterranean.

c) Mixed holm oak and hornbeam forests (*Ostryo-Quercetum ilicis*, Trinajstić /1965/1974)

At higher elevations, the holm oak creates mixed communities with hornbeam (*Ostrya carpinifolia*), which indicates comparatively colder and more humid conditions. They usually form low forests. These communities can be found on the islands of Brač and Hvar. The most common tree species, are the strawberry-tree (*Arbutus unedo*), laurestine (*Viburnum tinus*), jasmine box (*Phyllirea latifolia*), *grahor* (*Coronilla emeroides*), flowering ash (*Fraxinus ornus*), and turpentine-tree (*Pistacia terebinthus*).

d) Mixed Dalmatian pine and holm oak forests (*Querco ilicis-Pinetum dalmaticae*, Trinajstić 1986)

Mixed forests of Dalmatian pine (*Pinus dalmatica*) and holm oak (*Quercus ilex*) can be considered a permanent feature, resulting from the degradation of either pure or mixed holm oak forests. The largest areas covered by this type of forest are on the island of Brač, where we can find magnificent forests with trees of various ages, and it can be, therefore, assumed that pine in a pioneering development, has gradually filled in the clear areas. The pine creates the overlaying communities with the holm oak creating the underlying ones.

Sub-Mediterranean and epi-Mediterranean thermophilous, deciduous forests of pubescent oak or live oak with yoak elm or hop hornbeam

a) Mixed pubescent oak and yoak elm forests (Querco-Carpinetum orientalis, H-ić, 1939)

Mixed forests of pubescent oak (*Quercus pubescens*) and yoak elm (*Carpinus orientalis*) mainly grow at lower elevations, upon shallow, rocky ground. Such forests were used as a source of firewood. In the preserved communities, the overlaying strata are made of pubescent oak, yoak elm, flowering ash (*Fraxinus ornus*), and sycamore (*Acer monspessulanum*). In the communities under anthropogenic influence, these communities develop mainly as shrub layers.

b) Mixed live oak and yoak elm forests (*Carpino-Quercetum virgilianae*, Trinajstić 1987)

Mixed forests of live oak (*Quercus virgiliana*) and yoak elm (*Carpinus orientalis*) thrive on grounds with deep brown soils. Forest communities, when preserved, constitute typical examples of the old, tall oak which have not been cut down and remain an important source of seeds (acorns) for natural reproduction of the live oak communities.

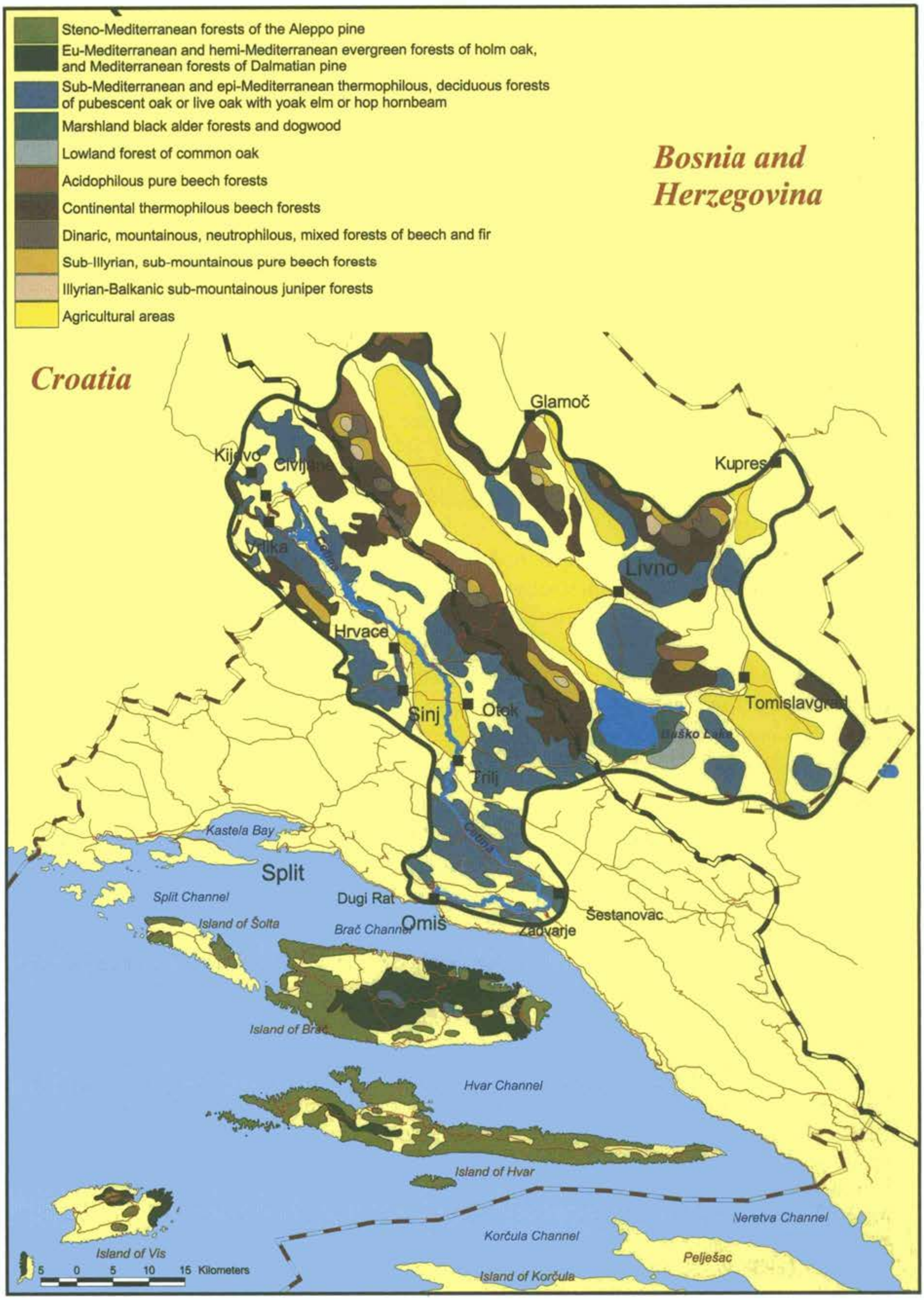

Figure 4.14: The forest map

c) Mixed live oak and flowering ash forests (*Orno-Quercerum virgilianae*, Trinajstić 1985)

Mixed forests of live oak (*Quercus virgiliana*) and flowering ash (*Fraxinus ornus*) are mostly sprout forests, previously greatly affected by goat grazing to such a degree that their floral composition became rather heterogeneous. Evergreen tree or herbaceous Eu-Mediterranean elements are completely absent, which is typical of relatively cold local microclimates.

d) Mixed pubescent oak and hop hornbeam forests (*Ostryo-Quercetum pubescentis*, (Ht.) Trinajstić 1977)

Mixed forests of pubescent oak (*Quercus pubescens*) and hop hornbeam (*Ostrya carpinifolia*) develop on mountainous zones. The emergence of this community is indicative of colder climate conditions. There are neither evergreen elements, nor any thermophilous deciduous ones. In the flora composition, other prominent communities include flowering ash (*Fraxinus ornus*), corneltree (*Cornus mas*), and autumn *šašika* (*Sesleria autumnalis*) species.

e) Mixed live oak and hop hornbeam forests (*Ostryo-Quercetum virgilianae*, Trinajstić 1987)

These forest communities develop at higher elevations, especially in the Dalmatian hinterland, where, at the altitudes between 750 and 900 m, they cover comparatively broader areas. Unfortunately, the live oak has become rather rare, and for this reason, its trees usually stand alone, while they regenerate relatively slowly, despite the fact that anthropogenic influence has been almost completely eliminated. In addition to live oak (*Quercus virgiliana*) and hop hornbeam (*Ostrya carpinifolia*), sycamore (*Acer monspessulanum*) is quite common. The low growth strata are dominated by autumn *šašika* (*Sesleria autumnalis*), along with some thermophilous species.

f) Dalmatian pine and heath forests (*Erico manipuliflorae-Pinetum dalmaticae*, Trinajstić 1977)

Forests of Dalmatian pine (*Pinus dalmatica*) with heath (*Erica manipuliflora*) have been developed on a dolomite lithological base in the Brač and Hvar islands, and can be considered as primary (original). From these forests, the pine has spread to other, secondary habitats. Additionally to the pine, this community contains heath (*Erica manipuliflora*), Dalmatian greenweed (*Genista dalmatica*), flowering ash (*Fraxinus ornus*), and hawkweed (*Hieracium heterogynum*).

Marshland black alder forests and dogwood

Forests of black alder (*Alnus glutinosa*) and dogwood (*Frangula alnus*) grow in the Buško lake region, on marginally swampy soil, with low acid reaction. Throughout most of the year, this community is flooded by 20-70 cm of water. In the tree layer, narrow-leafed ash (*Fraxinus angustifolia*) and elm (*Ulmus laevis*) also appear. The shrub layer has been thinly developed.

Lowland forest of common oak

a) Forest of common oak with large green weed (*Genisto elatae-Quercetum roboris*, Ht. 1938)

Forests of common oak (*Quercus robur*) with large green weed (*Genista tinctoria* var. *elata*) grow above the black alder forests. They flourish on mineral-swampy soils, more or less acidic, several meters above the mean water level that is periodically flooded.

The great value of these forests lies in their utilisation as a source of construction material. However, these communities have suffered great damage from parasites.

b) Forests of common oak and common hornbeam (*Carpino betuli-Quercetum roboris*, Anić 1959/ Rauš 1969)

Forests of common oak (*Quercus robur*) and common hornbeam (*Carpinus betulus*) are not vulnerable to flooding, but appear on fresh drained terrains. Bird's-tongue (*Acer campestre*) is an additional species of the tree layer.

Acidophilous pure beech forests

Forests of beech (*Fagus sylvatica*) and wood rush (*Luzula luzuloides*) develop in mountainous zones on steep, mostly northern slopes, on brown, shallow to medium-shallow soils. The community is poor in species. The shrub layer is not developed and in the ground layer we can often find indicators of acidity.

Continental thermophilous beech forests

Beech (*Fagus sylvatica*) and autumn *šašika* (*Sesleria autumnalis*) forests are typical communities of high karst, developing on skeletal carbonate soils. These are the most significant thermophilous beech forests. In the tree layer, the lithy tree (*Viburnum lantana*) and corneltree (*Cornus mas*) can also be found.

Dinaric, mountainous, neutrophilous, mixed forests of beech and fir

Dinaric forests of beech (*Fagus sylvatica*) and fir (*Abies alba*) appear at elevations between 500 and 1,200 m a.s.l, on carbonate sub-strata, at all inclinations and expositions of the terrain.

Sub-Illyrian, sub-mountainous pure beech forests

Sub-mountainous beech (*Fagus sylvatica*) forests with *urezica* (*Homogyne alpina*) develop at elevations between 950 and 1,500 m a.s.l. Beech trees, with characteristically twisted lower trunks dominate. The community faces unique living conditions, with abundant snow, low temperatures, short vegetation period and strong winds. The geological basis is made of calcareous and dolomite layers.

Illyrian-Balkanic sub-mountainous juniper forests

Mugho pine (*Pinus mugo*) and woodbine (*Lonicera borbasiana*) constitute the top border of the forest vegetation, rising above 1,350 m. Without pronounced stratification, it grows on numerous shady peaks and slopes, with very little black earth-soil with raw humus. Apart from their natural-scientific and recreational-aesthetic values, these forests are important as they grow on steep and shady terrains with numerous endemic and rare species of flora.

Grassland vegetation

Due to direct or indirect human impact, the development process of grasslands (meadows and pastures) has been anthropogenic. They represent an extremely important type of ecosystem either in floristic and ecological or in plant-geographical terms.

Grasslands can be divided into the following categories:

- Dry grasslands and rocky ground pastures, that were created by the felling of evergreen forests and dense evergreen underbush; they belong to the *raščica* (*Thero-Brachypodietea)* grass family.

- Dry grasslands and rocky ground pastures, which were created by felling deciduous trees and coppice and belong to the brome grass family (*Festuco-Brometea*).
- Acidophilus highland meadows and hinterland heather belonging to the bastard spike-nard and *bodljikavi štopavac* (*Nardo-Ulicetea)* family.
- Field and mountain swards, mainly anthropogenically developed and partially natural mountain swards developed under the impact of the local microclimate. They belong to the carnation grass family (*Seslerietea tenuifoliae*).
- Humid and marsh grasslands that belong to the tall meadow oat (*Molinio-Arrhenatheretea*) grass family.

Rock vegetation

Almost half of 312 endemic vascular plants growing in the Republic of Croatia can be found in the steep coastal mountains, high craggy islands and exposed sea capes, as well as mountains peaks. Due to the relief characteristics, the forest vegetation could not develop on these steep rocks. Instead, a typical rock surface vegetation has grown here, which belongs to the *Asplenietea rupestris* family with specific vegetation types, such as the brown spleen-wort (*Asplenium trichomanes*), the ceterach (*Ceterach officinarum*) and pepper crop (*Sedum dasxphyllum*).

Slide vegetation

Below the mountain ridges composed of slide rocks and extremely spare soil, at the slopes of 45%, specific habitats have been developed. The primary vegetation is represented by the *Thlapseetea rotundifolii* family with characteristic sorts, such as *primorski mekinjak* (*Drypis jacquiniana)* and the mountain earth-nut (*Bumium montamum*).

Coastal sand and gravel seepage vegetation

The coastal sand and pebble seepages have been overgrown by a specific plant cover that belongs to the *Ammophiletea* family characterised, among others, by cypress-roots (*Pancraticum maritimum*), mixed sea grape (*Salsola kali*) and bindweed (*Calystegia soldanella*).

Calcareous coastal ridges vegetation

In dashing zones, that is, on coastal ridges, rocks and walls, halophytic habitats have emerged that belong to the *Crithmo-Staticetea* family. The most commonly represented plant types are the agrimony (*Crithmum maritimum*) and *rešetkasta mrežica* (*Limonimum cancellatum)*.

The free floating great duck-weed vegetation

It can be found at the surface or immediately below the surface of deep freshwater basins with stagnant water, which belong to the *Lemnetea* family and includes the *Lemna, Wolfia, Salvinia* and *Azolla* sorts.

The shallow freshwater basins vegetation

The shallow freshwater basins with stagnant water are characterised by the *Potamogetometea* family including the *Trapa, Potamogeton, Nymphea, Nuphar, Ceratophyllum, Myriophyllum,* plant sorts, which are either deeply rooted in the bottom, and completely immersed in the water or with leaves developed at the surface.

The shallow swamps vegetation

The *Phragmitetea* family, including two species, namely, the *Phragmitetalia* (reed) and *Magnocaricetalia* (marsh sedge), can be found in deep swamps of 0.6-1 m depth.

The low Cyperus family vegetation

During summer, when the water level is low, the glabrous edges of clay and humid soil can be seen in silty spots of shallow freshwater basins characterised by the *Isoeto-Nanojuncetea* vegetation family.

4.4.4.2. Characteristics of flora

The plenitude of flora in a specific area is not characterised by the quantity of the produced wood and agricultural crop, but rather by the diversity of plant cover, in particular if the rare, relic or endemic plant species can be found there. In the Red book of the plant species of the Republic of Croatia, 55 out of 226 plant families registered in the Cetina watershed have been listed as endangered, sensitive, rare and endemic. Naturally, not all endemic plants that can be found in the River Cetina watershed have been listed in this book.

The plant families that have been discovered in the Cetina watershed and registered in the Red book, have been listed, in alphabetical order as follows: *Achillea clavenae* L., *Adiantum capilus-veneris* L., *Anacamptis pyramidalis* (L.), L. Rich., *Aquilega dinarica* G. Beck, *Arctostaphylos uva-ursi* (L.) Spreng., *Arum Nigrum* Schott, *Arum Orientale* M.B. subsp. *longispathum* (Reincheb.) Engler, *Asperula beckiana* Deg., *Aubrietia croatica* Schott, Nyman et Kotschy, *Berberis croatica* (Horvat) Kušan, *Butomus umbelatus* L., *Campanula cochleariifolia* Lam., *Campanula portenschlagiana* Schult., *Cardamine carnosa* Waldst. et Kit., *Centaurea biokovensis* Teyb., *Cephalantera rubra* (L.) LC.M. Rich., *Cerastium dinaricum* G. Beck at Szysz., *Cyclamen repandum* Sibith. et Sm., *Dianthus bebius* Vis., *Dianthus croaticus* Borb., *Dianthus integer* Vis., *Dryas octopetala* L., *Edraianthus dalmaticus* (A.DC.)A.D.C., *Edraianthus dinaricus* (A. Kern.) Wettst., *Ephedra compylopoda* C.A. Mey, *Ephedra major* Host, *Gentiana symphyandra* (Murb.) Fritsch, *Heracleum orsini* Guss. var. *balcanicum* Thell., *Hypochoeris illyrica* K. Maly, *Leontopodium alpinum* Cass. var. *krasense* Derg., *Lilium bosniacum* (G. Beck) G. Beck ex Fritsch, *Lilium carniolicum* Bernh. ex koch, *Lilium martagon* L. var. cattaniae Vis., *Linaria alpina* (L.) Mill., *Limun capitatum* Kit. ex Schultes, *Moltkea petraea* (Tratt.) Gris., *Narcisus radiiflorus* Salisb., *Orchis coriophora* L., *Orchis laxiflora* Lam., *Orchis provincialis* Balb., *Pevalekia triquetra* (DC). Trinajstić, *Polygala croatica* Chodat, *Portenschlagiella rumossisima* (Portenschl.) Tutin, *Potentilla clusiana* Jacq., *Pulsatilla alpina* (L.) Delarbe subs. *alpina*, *Ranunculus scutatus* Waldst. et Kit., *Saxifraga moschata* Wulf., *Saxifraga oppositifolia* L., *Saxifraga paniculata* Mill., *Saxifraga prenja* G. Beck, *Saxifraga rocheliana* Sternb. subsp. *velebitica Deg.*, *Senecio doronicum* (L.) L., *Taxus baccata* L., *Tulipa sylvestris* L., *Veratrum lobelianum* Bernh.

4.4.4.3. Threats to flora and vegetation

Forests are not only essential for the production of wood and oxygen. Tree tops also delay the impact of rain while their roots and fallen leaves facilitate the absorption of waters by the soil. Owing to surface vegetation destruction, the water flows along surfaces and it is only partially absorbed by the soil causing soil erosion, and a reduced penetration of water into the soil. Due to this process, the quantity of water flows decrease and periodically run dry, endangering both flora and fauna. Flora and vegetation are mainly endangered by processes of industrialisation and urbanisation. Throughout history, forests have been irrationally destroyed by people. This has happened either as a result of tree felling for firewood and construction uses, or for the creation of arable land. Forests have also been burnt down to obtain pastures. This situation has been made worse by the disappearance of certain habitats, such as grasslands, due to the absence of mowing or pasturing. Moreover, vegetation has been replaced by sand and pebbles on the beaches in the course of unplanned tourism-development activities. Water and humid habitats have been also disappearing by the capping of springs, land melioration, levelling and pollution. Certain rare and endemic plants have also been destroyed (a small number of individuals and as a result of careless gathering by amateur botanists).

4.4.4.4. Protection and enhancement proposals

Forests have been developed in areas free of human impact, except in cases of limited small areas of steep rocks, slides and the narrow coastal area, in which, due to their relief characteristics, alternative types of ecosystems have been developed. Therefore, areas suitable for forest vegetation development that cannot be used for agricultural production, should be reforested. Particular attention should be given to the prevention of any experimental introduction of plant species that are not adaptable to the particular vegetation zones, as such reforestation would be harmful. Tree felling should not exceed tree growth so that tree reduction can be avoided. The creation of open spaces in forests to the extent to which it could expose trees to the harmful effects of wind, should also be prevented.

The areas suitable for agricultural production should be cultivated by the cautious use of fertilisers and pesticides as any surplus of these sink into deeper soil layers with harmful effects. Moreover, sewage should not be discharged into water flows.

5. Pressures on the environment

5.1. Pollution

5.1.1. Sources of pollution

Given that within the analysed area, pollution sources have been only periodically recorded, there is no centralised data bank, i.e. inventory of polluters. However, the new legislation in the Republic of Croatia (Law on Waters, National Gazette No. 107/95) has made compulsory preparation of an inventory of polluters, aiming to both inspect and control pollution, and prescribing the levying of fines on polluters who will have to pay for polluting the river waters and the sea. In accordance with this legislation, a system of water quality measurement for particular water discharges into sea and other waters, has been gradually established. The Croatian Waters has issued water management guidelines defining water pollution quotas for each individual polluter (economic structures, sewage system, etc.). In addition, the water quality of individual coastal polluters has been defined within the UNEP/MAP protocol on Land-Based Sources of Pollution (LBS Protocol).

The state of pollution will be separately analysed with reference to the river basin and the coastal region, as these relate to two basic types of pollution: the diffuse and point pollution.

5.1.1.1. River basin

Diffuse pollution sources

Quantitative and qualitative data on diffuse pollution sources, such as: agriculture; solid waste disposal; air pollution; fish farms; rainwater from the roads and mining as well as on their impact on water quality, do not exist. A comprehensive analysis of the waters affected by the above-mentioned pollution sources should be implemented, so that their impact on water resources and the sea can be evaluated. It is also necessary to highlight that this area constitutes a typical karstic terrain with a very high infiltration coefficient. This means that the period of underground water retention is very short, and thus that all run-off surface pollution penetrates directly and rapidly into the water resources. Taking into account certain general facts, however, the following can be concluded:

- The agricultural activities in the analysed area probably constitute the main pollution source as agriculture has been rather highly developed, especially in the Sinj field.
- In the analysed area, there are no solid waste treatment systems in existence while quantities of solid waste have been disposed of in an unregulated manner, probably causing water resources pollution.
- The air pollution in this area has so far been insignificant, given that the local industry has been undeveloped. However, the future operation of the thermo-electrical power plant that has already been planned within the territory of Bosnia and Herzegovina, utilising local coal resources, is expected to add to air and other pollution loads.
- Mining is not particularly developed in the area. Mining mainly refers to the extraction of construction material. The quarries have been situated at some distance from surface waters and thus cannot affect them. However, excavations harm the quality of the underground waters due to the pollution caused by the intensive use of heavy vehicles and other mining equipment. The Livno field is rich

in coal resources, which have not been intensively exploited and, therefore, negative effects on water resources have not yet been registered.

- In the analysed area, there are a number of fish farms whose impact on water resources is yet to be assessed.
- The local and regional traffic is rather dense in this area and it is postulated that its impact on water resources is significant during the rainy season. This impact most probably increases for underground waters and deposits, especially in summer, when the traffic intensifies and the volume of water in accumulations and underground aquifers is minimal. This postulation has been confirmed by water quality analyses of deposits which have recorded a concentration of lead and other heavy metals.
- Port traffic has an inferior impact on water quality, only affecting the river mouth, where these activities have been developed.

The above conclusions refer to both the Croatian and Bosnian parts of the Cetina watershed.

Point sources of pollution in Croatian territory

The most damaging point sources of pollution are the settlements, followed by industry and to a lesser extent by tourism. Their polluting impact on the quality of water resources can be evaluated by water quality analysis.

The majority of settlements do not possess an adequate sewage system network. Certain parts of larger settlements utilise a system that merely collects wastewaters from the settlements and discharges them directly, without any prior treatment, into the water resources. All other wastewaters are mainly collected in propellant septic pits, causing the rapid absorption of wastewaters directly into the underground layers. The existing sewage systems, do not absorb surface rainwaters that often rush directly into water resources. Conclusively, settlements constitute the main sources of water resources pollution (Table 5.1).

Table 5.1.
Presentation of the measured characteristics of wastewaters and the quantities of organic pollution by polluters

Settl./Munic.	Number of residents	BOD_5 (mg/l) max	min	mean	KPK (mg/l) max	min	mean	BOD_5 (kg/day) (60 g/EP)
Sinj	26,410	94.9	59.9	72.0	147	84	122	1,584.6
Trilj	13,894							8,33.64
Vrlika	5,621							337.3
Hrvace	5,296							317.7
Otok	6,574							394.4
Šestanovac	3,318							199.1
Zadvarje	292							17.5
Kijevo	1,261							75.6
Civljane	1,672							100.3
Total	**64,338**							**3,860.1**

Despite the fact that most of the industries have installed a network of wastewater sewage systems, these are usually inadequate while rainwater treatment systems are often lacking. Industries thus discharge their polluted waters directly into the water resources (Table 5.2).

Table 5.2.
Overview of the largest industrial polluters (medium values)

Industry	Capacity (m^3/year)	BOD_5 (mg/l)	pH	Total N (mg/l)	KPK (mg/l)
Dalmatinka – Sinj textile industry	480,000	74	10.32	13.33	210
Cetinka – Trilj processing of plastic masses	10,000	10	7.79	6.97	38
Galeb – Omiš textile industry	52,300	150	7.36	20.95	306
Omial – Omiš processing of aluminium	30,000	49	7.19	0.234	49
Total	**572,300**				

As tourism remains undeveloped, it has not been a significant source of pollution so far. (Table 5.3). The existing tourist facilities have been developed only in the larger settlements of Sinj and Trogir. Water resources have been severely harmed by weekend holidaymakers camping by the water resources, especially by water springs. They degrade the landscape surrounding the springs and pollute the waters either directly, by dumping quantities of waste into them, or indirectly, by discarding rubbish at the expense of the environment.

Table 5.3.
Overview of the key tourism-related polluters

Region	Private accommodation	Hotels	Camping	BOD_5 (kg/day) (60 g/EP)
Sinj	20	180		14.16

Point sources of pollution in the territory of Bosnia and Herzegovina

The majority of settlements do not possess an adequate sewage system network network (Table 5.4.). Certain parts of larger settlements utilise a system that merely collects wastewaters from the settlements and discharges them directly, without any prior treatment, into the water resources. All other wastewaters are mainly collected in propellant septic pits, causing the rapid absorption of wastewaters directly into the underground layers. The existing sewage systems do not absorb surface rainwater that often rushes directly into water resources.

Table 5.4.
Overview of pollution volumes of main urban polluters

Settlement/ municipality	Number of residents	BOD_5 (kg/day) (60 g/EP)
Livno	40,600	2,436
Tomislav Grad	30,009	1,800.5
Glamoč	12,593	755.6
Kupres	9,618	577.1
Grahovo	8,311	498.7
Total	**101,131**	**6,067.9**

5.1.1.2. Coastal area

Diffuse pollution sources

As we have already mentioned in our general discussion of diffuse pollution sources, quantitative and qualitative data on diffuse pollution sources do not exist. For this reason, any scientifically validated knowledge on the impact of these on water resources and the sea is not possible in this moment. A comprehensive analysis, therefore, on this impact should be necessarily performed. Nevertheless, taking into account several general facts at our disposal, we can draw the following conclusions:

- In the analysed coastal area, agricultural activities remain undeveloped and thus do not represent a significant source of pollution.
- Any organised sanitary solid waste disposals are absent in the entire area, in which solid waste has been disposed in an unregulated manner, partially in unadjusted solid waste disposal sites. This most probably contributes to the pollution of water resources and the coastal sea.
- The air pollution in this area and its surroundings remains very low owing to its currently thinly developed industry (many former polluters have been closed down in the course of the economic transition process) and thus does not constitute a major source of pollution.
- The local and regional transportation is rather intensive and, therefore, its harmful effect upon the coastal sea can be significant, especially during the rain season.
- The port traffic has minor impact on water quality and only occurs in the river mouth area, where these activities are more prominent.

Point sources of pollution

The most damaging point sources of pollution, in the analysed coastal area are that of settlements, industry and tourism. The water quality of these pollution sources has been monitored and thus its impact on the coastal sea can be evaluated.

The majority of settlements do not have a completed sewage system network. In larger settlements, only parts have a sewage system which collects wastewaters from the settlements and discharges them directly, without prior treatment, into the coastal sea. All other wastewaters are mainly collected in septic pits that are regularly propulsive so that the wastewaters are directly sieved into the underground and from there into the sea. The sewage system, if any, does not collect the surface rainwaters which usually flow directly into the coastal sea. Accordingly, it can be concluded that the settlements are significant sources of coastal sea pollution (Table 5.5).

Table 5.5.
Presentation of main urban polluters

Settl./Munic.	Number of residents	BOD_5 (mg/l)	KPK (mg/l)	BOD_5 (kg/day) (60 g/EP)
Omiš	15,630	47.0	98	937.8

The state of the existing industry is presently in its restructuring phase, with only a few operating plants, such as those of Dugi Rat, Omiš, and Makarska. For this reason, the current pollution of the coastal sea has been only temporarily reduced.

Coastal tourism has been relatively well developed, representing a significant source of pollution. Tourist accommodation facilities have been emerging along the entire coastline, in certain smaller settlements and their surrounding area. The region does not possess a sewage system network, while wastewaters have accumulated in septic pits. As these are propellant, wastewaters are rapidly absorbed underground and flow into the sea (Table 5.6).

Table 5.6.
Types of tourist capacities with estimated organic pollution during summer

Region	Private accommodation	Hotels	Camping	BOD_5 (kg/day) (60 g/EP)
Omiš	5,128	194	223x3	361.6
Brač	7,660	3,900	690	790.1
Hvar	9,131	5,400	483	971.4
Šolta		628		45.2
Makarska	23,400	8,000	436	2,011.3
Total	**45,319**	**18,122**	**2,278**	**4,179.6**

5.1.2. The specific problems of the water and sea quality

The quality of the Cetina waters and the coastal sea has been monitored for some time. However, this analysis was not systematically organised, and therefore, neither a database nor any other appropriate system of information has been established. One such system is currently in preparation and its future operation is anticipated.

5.1.2.1. River basin

The quality of the Cetina waters has been monitored at 11 stations. This analysis is carried out 12 times annually and includes the following parameters: temperature, turbidity, free CO_2, dissolved oxygen O_2, % saturation, BOD_5, consumption $KMnO_4$, total N-N, protein N-N, NH_3-N, NO_2-N, No_3-N, chlorides, sulphates, PO_4-P, hardness, Ca-$CaCO_3$, total number of bacteria, total chollyformi in 100 ml, and faeces chollyformi in 100 ml. The Table 5.7. shows some of these values.

Table 5.7.
Data on the River Cetina water quality (mean values for 1996-1998)

Station	Indicator								
	temp. (°C)	pH	turb. SiO_2	oxyg (mg/l)	% satur.	BOD_5 (mg/l)	$KMnO_4$ (mg/l)	total. N (mg/l)	total cholly/ 100 ml
Vuković spring	10	7.25	3.2	11.3	100	1.71	9.3	0.214	254
Vinalić	10.8	7.34	3.4	10.7	96	1.7	9.13	0.204	383
Peruča	11.7	7.66	6.1	12.24	113	1.4	9.8	0.301	252
Trilj	11.2	7.56	5.42	10.8	98	2.71	9.9	0.348	1,125
Blato on the Cetina	12.7	7.85	4.5	11.0	104	2.4	9.7	0.247	1,052
Čikotina Lađa	12.17	7.87	4.0	11.1	104	2.1	9.88	0.280	941
Radman's Mlinice	13.18	7.71	5.7	10.8	104	1.7	9.9	0.185	1,094
Prančevići dam	12.57	7.8	7.5	11.1	104	2.3	10.3	0.230	968
Gata	13.11	7.8	4.5	10.8	102	1.49	9.1	0.211	486
Zadvarje	13.0	7.74	4.9	10.5	101	1.68	9.8	0.210	259
Gubavica	12.4	7.8	7.4	10.4	97	1.7	8.4	0.290	696

In addition to the measurements undertaken in the Cetina River, the water quality of its most significant sources and tributaries, such as: Mala Ruda, Velika Ruda, Grab, Kosinac, Šilovka, Studenci has also been measured (Table 5.8). This task has been carried out 12 times annually (every month), and takes in the following parameters: temperature, pH, turbidity, free CO_2, dissolved oxygen O_2, % saturation, BOD_5, consumption of $KMnO_4$, Ca-$CaCO_3$, total N-N, protein N-N, NH_3-N, NO_2-N, No_3-N, chlorides, sulphates, PO_4-P, hardness, Ca-$CaCO_3$, total number of bacteria, total chollyformi in 100 ml, and faeces chollyformi in 100 ml.

Table 5.8.
Data on the water quality of River Cetina sources and tributaries (mean values for 1996-1998)

Station	Indicator								
	temp. (°C)	pH	turb. SiO_2	oxyg. (mg/l)	% satur.	BOD_5 (mg/l)	$KMnO_4$ (mg/l)	total N (mg/l)	total cholly/ 100 ml
Mala Ruda	10.8	7.53	6	11.3	102	1.77	7.61	0.257	564
Velika Ruda – mouth	10.5	7.59	5.7	10.9	97.5	2.6	8.19	0.513	1,064
Grab	11.8	7.52	3.75	10.9	101	2	9.07	0.108	1,112
Kosinac	10.6	7.29	2.58	10.8	97	1.78	9.46	0.15	904
Šilovka	10.4	7.3	3.3	10.6	96.7	1.7	9.5	0.291	709
Studenci	12.7	7.42	4.4	11.1	106	1.07	8.5	0.05	209

The water quality in the Cetina watershed has been evaluated in the following storage reservoirs (Table 5.9):

- Peruča, 4 locations;
- Buško Blato, 4 locations;
- Jagma, 1 location;
- Lipa, 1 location;
- Prančevići, 1 location; and
- Mandaka, 1 location.

This analysis has been undertaken 12 times annually (every month) and has included the following parameters: temperature, pH, turbidity, free CO_2, dissolved oxygen O_2, % saturation, BOD_5, consumption $KMnO_4$, Ca-$CaCO_3$, total N-N, protein N-N, NH_3-N, NO_2-N, No_3-N, chlorides, sulphates, PO_4-P, hardness, Ca-$CaCO_3$, total number of bacteria, total chollyformi in 100 ml, and faeces chollyformi in 100 ml.

Table 5.9.
Data on the water quality in storage reservoirs in the Cetina watershed (mean values for 1996-1998)

Station	Indicator								
	temp. (°C)	pH	mud SiO_2	oxyg. (mg/l)	% satur.	BOD_5 (mg/l)	$KMnO_4$ (mg/l)	total N (mg/l)	total cholly/ 100 ml
Peruča dam	17.7	22	16.4	9.9-12.5	95-127	0.2-1.2	7.2-10.1	0.142	0-1,300
Buško Blato	11.4	20		8.5-13.3	67-118	1.9-3.4	7.2-10	0.233	0-1,300
Prančevići	13	28	4.8	9.8-12.6	91-123	0.5-4.9	8.2-11.6	0.434	89-1,300

It is necessary to mention that the concentration of particular indicators exceeded the permissible values in the following storage reservoirs:

- fats: Prančevići dam (16.7%);

- mineral oils: Prančevići dam (16.7%);
- phenol: Peruča (8.3%), Buško Blato (8.3%); and
- heavy metals: Prančevići dam Cd (8.3%), Pb (8.3%), Buško Blato Cr (16.7%).

From the above data, the following conclusions can be made:

- The number of measuring stations is insufficient;
- The number of annual samples is satisfactory;
- The number of measuring parameters is unsatisfactory;
- The information system is unsystematic and inadequate; and
- There is no permanent public information system.

With reference to the Cetina water quality, the following may be concluded:

- The water quality remains mainly satisfactory;
- The river has been insignificantly polluted within its upper flow;
- The river has not been polluted in its lower flow; and
- The most polluted section of the river is the part upstream of the Prančevići dam.

With reference to the water quality of the Cetina sources and tributaries, the following conclusions can be drawn:

- The water quality of the river sources remains satisfactory;
- The water quality of the river tributaries also remains satisfactory;
- The (bacteriologically) most polluted river source is Kosinac; and
- The (bacteriologically) most polluted river tributary is Grab.

With reference to the water quality in the Cetina storage reservoirs, we may conclude the following:

- The water quality is relatively satisfactory;
- The most disturbing values are those of phenols, mineral oils, Pb and Cd, which have exceeded the permissible standards;
- The lowest water quality standard has been found within the Prančevići storage reservoir; and
- The storage reservoirs are olygotrophic.

From the above data, it is apparent that the most polluted section is the area extending from Trilj to the Prančevići dam (see Figure 5.1). This area has been mainly polluted by wastewaters because the majority of agricultural areas, roads, industry and settlements are all located nearby. This section has been extremely vulnerable to pollution after the formation of the water retention of the Đale and Prančevići storage reservoirs, within which the pollution has been accumulated and dissolved.

In terms of water supply applications, the degradation rate of water quality has reached its maximum, in this section, as it is the water from the comparatively most polluted Prančevići dam, that has been supplying the regional waterlines of Makarska and Omiš-Brač-Hvar-Šolta-Vis. This is made worse by the fact that the Cetina waters of this section supply the underground waters of the Jadro source which in turn, constitutes the water supply of the 500,000 inhabitants of the town of Split.

In terms of pollution, the next most affected region is the river section crossing the Sinj field. This section has been overloaded with wastewaters discharged from the town of Sinj and its local industry, in addition to pollution deriving from agricultural and badly managed urban sectors. As a result of their present unfavourable living conditions, several animal species needing clean waters to survive, including certain commercially exploitable ones, such as the crayfish, have now become extinct. This status quo reveals that this particular section of the river has lost not only its ecological, but also its socio-economic values.

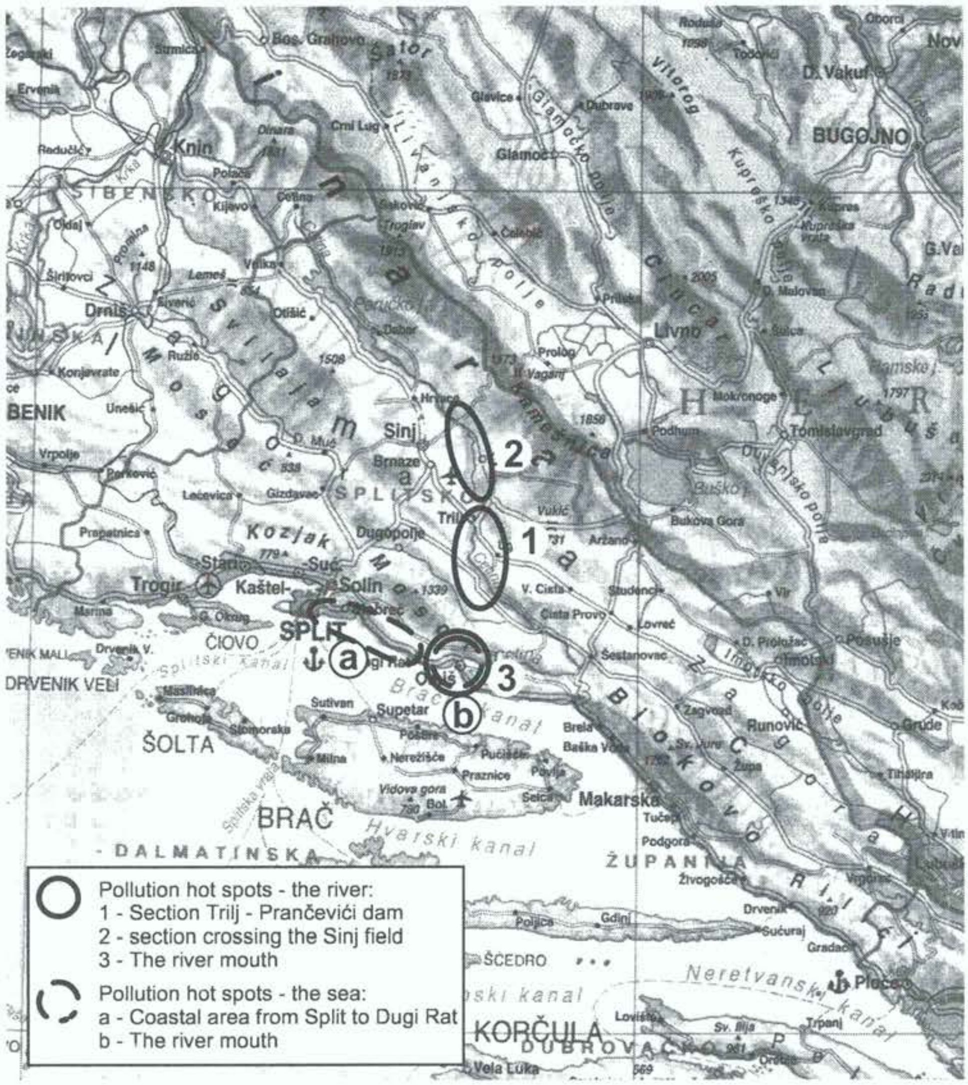

Figure 5.1: Pollution hot spots

The third most endangered area is the river mouth. This section has undergone important changes, and is densely populated. The pollution loads transferred by the river have been compounded by local pollution resulting in the absence of a number of species that could be previously found in the river mouth, an area where the river flow mixes with seawater.

5.1.2.2. Coastal area

Seawater quality can best be assessed by parameters that have been monitored over longer periods of time:

- The transparency of the seawater has been measured within a range of 5-37 m. The average value obtained was 12.23 and the standard deviation 5.74 m. The transparency changes do not indicate any development trends.
- Saturation with oxygen is one of the parameters that characterise the appearance of eutrophication in the system. The saturation level is regularly changing on a seasonal basis. The highest average values are registered at the end of September and in March, while the lowest average values are registered in December (range: 80-90%). More importantly the time and spatial distribution of the saturation level reflects the dominant phytoplankton community activities, during spring and

autumn periods, i.e. the heterotrophic deterioration of organic substances and the decrease of primary production due to the lesser insulation during winter. The alterations in the oxygen saturation level do not indicate sea pollution deriving from organic substances, nor any other disturbances within the trophic chain.

- The concentration of nutritive salts are indicative of the significant seasonal changes deriving from the primary production and the heterotrophic deterioration of organic substances. The annual changes are insignificant.
- The characteristics of the density alterations of the phytoplankton population, as well as its composition establish that these changes have not been impacted upon by land pollution, rather that they reflect the region's natural characteristics. The phytoplankton community retains all the essential characteristics of a healthy community category, and it can be concluded, that this area has not been significantly affected by any pollution originating on land.
- Specific data on the seasonal and spatial changes of the population size and the biomass of certain zoo-plankton species, show that this region is not homogenous and that there are no changes that would have been caused by anthropogenic influences.
- The main sources of the faecal pollution of the sea are the urban wastewaters discharged directly into the sea either through coastal and submarine outlets, or from septic pits without any prior treatment.

5.1.2.3. Kaštela Bay

The Kaštela Bay has not been directly affected by Cetina, but it nevertheless suffers the indirect pollution effects of wastewaters originating in the wider Cetina watershed. Considerable quantities of untreated household wastewaters are discharged into the bay in addition to partially treated industrial waters, deriving from the wider Split area. For this reason, it has long been recognised as one of the major "hot spots" along the Croatian coast. The water supply of the Kaštela Bay area comes from the Jadro river source.

The Kaštela bay is the largest in central Dalmatia. Its total surface area is 61 km^2 and with an average depth 23 m, its volume amounts to 1.4 km^3. It is bordered by the Čiovo and Split peninsulas to the south, and the Kozjak mountain slopes to the north. The eastern part of the bay receives the karstic waters of the Jadro river with an average annual flow rate of 10 m^3/s. This rate can vary greatly from one season to another, by an analogy of the 2/3 of the total quantity, derived in winter months. The narrow coastal strip is densely populated and hosts various industries.

The wastewaters of these industries are mainly discharged into the eastern part of the bay. It is estimated that the bay receives a total wastewater volume of approximately 30 million m^3 (annually). The total pollution load the bay is subject to, is also high (Table 5.10), while additional sources of high pollution levels are those of storm and surface runoff waters.

The Kaštela Bay exchanges waters with the neighbouring Split Channel, through the passage between the Split and Čiovo peninsulas. The average time needed for the change of the total water mass of the bay is approximately one month, while the same period for the eastern part of the bay, which receives most of the wastewaters, is only about 15 days. Given that the total volume of the bay is four times that of the eastern part, the speed of water mass change in the eastern part is lower than that of the bay as a whole. Therefore, the eastern part designates a lower aeration, especially during warmer seasons, and it is thus more vulnerable to pollution effects.

Table 5.10.
Estimated load of the Kaštela Bay by pollutants from various sources

Source	BOD_5 (t/year)	Suspended matter (t/year)	$P_{inorganic}$ (t/year)	$N_{inorganic}$ (t/year)
Household wastewaters	2,226	2,431	14.1	64.8
Industrial wastewaters	1,562	954	3.1	14.4
Storm waters	984	4,920	-	-
Sedimentation from atmosphere	-	-	1.2	9.6
Ground waters	205	89	-	-
Surface runoff	27	87	6.1	16.0
Rivers	388	1,419	6.5	55.2
Total	**5,392**	**9,900**	**31.0**	**160.0**

The change of temperature over the water column can be explained as an analogical consequent of the surface's seasonal conditions. The thermocline is present in the period between April and October, in depths between 10 and 25 m. Fresh water inflows have a minor effect on the distribution of salinity in the Bay.

With regard to primary production, the bay is naturally highly productive. Unfortunately, due to wastewater discharges, the primary production in the central part of the bay has doubled over the past 20 years. The summer of 1980 was the first time that a "red tide", that is to say, an extreme bloom of a *dinoflagellatae* species named *Gonyaulax polyedra*, occurred in the eastern part of the bay. This phenomenon caused the mass mortality of sea organisms, by diminishing the oxygen concentration rate (found) in the water column. In recent years, "red tide" has frequently occurred, as a result of the fact that household wastewaters are being discharged into the eastern part of the bay. The phytoplankton population has undergone significant changes. More specifically the typically diatomeian community has been gradually transformed into *dinoflagellatae*. The increase of the *dinoflagellatae* ration was followed by a corresponding increase of the primary production ratio. New species have emerged, such as *Alexandrium minutum*. The research performed over the past 30 years has revealed alterations to the bottom flora, as well. Of particular interest is the introduction of new species that have been classified as nitrofile species. The bay's eutrophic conditions favoured their emergence.

Eutrophication has reached disturbing levels. Nitrate concentrations have been constantly growing over the past 20 years, while the nitrogen/phosphorus concentration ratio has dropped, which is indicative of the introduction of phosphorus into the bay through wastewaters. The dissolved oxygen concentration has been increased in the euphotic layer, and has decreased in the bottom layer. These diametrically opposed compositions, with regard to oxygen dissolution, indicate a long-term trend of intensified photosynthetic activity of the phytoplankton in the euphotic layer, and an increased decomposition of organic matter in the bottom layer. Long-term measurements of transparency using the Sechi plate method, confirm the increased intensity of eutrophication in the bay which has a highly negative impact on the bay's ecosystem.

In most of the bay area, the concentrations of faecal pollution indicators in the surface layer exceed acceptable values for bathing and recreational sea waters. The physical distribution of faecal pollution indicators shows that polluted waters spread from the eastern part of the bay, facilitated by winds. As a result, the otherwise attractive beaches of the bay are rendered unsuitable for bathing.

5.1.3. Particularly sensitive areas and areas of high risk

5.1.3.1. River basin

As has already been mentioned, the river sections most vulnerable to pollution are (Figure 5.2):

- the section crossing the Sinj field and the river mouth, from a broader environmental point of view; and
- the section of Trilj, including the Prančevići storage reservoir, from the viewpoint of water supply.

The river in the Sinj field retains the optimal characteristics for the development of the particular species of the mountain/river ecosystems (the slow, calm flow, banks rich in vegetation and a wide, rich riverbed). This explains the fact that this particular river section used to be quite rich in high-bred fish and crayfish, as well as in other species that had been inhabiting the river and its surrounding area. The construction of the Peruča storage reservoir, by altering the river's flow, temperature and composition, caused damaging changes in terms of both the characteristics of the section's natural habitats and their biocenosis. Moreover, the entire river's natural characteristics and biotope have been changed, while the construction of artificial dams to direct the migration of its species have resulted in severe biological changes within the entire Cetina flow.

The river mouth is the area where its clean, nutrient-rich waters meet the sea. This location is extremely significant to the survival of the numerous species as it has been their home, spawning and breeding area. This area had also constituted an important habitat for many migratory species of birds and fish. By the construction of storage reservoirs, and especially of the Zakučac HPP, the annual and daily cycles of the natural water regime of the river mouth had been completely changed.

The quality control of the Prančevići reservoir water is also of utmost importance, as this storage reservoir supplies a broad area with water. All pollution originating upstream rapidly accumulates here, jeopardising the lives of residents and tourists. As the waters of the Prančevići dam flow underground, directly influencing the Jadro river source, the reach of threats to the residents and tourists alike is far broader, encompassing the entire area of Split.

An additional sensitive category is the area embracing the river sources that are located downstream of Trilj, such as Ruda and Kosinac, which supply the wider area extending from Sinj to Omiš. These sources are extremely sensitive to any pollution deriving from the higher horizons of the Livno, Duvno, Glamoč and Kupres fields. Among the most sensitive areas of the Cetina watershed are its sections belonging to the Jadro and Žrnovnica sources. Considering the particular karstic characteristics of this area, these sources can be extremely vulnerable to any surface pollution. As these sources are connected with Cetina, their pollution directly impacts not only upon the water supply of Split, downstream from Trilj, but also on the broader area stretching to the edges of the watershed.

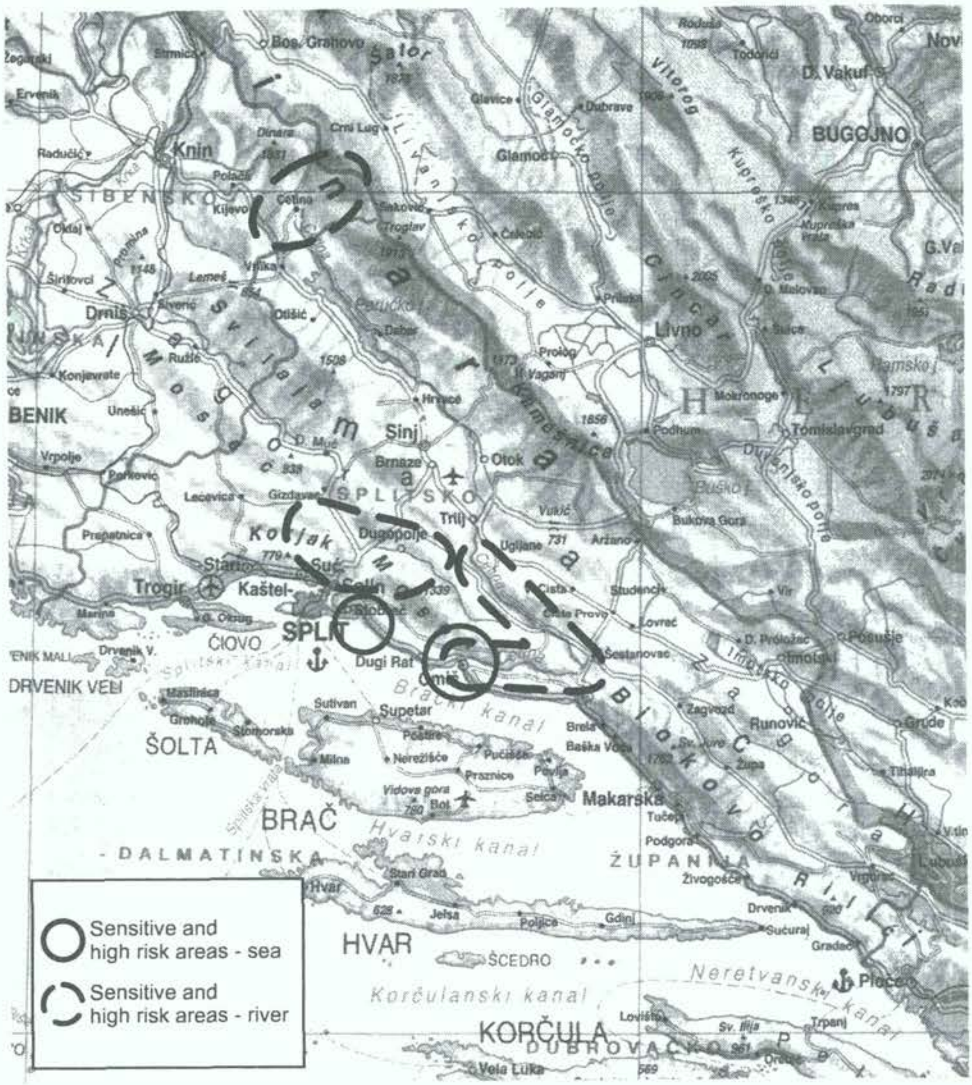

Figure 5.2: Sensitive and high risk areas

5.1.3.2. Coastal area

In the coastal part of the watershed, the Cetina and Žrnovnica mouths constitute particularly sensitive areas (Figure 5.2). These sections retain specific ecological conditions that favour the development of the larvae and juvenile states of many organisms, especially those that can be commercially exploited.

Additionally, the river mouths are areas that are most at risk from pollution originating in the rivers. The Žrnovnica mouth is particularly threatened by the unplanned and random interventions occurring in this area, such as the coastal population density, as well as by the scheduled marina development. At particularly high risk is the area south-west of the Lav hotel, where the construction of a submarine outlet for the urban wastewaters, discharged from the broader Split and Solin areas, has been planned.

5.2. Freshwater shortages and quality degradation

5.2.1. Surface water

5.2.1.1. Surface water sources and water flows status

As it has been already mentioned in Chapter 2, the Cetina River basin is relatively rich in surface waters, but not particularly rich in water flows. Due to the particular karstic terrain characteristics, the favourable conditions for the formation of a larger number of surface waters flows are absent, and consequently, Cetina has been additionally supplied by the water of several karstic sources. The surface flows are formed at higher horizons and during the winter period, penetrating into the ground and appearing again at the surfaces of lower horizons, forming Cetina. These surface water flows are: Jaruga, Plavuča, Bistrica, Sturba and Mandak, in the Livno field; Šujica, in the Duvno field; and Ribnjak, in the Glamoč field. Within the Sinj field, some short but permanent water flows, such as Karakašica and Ruda are significant. Downstream of Trilj, at some 50% of its entire flow length, the Cetina passes through the deep, rocky canyon with neither significant tributaries, nor permanent waterflows.

A commonly shared characteristic of the surface waters is the large fluctuation of their flow volume, which is the result of variations in climate, i.e. cold and rainy winters and dry and warm summers, as well as of the particular geological characteristics of the karstic area, with few underground deposits and rapid water flows. For this reason, large quantities of water rapidly flow from the underground into the surface flows, and then into the sea. From a globally-informed perspective and over a year-long period, the surface waters appear rich and sufficient for the needs of the entire area. From the viewpoint of water exploitation, however, which reaches its peak during the summer period, water volumes remain insufficient during the summer because most stocks dry out. The Cetina flow represents the exception, given that due to the construction of the Buško Blato and Peruča storage reservoirs, it is now completely regulated without any seasonal flow fluctuations, providing an average of 118 m^3/s, even during the summer months.

5.2.1.2. Demand for surface water use (by sector)

The major uses of the river basin's water are the following: hydro-power production; water supply; irrigation; fishing; tourism and recreation and the maintenance of the ecosystem. Given that its topographic characteristics are extremely favourable, Cetina and its major tributaries are currently the most appropriate water sources for both hydro-power production and water supply applications. Five large hydro-power plants (HPPs) have already been constructed, while another twelve smaller plants have been scheduled. Such high concentration of HPPs on a river only 105 km long is extremely problematic.

The surface waters are rarely used for water supply directly from the water flow or indirectly from the surface water sources. The main water supply systems that utilise the Cetina surface waters are those of Makarska, and the regional systems of Omiš-Brač-Hvar-Šolta-Vis. The water volume of the demand of these systems has been estimated to be approximately 2.5 m^3/s. The long-term plan tackling the use of Cetina waters has included its future industrial use in the area of Split, in the amount of 1.0 m^3.

Despite the fact that irrigation needs are in principle greater, they have not yet been forcefully promoted, given that the needed irrigation systems have not been completed.

The estimated water quantities for field irrigation reach their highest levels for the higher elevated Livno and Duvno fields ($20 \cdot 10^6 m^3$), as well as for the Sinj field ($10 \cdot 10^6 m^3$).

Today, Cetina and its tributaries supply fish farms, of which the largest is located on Ruda. Several additional farms are expected to operate along the entire river.

The numerous sources, fast streams and smaller waterfalls of Cetina are a magnet for tourism and recreational activities throughout the year and especially during the summer when the surrounding landscape offers good recreational opportunities. The river's reservoir lakes and the mountainous scenery are also a natural setting for recreational activities, including fishing and various watersports. Despite the fact that these activities are at an embryonic stage, excellent prospects for development exist.

5.2.1.3. Areas lacking surface water or areas with the low-quality surface water

Considering the present level of development with regard to the entire river basin, it could be argued that no water shortage is evident. However, certain river basin locations have suffered water shortages, particularly during the summer period. This implies that appropriate water storage facilities should be constructed for the water storage and for the transfer of surplus water quantities from locations with sufficient water quantities to those experiencing scarcity. From the above mentioned fact, it can be concluded that this area is characterised by a so-called "socio-economic drought".

Shortage of water is particularly evident in the highly elevated Bosnian fields, such as the Livno, Glamoč and Duvno fields, from where the water rapidly flows to lower surfaces, leaving the local springs completely dry during the summer. Another area that lacks water is the area downstream of Trilj to Kraljevac. The river flows through a deep canyon, so that the river waters are not directly accessible. Given that there are neither surface, nor any underground waters in this river section, this area remains extremely dry throughout the entire year. To make matters worse, this particular river section remains the most polluted and the least exploitable. Consequently, the area's water supply depends to a great extend on the availability of rainwater.

5.2.1.4. Causes of conflicts and problems including sectoral demand for surface water and water supply restrictions

Reflecting on the analysis of the entire area, we may conclude that water shortage cannot be established. It should be pinpointed, however, that plans relating to a well-developed and rational water utilisation strategy, as well as to the availability of adequate financial resources required for the construction of specific facilities, are both absent. This clearly places the problem within the sphere of water resource management.

Given that Cetina's topographic characteristics enormously favour the generation of hydro-electric power, severe conflicts have arisen between the managing bodies of hydro-electric applications and those managing the remaining water applications, including the ecologically prescribed requirements relating to the water flow and the environment. More specifically, the Croatian Electricity Company, that manages the operation of the HPPs in Croatia, is not likely to decrease its water demand for the sake of other consumers.

The main shortage of water in particular river sections has been experienced in ecological terms, as their flow rate has been drastically decreased. This has mostly been the case for the river sections downstream from the HPP Kraljevac. The reason for this is the diversion of the above stream towards the Prančevići dam for its power generation supply needs. These changes are accentuated due to the reduction of the flow capacity of all the underground waters in this section.

The high level of the underground waters in the Sinj field, which is a consequence of the levelling of the river flow in addition to the creation of a water flow retention by the Đale HPP, is also problematic. This difficulty, previously only registered during the rainy winter periods, is now occurring frequently during the vegetation (drought) periods, thus jeopardising agricultural production in a certain part of the Sinj field.

The current situation has mostly harmed the river's ecological system as a whole. This impairment has been reflected in the alterations to the river's natural appearance, water regime and quality. These changes have triggered numerous ecological disturbances in both the river and the coastal area that have not yet been assessed in detail.

A growing problem that demands attention has been the alteration of the approach to water use imposed by the existing market economy regulations. As Croatia and Bosnia and Herzegovina constitute countries in transition from a socialist to a free market economy, and as they are required to transform their old habits and adapt to new situations, a number of conflicts relating to the division and use of the Cetina waters have arisen, mostly between their private and public sectors.

5.2.1.5. Impacts of global changes on surface water

Global climatic changes may also result in alterations to the river basin. However, an analysis assessing such impacts has yet to be implemented. We are thus unable to estimate the possible impact of global changes on the river basin in this general study.

According to certain general facts, global climatic changes will be reflected in an extreme increase of rains and temperature. If these extremes, as it has been postulated, increase due to the climatic changes, they would severely impact upon the water supply. This is because water quality would deteriorate as a result of the intensive washing of the terrain, while an increase of water quantities would overcome the capacities of the flood protection system. The extreme droughts would negatively affect field irrigation and water supply, while endangering several species.

5.2.1.6. Proposed interventions and sustainable rates of surface water extraction

In terms of the future improvement of the current state of the Cetina watershed, the preparation of a holistic and detailed water management strategy, constitutes an imperative. This strategy must follow the new developments presently occurring within the political system, and anticipate any future requirements and conflicts. Furthermore, it should critically reconsider the extensive current use of the Cetina waters for hydro-electric power production, and suggest optimal solutions for water use based on the principles of sustainable development.

The most ecologically endangered river section, as a result of decreased water flow rates, is the section spanning from Prančevići to Omiš. Here, the water flow rate, e.g. the water flow capacity from the storage reservoir Prančevići in the direction of Kraljevac, and further on, should be increased. This would significantly improve the ecological conditions and at the same time, it would contribute to an improved water quality for the water supply systems of the Makarska region and the Omiš hinterland. As none of the villages within the river basin possess wastewater treatment systems, the first priority in terms of the protection of water quality should be the construction of wastewater treatment systems at the main sources of pollution (larger settlements). Priority should be given to the towns of Sinj and Trilj to protect the large downstream water supply systems, to the town of Livno, to protect the water supply systems in the Sinj field and then to all other settlements in the area.

5.2.2. Groundwater

5.2.2.1. Groundwater aquifers and their current status

As we have already mentioned in Chapter 2, the karstic aquifers in the analysed area are characterised by rapid water exchanges and small retention capacities. Their karstic, rocky geological composition does not permit the required degree of absorption, or the longer-term accumulation of underground deposits. It is characterised by its cracks and smaller or larger openings through which the water of the higher horizons can in relatively rapid and concentrated fashion, flow towards lower parts, in the form of karstic springs (Figure 5.3). These springs form surface flows and finally the Cetina River. Due to the pre-mentioned characteristics, the aquifers' quantities depend on volumes of rainwater and it thus decreases significantly, over summer periods. The large oscillations of the underground water levels, as well as, the geological composition of the ground does not favour the exploitation of these aquifers, except from the surfaces upon which they emerge, as in the case of springs.

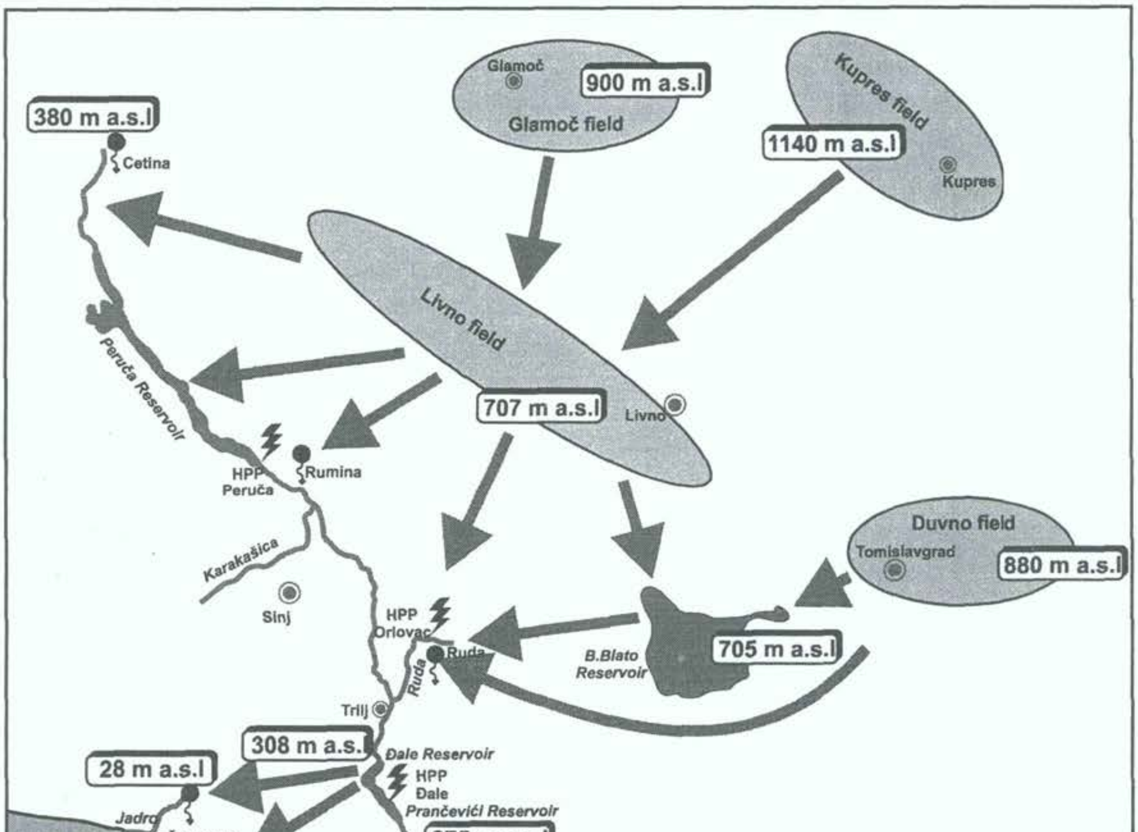

Figure 5.3: The topology of systems in the River Cetina watershed and their interrelations

We must distinguish between the high aquifers above the plateau of the Sinj field and the low aquifers underneath it. The high aquifers supplied by waters extracted from the Livno, Glamoč and Duvno fields, as well as by those obtained from the high surrounding mountains, are used in the supply of the lower plateau of the Sinj field, from the water intakes of the Ruda, Kosinac and other springs, but not directly from the underground (i.e. wells or similar). The existing capacities of these springs have only been partially exploited.

The other group of aquifers are the water flows between Cetina and the sea. All along the coastline, a barrier has been erected to prevent the hinterland underground waters from rushing into the sea, creating in this way, the aquifers in the immediate hinterland of the coast. The water from these aquifers makes its way to the surface in the coastal area region either in the form of surface or submarine springs. The Jadro and Žrnovnica springs are the major springs supplying the region of Split, as well as the submarine springs of Pantana and Vrulja that mix with salty seawater. These aquifers cannot be exploited directly from the underground through bored wells or similar constructions due to the karstic characteristics of the terrain,. The extraction of water from their springs constitutes a more rational solution. The Jadro spring, being the largest, is practically completely exploited for the water supply of Split (the minimum capacity of the spring is 4.0 m^3/s, the maximum is approximately 60 m^3/s, while its average one 9.5 m^3/s). The entire capacity of the Žrnovnica spring is also earmarked for the water supply of the Split region. This implies that all the easily accessible and exploitable capacities of these flow carriers have already been utilised.

The quality of aquifers remains satisfactory, despite the fact that these have already been polluted by wastewater deriving from settlements located upstream. All springs and aquifers contain significant bacteriological pollution, which has been reflected more in the inhabited parts of the aquifers than in the unoccupied parts. In addition to bacteriological pollution, other substances have been registered which still remain within the permitted margin of concentrations.

5.2.2.2. Demand for groundwater use (by sector)

A further exploitation of aquifers, one utilising their springs has been planned, in accordance with the existing plans and requirements, both in higher terrains and by the sea. This exploitation has been largely planned to meet water supply and bottled water production needs.

In addition to their water supply utilisation, the aquifers would be harnessed for other applications, such as fish farming. The largest fish farm is currently located at the Ruda spring, while the construction of several new fish farms has been programmed. Additionally, the construction of the smaller HPPs (Ruda I and II, etc.) has been planned for installation in every significant river source.

Furthermore, the areas surrounding the sources, given that they attract tourists and locals alike, should be preserved in their natural state. Because all these water sources (springs) supplement the adjacent water flows their water flow capacity should be restricted up to the imposed biological minimum flow.

Finally, it can be concluded, that there is a great demand for groundwater use, but it has been incompatible with the existing availability, which is reflected in the present conflicts. It has also been clear that the preparation of a comprehensive study on the applications of the Cetina waters is essential.

5.2.2.3. Areas lacking underground water and areas with low-quality underground water

It is evident that due to the area's geological characteristics, there is a shortage of underground waters within the entire Cetina watershed. As it has already been mentioned, only the springs of the underground waters have been directly used. The quality of the underground waters declines as it flows from the upper stream, towards the lower stream sections, i.e. from higher to lower water springs positions, following the topography of the terrain (Figure 5.3 and 5.4). Accordingly, the best water quality has been registered in mountainous water springs, while the worst prevails in the springs by the sea. Since it is the coastal springs that are mainly exploited, quality problems are more accentuated here. This is the case with particular regard to the Jadro and Žrnovnica springs that have been supplying the broader Split region, as well as the Kosinac and Ruda springs which supply the Sinj area.

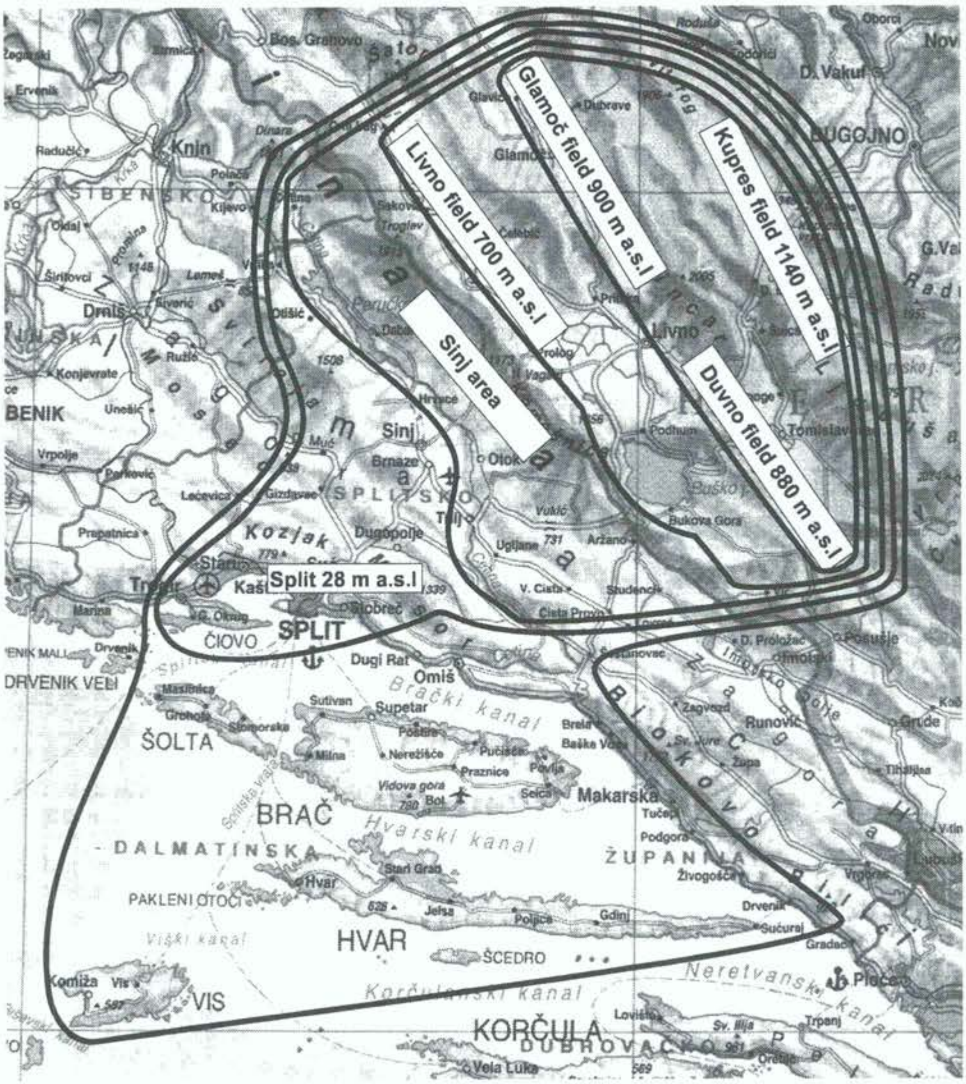

Figure 5.4: Hierarchy and impact of particular areas on water system and wider area

5.2.2.4. Causes of problems and issues including sectoral groundwater demand and water supply restrictions

Since water only accumulates underground for short periods and is hardly filtered, all the aquifers of the analysed area are exposed to surface pollution. For this reason, all aquifers are polluted to a larger or lesser extent by wastewaters. As their current pollution levels remain relatively low (due to the high distribution rate), they cannot constitute a threat to the water supply system. However, an intensified development of settlements within the watershed, would gradually increase the existing pollution levels, endangering the quality of the water supply.

Given the specific terrain configuration, it would be very difficult to create sanitary protection zones. More specifically, if we apply the common criterion for the definition of sanitary protection zones, i.e. that the time the water flow needs to cover the distance from the surface to the spring is 50 days, then the entire Cetina watershed would be defined as a zone under severe sanitary protection, in which settlement development and all economic activities should be prohibited, while the entire area should be evacuated.

This situation has severe repercussions for the development of the analysed area. The utilisation of underground waters for water supply presupposes the completion of a very costly transportation and sewage infrastructure, including the already limited use of the specific part of the watershed, where the construction of industrial facilities and storage of various materials, including the intensive development of agriculture and cattle breeding, needs to be prohibited. This would bring the entire watershed area into a disadvantaged position by comparison to other, especially coastal regions, which would in turn be the major cause of these prohibitions, as these are the main users of these waters. In recent years, we have been witnessing a growing conflict between the watershed (river basins) users and those utilising their springs in the coastal region, as the hinterland development has intensified due to the relatively cheap land and other benefits. Unfortunately, this development has not been complemented by the necessary measures and an adequate infrastructure that would protect the water springs from pollution. For this reason, it is postulated that water supply from the springs will remain a thorny issue.

5.2.2.5. Impact of global changes on groundwater

Global climatic changes might be partially causing the changes to the river basin and the underground waters. So far, a detailed analysis has not been undertaken; for this reason, any eventual impacts on the river basin and the underground waters caused by global changes cannot be assessed by this study. Any climatic changes would be manifested by increased incidence of extreme rains and temperatures. These would considerably affect the water supply. This is because water quality would deteriorate as a result of the intensive washing of the terrain, while the extreme droughts would negatively affect field irrigation and water supply.

5.2.2.6. Proposed interventions and sustainable rates of water use

In the analysed area, the problem of the excessive exploitation of underground waters has not really been addressed, despite the fact that certain springs have been fully exploited, and certain neighbouring springs represent possible alternatives. The problem is ultimately of a financial nature, given the cost of the completion of the necessary facilities for both the extraction and the distribution of the water supply.

Some springs, such as the Ruda spring, could be used for several applications, including water supply, hydro electrical power production, irrigation, fish farming, bottled water production and excursion tourism. This would require the preparation of relevant water-use plans within the framework of an integrated Cetina River watershed management plan.

Most pressing, however, are the issues relating to the pollution of underground waters, as well as their protection. In order to protect the springs used for water supply purposes, substantial financial resources must be invested in the installation of facilities, especially of sewage systems in smaller and isolated settlements as well as drainage and treatment systems for transportation routes and for surface waters and rainwater. Such projects can be very expensive in terms of both their implementation and maintenance. For this reason, the preparation of an integrated strategy for the entire watershed development and the use of underground and other waters of the relevant area is essential.

5.3. Threats to living marine resources

5.3.1. Status: productivity and human impact

The Brač Channel represents a very important fishing area, in which, according to maritime legislation, commercial, small-scale and recreational fishing can be practised. Here, the pelagic and benthos (demersal) fish species, as well as other benthos organisms are being fished.

5.3.1.1. Pelagic fish

Among the pelagic fish species inhabiting the Brač Channel, large and small pelagic fish could be found. Within the category of the small pelagic species, the most frequently fished are the pilchard (*Sardina Pilchardus*), anchovy (*Engraulis encrasicolus*) and horse mackerel (*Trachurus trachurus*) and of big pelagic fish, bonito (*Sarda sarda*), trigate mackerel (*Auxis rochei*) and tunny (*Thunnus thynnus*). With reference to other pelagic fish species of the Brač Channel, the sand shell (*Atherina hepsetus*), the black sea mullet (*Liza ramada*), the golden grey mullet (*Liza aurata*) and the leaping grey mullet (*Liza saliens*) could also be found.

5.3.1.2. Benthos species and other benthos sea organisms

In terms of their commercial significance, the following fish species and other benthos sea organisms, can be found in the Brač Channel waters: the hake (*Merluccius merluccius),* poor cod (*Trisopterus minutus copelanus),* dory (*Zeus faber*), red mullet (*Mullus barbatus*), striped surmullet (*Mullus surmuletus),* picarel (*Spicara smaris*), black scorpion fish (*Scorpaena porcus*), bogue (*boops boops),* striped bream (*Lithognathus mormyris*), charp snouted sparus (*Diplodus puntazzo*), bamboo fish (*Sarpa salpa*), two-banded bream (*Diplodus vulgaris*), dentex (*Dentex dentex*), sea bream (*Pagellus erythrinus*), gilthead (*Sparus aurata*), saddled bream (*Oblada melanura*), eel (*Anguilla anguilla*), musk poulp (*Ozaena moschata*), cuttle (*Sepia officinalis*) and lobster (*Nephrop nor vegicus*).

5.3.2. Fish catch

It is impossible to explicate any data on the total annual exploitation of fish and other sea organisms in the Brač Channel, or on the catch of individual species, because such quantitative and qualitative data has never been gathered for any type of fishing. It is also impossible to document either the present status and state of the fish habitats and those of other sea organisms, or the possibilities of development of the area's fishing industry, as this kind of research has never been systematically performed. Drawing upon previous sporadic data, and exclusively upon the application of certain fishing tools, only some general points on current status of certain habitats could be presented, with particular reference to commercially exploited fish and other sea organisms, as well as on catch potentials and future prospects for development of fishing in the Brač Channel region.

The qualitative and quantitative research on the status of the demersal habitats of the Split Channel (whose results can also be applied on the habitats of Brač Channel) was conducted in September 1990. Utilising pull/trawl method by a bottom fishing boat of 109 min. duration, it was established that 83.53 kg of fish and other sea organisms could be caught, i.e. 46.0 kg per pulling hour. This rate is significantly lower than the rate found 20-30 years ago, in the same area. Of the total catch, almost half the mass (45.7%) was hake (*Merlucius merlucius*) and 14% red mullet (*Mulus barbatus*).

The research of the coastal habitats of fish and other sea organisms, in September 1990, had utilised "poponica" nets. It established that the entire area has been intensively exploited, with expressed indicators of over-fishing (small mass of catch, poor quality of the catch composition and the absence of many species of fish from the catch, to name but a few).

The qualitative and quantitative structure of the fish catch applying the "kogola" method (the coastal pulling net with a rod between the wing ends of the net) on the area between Supetar and Splitska in the Brač island, undertaken in March 1988 and November 1989 yielded similar results as did research teams using an inshore trawling net in the Lokva Rogoznica area in February 1991 and an inshore "Tartan" type trawler in the Duilovo area in March 1991. In all the above catches mainly picarel (*Spicara smaris*) and blotched picarel (*Spicara maena*) prevailed.

The results of initial, recently completed research on Norway lobster habitats shows that this species possesses a very significant potential and that the proper management of these habitats would assure the permanent exploitation of this species (Table 5.11).

Table 5.11.
Results of catch with traps from the net tow for the fishing of lobster in the Hvar and Brač Channel in May 1997

No. of traps	Eyelet size (mm)	Catch						Total		Catch per trap	
		I drawing out		II drawing out		III drawing out					
		PCs.	Mass (g)	PCs.	Mass (g)	PCs.	Mass (g)	PCs.	Mass (g)	PCs.	Mass (g)
32	18	78	3,400	107	4,500	36	1,400	221	9,300	2.3	96.87
96	20	144	7,000	134	6,500	143	7,200	421	20,700	1.46	71.87
207	22	258	14,800	192	10,080	253	14,700	703	39,580	1.13	63.73

5.3.2.1. Human impact

It has been estimated that around 190 natural and legally entitled persons listed or resident in the villages of the Brač Channel area are currently engaged in commercial fishing. Their fishing activities involve almost every type of fishing tool used in remaining Croatian fishing territory. The types and quantity of the fishing tools utilised are explicated in Table 5.12.

Table 5.12.
Number of permits and total number of fishing tools by type registered in the Brač Channel area

Tools/equipment	No. of permits/length (m)/pieces
A. Trawling nets (fishing boats)	
a) Trawlers (max. power 184 kW)	86
b) Inshore trawlers (total engine power 18.5 kW)	41
c) Pelagic fishing boats	13
B. Floating nets	
a) Floating nets for small blue fish	34
b) Floating nets for small blue fish (tuna)	13
c) Floating net for mullet	37
d) Floating net for garfish	4
e) Floating net for smelt oliga	1
C. Inshore trawling nets	
a) Trawling net for pilchard	10
b) Trawling net for picarel	65
c) Trawling net for garfish	5
D. One layer stagnant net for fishing of:	
a) Smelt oliga	1,300 m
b) Smelt	15,765
c) Picarel	22,500 m
d) Pilchard	1,700 m
e) Bogue	45,900 m
f) Various fish	89,050 m
g) Bonito	9,100 m
h) Sea game	81,000 m
i) Lobster	16,600 m
E. Triple layer stagnant nets for fishing of:	
a) Various fish and other sea organisms ("poponica")	55,250 m
b) Sole	7,300 m
F. One layer – triple layer stagnant nets for:	
a) Bamboo fish	7,800 m
b) Cuttle	1,000 m
G. Traps for:	
a) Fish	810 PCs
b) Lobster	746 PCs
c) Norway lobster	2,210 PCs
H. Hook fishing tools	
a) Fish lines	3,255 PCs
b) Fishlines for Cephalopods	2,070 PCs
c) Stagnant fish line	155,000 hooks
d) Floating fish line	3.000 hooks
I. Fishing with stagnant nets and trawling nets with usage of fish shocking rope which embraces the fishing section	12 privileges
J. Hunt for the big sea worm	437 devices
K. Trident	265 PCs

According to the respective legislation, small-scale fishing should not constitute a commercial activity, but is only permissible to cover personal needs. Today, in the Brač Channel area alone, 800 permits have been issued for this type of fishing. It remains unknown what type and quantity of fishing methods the holders of these permits use. Nevertheless, the current legislation permits only a total of 250 m length for all types of nets with reference to small-scale fishing utilising one or triple-layer stagnant nets. This legislation also prescribes which permissible fishing methods. (Table 5.13).

Table 5.13.
Type and number of fishing tools/equipment allowed for small fishing

Tools/equipment	No. of permits/length (m)/pieces
A. One layer stagnant net for fishing of:	
a) Smelt oliga	Up to 50 m
b) Smelt	Up to 60 m
c) Picarel	Up to 120 m
d) Menula	Up to 120 m
e) Bogue	Up to 100 m
f) Various fish	Up to 200 m
B. Triple layer stagnant nets for fishing of:	
a) various fish and other sea organisms ("poponica")	Up to 150 m
C. Traps for fishing	Up to 5 PCs
D. Hook fishing tools	
a) Various fish lines	Up to 50 PCs
b) Fish line	Up to 50 hooks
E. Hunt for the big sea worm	3 PCs
F. Inshore trawling nets without spreaders (with rod or stick)	2 PCs
G. Tools for collection of shells (pliers, shell cleaning tools, etc.)	Of each tool 1

Furthermore, in the Brač Channel area, approximately 8,000 permits have been issued to locals for recreational fishing. The type of method and quantity of fishing equipment involved in this fishing category is presented in Table 5.14.

With reference to the commercial fishing category, in the Brač Channel, 196 vessels have been registered, of which:

- 58 can be classified as "ships" – accordingly to the criteria that their length and volume should be over 12 m and 15 GT, respectively; and
- the rest, i.e. 138 are classified as "boats" with the length and volume below 12 m and 15 GT, respectively.

Table 5.14.
Type and number of fishing equipment allowed for sports-recreational fishing

Tools/equipment	No. of permits/length (m)/pieces
A. Hook equipment	
a) Different fish lines	19 PCs
b) Fish line	up to 150 hooks
B. Stabbing tools	
a) Trident	3 PCs
b) Underwater gun with harpoon or trident	3 PCs
C. Device for catching shellfish	3 PCs
D. Device for catching the big sea worm	3 PCs

Most of the "ship" vessels do not operate here, because they constitute professionally-equipped ships, with an engine power of over 184 kW, and they are thus prohibited from utilising trawling nets in the inshore fishing grounds, or they constitute specialised ships for tuna fishing in the open Adriatic. A proportion of the "ship" category members catch small blue fish, as well as anchovies, utilising floating nets and illumination. A proportion of the "boat" category members possessing engine power of less than 184 kW, use trawling nets, in periods in which this type of fishing is permitted. In addition to the use of trawling nets, these boats also use every other legally prescribed method.

With reference to small-scale fishing, this may be undertaken exclusively by "boats". These boats are estimated to be around 800, judging by the number of permits granted. In small-scale fishing there are not any particular vessel requirements, while such permit-holders may utilise any method conforming to the existing legislation. It is impossible to determine the number and type of vessels operating in every location, since there has never been any systematic registration organised at the local level beyond that of the branch offices of the Ministry of Agriculture and Forestry in the counties issuing permits.

5.3.2.2. Prohibitions and fishing quotas

Like other fishing zones, the Brač Channel is governed by certain prohibitions and quotas relating to fishing. It is prohibited to collect the date-shell (*Litophaga litophaga*), even in the northern coast of Brač, which is very rich in this shell. The method of trawling nets is also restricted, not only to certain periods of time, but also in terms of the vessels' engine capacity.

The method using either stagnant nets or trawling nets with fish shocking rope is also restricted, permitted only from beginning July until the end of August, along the northern coast of Brač, and solely along the following sections:

- The cape of Gomilica to the western cape of Livka bay;
- Outside the Supetar port light to the western cape of Zastup bay;
- The eastern cape of Trstena bay to the eastern cape of Česminova bay;
- The eastern cape of Veselje bay to the Crni cape; and
- The eastern cape of Tičja luka to the cape of Sumartin.

Other common fishing techniques may be used in the Brač Channel area providing that they conform to the existing maritime legislation.

5.3.2.3. Fishing-related economic activities

The most substantial economic activities relating to fishing are those of the fish processing industry. In the Brač Channel region, there are two fish processing units, operating on the Brač island at Postira and Milna.

The "Sardina" fish factory in Postira had been established as early as 1906 and today specialises in blue fish products, processing an annual catch of some 4,000 tons and annually producing 2,000,000 tins of fish. They also produce fish meal with an annual production total of 200 tons, and run their own site producing aluminium (packing tins) and a sea bass (*Dicentrarchus labrax*) and gilthead (*Sparus aurata*) farm. The farm produces an average of 90 tons of commercial fish.

Another fish processing factory is run by "Bračanka" Ltd, established in Milna in 1908. It is equipped with its own fish processing and tin-filling facilities, specialising in tuna and anchovy products, with an annual production rate of 10,000,000 tins. This factory is also equipped with fish preparation facilities for the packaging of 360-480 tons of fish and other sea products. It imports its raw material from New Zealand, with the exception of anchovy that is supplied from our own waters. The firm owns its own fishing fleet of six ships, of which three are for small and large blue fish and three are for the fishing of demersal fish. These are equipped with their own freezers that keep the catch fresh, producing their own ice in an ice-storing silo.

5.3.3. Endangered, rare, introduced, transboundary and migratory species

Until now, no data has been collected documenting whether any of the above-mentioned fish species or any other sea organism caught within the Brač Channel is either endangered or extinct as a result of over-fishing and other types of human intervention.

Within the Brač Channel region, especially in the Cetina mouth, the following rare and endangered fish species, which are not commercially significant, can occasionally be found:

- The *Petromyzon marinus* – sea lamprey – is a member of the Petromyzonidae family. It can be found in the eastern Atlantic from Portugal to the northern Baltic and Barents Sea, in certain parts of the western Atlantic up to the Gulf of Mexico, from Labrador to Iceland, as well as in the Mediterranean (except from its eastern part) and in the Adriatic. This fish used to be a relatively common Adriatic species, but today it has become rather rare, due to pollution and the destruction of the fresh water flows where it spawns, in addition to the hydro-accumulations and the over-fishing of fresh waters. Its commercial value and its further exploitation have not been explored in our country. In some Mediterranean countries, notably France, it is considered a delicacy.
- *Ophisurus serpens* – is a cosmopolitan species that inhabits sandy and muddy grounds, a typical benthos species of the shelf and the upper part of the bottom up to a depth of 300 m, and very rare in the Adriatic. Its meat is tasty, especially when fried, as it is rich in fat (like eels and moraines), although it is not consumed in this country.
- *Argyrosomus regius* – meagre – is another rare Adriatic species that normally inhabits shallow waters over muddy grounds. At the start of summer, it travels upstream of the river, and by the end of autumn it returns to the sea. Fishermen from Omiš commonly call it salmon. They also argue that it is harder to catch by comparison to other fish. It is only of average commercial value despite the fact that it tastes good, because the annual catch is minor due to its small population size.
- *Phycis blennoides* – is another rare Adriatic fish, found in the deepest parts of the eastern Adriatic (i.e. at a depth of 1,100 m.); its actual habitats are at 400 m and deeper over muddy grounds. This fish has occasionally been caught both in the central Adriatic and in the channels of the northern Adriatic, at a depth of 30 m. Its commercial value is average, its meat is tasty, both raw or dried, as is its liver.
- *Centracanthus cirrus* – is s another demersal fish, that can be found living in shoals over rocky and sandy grounds, especially those covered by phytal algae and Posidonia, up to a depth of 250 m. During its spawning season, it migrates to shallow waters. As this fish is quite rare, its commercial value remains insignificant. Nevertheless, it has a very tasty meat, and it has been caught and sold in many markets all over the Mediterranean region, especially in Cyprus and in Sicily where it has acquired the status of a semi-commercial fish. One member of this species was found in Omiš between 1987-1989, while it was first recorded in the southern Adriatic in 1973 in depths of between 60-200 m.
- Coraline goby (*Odondabuenia baelarica)* – is an endemic Mediterranean species, rarely found in the Adriatic, with no commercial value and often caught south-west of Stobreč.
- *Vanneaugobius pruvoti* – is a crypto benthos species of rocky and coralligene grounds at depths of 20-120 m. Very rare, it is found in only a few locations (south-west of Stobreč).
- The most commercially significant species that has been introduced to this region, is the Norway lobster (*Nephros norvegicus*). Twenty years ago, it was absent from

the Brač Channel and was subsequently introduced by fishermen with bottom pulling nets from the open sea waters. This species is found in the Brač and Hvar Channels, which are roughly bordered by the lines stretching from Omiš to Pučišća and from Bol-Pokrivenik to Podgora, with its maximum population size to be found in the wider region of Vrulja. It can be caught with trawler and traps of the net tag.

- Giant anchovy (*Sardinella aurita)* – is a pelagic fish belonging to the small blue fish family. It normally migrates from the Atlantic to the Mediterranean and inhabits the northern shores of Africa. It entered the Adriatic in the spring and early summer of 1974, from its south and central region, and it has also been found in the Brač Channel. We can also witness the presence of its early developmental stages (eggs, larvae and post-larvae stages) in the central Adriatic. Currently this fish can be found in sufficient commercial quantities, even in winter (it is well known that this specie is very sensitive to low temperatures and perishes in temperatures below 10°C) in the entire Adriatic, including its northern part along the Istrian coast. To date this fish has remained commercially insignificant. Nevertheless, since its mass appears to be growing, its commercial usage may be reconsidered. Its meat is tasty but due to its many bones, it is not especially favoured in our region. Some are of the opinion that their increasing presence may endanger the Adriatic anchovy. These arguments remain undocumented, as to date no competition between these species has been noted; it is most probable, that these arguments derived from the observation that the giant anchovy disturbs the fishing of the anchovy under illumination, because its restlessness scares the other fish away.

With reference to the transboundary species that spend part of their lives in the sea and part of it in rivers, the most important is the eel, while the sea bass and mullet are species that can occasionally be found in the fresh water of sections of river estuaries with less salinity, but they never migrate into the fresh water flows. The eel (*Anguilla anguilla)* can be found all along the Adriatic coast, as well as in all the fresh waters running into the sea. It flourishes in all bays and ports with muddy grounds. Its greatest populations can be seen in the Neretva delta, Cetina, Zrmanja mouth, and in the Vrana lake. Its commercial value is high and stable, its meat very tasty and nutritious (and thus very popular), while it can be conserved in tins, marinated or even smoke dried.

Within the migratory species category, a larger number of pelagic fish can be counted, which periodically migrate out of the channel regions and into the open sea.

5.3.4. Major causes of fisheries problems

The major causes of the present impoverishment of certain commercial species are the unregulated over-fishing of their juvenile populations and the use of irrational fishing methods. Also responsible is the type of fishing that utilises large ships and pulled bottom nets, which is not a traditional local method, and the fact that a legally prescribed annual quota system by species of fish and other sea organisms has not yet been established. Another difficulty has been that prohibited seasons for the fishing of several species have not been yet determined. The lack of this protection measure means that many species are vulnerable, particularly in the spawning period when these fish gather in large flocks in a narrow coastal area.

In order to improve the current situation, it is necessary to prescribe and implement regulations relating to quotas on commercially important species of fish and other sea organisms and to ensure that tabs are kept on sales. The use of methods and equipment facilitating the catch of large juvenile populations (over 20%), a common occurrence, should be also prohibited. By prohibiting fishing utilising trawlers with an engine power of over 73,5 kW (100 HP), it would be guaranteed, that within the channel, fishing activities are primarily undertaken by local fishermen. The establishment of annual quotas by species of fish and other sea organisms complemented by the introduction of a closed fishing season determined by spawning periods, would definitely ensure the necessary level of reproduction. In addition to the above proposals, a programme monitoring the status of habitats should be prepared for the determination of the total permissible level of the exploitation of Brač Channel species.

5.3.5. Impact of global changes on fisheries

The consequences of the expected climatic changes on the population sizes of the commercially important sea organisms could vary and can hardly be foreseen given that their life cycles are completely unknown. The most severe outcome of the global rise in temperature could be that pilchard spawning, in areas with a relatively narrow temperature range, are permanently affected. The global temperature rise would probably have a favourable impact on the giant anchovy, increasing its numbers to commercially viable levels.

5.4. Degradation of the river basin

5.4.1. Changes of the river flow regime

The construction and operation of HPPs in the Cetina watershed, have significantly affected not only the hydrologic regime of the river itself, but also the entire surface and underground waters of the watershed. The Buško Blato and Peruča storage reservoirs along with certain other smaller reservoirs, have been subject to the most significant alterations. One of their harmful effects is due to that fact that they divert Cetina water quantities utilising two pipelines, from the Prančevići storage reservoir to the Zakučac HPP, leaving almost 25 km of the Cetina bed, downstream of Prančevići, without sufficient water quantities. It goes without saying, that the operation of certain hydro-electric power production stations have not only altered the hydrological regime but have constantly impacted, and continue to impact enormously on the environment.

The Buško Blato storage reservoir, with a top volume of $831 \cdot 10^6 m^3$, is actually a flooded karstic field. The same could be argued for the Peruča storage reservoir, with a size of $578 \cdot 10^6 m^3$. Buško Blato has been flooded in winter periods, during its natural regime. By constructing several dams in front of the major sinking zones, the field has been literally transformed into a permanent reservoir lake, in which the waters first travel through an open channel and are then forced by air pumps via a pipeline to the turbines of the Orlovac HPP, which is located by the Ruda spring. This anthropogenic intervention has altered the hydrological regime of the Ovrlja, Ruda, Grab and of several other permanent and temporary karstic springs, that form the main left bank of the Cetina tributary – the river Velika Ruda. At the juncture of this river and the Cetina River, some 2 km upstream from Trilj, its medium, average annual water flow rate has not been altered. However, the minimum water levels have been increased, the maximum levels have been decreased, while the annual rate of the regulated flows remains in equilibrium to the natural ones. The hydrological regime of individual springs has been altered in unique ways, demanding a separate analysis.

The electrical power industry itself was obliged to utilise, from the Prančevići storage reservoir, the ecologically acceptable water flow rate, which at that time represented the "biological minimum" of 8 m^3/s of water. It must be pinpointed that their obligation never materialised in practice, as far as we know. As a result of their persistence the harmful environmental impacts on the areas downstream of the Prančevići dam have become more severe. It is important to emphasise that during the dry season (mainly from May to September and often up to October), in the Cetina section, 25 km downstream of the Prančevići dam, substantial water quantities sink underground through karstic fissures.

Occasionally, some sections of the riverbed dry out completely, and this has a significant and dangerous impact on the environment. The bulk of the quantity of water that sinks underground, returns to the Cetina bed, via the Studenci water spring zone, which is located some 15 km upstream of the mouth and 25 km downstream of Prančevići dam. The waters that are pumped from the Prančevići reservoir via pipelines to the turbines of the Zakučac HPP return to the Cetina River directly at the site of its mouth, significantly altering, in this way, its natural hydrological regime. On the basis of the above-mentioned facts, we may conclude that the construction and the operation of the HPPs have significantly altered the hydrological status of the surface and underground waters in the entire Cetina watershed. Since the karstic river flows are very sensitive, complex, and difficult to regulate and analyse, their basic changes to date have only partially been analysed.

It is important to emphasise the relationship between the water of the Jadro spring and the Cetina River waters. Since the Jadro has for almost seventeen centuries supplied the area with high-quality water, from the ancient Roman Salona and Diocletian's palace to today's modern town of Split and the wider area, it is understandable why it is necessary to analyse in detail the extent and repercussions of any hydrological and ecological changes and to forecast changes likely to occur in the future.

An analysis should be carried out to establish the relationship between the inflows of surface waters and the inflows of underground waters, aiming to produce the common balance of all waters in the Cetina River watershed. A hydrological analysis must be linked with an ecological analysis, especially with the state of biological differences and varieties in the watershed area. The mouth of the River Cetina leading into the Adriatic Sea, like any other river mouth, represents a very important region which is crucial to the existence of many plant and animal species, and thus also needs to be the subject of careful analyses, which should include the establishment of changes trend.

5.4.2. Changes to river banks and the riverbed

With the construction of five hydro-power plants and the adjacent storage reservoirs and dams, the major part of the river banks and riverbed were completely altered since the natural riverbeds were flooded. It is estimated that 40% (approx. 50 km) of the water flow has completely changed the characteristics of the river bank and the riverbed. This change is very drastic. The remaining parts of the river have also suffered certain changes because the river banks have changed along with the water regime. Due to the intensive hydro-energetic exploitation, the river banks and the riverbed have faced changes affecting the entire length of the river (105 km).

Considerable changes experienced by the river banks and the riverbed occurred at the river mouth in Omiš. After the construction of the first phase of HPP Zakučac, with the nominal flow capacity of 100 m^3/s, and the construction of the second phase of the HPP, the river's flow regime changed significantly. The transportation of sediment by the river has now been interrupted by the Prančevići storage reservoir and sediment quantities, created in the watershed downstream of the dam remained on the riverbed, because the flow's strength and capacity decreased significantly.

With higher water inflow, particularly in the summer months, the area of the right river bank in the river mouth is permanently moored. Thus, first regulation works were undertaken as far back as 1963, when the riverbed was cleaned up and refilled downstream of the bridge in Omiš while this material was used to elevate the right bank. In this way, the sand barriers from the mouth disappeared, so that the flow capacity has been increased up to installed flow capacity of HPP of 215 m^3/s and the maximum flow capacity to 1,000 m^3/s. But the above has caused penetration of larger amounts of sea energy created by waves upstream into the riverbed. Downstream of the bridge, some 10 m distant, the elevation point of the bottom is –2.80 and at the mouth itself the bottom is at –5.00 m. The width of the bed at the bridge is 102 m and remains constant until the very mouth, where it slowly widens. The area called Sinaj is the river right shore region. It has been filled up with the river sediment by refilling to the elevation point of 1.20 m above sea level, which is above the level of mooring in the Cetina River mouth area. In this way, the right river bank was permanently protected from flooding, except in the case of extremely high water levels. Under these conditions, urbanisation commenced in this area. A regulation line of the riverbed was defined and the construction of the bank along the left shore in a length of 287 m, downstream of the bridge was underway. This bank is used for the berthing of boats. The bank construction is of a type with a vertical wall, made of concrete blocks. After the completion of the right bank construction, the whole mouth area has been reconstructed and the river mouth has been extended and widened.

After these works were completed, the natural situation was completely altered in this section of the river flow, i.e. all natural characteristics of the river mouth disappeared.

5.4.3. River pollution

The water of the River Cetina is a typical karstic crack water of a calcium – carbonate type, of relatively low mineralisation (evaporated residue approx. 300 mg/l), of small total and carbonate strength/hardness (from 170-250 mg/l $CaCO_3$), small differences between the carbonate and the overall strength. It is a moderately hard water and contains little dissolved CO_2 and sulphates. The chemical composition of the river's water doesn't change very much during the year. The water temperature is within the range of 10-13.8°C and the water rarely becomes muddy. The BOD_5 values are mainly low and only temporarily very high. The worst situation with the water quality is apparent in the Trilj area and downstream of Trilj, where the total pollution of the upstream flow accumulates in the accumulations of the Đale and Prančevići HPP. The water quality in these sections is almost unfit for consumption, due to significant concentrations of nitrates, bacteria and phosphorus. If the necessary protection measures (the implementation of water treatment systems in Sinj and Trilj) are not undertaken, the water from these sections will no longer be fit for drinking without the application of very costly and complex water treatment technologies.

Similar water characteristics are to be found in all springs in the river watershed that are still used for water supply purposes without prior water treatment except for water disinfection. The situation in parts of the watershed is critical in springs where the nearby settlements have undergone extensive development as in the watershed of the Jadro river.

As mentioned in previous paragraphs, in the entire watershed there is still no installation for wastewater treatment, nor completed sewage systems. This situation is definitely responsible for the pollution of the waters in the watershed. Thus, the main pollution sources are the settlements. A positive aspect is the fact that this region is not densely populated; the total number of inhabitants in the watershed area is about 200,000. This region is to date, still rather poorly developed in the industrial sense. The sum of waste quantities is still small in proportion to the existing water quantities (about 12,000 kg of BOD_5/day) in relation to water abundance (the average river flow capacity is about 100 m^3/s in the downstream river flow) so that the displacement of the waste materials and substances is very large and the concentrations of pollutants low, which classifies the waters of the Cetina River as mainly group II waters. This water could be used for drinking after adequate treatment.

One of the major polluters of the water in this area is traffic, which has become very intensive in the contemporary period. In periods of low flows and rare summer rainstorms, the traffic causes considerable pollution of the water resources. Potential additional pollution sources are agriculture in the fertile plain parts of the Sinj field and inadequate solid waste disposal.

It is necessary to stress that in the case of intensified industrial development, at least at level existing prior to the recent hostilities, the pollution of waters will be significantly increased in the entire Croatian area as well as in Bosnia and Herzegovina, jeopardising opportunities for water supply provision.

5.4.4. Landscape degradation

The construction of storage reservoirs and power plants along the river has significantly altered its natural landscape. Certain other constructions on the riverbed, at several different locations, also degrade the landscape. However, the establishment of reservoirs in the dry, karstic regions should not represent a damage to the landscape, but should serve to ennoble it.

Constructions related to water supply use represent the main changes to the landscape and have damaged the natural shape of the wider spring. The major degradation of the landscape by the springs, the most scenic parts of this water resource, is the fault of visitors who come to these areas on unregulated excursions, and who leave tremendous quantities of rubbish and other waste material in their wake.

The natural landscape of the river is also damaged by uncontrolled and prohibited construction works along the river banks and around the majority of the water sources. This uncontrolled construction is heavily apparent at the very source of the Cetina River, which is devastated by the construction of family houses.

5.4.5. Erosion and sedimentation

The slowing down of the water flow of the river as a result of the construction of reservoirs and embankments of the riverbeds has changed the erosion and sedimentary processes. The shore erosion has decreased because the banks have been reinforced and have stabilised and because they are flooded in the reservoirs. Increased erosion happens only within the region of the large storage reservoirs of Peruča and Buško Blato where the waves cause erosion of the banks of these new, man-made lakes. The eroded sediments are transported to storage reservoirs and remain there. For this reason, the river sediments are not transported by the river flow towards the river mouth and the Adriatic Sea as was the case before the construction of the storage reservoirs.

The same happens with all other sediments transported by floods along the river and remaining in the newly-constructed storage reservoirs, and eventually, only during the winter period, transported by large floods to the sea. It can be concluded that the natural transport of sediments from the river watershed to the river mouth into the sea is today mainly halted, or only occurs in gradually. Only in the case of extremely high water levels, when the reservoirs become mud-ridden and have to be intensively emptied, are significant quantities of sediment carried in a seaward direction.

Measurements of sediments have never been carried out, so the quantity of sediments transported by the river has never been calculated. This also means that the values of changes in the past are also unknown. Due to the lime geological composition and pedological characteristics of the watershed (see Chapter 2) however, the quantities of sediments have never been large, nor are they today. The proof of this is in the muddy condition of the reservoir waters, witnessed periodically, when the reservoirs are emptied.

5.5. Coastal degradation

5.5.1. Coastal erosion

After the construction of hydro-power plants and storage reservoirs in the Cetina River watershed and the riverbed, the dynamics of sediment creation and transportation were completely transformed, triggering great changes to the sediment dynamics of the coastal area. The sediment is constantly being reduced by the action of waves and sea currents, while the sediment transported by the river is considerably reduced, causing the sediment deficit in the river mouth area. This process is developing slowly, but over a longer period of time, this decreased quantity of sediment will be more apparent in the wider coastal area in the river mouth. The sea streams mainly move the sand reefs in a westerly direction. The sand banks outside the river mouth will in time, disappear completely. The sea will become progressively deeper causing an increased flow of wave energy from the sea into the river mouth, which means that the wave action in the river and coastal erosion will strengthen.

The consequence of decreased sediment transport from the river coincides with the exploitation of sand near Dugi Rat and Jesenice in such a way that the dynamic balance of sediment transport at the coast and the seabed is disturbed. The consequence is the collapse of parts of the coast, so that at some parts even the Adriatic road is threatened.

With the construction of the road along the sea coast and urbanisation, the natural regime of sediment transport with strong water streams to the coast has been disturbed, if not interrupted completely. In many places, where natural gravel beaches exist, the gravel has to be transported by trucks from various exploitation locations and spread over these beaches. However, this has been done without any detailed analysis and sediment balance. Data on measurements is also lacking.

5.5.2. Coastal sea pollution

Since there are no sewage systems or wastewater treatment system in the entire area under analysis, all wastewaters are directly discharged into the coastal sea. Accordingly, the pollution of the coastal sea water is significant and exclusively caused by household wastewaters, as there are no industrial activities within this region. The pollution of the coastal sea is mainly bacteriological. This type of pollution is accompanied by that of nutritional substances, detergents and other waste materials originating from households. Due to the intensive coastal road traffic, the sea is also polluted with chemicals and other vehicle emissions.

The coastal area affected by the above-mentioned pollution is relatively small and includes the coastal strip which is some 100 m wide, while the remaining part of the coastal sea is of good quality, i.e. olygotrophic.

The most polluted part of the coastal sea is the section around the river mouth, i.e. the town of Omiš, the settlement of Dugi Rat and other settlements in the direction of Split. The coastal sea in the area east of the river mouth is less polluted due to the lower population density.

5.5.3. Loss of open space

The coastal area of the Cetina River watershed is characterised by a narrow coastal flysh strip bordered by steep mountainous hinterland. The immediate hinterland is mostly occupied and devastated by intensive uncontrolled building in a continuum from Split, over Omiš to Makarska. The built-up area mostly follows the existing state road to which a badly developed side-road network is connected. In many places, and particularly on the stretch between the Lav hotel and Omiš, the coastline has been completely built up so that open access to the sea is almost impossible, and its use for recreation and other sea-related activities proves very difficult. This shallow built-up urban matrix is almost uninterrupted in the entire coastal strip under the influence of the Cetina River.

The part of the coastal area stretching from the built-up area to the mountaintop or to the barren slopes is characterised by abandoned agricultural land on terraces, now covered in pine forests and maquis. On these slopes, far from the sea, old settlements exist which are linked to modest agricultural and grazing zones. These settlements have largely been abandoned and the old stone houses and structures are falling apart.

A part of the coastal strip is exposed to landslides. This is partly due to the neglect or blocking of the natural streams and storm water flows that lead storm waters into the sea. Construction is impossible in those parts unless recovery works on the site and biological works in the stream watershed are previously done.

The most spacious area of this part of the coast is the Cetina River mouth where the town of Omiš is situated. Originally, it was a wetland area, but urban development, the filling of the river mouth and construction works on the banks of the river, were responsible for construction sites that prompted the creation of larger population centres. With approximately 6,100 inhabitants and about 90 ha of built-up urban land, the population density is relatively low at 68 inhabitants/ha. The physical plan envisages the possibility of further expansion of the town to a total of 200 ha, which practically saturates the urban area of Omiš. One of the problems facing future urban development is posed by potential landslides on the slopes of the hill on the left bank, so rehabilitation works will be required.

The widening of the coastal strip facilitated the establishment of an industrial zone in Dugi Rat. Filling (deposition of dross and other waste materials of technological processes) solved a lack of space.

There is a large area on the coast free from construction activity, situated between Pisak and Brela, with the cove of Vrulja, a specific topographic and climatic zone, where two mountains meet (Omiška Dinara and Biokovo). Due to a very steep coast and unique landscape features, there is no construction in that zone, nor has it been envisaged by existing physical plans.

The uncontrolled building, primarily of housing constructions causes the lack of open spaces on the coast. The uncontrolled building, which followed the construction of the coastal road and the development of tourism in the early 1970s, is the result of a misguided long-term urbanisation process. A consequence of the uncontrolled building is the non-rational and inappropriate land-use, and the appearance of permanent deficiencies in infrastructure and other services. Threatened too are the planned tourist zones which are few in number due to the configuration of the terrain and the spatial capacities of the coast. Eventually, the devastation of the coast by uncontrolled building will represent an obvious economic loss, and an almost irreversible loss of a valuable and sensitive area.

The uncontrolled building is more pronounced in the part of the coast east of the river mouth as there were no traditional settlements and no longer-term urbanisation history. The western part of the coast, i.e. from the river mouth to Split, has been urbanised over a long period with defined settlements that have a complete urban structure at their core.

The lack of open spaces on the coast poses considerable constraints to further urban development, and to the improvement of urban structure by public and economic functions and infrastructures. Particularly difficult is the construction of wastewater disposal systems. In recent times, the lack of space has been compensated for by the filling of the coast in order to secure open spaces or space for the construction of marine structures and infrastructures. Some of those interventions have also been uncontrolled, so negative effects cannot be ruled out, both in the sea and on land.

5.6. Modification of natural habitats

5.6.1. Assessment of the major river basin and coastal habitats

The development of the coastal region, primarily in the mainland part of the Brač Channel which has been especially intensive over the past 50 years, has led to significant human impacts on the coastal habitats.

The major impact comes from mainland urban centres which modified the entire coastline and continue to generate a tremendous amount of wastewaters that are discharged into the coastal sea. The other important impact is created by the over-exploitation of particular sea organisms. All this has resulted in changes to the coastal ecosystem which is not the same as it was prior to this intensive urbanisation process.

5.6.1.1. Change of area and species composition

Changes directly resulting from the impact of pollution from the mainland have been found until today in the biocenosis of the medio-littoral, the upper infra-littoral and in some parts of the supra-littoral and lower littoral. The impact from the mainland, mainly as a result of urban wastewaters, is the most significant in the demersal communities and apparent in the prevalence of green types of algae (*Chlorophyta*) negatively impacting the brown algae (*Pheophyta*), as well as the decrease of number and diversity of animal species in regions under the direct impact of these wastewaters. Their impact on the phytoplankton population is less visible.

The main changes to the structure of the phytobenthos was found in the region of Split, at the locations under the strongest influence of wastewaters. Here too, the smallest number of benthos algae (89) was found, while the share of green algae is the largest (19.8%) and that of the most sensitive brown algae, the smallest (11.6%). In specific locations under the direct influence of urban wastewaters, with greater or lesser coverage, nythrophile types show, like the Ulva rigida, some species and genus of the Enteromorpha and Cladophora. In the part of the northern coast of the Brač island, which is least affected by the impact of wastewaters, the largest number of species (173) was found, with a majority of brown algae (23.1%) and the smallest percentage of green algae (13.6%).

The emergence of rich settlements of shells, in particular mussels (*Mytilus galloprovincialis*) and a crabs of the Balanus genus has been noted. In the phytoplankton community, changes to the density of phytoplankton organisms were found, but not in the composition of the community itself.

5.6.1.2. Causes of habitat changes

In the major part of the coastal area, at the mainland part of the channel, the coastal part has been filled in with material leading to the destruction of coastal communities. It has been registered that the filling of the shores caused partial destruction of the two main biocenoses – meadows of the sea blossoms *(Posidonia oceanica, Cymodocea nodosa, Zostera marina, Zostera noltii*) and the community of photphyle algae (brown algae of the genus Cystoseira). The uncontrolled discharge of urban wastewaters has caused changes to all living communities so that some species, more sensitive to pollutants, disappeared entirely, while the ones that are less sensitive became dominant.

5.6.1.3. Major human-impacted areas

Areas under significant human impact are: the mouth of the Žrnovnica river where the mouth area was filled in with material; the mouth of the River Cetina where a protection wall was constructed, altering the area's natural characteristics and the Dugi Rat region, at the ferroalloy factory, where mining dust sediments at the sea ground. The entire coastal region from Omiš-Split where wastewater is discharged directly into the sea, is also affected by this pollution.

5.6.2. Critical natural habitats, ecosystems and species of importance

5.6.2.1. Importance for sustainable fisheries

Critical fishing grounds are the mouth of the Žrnovnica and Cetina Rivers and the Vrulja area.

Of the habitats, the critical ones are those located on the rocky coast as well as on sheltered sand beaches. Of the communities, the most important are the two biocenosis – the meadow of sea blossoms (settlements of the *Posidonia oceanica, Cymodocea nodosa, Zostera marina, Zostera noltii*) and the community of photphyle algae (brown algae of the genus *Cystoseira*), as well as the community of the deeper littoral – the community of clay grounds (biocenosis *Nephrops norvegicus – Thenea muricata (Turittela profunda).*

Of the fish species important to the sustainable fisheries, critical are the pilchard, picarel, hake, poor cod and the red mullet, while the key sea organism is the Norwegian lobster. The giant anchovy could become an important species due to the increase of its mass, but to date, demand for it remains low due to the number of bones in its meat.

5.6.2.2. Importance for regional/global biodiversity

The critical habitats with respect to regional and global biodiversity are the biocenosis of the sea blossom meadows (*Posidonia oceanica, Cymodocea nodosa, Zostera marina, Zostera noltii*) and the community of photphyle algae (brown algae of the genus *Cystoseira*). Species important to regional/global biodiversity are the algae of the Fucus genus, especially *Fucus virsoides* (endemic Adriatic bladder wrack) and some of the *Cystoseira genus* (like *Cystoseira adriatica*). Of the fish species, the important ones are coraline goby (*Odondabuenia baelarica)* and *Vanneaugobius pruvoti*.

5.6.2.3. Sensitivity to damage

Of the most sensitive habitats, there are three biocenoses: the sea blossom meadow (*Posidonia oceanica, Cymodocea nodosa, Zostera marina, Zostera noltii*), the community of photphyle algae (brown algae of the genus *Cystoseira*), and the community of the deeper littoral – the community of clay grounds (biocenosis *Nephrops norvegicus – Thenea muricata, Turittela profunda*).

Apart from the above mentioned, very sensitive to destruction or damage are the biocenoses of the supra-littoral and medio-littoral types with sensitive species: snail (*Littorina neritoides*) and algae (*Nemalion helminthoides, Endoderms endolithicum, Fucus virsoides*). All these species are endangered by sea pollution and the filling in of the coast as well as by extensive fishing with ships using drag nets in the coastal, shallow regions. There is no known data that would indicate the economic losses caused by the degradation of critical habitats, ecosystems or important species.

5.7. Concerns related to the use of other resources

5.7.1. Energy production

At present, the only energy production plants in the study area are HPPs. However, the construction of a large coal burning thermo-power plant in the Livno field is planned. This construction would lead to a deterioration of water quality in the entire Cetina River watershed due to air pollution and coal exploitation in the Livno field for the needs of the power plant. Namely, the Livno field is in the uppermost part of the watershed so that the pollution originating there would lead to the pollution of all downstream areas and water resources. In addition, the construction of the thermo-power plant is likely to stimulate population immigration and other socio-economic activities that are always potential sources of water and environmental pollution.

5.7.2. Mineral resource exploitation

As mentioned earlier, there is no significant mineral resource exploitation in the watershed at present, so these have no significant impacts on the environment or water resources. However, considerable coal exploitation is possible in the Livno field, if the thermo-power plant is built.

Sand exploitation at the mouth of the Cetina River is a traditional activity. However, it has now been restricted because the reduced transport of sediments by the river means that sand exploitation threatens the area's beaches.

5.7.3. Other concerns

The greatest problems occur with conflicting demands for land-use for housing, tourism, and economic development. Uncontrolled immigration and building directly threaten the natural resources which are the basis of development and survival in the area. This refers to both the river basin and the coastal area.

Population immigration and agricultural development in the watershed areas of the water springs used for water supply endanger the water quality and, consequently, the water supply of the population and tourists over a very large area. In addition, uncontrolled urbanisation threatens the already scarce fertile land in the hinterland fields of Livno, Sinj and Duvno, thus diminishing agricultural production capacities, when a high demand for such produce exists in the coastal area in the immediate vicinity, especially in the summer when the area hosts large numbers of tourists.

6. River-coast interactions

6.1. Sediment transport

Flowing through its canyon between the slopes of Mošnica (Komornjak) on the right bank and Omiška Dinara (Rat) on the left, before meeting the Adriatic Sea, Cetina is formed, possessing a characteristic wide mouth with several short branches. In the past, the mouth had extended in a south-westerly direction. During the rainy (winter) season, the entire mouth was rendered marshland by high river flows. However, in the dry (summer) period, the river flows remained low and the river mouth above water level, even during higher tides.

The sediments were formed in the river watershed by erosion processes, and transferred by floods, from the riverbed to the sea. On the riverbed, downstream of the Gubavica waterfall, larger sediment quantities were deposited, while gravel and sand was transferred into the sea. A larger amount of gravel was deposited by the Tisne Stine strait and Radman's Mlinice, while in the section located at a distance of 3-4 km from the mouth that has always been affected by the sea, smaller gravel quantities were deposited, while the sand was transported into the sea.

In the geological past, the sea level had been approximately 100 m lower, while the riverbed and its mouth were located near the present island of Vis. With a raised sea level, the river was inundated, while as a result of the slowing down of its flow, sediments had been deposited further upstream forming the Cetina mouth. The part of the riverbed located upstream of the Zakučac HPP supply tunnel has not yet been filled up and so the depths in this area have exceeded 10 m. The sand deposited into to the sea had been forming a threshold (shallows). Throughout its geological history, Cetina has been depositing, in this way, large quantities of sand in its mouth. Sediment deposits have travelled far into the sea, in a west to south-westerly direction which is also the direction of sediments transported by sea currents and waves. The waves are mainly generated by winds from the 2nd quadrant so that the sea currents are also generated in a south-easterly to a north-westerly direction. Under such conditions, sediment deposits stretched along the coast in a length of approximately 3 km to the cape in Dugi Rat forming large shallows. The approximate width of the shallows is 350 m, while the depth is between 1 and 2 m. The edge of the sand shallow area formed in this way is at the depth of about 40 m. Shallows considerably influence the generation of waves in the river mouth area, while the presence of beach grass "absorbed" the energy of waves which, after breaking down in the shallows, entered the river mouth.

With the transformation of the river mouth, from an original natural mouth – with shallow tributaries overgrown with beach grass – into its present day funnel-shape regular riverbed, the river/coast interactions have changed completely. This change is best manifested in the generation of waves. The strong waves in the Brač Channel have been generated by the predominant influence of the wind blowing from the south-east (*sirocco*), affecting the coast and further on, the Cetina mouth. Changes in wind direction to the south (*oštro*) and south-west (*lebić*) have altered the Cetina mouth. Its new shape effectively "captures" the wave energy which is then transferred upstream into the riverbed. The waves are first apparent from the right and then from the left bank, while at the height of the bridge, the waves are superimposed and the water level rises to such a degree, that boats can be tossed out onto the banks. The waves reach as far as the meadow at Planovo, which is upstream of the HPP's outfall channel.

In Omiš, the roads and sewage system have been subject to flooding, and are urgently in need of additional river flow regulation and reconstruction works at the mouth. Previously, under natural conditions, the entire wave energy was almost neutralised by the tributaries and beach grass and the upstream part of the riverbed was completely calm. Regretfully, such conditions cannot be reconstituted in the newly regulated riverbed. A physical model has been constructed in an attempt to "test" various options relating to the reshaping of the river mouth, as well as the creation of additional transverse structures. The best solution has been chosen and scheduled for construction. All research on the model was undertaken taking into account the issues relating to wave generation as discussed in the "Study of Wind and Wave Climate in the Vicinity of the Mouth of the Cetina River". Unfortunately, as a systematic mareographic evaluation has never been performed in natural settings, very little data on waves is currently available. The proposal was based on wind data recorder findings from the meteorological stations of Dugi Rat and Split.

Sea currents are subject to similar processes. Because the location of the river mouth has been changed, the mixing of the cool river water with the sea has been completely changed. The river mouth has been extended by construction from the natural coast into the sea. Unfortunately, very little, if any data exists on the sea currents in the vicinity of the river mouth. Knowledge on waves and sea currents in this part of the river as well as in the area more broadly, is extremely useful to the process of adopting solutions for coastal construction works, and particularly for the arrangement and the stabilisation of beaches.

6.1.1. The coastal part of the watershed

The coastal part of the watershed, characterised by steep and high coasts and unstable materials, has always been exposed to soil/sediment transfer processes, which were facilitated by local storm water flows into the sea, creating its beautiful pebble beaches. The sediment input used to be very high and was a regular annual occurrence throughout the coastal strip area covered by this study, during the winter rains. The urbanisation of the coastal strip in general, and the completion of the coastal road in particular, has resulted in a considerable sediment deficit and the gradual disappearance of these beaches.

6.1.2. Major characteristics of the sediment flow

The natural interaction between the river basin and the sea can be summarised as follows:

- Sediment input from the river basin to the coast had exclusively been transferred through Cetina surface waters.
- Due to the particular geological characteristics of the watershed, sediment quantities have never been very high.
- Quantities of dragged sediment have been low.
- Sediment input into the river mouth and the coast occurred during the winter, when the waters were high.

- Sediment is a significant ecological and coastal economic resource that can be used as a construction material, especially in the creation of beautiful sand beaches, which are more likely to attract tourism.
- The sediment input from the local coastal watershed is much greater and far more important.
- The local sediment input from the coastal watershed impacts on the entire coastal area and is of great importance for the creation of pebble beaches.

Despite the fact that the Cetina River has never been particularly rich in sediment, the changes affecting its flow have significantly altered the sediment transfer processes occurring in both the watershed and the coastal area. These can be summarised as follows:

- The transport of sediments along the river course has been halted by the construction of reservoirs.
- Sediments, particularly dragged sediments are mostly retained in the reservoirs.
- Sediment input into the river mouth area and the sea has been substantially reduced rising only on the occasion of heavy rains and high flow, when large quantities of water are released from the reservoirs.
- The input of larger quantities of sediment into the river mouth area and into the sea has been completely halted.
- Due to the reduction of sediment input, the sand banks at the river mouth and the coastal area have been gradually disappearing.
- The disappearance of sand banks results in coastal erosion and diminishes the protection of the river mouth area against wave action.

Furthermore, construction along the coast has reduced the input of the local coastal sediment from the coastal storm water flows to the local beaches, which are gradually disappearing.

6.2. The hydrological interaction between the river basin and the coastal area

The hydrological interaction between the Cetina basin and the coastal area is a very complicated issue that remains insufficiently researched. As it has been already mentioned in previous chapters, the Cetina River and its wider area are situated in a typically Dinaric karstic area, characterised by several underground hydrological links. The Cetina River waters flow from its basin and into the sea, via its primary surface flows and via its numerous coastal and underground springs. Although relevant research has never been undertaken, it is assumed that greater quantities of fresh river basin waters flow into the sea from the coastal springs, rather than via the Cetina River.

The outlets of the river basin waters into the sea are distributed over a very large coastal area, which stretches from Vrulja in the south-east, to the Kaštela Bay in the north-west, spanning a total length of 30 km. Substantial underground outflows have been manifested at the south-east (in the Vrulja area), in the central part (near the town of Omiš), and in the north-west, near the town of Split (Žrnovnica, Jadro and Pantana). The Cetina River remains the most important surface outflow in the central coastal part of the research area.

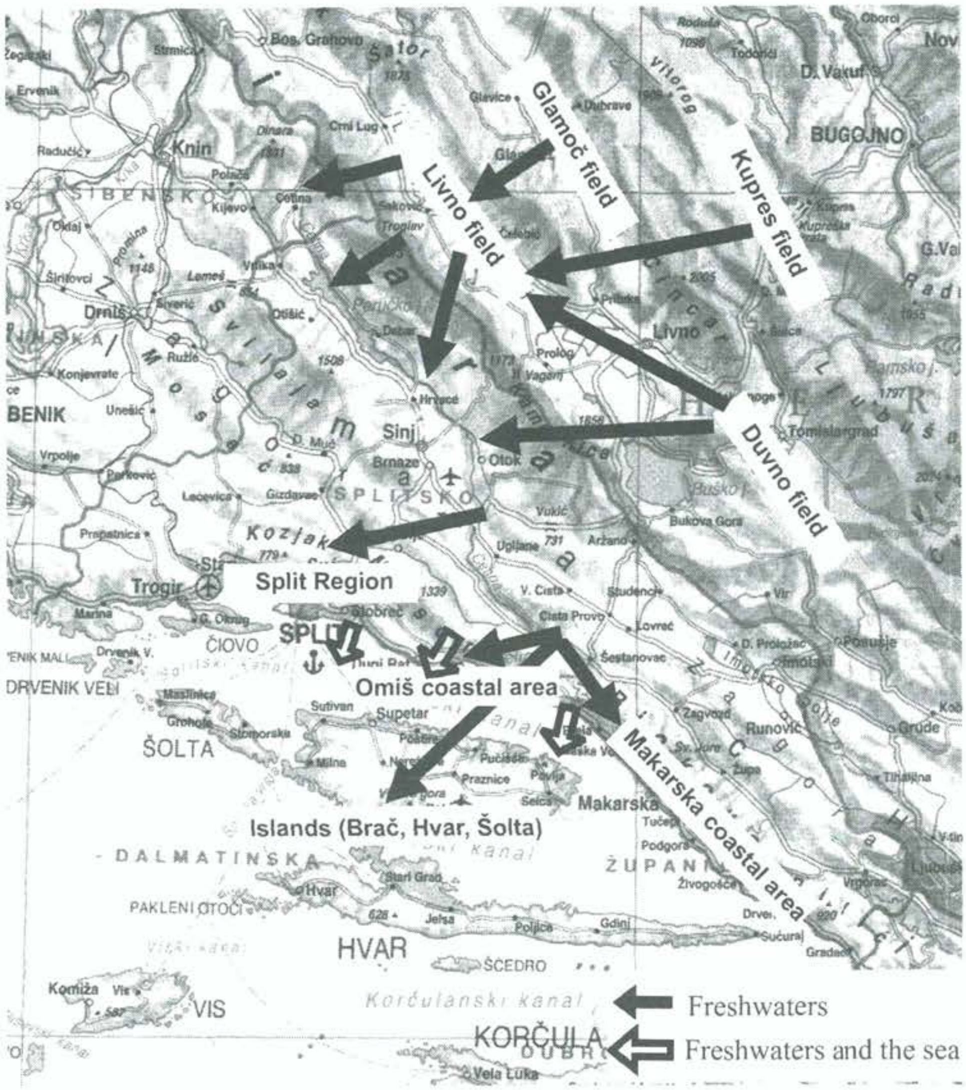

Figure 6.1: Locations of important interaction between freshwaters, and the freshwaters and the sea

6.2.1. Outflow regime

Due to the area's specific geological and climatic characteristics, the outflow of the natural waters into the sea can vary extremely throughout the year, with markedly high winter outflows (more than 1,000 ml/s) and comparatively low summer outflows (around 8 m^3/s). This variation affects both the underground and surface waters, whereas fluctuations have been more accentuated in the surface waters.

The construction of retention reservoirs has totally altered the regime governing surface water outflow into the sea, harnessing it to the requirements of hydro-electric energy production. Thus, throughout the year, the high Cetina flows are being reduced, while the low ones are being increased. This means that the extreme seasonal flows have been avoided and that the outflows have been balanced throughout the annual hydrological cycle. The daily regime of surface water outflow, however, has been significantly altered. Given that the Zakučac and Orlovac HPPs most often operate to their maximum potential in order to meet peak energy demands, they are liable to discharge enormous quantities of water (290 m^3/s) over a period of a few hours. These sudden high volume discharges impact negatively on the environment of the water resources and the sea particularly in the summer, as there is always little natural water in the river at this time. In winter, this effect is minimised by the greater quantities of water present in the flow that originates in the Cetina tributaries. At this time of year, when the flow is high, these plants often work continuously in order to make use of the greater quantities of water available. The harmful effects relating to these enormous discharges have been particularly felt in the vicinity of the Cetina mouth section, where the Zakučac HPP is located.

The alterations to the surface water outflow regime, also affect that of underground waters, given that any river flow alteration implies the existing infiltration processes of the river waters into the ground will also change, triggering analogical changes in the underground waters of a broader area. As the regime of the underground water outflow into the sea has been changed, the winter maximum quantities have been slightly decreased, while the summer minimum values have increased substantially. Moreover, it has been noted that, with the operation of the HPPs, certain springs that used to dry up during summer have now become permanent sources of water (Žrnovnica).

6.2.2. Changes in outflow location

It has been observed that after the construction of reservoirs and power plants, several changes have occurred in terms of the location of natural water outflows into the sea, mainly during the dry summer season. More specifically, the freshwaters of the river flow into the sea from new locations and in substantially greater quantities.

With the completion of the regional water supply systems, the outflow section of the Cetina waters has been significantly artificially expanded, embracing the Makarska coastal zone, the wider area of Split, and the islands of Brač, Hvar and Šolta, while Vis island is soon to be included. The outflow from these systems is estimated to be around 3.5 m^3/s, while the planned amount is 6.0 m^3/s. It must be pointed out that these outflows have now been transformed into wastewaters as a result of the intense exploitation of water and thus the harmful effects inflicted upon the coastal sea have been further accentuated with regard to the outflow balance between freshwater and wastewaters. In the summer period, the outflow of significant quantities of polluted freshwater through sewer outlets has been registered at places where wastewaters have never been flowed into the sea before. As a result, the natural characteristics of the coastal sea of the broader coastal area have been altered.

6.2.3. The interface of fresh and sea waters

It is well known that due to the different densities of freshwater and seawater, an interface is formed at the point where they meet. The contact is made with both surface and groundwaters. Combining with the Cetina surface waters, a wedge of sea water intrudes, via the river, into the mouth area. This phenomenon has not been researched to date, and, therefore, any actual effects remain unknown. Nevertheless, it is quite certain that the repercussions of this process could be severe. Two kilometres away from the present Cetina mouth, the Zakučac HPP outlet, with a capacity of 220 m^3/s, has been operating. When the outlet is in operation, a sudden change occurs in the salinity of the river waters and the interface between the river and the sea is totally disturbed. This constitutes a "shock" to the fauna in the area. As a consequence, some organisms have completely disappeared in this area.

The situation, with reference to groundwaters, is different. More specifically, their outflows are concentrated rather than dispersed, and, therefore, a stable interface of fresh and seawater cannot be achieved, while a kind of turbulent zone is formed instead. In certain other areas, however, interfaces have been established but as they have not been researched so far it remains unknown if the sea (and if yes, to a what degree) penetrates into the land. The effects of the changes to the regime of the surface and groundwaters remain unassessed.

6.2.4. Local watershed

In addition to the Cetina basin, there is a local coastal watershed, which stretches along the entire coastline. This watershed plays an important role in the formation of the local freshwater, as well as in the interaction between the freshwaters and the sea along the entire coastline. This seasonal interaction occurs mostly during the winter period, given that over the dry summer period, these local water resources either dried up or retain only minimal quantities of water. Unregulated coastal urbanisation, by altering the characteristics of the watershed surfaces, has also changed the inflow regime, and consequently, the quantity of surface run-off has been increased, while the underground flows have been decreased. Harmful impacts on water quality caused by pollution originating in urban areas have also been registered.

6.2.5. Issues and problems

The interaction between the river basin and seawaters can be summarised by the following:

- The interface area is very large and complex due to the particular karstic hydro-geological conditions in the research area (Figure 6.2).
- In the annual water balance, the surface and underground waters have almost even inflows.
- The only important surface interaction between the river basin and the sea occurs at the Cetina mouth.
- The interaction between the underground waters and the sea has a predominantly point character, and involves coastal and underground springs.
- The interaction between the coastal watershed and the sea occurs along the entire coastline, but is less significant.
- The construction of the regional water supply systems has significantly widened the interface area to the islands.

The operation of the HPPs and the creation of their adjacent storage reservoirs have resulted in the following changes:

- The seasonal and daily natural outflow regimes have changed.
- The changes of outflow locations are more visible during dry periods.
- Changes have also occurred in the quality and salinity of the water.
- The minimum flows have been increased in the dry season, at the springs and in the Cetina River.
- New springs have appeared during the dry season.
- Changes caused by the interface between the river and seawaters, occurred in the river mouth and its broader adjacent area.
- Interruptions to the natural interface between the river and seawaters occasionally occur in the river mouth area.
- The urbanisation of the coastal area has changed the characteristics and quality of the water resources of the local coastal watershed.

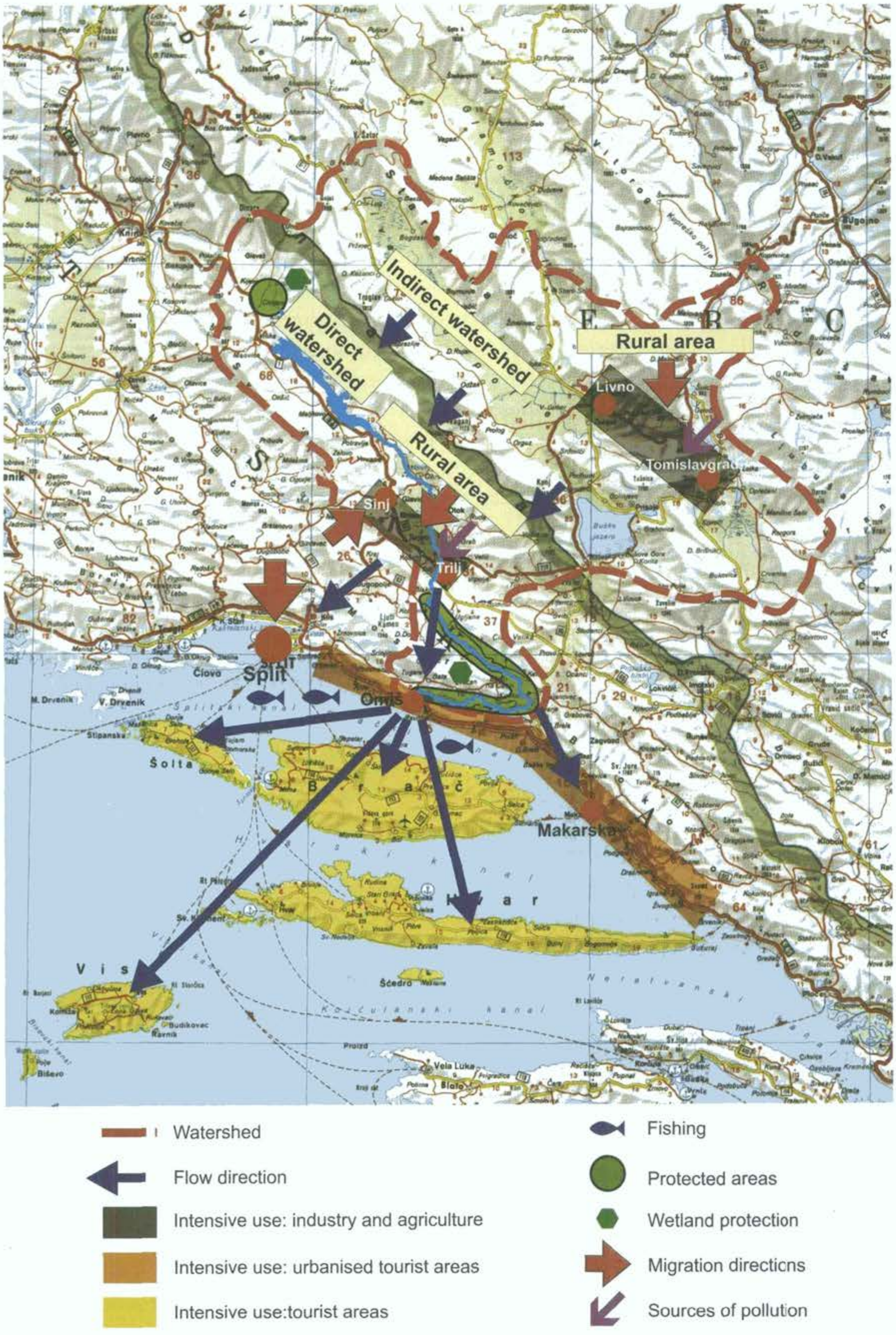

Figure 6.2: Schematic presentation of links and interactions in the Cetina River watershed

6.3. Enrichment by the organic matter and nutrients

The Cetina River has always enriched the coastal area by transferring organic matter and nutrients. The inflow of organic matter and nutrients may be described similarly to that of the freshwaters (Figure 6.2). This implies that the part of the sea under the influence of the river is enormous, spreading from Vrulja to Split, while the most intense contact occurs in the area of the river mouth. Thus all changes to the river flow regime have directly impacted on the transfer of organic matter and nutrients and on the interface between the river basin and the sea.

6.3.1. The inflow regime of organic matter and nutrients

The greatest inflow of organic matter and nutrients is registered with the first rains of the autumn period, lasting throughout the entire rainy period. In summer, the inflow quantities have been smaller. It is difficult to evaluate these quantities, as systematic measurements have never been performed. In any case, those quantities have sustained the development of numerous species in the interface areas.

The operation of the HPPs and reservoirs, has substantially altered the nutrient inflow regime in analogy to the changes of the water flow regime. Apart from this fact, the reservoirs accumulate nutrients, where these are decomposed and used. It is difficult to assess the effects of the changes in the inflow of nutrients and other substances into the sea, without a detailed analysis.

Nevertheless, it is certain that the increase in the population of the watershed has resulted in an enhanced presence of nutrients in the river and, consequently, boosted their proportions within their inflow into the sea. It is estimated that the river receives some 6,200 kg BOD_5/day, from the indirect Bosnian watershed in addition to 6,700 kg BOD_5/day, deriving from the direct Croatian watershed. This means that a total of 13,000 kg of anthropogenic BOD_5/day (nutrients, i.e. dissolved matters) have been reaching the sea carried by Cetina and individual springs. These quantities could be even greater, considering the inflow of diffuse sources. As such analyses have never been performed, the actual values of these quantities remain unknown. It is estimated that during the summer period, the coastal sea receives around 6,000 kg BOD_5/day originating in the coastal strip, while this quantity drops by approximately 2,000 kg BOD_5/day, in winter.

6.3.2. Spatial changes

The spatial changes with reference to the outflow of fresh river waters into the sea, trigger changes in the outflow of the organic matter into the sea. We may distinguish between a “direct” and an “indirect” outflow of organic matter. The direct outflow is the one that mainly occurs through Cetina and the large underground springs. The “indirect” outflow into the sea is generated by the use of water from the water supply systems covering a large coastal area between Spilt and Makarska, and the islands of Brač, Hvar and Šolta. The spatial balance of the organic matter inflow has never been analysed.

6.3.3. Inflows in local coastal watershed

The local coastal watershed contributes greatly to the inflow of organic matter, primarily that of anthropogenic origin, through pollution via household wastewaters, especially in the summer season when the area’s population size is increased by the presence of numerous tourists. This inflow was once relatively low, at a time when the coastal population size was significantly smaller and tourism less developed.

6.3.4. Major issues

The interaction between the river basin and the coastal sea can be summarised by the following:

- The construction of water supply systems and economic development of the area influenced the interaction between the coastal watershed and the sea.
- The actual situation remains unknown, because the balance of organic and other matter and inflow have never been analysed.
- The quantities of past and present inflows do not endanger the coastal sea as a whole, as it is so far olygotrophic.
- The local situation regarding sewage disposal is at particular places unsatisfactory (Omiš, Stobreč) while the sea at these sites is not olygotrophic any more.
- The actual physical effects of the interaction of organic matter between the river basin and the sea are also unknown as they have never been analysed.
- It is assumed that the Brač Channel as a whole has not been severely harmed by the organic matter and there are a sufficient number of reserves for its assimilation (the ability for self-filtration).

6.4. Economic links and interactions

The numerous economic links and interactions between the watershed and its adjacent coastal area have always been significant, but with the rapid urbanisation of the area, they have gained in importance. The historical development of the area strongly hinged on coast-hinterland interactions through important natural passages such as Vrulja and Klis which facilitated trading activity. The river valley still represents the basic natural and economic link.

When analysing socio-economic links and interactions between the watershed and the adjacent coastal area, the role of the macro-regional centre of Split should be mentioned as the town's impact on demographic and economic development was of particular importance.

6.4.1. Demographic changes

The balanced development of the watershed is aided by the area's limited "demographic potential", the negative demographic growth of the area as a whole, and the need for the demographic recovery of the depopulated hinterland areas. Positive steps forward in the socio-economic development of the watershed as a whole are not possible, however, without the demographic revitalisation and the re-population of the area.

The development of tourism and industry on the coast, attracted large numbers of people and has been responsible for the current higher population density in the coastal strip and the intensive, mostly uncontrolled, construction of houses and tourist structures (Table 6.1).

Table 6.1.
Changes in population distribution structure in the county of Split-Dalmatia

Area	1953	1971	1981	1991
Hinterland	31.18	29.41	24.82	22.52
Coastal area	58.91	62.19	68.03	70.39
Islands	9.91	8.40	7.15	7.09
County	**100.00**	**100.00**	**100.00**	**100.00**

In Split, the period following the Second World War was characterised by a significant population rise. The greatest population increase was recorded between 1961 and 1971 when the population swelled by 39.3%. Between 1971 and 1981, the population grew by 27.5% while it increased by 24.5% between 1981-1991. The steady population decrease in the hinterland and islands on the one hand, and the sustained population increase in the coastal area (particularly in the town of Split, and then in Makarska, Omiš and Trogir), on the other, has skewed the distribution of the population in the area and limited its development potential.

Out of all the processes related to demographic trends, the move away from agricultural areas and the increase of urban populations have most affected the efficiency and structure of the economy, making balanced development a far more complex goal. According to the 1991 census, the percentage of the population in agricultural areas within the County of Split-Dalmatia was only 2.2%. This move away from agriculture has impacted on parts of the hinterland (Sinj, Vrlika, Trilj) which are now the site of stagnant economies. Taking into account the fact that more than 67% of the population in the county of Split-Dalmatia lives in towns, it is obvious that the uneven population distribution jeopardises the balanced future development of the area, particularly in relation to the coast, the hinterland and the islands. There has been significant emigration from the Herzeg-Bosnian part of the watershed. This has, for example, boosted coastal area population levels in the greater Split area.

6.4.2. Economic changes and employment

The economic links and the interrelations between the hinterland part of the watershed, and the coastal town of Split as a macro-regional centre, are best illustrated by the daily migrations. This type of migration should be taken into account because of its impact on the demographic and socio-economic development of the area. In 1981, in the hinterland of the Cetina River watershed, almost 45% of the total labour force was employed outside their area of residence. This year is representative of the former demographic movements, as the recent hostilities and their consequences completely destabilised economic development as a whole.

Surveys show that more than half of "daily migrants" were employed in enterprises based in Split. The influence of Split on the socio-economic transformation of the watershed area was quite substantial. The majority of "daily migrants", i.e. almost 70%, originated from the area located along the main Split-Sinj road and in settlements nearer to other centres of employment (Sinj, Trilj). The greater the distance of these centres from areas of residence, the smaller the proportion of such migrants employed. The proportions were drastically down in areas such as Vrlika and Podkamešje.

6.4.2.1. Agriculture and tourism

All the agricultural land of the watershed is found in the hinterland, on planes located at more than 400 m above sea level. With respect to intensive agriculture, the area has rather limited capacities. The area's arid climate and the lack of irrigation systems diminish the value of the agricultural land. On the other hand, an unpolluted pedosphere, the possibility of field melioration and the prospect of an irrigation network, as well as an absence of large polluters, increases the significance of the natural characteristics of this area, making it attractive to specialised forms of agricultural production such as organic farming. The present shortcomings in agricultural development should be transformed into comparative advantages for the area as a whole.

Parts of the land are suitable for grazing and offer great potential for the significant development of cattle breeding, aimed at meat production, particularly as such production has long been insufficient in this area. Freshwater fish cultivation also represents one of the area's unexplored potentials. The market for agricultural produce, especially in relation to tourism, is very favourable for producers. Their comparative advantage over competitors outside the vicinity primarily lies in lower distribution costs and their offer of fresher produce. It is advisable to maximise direct trading channels and to promote the unique local character of the produce. Since agriculture and tourism are two key economic activities that should form the basis of the area's development, it is clear that such a development path needs to be premised on a protected environment. One that sustains a wealth of flora and fauna as well as a level of agricultural production meeting the requirements of both the local population and tourists.

At present, tourism capacities are concentrated in the coastal area and islands. Existing tourist infrastructures including hotels, private accommodation and camping structures, restrict tourism to these areas, when there is a need for tourism to branch out to hinterland locations. The area needs to develop specific forms of tourism that can enhance the attractiveness of the area as a whole to tourists.

The strategy for future tourism development in the area comprises the following:

- The hotel capacities on the coast and in the islands will not be increased. Instead, the quality of the tourists' experience will be improved.
- The development of small family-run hotels and motels in the entire watershed area will be stimulated.
- Facilities for tourists will be improved. They will be developed to optimally and sensitively exploit the natural riches of the watershed areas. Growth areas will include rafting, golf, hiking, hunting and eco-tourism.

6.4.2.2. Industry

The development of industry in the watershed area was based on the macro division of work without respecting micro conditions, namely natural, socio-cultural and other unique and traditional values of the area. Such a division was premised on cheap and plentiful energy supplies, inexpensive transportation and a constant labour supply. Following the opening of hydro-power plants, factories were immediately constructed along the coast (Dugi Rat, Omiš). In the period of industrialisation (following World War II), labour-intensive industries (textile, chemicals, cement, etc.) were developed in the watershed area (in the river valley and on the coast). Employment opportunities and the abandonment of insecure livelihoods linked to agriculture and cattle breeding, triggered an intensive migration within the watershed, from the hinterland to the coast.

The impacts of this trend are still felt today. The development of industry was not based on the rational use of natural resources, i.e. it did not contribute to the gradual development of the area as a whole, but led to the deterioration of several localities, particularly those along the coast, exposing them to ecological risks.

Apart from restructuring existing capacities, it is, therefore, necessary to stimulate the development of small and medium-sized industries in a way that is sympathetic to the area's available natural resources. Industries related to the processing of agricultural products and to tourism (such as dairy plants, cheese-making plants, etc.) do not consume much energy, nor do they heavily deplete natural resources including raw materials.

During the hostilities of the 1990's, most of the area's industries were destroyed, particularly those in Bosnia and Herzegovina and in parts of the Sinj area. Thus today, there is a need to review the economic development that has occurred to date and to boost the realisation of the sustainable development based on respect for the local environment. The area's economic rehabilitation needs to be grounded in its natural potential. An emphasis on fishing, tourism, hotels and catering in coastal areas, and on agriculture and processing industries in inland areas should be encouraged.

6.4.3. Urbanisation and land use

As well as major differences in the ways coastal and inland areas are used, numerous interrelations are at play. Population migrations to the coast and larger centres impoverish the hinterland and are to the detriment of agriculture even in areas with favourable natural and man-made conditions (large fields with melioration systems). In the area where the sea meets the land, complex manifestations of natural, economic and social life have been created. Ports and coasts have become focal points of economic activity and tourism infrastructures. Such excessive congestion, however, can lead to the inadequate use of coastal areas, the degradation of coastal resources and to developmental restrictions. In the coastal area, due to intensive land-use pressures, the demand for water, energy, agricultural products, etc. is directly connected to the exploitation of resources in the hinterland. The need for the preservation of inland areas is thus part and parcel of the development of coastal areas.

The harmonious development of the entire area is only feasible within the framework of a balanced system of settlements with adequately sized centres. Future centres, comprising smaller and medium-sized towns, currently lacking in the area, need to develop the infrastructures to satisfy the area's needs.

6.4.4. Infrastructure systems

In the area overall, road and sea transportation is relatively developed. The integration of the entire area and its links with the both states' wider areas as well as with Europe, is mainly realised through road transportation. Since the coast-hinterland perpendicular axis has not been given much attention to date, the links between the coast and the hinterland are inadequate.

In order to attain a balanced and polycentric development of the area, particularly of tourism and agriculture, it is necessary to prioritise the perpendicular axis to provide fast and efficient links between the coast and hinterland. The realisation of that route is restricted, however, by the natural characteristics of the terrain. Natural passes, for instance, only exist in some areas. For this reason, these localities have historically become the traditional, favoured links between the coast and hinterland (Trilj, Klis). It is clear that the entire course of the Cetina River cannot be utilised due to the narrow and steep canyon, as well as the fact that environmental considerations dictate that certain parts of the river and its adjacent areas require rigorous protection from any form of exploitation.

The links between coast and hinterland are particularly pronounced in the domains of energy, water supply and the protection of water resources. For instance, further electricity supply needs have to be evaluated bearing in mind that water resources can be used for various energy producing purposes.

The planned construction of a thermo-power plant in the Duvno field, which would use coal as an energy source, would be detrimental to the river basin's environment. The potential for air pollution is considerable because the coal contains high percentage of sulphur (1.34-3.5%). Special attention needs to be paid to the protection of water resources against pollution, i.e. to the construction of treatment plants, especially along the upper course of the river.

6.4.5. Basic elements of future economic links between the coast and river basin

The entire watershed represents an economic entity, the future development of which should be viewed through the assessment of impacts of various activities on the environment as a whole, i.e. of socio-economic trends on natural resources. Each development programme relating to economic activities has to be evaluated with regard to the area's carrying capacity and the sustainable development of the entire area.

Since heavy users of space are clustered in the narrow coastal strip (settlements, tourism), economic policies, including taxation policies as well as electricity and particularly water rates, should aim to reflect the expense of the increased exploitation of the area's natural resources. Utility charges should be imposed in a selective manner, according to the level of development and the quantities used by individual administrative units.

The solution to pollution-related problems in the hinterland (the construction of urban and industrial wastewater treatment plants and of solid waste dumping sites) should also be comprehensively considered due to the value and protection of the watershed. Thus, all users of water hailing from the Cetina River (the coast and the islands) have to participate in the solution to existing infrastructure problems and the protection of the watershed.

The lack of water, so vital in intensive agricultural production, is a problem common to both the islands and inland areas. Although the population's water supply problem has not yet been fully resolved, it is believed that the provision of water for irrigation of agricultural lands would facilitate more intensive agricultural practices, which, along with cattle breeding, are essential to the revitalisation of the area. It is, therefore, necessary to build an irrigation network that is linked to an appropriate water supply network meeting the water needs of each production unit, while lowering the price of water for agricultural use (the cost should be borne by other users). Water used for irrigation is largely recycled, still clean and non-polluting through evapotranspiration, and thus does not burden existing sewage systems.

7. Prospects

7.1. A sustainability assessment

7.1.1. Water resources

7.1.1.1. Water resources in the river basin

The present exploitation of Cetina River water by various user sectors is intensive and irregular (Figure 7.1). The most important uses relate to hydro-energy needs and water supply needs. Although of minor importance, other river resources are similarly exploited to a near-maximal capacity.

With regard to hydro-energy production, almost all available capacities for the construction of storage reservoirs are fully exploited. The levelling of the river flow has reached saturation point making further levelling impossible. These capacities are now exhausted, however, with the exception of construction for the small hydropower plants which make use of water outflow needed for keeping up the biological minimum.

With regard to water supply, some sources have been almost completely exploited so that there are no more available capacities (Kosinac, Jadro, etc.). However, other significant water supply sources exist which could be used for the same purpose.

Whilst water resources have been exploited, no attention has been paid to ecological considerations. Thus the river has been completely "built" and a new watercourse created, with altered characteristics. The river was formally characterised as a continental water flow, being steep and rapid near its source, with a steady flow in its middle segment, flowing steadily to the wide mouth before entering the Brač Channel. Natural processes regulated the water flow, in the first instance by precipitation and riverbed inclination. The river no longer manifests these characteristics. Biodiversity has been severely compromised. Instead, a new river has been created, one with storage reservoirs and water flowing between them, aiming to satisfy the needs of hydro-energy production. The natural water flow regime of the river has disappeared. The environmental priorities of the river in its current state are difficult to evaluate without a detailed and comprehensive study that examines the sustainability of the current use of the river.

The present sustainability of water resource use is closely related to the use of hydro-energy systems as a whole. Any changes in this system will result in direct consequences for the river's water system. All river construction activities generate threats of high-risk negative impacts. These risks include danger to life, flooding, pollution of the river mouth and the sea, as well as impacts on sediment transport and hinterland development. The reduction of these risks requires strong management and quality maintenance. Each mistake made in the management process is accompanied by harmful impacts on the natural and socio-economic environments.

The sustainability of the present so-called single-purpose use (in relation to the hydro-energy function) of the river basin, is also questionable. This is due to several other demands stemming from assorted users who are interested in the river as a source of water for irrigation, aquaculture, or due to its support to flora and fauna. The present single-purpose use of the river cannot satisfy all the demands of these users and does not allow the economy to grow more strongly in the future.

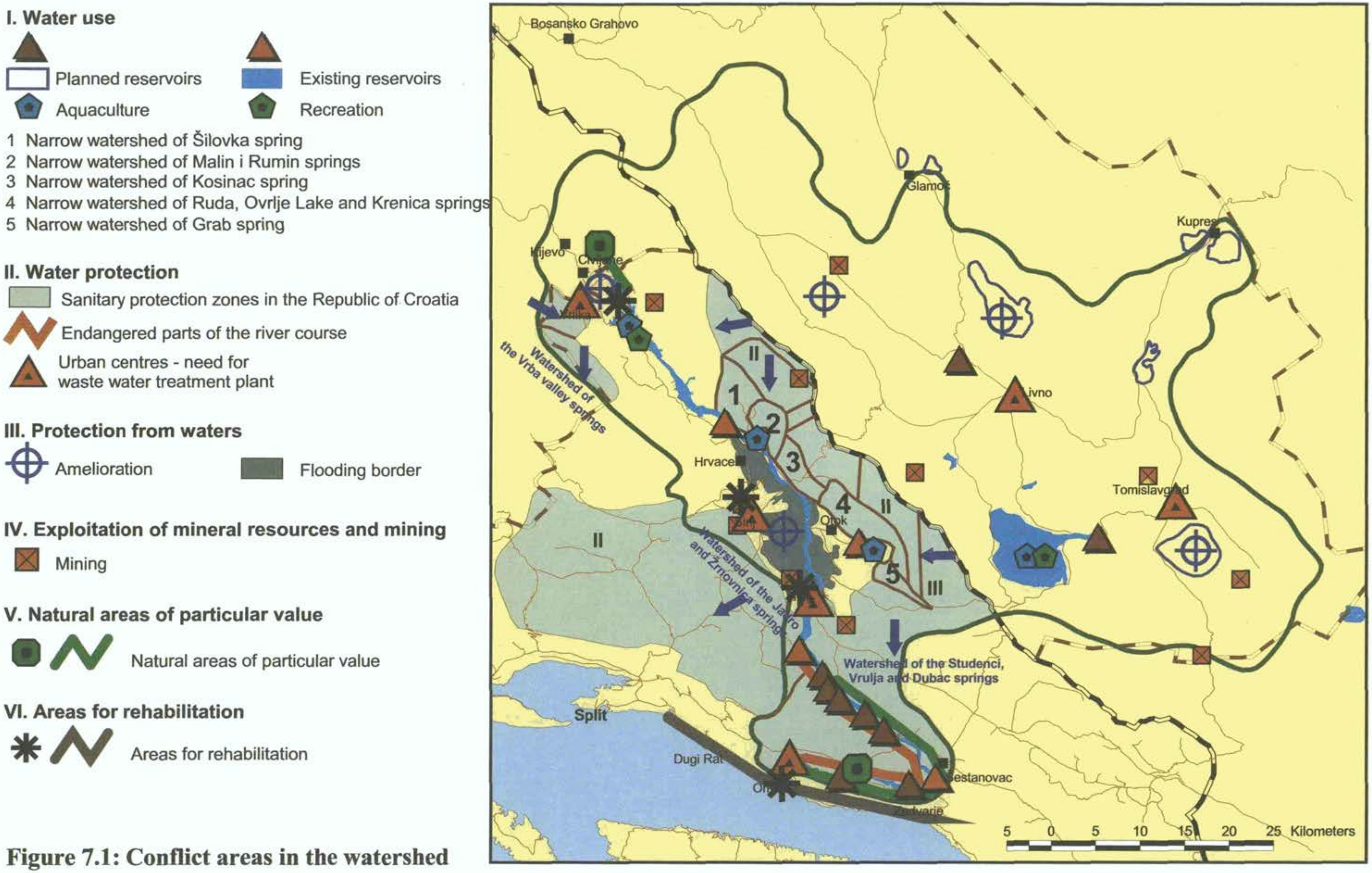

Figure 7.1: Conflict areas in the watershed

As can be seen from previous practices, the following basic principles of sustainable water resource use were not respected:

- The integrated river basin management;
- The encouragement of rational water use and protection;
- Continuous research and monitoring of changes and states in the river basin;
- Informing the public; and
- The local management of the river basin.

7.1.1.2. Coastal water resources

The coastal water resources are not significant in terms of their quantity and use. However, they play a role in the coastal ecosystem. These resources have never been adequately researched or evaluated. Since the sustainability of their use has never been fully taken into account, they experienced significant changes, primarily as a result of urban coastal construction. Thus, for example, in the immediate coastal area near the mouth of the river, such resources no longer exist as the entire area is urbanised.

7.1.2. The river mouth and the adjacent coastal sea

The mouth of the Cetina River and the adjacent coastal sea have long been used by the coastal population to satisfy many everyday needs (i.e. seafood, fish processing). The unsustainable coastal sea uses are characterised by the following:

- The use of new fishing techniques and the orientation of larger numbers of the local population to fishing as a result of an increased demand for seafood, endangers existing fish stocks. Over-fishing of particular species and of the fish fry has been recorded.
- Sand deposits transported by the river have in recent decades been used as an indispensable construction material in the greater Split area. Following the erection of barriers in the river, the transport of sand has decreased considerably. Due to this fact, the over-exploitation of sand in some areas (such as in Duće) could jeopardise the coastal strip and cause coastal erosion.
- The coastal sea can only cope with a limited volume of wastewater. Heavy discharges negatively impact on the marine environment causing health risks to humans. In order to avoid harmful impacts, it is essential to control any increase in waste quantities.

The sea is an important nature resource and the basis of the regional tourism industry. Any development of this industry requires the sustained high quality of sea bathing waters, its maintained transparency and the preservation of its natural light blue colour. The existing tourism development has resulted in the full urbanisation of the coastal strip and has brought increasing pressures on the coastal terrestrial and marine environment.

7.1.3. Population

Demographic changes recorded in the watershed area have revealed the following unsustainable trends:

- Almost the entire area, with the exception of its coastal areas and some central parts, is an active emigration area (in particular the territory of Bosnia and Herzegovina).
- Recent hostilities have considerably diminished the total demographic potential of the watershed. In 1991, the number of inhabitants in this area totalled 192,884. Today, it is believed that this total stands at 157,000 inhabitants.
- The distribution of inhabitants varies and they are concentrated in a small number of larger centres (Livno and Tomislav Grad in the territory of Bosnia and

Herzegovina), in the Republic of Croatia in the Cetina River valley (Sinj and Trilj) and in the coastal area. Over and above the influence of natural living conditions, the uneven population distribution pattern is a result of socio-economic conditions. These have prompted the migration of populations from the hinterland to the coast, from villages to towns, and from areas beyond the country's border (in particular in the territory of Bosnia and Herzegovina).

- The hilly and mountainous parts of the watershed area are almost uninhabited. This is partly due to an ageing population.

The sustainable development of the entire watershed area cannot be achieved without a more equal population distribution and reduced population pressures in some areas, in particular in the coastal part of the watershed. The steady increase of the population of the coastal zone and the larger centres along the river (Sinj, Trilj) has considerably mitigated the overall population decline of the watershed, concealing the pronounced population decreases in other hilly and mountainous areas. A sharp population decrease in these areas illustrates the critical demographic situation in the area as a whole, indicating that this process, particularly in the period following the recent hostilities, is developing without any significant social control. If this process continues, it could impact negatively on the sustainable development of the watershed area.

7.1.4. Economic activity

Economic activity in the watershed area immediately before the recent hostilities shows that:

- The optimal realisation of the rich watershed potential has not been achieved. Economic activity remains specialised according to area, namely in the territory of Bosnia and Herzegovina industry and mining; in the Croatian hinterland industry and trade; and tourism and industry in the coastal area.
- Agricultural production, cattle breeding and aquaculture have not been aptly considered. Problems of land reclamation, irrigation and depopulation of particular areas, for instance, remain.
- Due to the recent hostilities, economic activity in the area as a whole has declined significantly. Many industries, especially textiles and chemical enterprises were shut down, triggering high unemployment levels.
- The major economic centres (Livno, Tomislav Grad, Sinj, Trilj and Omiš) are currently not in a position to facilitate development. They cannot attract investment capital, nor can they kick-start a more widespread distribution of business activity in the area.

This region thus finds itself at a turning point in its economic development. In the absence of integrated development concept and without taking into account the impact of economic activities on the environment as a whole (such as the construction of the thermo-electric power plant in the Bosnian part of the watershed, the construction of other polluting plants, etc.), the economic development of the area cannot be sustained. The concentration of economic activities in a small number of centres (as in the period preceding the recent hostilities) should now be replaced with a diffusion of activities over the wider watershed area.

7.1.5. Urbanisation

Urbanisation in the Cetina River watershed is manifested in several different ways:

- Urban congestion coupled with intensive urban construction is prevalent in the coastal area, particularly between Split and Omiš. This area is characterised by a growing population, as well as by unplanned land use.
- The river mouth area is used for several, often conflicting purposes such as settlement growth (Omiš) and the development of industry and tourism despite the fact that the protection of the unique natural characteristics of the Cetina River canyon is a priority.
- In the middle course of the river, fringed by fields, urban development is intensive. This development jeopardises agricultural land and the hydro-melioration of fields.
- The Bosnian part of the watershed is characterised by more intensive urban development near the Livno field (the town of Livno and surrounding settlements) and the Duvno field (Tomislav Grad). The urban development of smaller centres, such as Kupres, Glamoč and Grahovo, has stagnated, with these areas showing few signs of development growth.

Throughout the whole area, even in its coastal part, urbanisation process is generally characterised by a high growth with little elements of the sustainable urban development. This means that the simple urban matrix is being dominated by the residential function, while settlement structure is lacking in many other important elements necessary for the improvement of the quality of life.

While the number of inhabitants is decreasing overall, the number of both small settlements, and larger ones with a population of over 5,000, is increasing. Medium-sized settlements are on the wane. The worst situation is manifested in the Bosnian part of the watershed where the average settlement size is constantly increasing. The situation has deteriorated as a consequence of the recent hostilities.

The sustainable urban development is necessarily tied to the ability to complete the infrastructure systems serving these settlements, particularly wastewater and solid waste management. The tendency for population growth and economic development was partly interrupted by recent hostilities, in particular in the greater vicinity of the Cetina River watershed, so that today, only minor pollution loads generated by settlements, industry or the exploitation of natural resources such as coal, are recorded in downstream areas (the course and mouth of the Cetina River as well as the adjacent coastal area and the sea). Various watershed land-use interests should be taken into account together with the need for sustainable development and the preservation of the Cetina River as a whole. This needs to be done in a way which incorporates environmental and economic considerations.

7.2. Major trends

7.2.1. Water resources

7.2.1.1. Water resources in the river basin

Based on the current plans of various sectors drawing on the river's water resources, the future situation looks set to deteriorate. There are still plans envisaging an increased use of the hydro-power potential of the river, use of the river for irrigation, water supply, aquaculture and as a recipient for wastewaters from point and diffuse sources of pollution. This means that, if all the above plans will be implemented, the current, heavy utilisation of the river will not be curbed and that it will be absolutely unsustainable.

If the observed negative trends persist, they will be responsible for:

- The water regime changes;
- A diminished input of sediment to the coastal area;
- The erosion of river mouth and the coastal beaches;
- An increased input of organic matter and of pollution into the coastal sea;
- A threat to the coastal springs used for water supply;
- A threat to the water quality of the river and to all water supply systems using the river water; and
- A threat to the flora and fauna of the river, the river mouth and the sea.

The present uses and planned development also raise the following issues:

- As a consequence of the construction of reservoirs and hydro-electric power plants new lake ecosystems have been created whose impact on the environment has never been assessed. The construction of the hydro-electric power system has boosted the trend towards an increased use of water and flow.

  Since most resources have been largely used up, future use of water flow and volume will not rise significantly.
- To date, the trend towards the redistribution of river basin waters has been constantly increasing. Numerous reservoirs have been built and water has been diverted from the riverbed towards the plants, thus altering the natural water resources upstream and downstream, as well as their physical distribution. There are still plans to redirect waters from higher levels of the Livno field through pressure pipelines to lower levels (Orlovac), which will further alter all natural characteristics of the downstream areas. The most significant physical changes related to the transfer of waters have occurred through the regional water supply systems, in that the waters of the river basin have reached a wide coastal area and a number of islands. It is expected that in future, the volume of water thus transferred will at least double, while their reach will be further extended to include new islands (Vis) and coastal areas, as well as zones in the watershed. The continuation of watercourse regulation, very intensive in the past, will not increase significantly since the reservoir capacities are almost exhausted.
- The river has also been used as a recipient for wastewaters from point and diffuse sources of pollution. This trend will continue, especially with regard to pollution generated by agriculture and transport. Following the planned construction of irrigation and water disposal systems in the Sinj, Livno, Glamoč and Duvno fields, agricultural production will intensify. This will result in increased pollution and erosion. New national and local roads are also planned. These will make the protection of springs even more complex. The heavy demand for water is also likely to be sustained since uncontrolled building in the sanitary protection zones of the present and planned water sources is increasing. In this region, existing and planned industrial areas represent sources of highly negative impacts on the quality of water resources.
- The erosion of the seashores and the river mouth will continue due to the operation of reservoirs and hydro-electric power plants. The beaches around the river mouth will probably disappear. For the same reasons, threats to the river's ecosystems make them liable to be transformed in line with the new characteristics of the habitats and the water regime. Changes in the state, quantity and quality of the water will lead to the disappearance of native species of flora and fauna and the appearance of new species according to the newly created characteristics of the ecosystem.

- The trend towards conflicts between hydro-electric power and other water uses will be intensified since demands for the redistribution of the present capacities continue to rise. The increase in conflicts between the general public and other users is also growing since ecological changes are becoming ever more apparent, while increasingly more difficult to justify as well as less acceptable to the general public. The issue of charges and fines for damage is increasingly a subject of debate amongst the users of the water resources and the population of the study area.

7.2.1.2. Coastal water resources

The changes to the characteristics of the coastal water resources will continue based on the acceleration of coastal area urbanisation. Therefore:

- Increasing amounts of water will skim the surface running into the sea rather than into the ground.
- The waters will become increasingly polluted, and consequently, so will the coastal sea.
- The input of sediment into local beaches will decrease leading to their gradual disappearance.
- The capacities of the groundwater will diminish, leading to an increasing intrusion of seawater.
- Changes to the characteristics of coastal water resources can cause floods and landslides that threaten the population and buildings.
- The coastal water resources will be more and more polluted by coastal area urbanisation and tourism development.

7.2.2. The river mouth and its adjacent coastal waters

The last decade has been characterised by a sudden increase in demand for the use of living resources. It is a result of the increased demand for high quality species, the rise in the price of fish and thus the potential for quick profit.

The consequences of this rise in demand are reflected in the over-fishing of some species and in the fishing of immature specimens, incapable of reproduction. If this practice continues, the sustainability of fishing in this area could be seriously threatened.

With regard to sand exploitation, a recent drop in the quantities demanded is due to alterations in building techniques and to the diminished building activity in the area. It is realistic to suppose that in the future, the demand for sand will further decrease. Since the input of sediment has been reduced, decreased demand for sand would contribute considerably to the conservation of sand reserves.

A 15-year period of accelerated growth of the area's tourism industry was halted by the hostilities a decade ago. It is realistic to assume that growth in this lucrative field will revert to pre-war levels in the foreseeable future. For it to do so, however, it will be necessary to improve urban infrastructures, not only the facilities for tourists, but also those serving all the area's settlements and towns. To date, most of the wastewaters of the area between Omiš and Split have been discharged into cesspools so that the wastewaters have ended up in the sea, with only a small proportion being discharged untreated into the sea via submarine outfalls at greater depths.

Measurements of the sea near the river mouth area have only been carried out intermittently. Such measurements show that some changes have occurred in the marine ecosystem as a consequence of wastewater discharges. So far, those changes have been manifested in some bottom biocenoses where the number of nitrophilous algae species has grown, while the number of brown ones has dropped. The changes are still not significant enough to threaten seawater quality, but they highlight the need to pay greater attention to the problems of wastewater discharge into the sea, especially if the population growth trend continues in the narrow coastal area between Omiš and Split. Negative consequences are felt in a very narrow coastal belt that is a mere 300 m wide.

7.2.3. Population and the economy

The demographic changes in the area have been typical of an "open type" population. Migrations have caused population decreases in the areas in parts of Bosnia and Herzegovina and in hilly-mountainous zones, and corresponding increases in urban centres of the hinterland and in the coastal zone in the Republic of Croatia.

The recent hostilities caused considerable changes to population trends and economic development, especially in the areas directly affected by the war. It is impossible, therefore, to consider future population growth and improvement of the population structure if economic activities are not increased in the area. However, in the midst of the present transition processes, privatisation and economic transformation, it is extremely difficult to predict future trends, especially in the territory of Bosnia and Herzegovina.

In spite of the above statements, the trends witnessed so far, if continued in the future, could result in the following:

- The area is differentiated (coast, hinterland areas along the fertile fields and the river valley, hilly-mountainous area), and is likely to remain so in the future;
- The differentiation of the area will continue to affect, albeit in a less profound way, the structuring of the characteristic features of the demographic profile of the area;
- The conflict between 1991-1995 was responsible for significant interruptions to existing population and economic trends. Great efforts are needed if the area is to revert to these pre-war trends; and
- Future population trends will be affected by the type of economic restructuring, the development of economic trends in the wider area and the revitalisation of tourism including its expansion into hinterland zones.

The continuation of the concentration of population and economic activities in the narrow coastal area (which has no more physical capacities to accommodate new populations), along with the depopulation of the hilly-mountainous areas, points to the need for planned processes encouraging a reversal of this trend. Economic activities and demographic revitalisation in the vicinity of the river's upstream parts (especially of the relevant part of Bosnia and Herzegovina) pose a potential threat to the water resources (pollution via urban and industrial wastewater, intensive agriculture, tourism, etc.).

It is clear, therefore, that a continuation of the existing trends is simply not sustainable since all demographic, economic and physical potentials that could enhance further immigration to the coastal strip, have been totally exhausted. In the future, the enhancement of the perpendicular, coast-hinterland axis will be of primary importance.

7.2.4. Urbanisation and land use

If these urbanisation trends continue, we can expect further pressures on the narrow coastal strip, river mouth area and areas surrounding the fields in the upper and central parts of the Cetina River course. At the same time, depopulation and the abandonment of the wider watershed and hilly-mountainous areas will continue.

With reference to land-use patterns, the proportion of arable land will decrease, while the sum of grazing and forestland will increase. Urban areas would also expand, especially along the coast and in the vicinity of the fields, representing the unplanned growth of urban centres where housing is the basic and dominant function. Without the planning intervention, we can expect further unfavourable trends in the development of settlements with an increased number of small settlements, and a reduction in their size. Only the few larger settlements (Sinj, Omiš, Makarska, Livno, Tomislav Grad) and their immediate surroundings will experience population growth.

7.3. Basic principles for the sustainable development of the Cetina River area

7.3.1. Water resources

- The hydro-geological karstic characteristics of the river basin make it extremely sensitive to all forms of pollution. These characteristics make all activities related to the protection of these waters against pollution more complex, difficult and expensive.
- The vicinity of the coast and islands, and the extremely unfavourable hydrological situation in these coastal and island areas make the springs and Cetina River very attractive to coastal and island dwellers. However, the heightened sensitivity of the river basin waters to all forms of pollution which flow speedily through the hydro-geological system from upstream to downstream areas makes the use of these waters as a water supply source very risky, and requires a good system of control, monitoring and management of the river basin's water resources.
- The high quality of the ground and surface waters of the upstream parts of the river basin makes these waters very attractive for specialised uses, such as bottled water factories and the high quality fish species farms.
- The pleasant and unique landscape of the karstic water phenomena makes this area very attractive to visitors and to the development of tourism generally.
- Given the favourable elevation relations, a number of reservoirs and hydro-electric power plants have been built along the river basin, resulting in an overall levelling of the river flow regime and changes to the ecological characteristics of the system, including biodiversity. Moreover, most of the volume capacities have already been exhausted.
- Natural habitats and features of the river have been destroyed, as well as the relevant biocenosis along the entire river course, some irreversibly (reservoirs), although the part downstream from the Prančevići could be restored.
- The general public is interested in a reduction of the utilisation of the river basin waters and conservation of its natural characteristics.
- The present low level of industrial activity in the river basin area creates an impression of a positive situation. However, if industrial activity recovers to 1990 levels, the environmental situation could worsen considerably. This is therefore the right moment to embark upon an integrated approach to the river basin and to define guidelines for the development of the wider area according to the principles of sustainable development which have been adopted at the state level by both Croatia and Bosnia and Herzegovina.

7.3.2. The river mouth and the marine environment

The sustainable use of marine resources requires the following:

- The conservation of the basic stock needed for reproduction, which includes the protection of fishing specimens too young to reproduce. In order to achieve this goal, it is necessary to establish an appropriate management system for living marine resources which should include: the monitoring of the state of living resources; control of fishing: use of certain tools and techniques; and periods when fishing of some species is forbidden and fishing quotas by species.
- A level of sand exploitation in certain quantities and at sites that will not cause coastal erosion. In order to avoid any undesired effects, it is vital to establish a monitoring programme for the coastline and sediment input. It is essential that the quantity of the exploited sand should not exceed the quantity brought in by the river.
- The protection of the coastline against further landfill activity, especially by the mouths of the Cetina and Žrnovnica rivers.
- It is necessary to ensure that urban wastewaters are only discharged into the sea once they have undergone primary treatment, and that they are then discharged via submarine outfalls at a satisfactory depth and at a minimum distance from the coast. A permanent monitoring programme must be implemented in order to note any changes over time in bottom biocenoses and plankton communities, and any presence of eutrophication resulting from discharges of organic matter and nutrients. Through the application of technical measures and an increased level of wastewater treatment it will be possible to eliminate the observed negative impacts.

7.3.3. Population and the economy

About 200,000 people living in this area and indeed those living further away are linked to the Cetina River by the water supply system (around 55,000 people living in the coastal area and on the islands have a functional connection with the watershed). A substantial list of human activities threaten to compromise the sustainable development of the watershed. These activities encompass:

- the rising concentration of population and endeavours in the narrow coastal strip;
- the haphazard exploitation of the natural resources of the hinterland (the unverified exploitation of mineral materials and mining, the neglect of agriculture cattle breeding; aquaculture and tourism); and
- a disregard for limits to the capacities of infrastructures (such as treatment plants and the organisation of sanitary landfills).

If we add some 300,000 tourists visiting the area, it is obvious that securing the sustainable development of the Cetina River watershed is of the utmost importance. Therefore, future population developments should follow the following principles:

- In the coastal area and that of the river mouth, population growth should be curbed. It should be based on natural growth rather than on immigration.
- In hinterland areas, around the fertile plains and in the river valley, further population growth should be encouraged as existing population centres become the focal points of future development.
- Hilly and mountainous areas need to be revitalised and their populations boosted through the provision of better living conditions and links with the towns (focal points of development).

In the economic domain, it will be necessary to:

- Restructure obsolete industrial capacities;
- Shut down polluting plants;
- Encourage the opening of small, environmentally "cleaner" production and processing plants;
- Locate industries so that they respect the area's environmental values;
- Encourage the opening of plants based on the local resources of the area (revolving around the processing of agricultural products, mineral materials, medicinal herbs and the like); and
- Improve the area's appeal to tourists through the development of hiking, mountain climbing, sports and other recreational facilities.

A prerequisite for the attainment of these goals (related to the coast-hinterland perpendicular axis) is a considerable investment in transport and urban infrastructures (roads, wastewater treatment plants, sanitary landfills, etc.).

7.3.4. Urbanisation

The obstacles to the desired urban development are:

- the lack of quality open spaces in the coastal area equipped with the necessary infrastructure for urban development, especially with regard to public, commercial and economic facilities;
- the fact that settlements in the Cetina watershed are widely dispersed; and
- the congestion in the vicinity of the river mouth accompanied by numerous conflicts related to land use.

It may be assumed that changes will occur in the current land-use trends, and that these will be reflected in a more rational use of land in urban areas, and the conservation of valuable agricultural land and forestland. To achieve this, an integrated approach to land use is necessary in order to be able to eliminate negative impacts originating in the wider Cetina watershed area, while stimulating the desirable ones.

The development of settlements should be harmonised with demographic development, and with the principles of rational urban development, one that bypasses agricultural and other valuable land as well as the immediate coastal strip. The development of settlements has to be approached in an integrated manner, with due attention paid to complex structures and functions characterising sustainable development. In particular, there is a need to resolve all the existing current shortcomings of the transport, water supply and wastewater treatment and waste disposal systems. Essentially, unresolved infrastructure problems in settlements generate considerable pollution loads that quickly impact on all downstream and coastal areas including the coastal sea.

8. Basic elements of the sustainable development of the watershed

8.1. Development based on physical plans and other plans and programmes

The Cetina watershed, particularly in the Republic of Croatia, is the focus of interest of various users and decision-makers, from the local, regional and national governments levels. Accordingly, various interests clash, partial approaches are pursued and conflicting, uncoordinated plans and programmes are often adopted (Figure 8.1).

The physical plans of local administrative units define the land use, protection of the environment, transport and other infrastructures, as well as the division of land for physical development. Very often, each local administrative unit focuses on its own prosperity, frequently neglecting wider aspects and impacts, a phenomenon which is, among other, due to the lack of a higher-level physical plans (physical plans of counties, strategies of economic and demographic development, etc.).

Physical plans have been prepared for all local administrative units within the study area, but many were prepared and adopted in a different socio-economic environment. This results in highly differing approaches and land-use criteria from one micro-unit to another, although they are all part of a unique and indivisible physical system – a watershed. In order to secure the prerequisites for an accelerated and more dynamic growth pattern, high rates of demographic and economic growth are envisaged in these plans. These will result in the allocation of large areas for various economic purposes and urban expansion.

This point is best illustrated by the fact that the area's projected population total for the year 2015, is 500,000, as opposed to 200,000 in 1991 (today, it is estimated that around 160,000 are living in the entire area). This is highly unrealistic when we take into account the demographic emptiness of the watershed hinterland and the unfavourable demographic structure of almost the entire area.

Sectorial plans and programmes are based on the maximal exploitation of natural resources of interest to particular sectors (energy, water potential, mineral and mining resources, fisheries, etc.). A good illustration is provided by the fact that despite the existence of five HPPs in the Cetina River system, plans exist for the construction of ten additional plants, although the natural features of the water course have already been completely transformed due to its overexploitation for energy production purposes.

Environmental considerations have meant that the entire course of the Cetina River and its tributaries have been the focus of various proposed protection measures. Even these decisions, however, have not been supported by appropriate systematic research, especially with regard to the area's flora and fauna and the river course. The status quo with respect to the area's cultural heritage is similar, both regarding archaeological sites (Tilirium, Aequm) and individual monuments. This situation persists even though this is a unique area of exceptional ethnological value (the ancient water mills).

Figure 8.1: Spatial development model based on the existing sectoral plans

Industry, mining and exploitation of mineral resources were planned as fundamental motors of economic development of the inner part of the watershed (especially the area within Bosnia and Herzegovina). One of the most pressing problems is the planned construction of a thermo-power plant in the Bosnia and Herzegovina territory based on the utilisation of coal of an inappropriate quality (lignite with high sulphur content). Using such coal would impact badly on the ecosystem as a whole and pose risks to human health such as air pollution as well as climate changes along with other, insufficiently studied impacts.

Islands and coastal areas linked with the watershed, in their development plans, usually fail to take into account the dependence of the development orientation (tourism, agriculture, etc.) on the watershed's energy and water resource potential. The above is evident in numerous tourist zones in coastal and island areas which remain incomplete and often lacking in appropriate infrastructures (more than 120,000 hotel beds planned, as opposed to the current 20,000). These cannot be completed because sufficient water from the Cetina River watershed cannot be secured.

In addition to the development of tourism, a significant role in the revitalisation of the islands is given to the development of agriculture, which is closely linked to the need for irrigation water. The existing water supply system (regional water works supplied from Cetina) is too expensive to be used in agriculture, so it is necessary to look for alternative sources of water for island agricultural purposes. No such research has been included in existing sectorial plans and programmes.

8.2. The integrated spatial-structural development model

The watershed area, along with its associated coastal and island area, is defined as the problem area, i.e. an area with developmental limitations requiring special measures and appropriate developmental planning concepts aiming for a comprehensive revitalisation of the area.

As problem entities within the watershed, each requiring a special physical planning and developmental approach, the following stand out:

- The inland karstic area;
- The coastal and island area;
- The area along the state border; and
- The area ravaged by war.

The inland karstic area (the largest in terms of surface area) requires a special approach since any activity has to be assessed with respect to the protection of surface and ground waters. The identification of sanitary protection zones of drinking water sources has top priority in the protection of this area and all other activities have to be subordinated to this vital protection regime.

The coastal and island area is a special problem entity linked with the hinterland (inner parts of the watershed). All activities in this area have to be assessed with regard to the possibility of using the natural resources of the watershed. Especially sensitive are river mouth areas as these are points of extreme conflict where different natural environments meet, and where economic activities and infrastructure interventions are located. The alleviation of the present congestion problems in the coastal area through a dispersal of activities and populations towards the hinterland, along with the selective use and rehabilitation of the land, stands out as the basic principle of the optimal approach to land-use management. The island area requires revitalisation of its demographic and economic structure, which could be achieved through a careful selection of development programmes that have to be assessed with regard to the sensitivity and carrying capacity of the area.

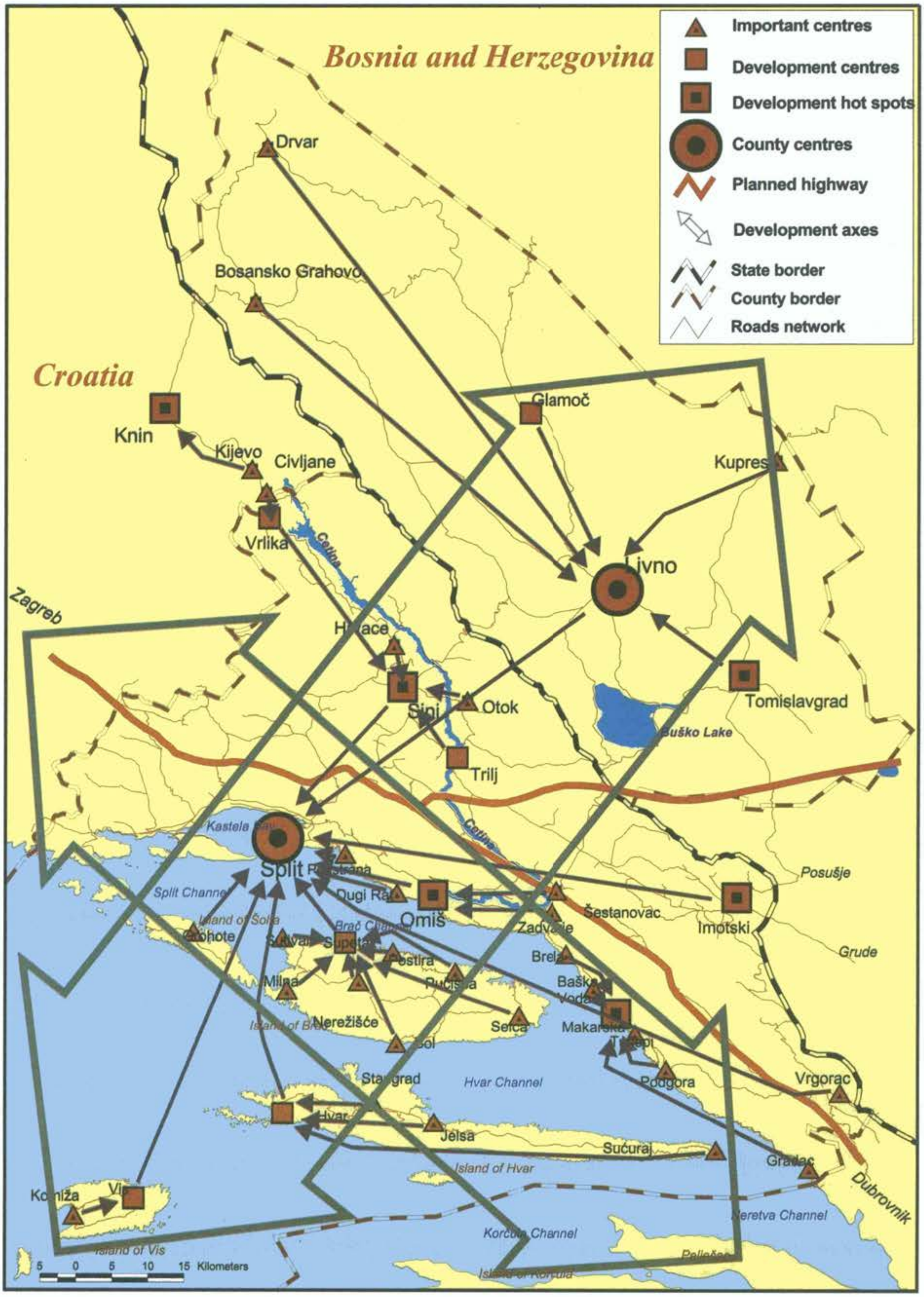

Figure 8.2: Spatial-structural development model of the watershed and the surrounding area

The island area requires revitalisation of its demographic and economic structure, which could be achieved through a careful selection of development programmes that have to be assessed with regard to the sensitivity and carrying capacity of the area.

The area along the state border also requires special institutional measures in order to secure the optimal use and protection of valuable natural resources. Its sensitive location also means that it harbours the potential for development.

The area ravaged by the recent hostilities requires special reconstruction and revitalisation measures, primarily of its technical and physical structures (reconstruction of settlements and infrastructures). The hostilities have also damaged the social environment which has to be revitalised through delicate social policy measures encompassing the return of the population, the cultivation of a sense of security and cultural policy measures.

Over and above the specific features of the individual entities, an integrated approach is necessary to encompass all the specific features in a single watershed entity. Generally speaking, the development of the watershed and the associated wider area is based on two spatial axes:

- A development axis along the coast, comprising the coastal and island areas; and
- A perpendicular development axis linking the coast and the hinterland, as well as the territories of the two states (Figure 8.2).

Through an integrated approach to development activities, it is necessary to stimulate the affirmation of the perpendicular axis which unifies the watershed area from the viewpoint of stakeholders' interests and development objectives. The affirmation of that axis will be established through:

- A balanced settlement network (polycentric settlement development) and a more evenly distributed population;
- An economic structure harmonised with the specific features of the area;
- A transport infrastructure;
- Other infrastructures;
- The use of resources in tandem with sustainable development; and
- The protection, enhancement and adequate appraisal of valuable natural sites and cultural heritage.

The polycentric development of settlements and urban functions aims at achieving a balanced distribution of population and activities in the watershed in order to secure good quality of life throughout the study area. This primarily implies a system of urban centres which will be able to meet the needs of all watershed inhabitants and those within the wider zone of influence. It is necessary to stimulate the growth of small and medium-sized towns (5,000 – 20,000 inhabitants) through active demographic measures, fiscal and land-use polices, and by equipping the towns with appropriate technical and social infrastructures. Generally, it would be unrealistic to expect a substantial population rise. Special population and economic policy measures should stimulate the redistribution of the population within the watershed, for example, by providing employment and improving the quality of life in hinterland areas. The creation of a network of small and medium-sized towns that can become focal points of development (Omiš, Dugi Rat, Trilj, Sinj, Vrlika, Livno, Tomislav Grad, Glamoč, Kupres) will secure the conditions for achieving urban expansion in all parts of the watershed, halting, at the same time, the hyper-urbanisation of the narrow coastal strip.

The area's economic structure should be adapted to the specific features of smaller spatial administrative units. Economic development must be based on a more intensive development of agriculture and ecologically acceptable industries and services in the inner part of the watershed, and on the further development of various forms of tourism in inner, coastal and island areas.

The transport infrastructure will depend on the construction of new motorways crossing the watershed region, spurring new developmental activities also resulting from better links with other areas. It is of the utmost importance that a network of transversal roads be linked to the motorway system, as these will secure communications within the watershed. Maritime traffic should be improved in the coastal region through the construction of public harbours and those with special purposes such as marinas and shipyards.

Other infrastructure requirements primarily relate to the construction of a wastewater treatment system, the extension of the water supply system to serve all settlements, and the final definition of the limits of the waters of the Cetina watershed for energy production purposes.

The sustainable development of the area requires a careful and balanced planning of the use of resources (water, sea, mineral and mining resources, etc.) in order to facilitate multiple use of these resources while minimising any conflicts related to their use.

The protection of the area's valuable natural and cultural heritage requires systematic research and the establishment of formal protection provisions in some areas. This protection should be linked with the overall development of the area, particularly through tourism, but should also embrace other economic, educational and scientific uses.

The lack of a comprehensive approach to the management and protection of this highly sensitive area has to be overcome as soon as possible through the preparation of a comprehensive integrated plan having as its agenda the sustainable development, management and protection of the Cetina River watershed.

From the above it is evident that at present, the watershed area requires a new developmental structure, and the mobilisation of all actors (international, national, regional and local) in order to create new foundations for the development and prosperity of the area. It will not be possible to achieve this goal through partial consideration of individual sectors: energy production; water resources management; environmental protection; and urban expansion and economic activities. An integrated and inter-disciplinary approach is needed which can in turn serve as the basis for a common system of national and international legislation (agreements).

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