Natural values and biodiversity of the VJOSA DELTA

Current situation and threats

FNS, UT,
Tiranë, 2024

Cured by:
Aleko Miho • Ferdinand Bego • Sajmir Beqiraj

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Electronic & printed version Hosted in:
https://fshn.edu.al/Info/delta-vjose
https://ecoalbania.org/wp-content/uploads/2025/01/Delta-Vjosa-EN.pdf

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Front cover: *Aerial view of the Vjosa Delta, May 2019. (©Piotr Bednarek)*

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CONTENT

PREFACE

Transitional ecosystems, estuaries, lagoons and related wetlands are the most important places both naturally and for the services they provide to humans. There are more than 1000 km² of transitional ecosystems in Albania, where the area of the Vjosa Delta with about 240 km² (24%), is among the most important and naturally preserved on the whole Adriatic coast, despite anthropogenic and natural transformations of the last 60-70 years.

The Delta area extends from the dunes and wetlands of Darzeza/Poro, Fieri, to the Narta lagoon, Vlora; a good part more than 160 km², is **Protected Landscape of Pishë Poro** - Narta (Category V). This area is evolved by the hydrodynamic and sedimentological activity of the Vjosa River and the Southeast Adriatic Sea, over hundreds of years. Up to 18 habitats are listed as Natura 2000, of which six are priority habitats. They shelter about 2,310 species known to date: 580 non vascular plants, 770 vascular plants, 70 mushrooms, and 890 animal species, where 248 are birds and more than 100 are fish. A significant part are rare and threatened species, nationally and internationally. Vjosa Delta is also listed both as an Important Bird Area (IBA), and an Important Plant Area (IPA).

Beside the pressure in the past, in recent years the delta area is **under a mass tourism threat**, too. Although it is a Protected Landscape, it has not prevented almost arbitrarily the construction of the Vlora Airport within the protected zone (in November 2021). From the documents of the Ministry of Infrastructure and Energy, it seems that there are infrastructure development plans for that area. All this will lead to deterioration of ecological integrity, further fragmentation of the habitats, loss of biodiversity, weakening of the ecosystem resilience, and reducing ecosystem services, which will impact both nature and humans.

Hence, the Delta of Vjosa has gained both the attention and concern of environmentalists and academia experts, local and international, and by other responsible international conventions and institutions. Two **Scientific Weeks** were organized in April 2023 & 2024, with experts from various fields, to better understand the situation on site as well as to update data on biodiversity, geology, geography, etc.

The experts reported their data in this **Special Volume** with people science view, in two languages (Albanian and English). There are about 15 papers, written by 37 co-authors, from Albania, Austria, Italy, and Slovenia. Beside the natural values and related services, considerations are given on the sensitivity, vulnerability and threats to habitats and species. Updated data are given on geography, landscape, intactness, habitats, flora and vegetation (aquatic and terrestrial), aquatic and terrestrial invertebrates, amphibians and reptiles, fish, birds and mammals, their sensitivity and threats.

The **Symposium** that was organized in Vlora in October 2023 had the same goal; on the one hand, it highlighted the natural values of the Delta area, their sensitivity and threats; and on the other hand, it brought the best international experience regarding the conservation and sustainable management of transitional coastal ecosystems. We are grateful to all of them.

Worth saying that most of the data belong to the Vlora part, and those are partial, and sporadic in time and space. The Fieri Delta part seems much less known. The interdisciplinary studies on environmental state, biodiversity and human impact towards integrated management are missing. It would be a task of science for the future.

Our goal is to help decision- and policy-makers, investors, and other interested stakeholders, to find the best practices for the development, and protect this area as an inseparable hydrodynamic and ecological part of the National Park of the Vjosa Wild River.

We suggest an interdisciplinary study of Vjosa Delta focused on its conservation and sustainable management, based on scientific evidence. Our opinion is that the whole Vjosa Delta must be preserved, left untouched by large-scale tourism. Instead, it should wisely be used for nature-based tourism (ecotourism) projects. It is now the right moment for the Pishe Poro - Narta Protected Landscape to be declared National Park (IUCN category II). Together with the Vjosa River, the Delta forms an indivisible hydrodynamic and ecological entity.

ACKNOWLEDGEMENTS

The Vjosa Delta Volumes would not have this form without the efforts of 37 experts, Albanian and from the region, authors of 15 manuscripts on each topic, who collected the existing data and information, updated it during field visits, and brought it here in bilingual version together with their comments and recommendations. We are grateful to everyone for this, and for actively participating in the Delta activities, in the two **Scientific Weeks** and in the **Vlora Symposium**. We also thank all the other experts, representatives of institutions or NGOs, as well as all the students participating in these activities.

All these Delta activities were supported from the financial and logistic aspects in cooperation by **Euronature** (Germany), **Riverwatch** (Austria), **Ecoalbania**, and the **University of Tirana**, to whom we are extremely grateful. Worth to evidence that the above-mentioned NGOs and most experts have supported in years the knowledge of Albanian nature values and their protection, especially of the Vjosa River, and its declaration as a National Park, but not only...

The graphic design and printing of this publication was supported by the Hans Wilsdorf Foundation. The information is updated by experts participating in the 2 Scientific Weeks, April 2023 and April 2024; this as well as the initial booklet about the Vjosa Delta (Miho *et al*., 2023) were supported by the ESPID4Vjosa project, implemented by EuroNatur (Germany) and EcoAlbania (Albania), and funded by the Austrian Development Agency (ADA). Endless gratitude to them, too! Lastly, thanks to the efforts and expertise of **Spontan Creative Media** for separation the initial bilingual electronic manuscript into two parts, Albanian and English, as well as for their layout, and **West Print Albania** for the print quality of both the initial brochure and these two volume editions (Albanian and English).

Prof. Aleko Miho, Prof. Ferdinand Bego, Prof. Sajmir Beqiraj

Vjosa Delta under the science focus - introductory reflections

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Vjosa River National Park - triumph of the academic and environmental world

On March 13th, 2023, the Albanian government declared the Vjosa and its tributaries (Drino, Bença and Shushica) as Wild River National Park (Category II according to the IUCN and Albanian law) (VKM/DCM 155/2023) (Fig. 1). There are about 12,727 ha, including the whole aquatic, riverscape area (more than 400 km of riverine flow in total). The decision was the culmination of the efforts of many national and international forces and actors (https://www.vjosanationalpark.al/; McVeigh, 2023; Miho, 2023; etc.).

Years ago, Vjosa River was identified by WWF (2014), Riverwatch, Euronature as the last free-flowing river in Europe, outside of Russia (Acta ZooBot Austria, 2018; Sovinc, 2021; etc.), 'wild' river as it is commonly said, but was under the threat of the construction of about 45 HPPs. The efforts were led by the non-governmental environmental organizations Riverwatch (Austria), Euronatur (Germany), and Ecoalbania, in the joint campaign 'Save the blue heart of Europe' (https://www.balkanrivers.net/). Experts of river ecology from several Austrian universities (University of Vienna, BOKU), etc., and also from Germany, Italy, etc. joined their efforts, too. In Albania, the campaign was joined by experts from conservation biology, chemistry, at FNS, UT, and from the Agricultural University, as well as experts from the Faculty of Geology and Mining, PUT, etc.

Schiemer *et al.* (2020) list 16 h**abitat types in the riverbed of the Vjosa river**, at low to mean flow, maintained by periodic flood conditions: 7 aquatic habitats (A1-A7); 3 terrestrial habitats within the active channel (AC) on coarse grained sediments (B0-B2); 3 terrestrial habitats within the AC on fine grained sediments (C0-C2); 2 habitats at elevated islands within the AC and on the floodplains (BC3 & BC4); and 1 degradation habitat (D). All are listed in Annex 1 of the European Union Habitats Directive (92/43/EEC, amended document from June 10th, 2013).

Figure 1.
Hydrographic map of Albania, where Vjosa/Aoos River is circled in red. (Miho *et al.,* 2013)

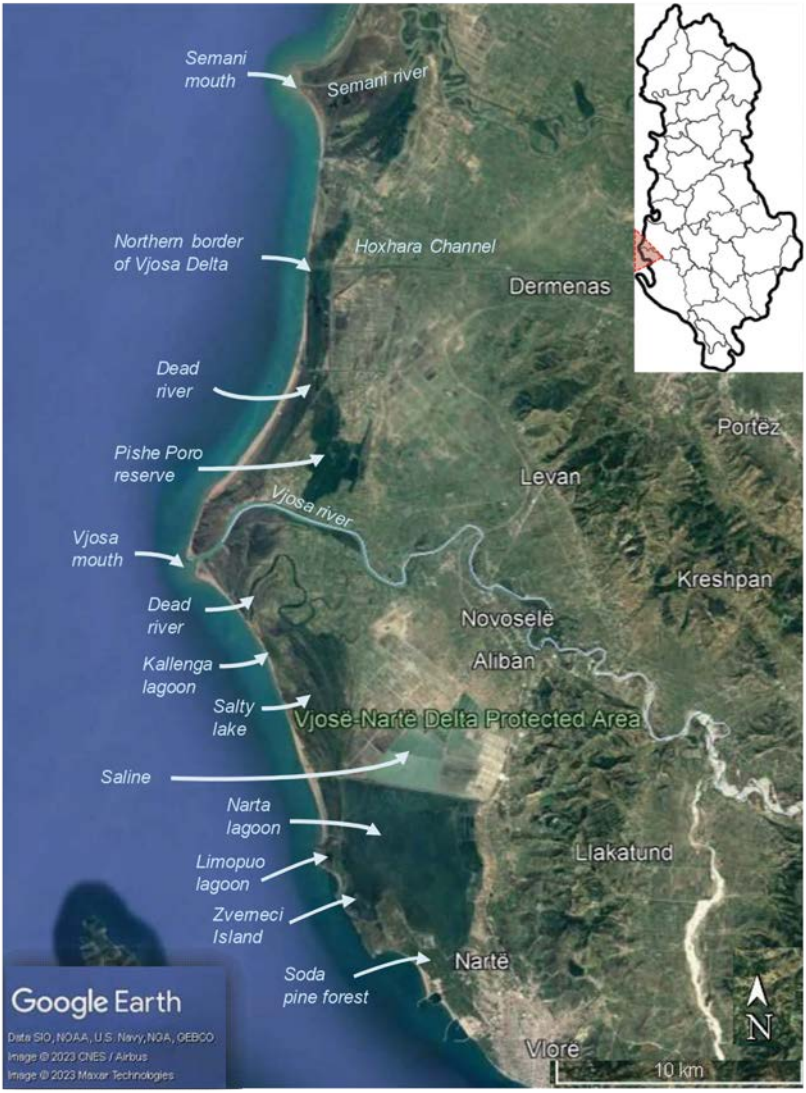

Figure 2.
Map of the transitional wetlands of Vjosa Delta. (elaborated from Google Earth 2023)

Figure 3.
Aerial views of the Vjosa Delta. (©Piotr Bednarek – above, May 2019; & Joshua D. Lim, below, April 2024)

The riverine habitats 3220, 3250, 3230, 3240, 92D0, 6210 and 92C0 cover up to 86% of the total area of the Poçemi-Kalivaçi river corridor. Four of them are priority habitats after FFH-Annex I/Natura 2000, EUNIS habitat classification 2004/2012 and EU Red List; respectively: Gravel/sand bars (3220; C3.62; VU); Initial vegetation (3250; C3.553; VU); Mediterranean riparian scrub (92D0; F9.31; LC); and Mediterranean and Macaronesian riparian woodland (92C0; G1.3157; EN); their total areal representation is up to 38%, referred to the morphological riverbed reach of the Poçemi and Kalivaçi area (see tables 1-3 in Schiemer *et al.,* 2020) (abbreviations: EN, endangered; VU, vulnerable; LC, least concern). This underpins the importance of the Vjosa river corridor at a European scale.

A total of 1,725 species are known for the Vjosa River to date: 653 plants and 1,072 animals (Fig. 4). Plants include: 354 non-vascular plants (algae) and 299 vascular plants. From animal species, 625 are invertebrates: 340 arthropods, 109 mollusks; and 447 vertebrates: 37 fishes, 32 reptiles and 13 amphibians, 295 birds and 70 mammals. Of them, 39 species are endangered according to IUCN, and 119 are on the Albanian Red List (2013). 148 species are listed in Annex 1–3 of the Berne Convention; 41 species in the Bird Directive; 78 species in the Habitats Directive (Meulenbroek *et al*., 2020). (Data from Meulenbroek *et al.,* 2020; Shumka *et al.,* 2018; updated with data from various authors in this volume).

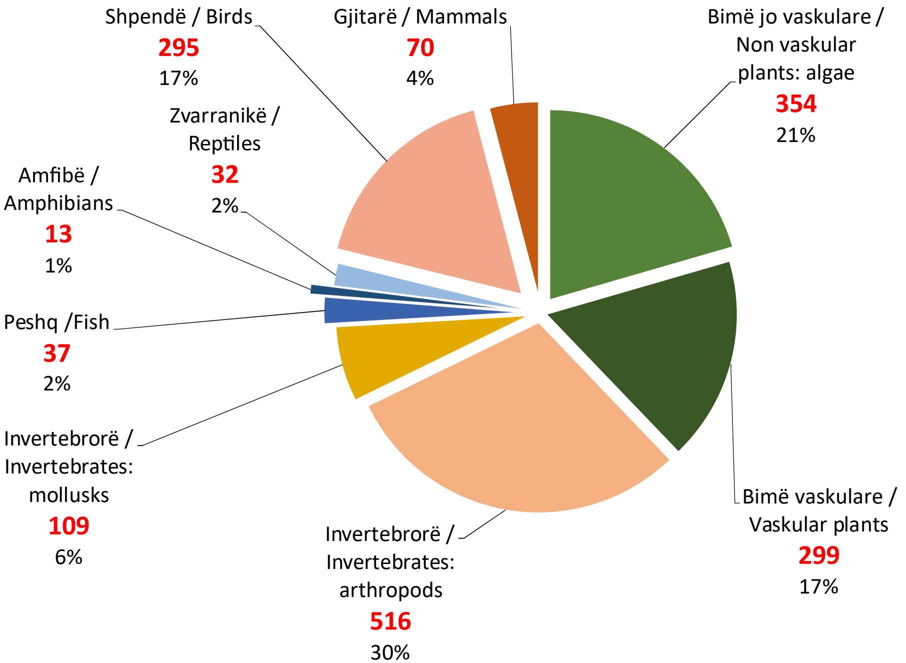

Figure 4.
The species number after major living groups known to date in the Vjosa river main course and its tributaries. (Data from Meulenbroek *et al.,* 2020; updated by Miho *et al.,* 2023; Bino *et al.,* 2023; and Shumka *et al.,* 2018).

The Vjosa River and its Delta – an inseparable hydrodynamic and ecological entity

The Vjosa/Aoos river is the largest in Albania after the Drini. It flows from the Pindus mountains east of Ioannina (Greece), called Aoos (Fig. 1). Vjosa is a transboundary ecosystem of 275 km (190 km in Albania), with a watershed of 6,799 km² (4,536 km² in Albania; 65%) (Qiriazi, *here*). The river corridor is a highly hydro-morphodynamic model, and therefore rich in threatened habitats of European importance (Schiemer *et al.,* 2020).

The annual average flow is 60 m³/s in the upper part of the river and 176 m³/s in the lower part, while in the estuary 195 m³/s (Qiriazi, *here*). But Vjosa is characterized by very high peak flows, that can be up to 6,680 m³/s (1% of probability), 5,570 m³/s (2%) and up to 5,040 m³/s (5%) (IHM, 1987; Mecaj, 2015; Pano, 2015). It is because of the simultaneous presence of torrential rainfalls throughout the whole area. Moreover, the watershed is very large and bare; only 22% of the area of the Vjosa basin is covered by forests (Hasenauer *et al.,* 2022). Based on these data, the Vjosa can likely overflow from its normal bed and flood the lower part (Fig. 5); see also figures 2, 3, 5 and 6 in Lushaj & Kacani (2019) for flood maps in the Delta area in the years 1971, 1980, 2015 and 2917, respectively. Experts confirm that even dams cannot control flooding events in Vjosa (Hauer et al., 2019).

Therefore, Vjosa has formed a wide and quite active Delta in the Adriatic Sea, the most important on the whole Albanian coast and beyond. Durmishi *et al.* (2018) confirm that 2/3 of Delta is the result of changes of the last 500 years. The River Mouth has moved from the Vlora Bay (where Narta Lagoon was created) to the foot of Frakulla (Fieri), less than 1 km southwest of the ancient city of Apollonia. It has changed twice during the yrs. 1870-2001, shifting about 10 km in the northern direction (Pano *et al.,* 2005); it was moved from the old mouth near the Kallenga Lagoon to where it is today; the former old mouth is today under evident erosion under the waves action. Experts say that even the Vlora town itself rises above the early sediments of the Vjosa River. Changes of the Delta shape in recent decades (1984-2015) have probably resulted from the interaction between sediment discharge by the river, anthropogenic removal of coastal sediment, wave energy and tidal effects (Kanjir & Gregorič Bon, 2015).

The Delta area begins from the Mifoli Bridge and expands in the coastal area from the Narta Lagoon in its southern part to Hoxhara Channel in the northern part (Fig. 2), where the Delta border is almost merged with the border of the Semani Delta (Fig. 1) (see the Map of the Fig. II.3.2.3 in Xhaferri, 2021). All this wave-dominated area is characterized by a succession of temporary wetlands and reed beds, large and small lagoons, saline and saltpans, sandy dunes, dead riverbeds, drainage channels, and agricultural lands, all together very interesting for the diversity of habitats and species (Figs. 3, 6, 8-11, 18-19).

Figure 5.
Vjosa view of the old Mifoli Bridge in January 2021 where it was confirmed that the water level was increased more than 7 m. (https://dosja.al/)

Briefly on natural values of the Delta of Vjosa

The Vjosa Delta includes the Narta Lagoon, the Vjosa estuary and its surrounding areas, with freshwater wetlands, marshes, reedbed, woodlands, islands and sandy beaches. It extends from the dunes and wetlands of Darzeze/Poro, Fieri, to the belt of dunes, areas and the lagoon of Narta, Vlora. They are formed by the hydrodynamic and sedimentological activity of the Vjosa River and the Adriatic sea over hundreds of years (Pano, 2015; *see* also the maps in figure 4 in Ciavola *et al.,* 1999). Still today there are dead arms of the River in Zhuka (Vlora) and Darzeza (Fieri), known as the ‘dead river’ (Fig. 6).

According to AKZM/NAPA (2022b), the zone shelters up to 18 habitats of Natura 2000, where 6 are listed as priority habitats, meaning that they need special protection measures. These habitats (along the delta, marshes and coastal dunes, lagoons, salinas) are luckily in good natural condition yet, with high ecological integrity (Figs. 3, 5, 7-9, 17-18). The Narta Lagoon (41.5 km²) is among the largest and most important wetland ecosystems, not only along the Albanian coast, but in the whole Eastern Adriatic. Plant and animal life flourish in these habitats, with many rare and threatened species.

Figure 6.
Dead arms of the Vjosa in Zhuka (Vlora) (***left***) and Darzeza (Fieri) (***right***), known as the '*dead river*', April 2023.

About **2,310 species have been known to date in various habitats of the Delta area** (1350 plants, 70 fungi and 890 animals) (Tab. 1; Fig. 6) (data after AKZM/NAPA, 2022b; Miho *et al.,* 2013; PPNEA/EURONATUR, 2021; Topi *et al.,* 2013; updated with data from various authors in this volume). From the photosynthetic plants, 550 are algae in aquatic habitats and 28 mosses, and more than 770 higher plants mainly in terrestrial habitats.

From animals, about 460 species are invertebrates (Beqiraj, 2001; 2004; Beqiraj et al., here), with 287 insects (lepidoptera and coleoptera), 92 mollusks (49 gastropods, 34 bivalves, 4 cephalopods)), 61 crustaceans, 18 nematodes, and 6 echinoderms; as well as 431 vertebrates (102 fish, 26 reptiles and 9 amphibians, 248 birds and 46 mammals).

About **198 endangered species** are reported to inhabit various habitats, or about 47% of the endangered animal species for the whole Albanian territory (Miho *et al.,* 2013; Topi *et al.,* 2013; MoE, 2013).
The area is listed as Important for Birds (IBA) by BirdLife International (BLI 2023), meeting criteria A1, A4i, A4iii, B1i (2000), but classified as endangered.

Narta Lagoon is the second most important in the country for waterfowl (20,780 wintering birds and over 40 species) (Bino *et al*., here) (Fig. 9). While Radford *et al*. (2011) list the area Pishe Poro – Vjosa Estuary (Vlora) among the Important Plant Areas (IPAs) (code A35). Habitats offer sheltering, food and reproduction conditions for many animal species: insects, fish, amphibians, reptiles, mammals and especially birds.

Table 1.
The species number of major living groups known to date in the area of the Vjosa Delta (data after various sources).

Living groups	Species (%)		Source
Mushrooms	**70**	*3*	AKZM/NAPA (2022); Miho *et al., here*
Mosses & Hepatics	**28**	*1*	Miho *et al., here*
Algae	**552**	*24*	Miho *et al., here*
Vascular plants	**770**	*33*	Meço *et al., here*
Invertebrates	**459**	*20*	Beqiraj, 2001; 2004; Beqiraj *et al., here*
Fish	**102**	*4*	AKZM/NAPA (2022)
Amphibians	**9**	*0.4*	Saçdanaku & Piroli, *here*
Reptiles	**26**	*1*	Saçdanaku & Piroli, *here*
Birds	**248**	*11*	Bino *et al., here*
Mammals	**46**	*2*	Bego, *here*
Total:	**2310**	*100%*	

The area is also a candidate for the NATURA 2000 network. The most quiet and food-rich habitats that support many species on their migratory route. Limopuo Lagoon, Narta Dunes (Fig. 8), Zverneci Forest and Zverneci Molasse Hills are on the list of Natural Monuments (Category III) (VKM/DCM 303/2019) (Fig. 2).

Transitional ecosystems, their importance

The area of Vjosa Delta belongs to transitional water bodies, which are under special attention in the Water Framework Directive (WFD, 2000). Transitional ecosystems are the interface between sea and land (Fig. 2 & 3), partially salted by the influence of coastal waters, but at the same time also under the influence of freshwater flows. They are represented by lagoons, river estuaries and other coastal marshes with brackish water.

Transitional habitats such as those found today in the well-preserved Vjosa Delta (Figs. 2, 3, 6, 8-10, 18-19) are among the world's most productive ecosystems. Who visits them, notices immediately that they are full of life. The very origin of life starts from these environments. Their net plant production is among the highest on the Planet, second after only to the tropical rainforest; production in swampy areas goes up to 2,200 g/m²/year (220 kv/ha/year); let's remember that the productivity in agricultural lands well cured by man is on average 3 times lower (about 650 g/m²/year or 65 kv/ha/year) (Salisbury & Ross, 1991).

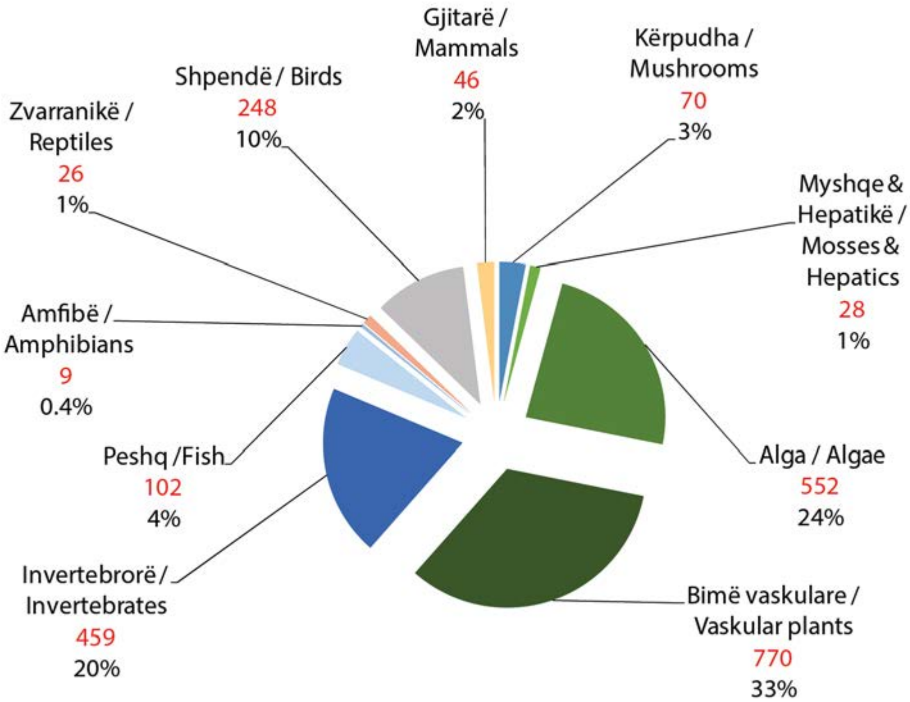

Figure 7.
The species number after major living groups found to date in the area of the Vjosa Delta, according to various sources.

Beside the abundant assimilation of carbon dioxide, they also help in the circulation of other nutrients (especially in the reduction of nitrogen); therefore, these ecosystems also help significantly in mitigating the climate changes and global warming.

They host rich and protected habitats for biodiversity, preserving within a very limited space numerous species of freshwater, but also marine and brackish waters. As very productive areas, they provide abundant food and protection for dense populations of birds, especially along their migratory routes.

The transitional ecosystems are important for the normal function of the biosphere, the control of coastal erosion and flood mitigation; they are the unique habitats where nitrogenous compounds are reduced to molecular nitrogen, returned then back to the atmosphere, thus helping to maintain its atmospheric composition over the last 400-500 million years. These ecosystems help filter freshwater inflows, protecting the coastal habitats and marine life.

Figure 8.
Sandy dunes (a) and with dune grass (*Ammophila arenaria*) (b) in the belt that separates the Salina from the Sea. These habitats are part of the list of Natural Monuments (VKM/DCM 303/2019) (Kategory III).

Figure 9.
a) Dalmatian pelican *(Pelecanus crispus) in one of the drainage channels between Narta Lagoon and Saline;*
b) colony of the Glossy ibis (*Plegadis falcinellus*) in a swampy area of Zverneci;
c) flamingo colony (*Phoenicopterus roseus*) in the Narta Lagoon (April 2023).

Figure 10.
Wetlands in the coastal area of the Narta- Vjosa estuary.

Transitional wetlands are breeding grounds for many species of fish and molluscs - important for fisheries and aquaculture. They are particularly useful in preventing loss of life and property by mitigating extreme floods and protecting land from storms; they also form natural basins and help maintain desirable water quality (USGS, 2023; Newton *et al*., 2023; etc.).

Human civilization is often developed near these aquatic ecosystems. They are important for natural tourism, but also for cultural tourism, in search of early traces of human civilizations.

On the other hand, transitional ecosystems are nowadays under the impact of tourism, fishing and aquaculture, salt-mining, industry, shipping and harbor activity, urbanization and agriculture. Not rarely, they cause changes in the physical environment, including geomorphology or salinity, dissolved oxygen values, etc.; in synergy, they can cause biodiversity loss and decline of ecosystem services, from coastal protection to seafood production. Understanding the causes and consequences of these anthropogenic pressures helps to identify effective management strategies that minimize negative consequences and promote the sustainable use of valuable resources (Newton *et al*., 2023).

Therefore, their knowledge, and proper use, conservation and protection is prioritized by national legislation and international conventions, including the Water Framework Directive (WFD, 2000), the Ramsar, the Bern and the Barcelona Conventions, IUCN, WWF, etc.

Figure 11.
Delta of Vjosa has been a field lab for each of us for years, for diploma or doctorate work. Working moments in the Dead River and Kallange, Zhuka/Poro, Vlora, on May 9-10, 2022.

Transitional ecosystems, Albania and the Delta of Vjosa

There are about 1000 km² of transitional ecosystems (Tab. 2) in Albania. The natural ecosystems of Butrinti (Saranda) (8,622.2 ha) and Divjaka-Karavasta (Lushnja) (22,389.08 ha) are national parks (Category II). The area of Kune–Vaini–Tale-Patoku–Fushekuqe–Ishmi (Lezha) (8,092.3 ha) was recently re-proclaimed 'Managed Nature Reserve' (Category IV) (VKM/DCM 60/2022). As mentioned above, the Vjosa Delta, i.e. the transitional area Pishe Poro-Narta was re-declared Protected Landscape (V) (16,124.61 ha) (Tab. 2; Fig. 12) (VKM 694/2022). The same category is the Buna River-Velipoja (Shkodra) (21,678.85 ha), Rrushkulli (Durres) (579.5 ha), Erzeni Delta, Lalzi Bay.

Table 2.
Data on transitional areas of Albania, their surface, protection category (national and international).

Name (Region in Albania)	Surface (ha)	Category	Albanian decision	International value (codes)
Buna River-Velipoja (Shkodra)	21,678.85	V		RAMSAR site (1598); IBA (Al013); IPA (01&02)
Vaini–Tale-Patoku–Fushekuqe–Ishmi (Lezha & Kurbini)	8,092.30	IV	VKM/DCM 60/2022	IBA (AL007; Drini Delta; AL014; Patoku Lagoon); IPA (21&26)
Rrushkulli (Durresi)	579.5	V	VKM/DCM 60/2022	IBA (AL015; Lalzi Bay)
Shkumbini Delta (Lushnja & Rrogozhina)	16,628	II	VKM/DCM 59/2022	Divjaka-Karavasta NP; RAMSAR site (781); IBA (AL006); IPA (33)
Semani Delta (Lushnja & Fieri)	20,413	-	-	Schwarz, 2024
Vjosa Delta (Vlora & Fieri	23,690	V	VKM/DCM 694/2022	Pishe Poro-Narta LPA; IBA (AL005; Narta Lagoon); IPA (35)
Orikumi wetlands (partly in Karburuni Nature Reserve Vlora)	800	IV (1.5 km^2)	VKM/DCM 60/2022	IBA (013; Vlora Bay, Karaburun peninsula, Orikumi lagoon, Sazan island and Cika mountain); IPA (36)
Butrinti (Saranda)	8,622.20	II	VKM/DCM 59/2022	RAMSAR site (1290); IBA (AL012); IPA (45)
Total	**100,503.85**			

Worth to mention that the above-mentioned coastal PAs were reduced by 30% by the revision process of AKZM/NAPA (2022a). Orikumi wetlands (Vlora) (ca. 800 ha) are only partly protected (https://geoportal.asig.gov.al/map), while Semani wetlands were never protected.

Butrinti, Karavasta-Divjaka and Shkoder-Bune-Velipoja are on the list of RAMSAR sites, as wetlands of special international importance. Some of them are also mentioned as part of EMERALD and IBA networks, including the area Pishe Poro – Narta (Tab. 2). Most of the transitory ecosystems mentioned above are in the list of Special Protected Areas (SPAs) for their biological diversity importance for the Mediterranean (Barcelona Convention).

Table 3.
Data about the Protected Landscape Pishe Poro- Narta (Category V):
a) according to the main cover;
b) according to internal zoning.
(elaborated after VKM/DCM 694/2022)

	Surface, ha	%
a) Cover		
Agricultural area	3125.3	19.38
Heterogeneous agricultural area	2300	14.26
Forests	2150.9	13.34
Aquatic area	119.6	0.74
Wetlands	2540.1	15.75
Marine waters	3471.8	21.53
Bare area or with scarce vegetation	815.2	5.06
Pastures	0.2	0.00
Shrubs	1392.1	8.63
Urban zone	209.41	1.3
b) Internal zoning		
Core zone (CZ)	6904.2	42.82
Area of traditional use and sustainable development (TUSD)	8780.49	54.45
Recreation area (RA)	440.1	2.73
Total	**16,124.61**	**100**

The Vjosa Delta with about 240 km², or ca. 24% of all Albanian transitional ecosystems, is certainly of particular importance. The whole area is among the most important and the most preserved on the whole Adriatic coast. Let‘s remember that the deltas of Buna, Drini of Lezha, Mati and Semani are today very transformed due to human impact, either in their rivers or related coastal areas. Schwarz (2024) & *here*, reports that the Vjosa, Semani and Shkumbini deltas, represent a relatively intact adjoining deltas (‘*triple-deltas*‘) among the Mediterranean Deltas, based on assessment of general intactness by hydromorphology and land use obstruction.

In the protected area Pishë Poro – Narta there are: 119.6 ha of water surface, 2,540.1 ha of swamps and 3,471.8 ha of marine water area (perhaps the lagoon area is understood here!) (VKM/DCM 694/2022; Tab. 3; Fig. 12); hence, **6,131.5 ha in total, or 38% of the whole protected area, are aquatic habitats, with salt, brackish or freshwater.** Worth noting that these are priority habitats (code 1150) in the EU Habitats Directive (EUNIS, 2019). The Narta Lagoon is among the largest and most important ecosystems, not only on the Albanian coast, but in the whole Adriatic. This Lagoon is the second most important in the country for waterfowl, and an important IBA area.

Delta of Vjosa out of the zoning process of Vjosa NP!

Since the 1960s, the Delta area has undergone major transformations due to human activity, starting from extreme reclamation, exploitation as a salt pan, to water pollution, from urban, agricultural, but also industrial activity. In addition to these, in recent decades the Vlora area has been under the pressure of uncontrolled urban development, uncontrolled fishing and hunting, exploitation of sediments, etc.

Rests of the former industrial area, Soda and PVC factories, built in the 1970s, pollute and make the area ugly even today. Almost inside the Delta area in 2010, the Vlora Thermal Power Plant (power 98 MW) (MWH, 2003) was built in the wrong place, which has not worked for a single day (Fig. 13). Moreover in 2015-2016, it was urged a lot to drill an oil well in the area, but it was stopped by the efforts of environmentalists (Miho, 2016).

The Narta Lagoon, the most important ecosystem of the whole wetland complex, is suffering from the limited water exchange; there are many factors acting together here: excessive evaporation; the sea waves action; heavy sediments from the Vjosa River; scarce water inflows from the basin; the use of Lagoon water to feed the Saltpans; etc. All synergically significantly affect the living world of the Lagoon, its eutrophication and decrease in productivity. This is also promoted by pollution with organic matter or other pollutants of urban, agricultural or industrial origin.

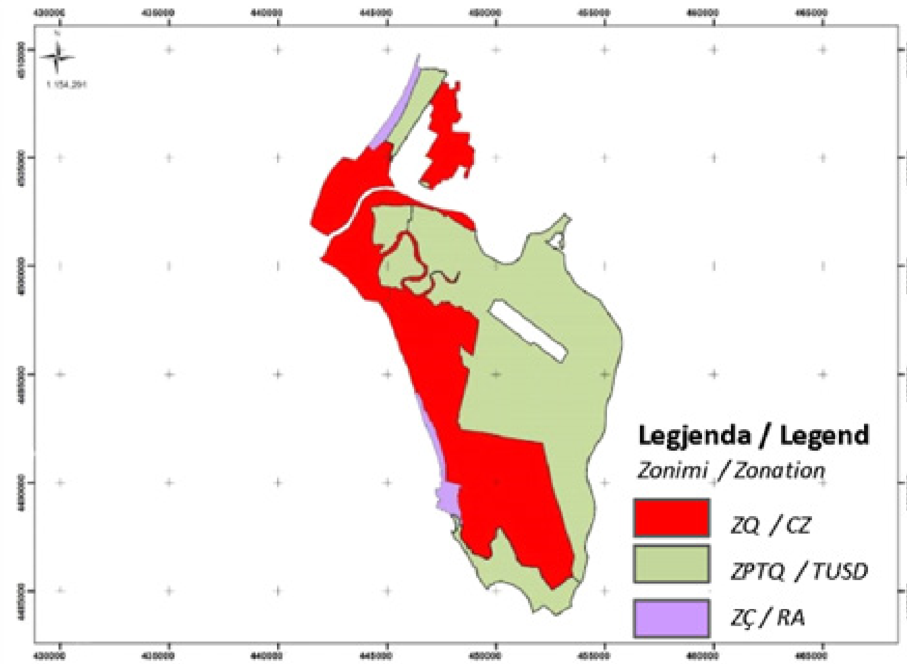

Figure 12.
The zoning map of the Protected Landscape Pishe Poro – Narta (Category V) (the explanations for the zones are given in table 1). The white rectangle inside the PA is the area where Vlora Airport has started to be built. (elaborated after VKM/DCM 694/2022)

In addition, in recent years it is also under the threat of mass tourism development. Although a good part of the whole area has the status of Protected Landscape (Category V), it has not prevented almost arbitrarily the construction of the Vlora Airport within the protected area (April 2022) (Figs. 12, 14, 15). Delta area was left out of the zoning process and not included within the Vjosa NP (MTE, 2022; VKM/DCM 155/2023).

The exclusion of the Delta, its wetlands, lagoons and coastal dunes, within the boundaries of the Vjosa NP zoning is nonsense, and out of the IUCN criteria for nature protection. In addition, Vjosa's case was highlighted in important international institutions, Berne Convention, IUCN, and European Commission, mentioning the habitats and rare species of the Delta area, which could be threatened, reduced or even disappeared in the long term due to the construction of HPPs on Vjosa.

Figure 13.
Two examples of bad practices from the not too distant past in Vlora, almost within the Vjosa Delta area: ***Left***, Rests of the former industrial area, Soda and PVC factories; built in the 1970s not in a proper place, heavy polluters during the operating period, with a negative impact still visible today. ***Right***, the Vlora Thermal Power Plant (power 98 MW), built much later in 2010th, but not in a proper place, investment of about 100 million Euros, for more than 10 years in conservation, not working a single day. (Photos from: https://ata.gov.al/ & https://www.monitor.al/)

From a recent review of the entire system of Protected Areas (PAs) in Albania, led by the National Agency of Protected Areas (AKZM/NAPA, 2022a), the whole natural/ wetland ecosystem of the Vjosa Delta, named Pishe Poro – Narta, was re-declared Protected Landscape (V^{th} Category) (VKM 694/2022) (Fig. 12; Tab. 3). The previous status of the Pishe Poro (Fieri) was decreased, from Managed Nature Reserve (IV^{th} Category) to Protected Landscape (V^{th} Category). Moreover, the total protected area was reduced by 5,551.7 ha, from 21,238 ha to 16,124.61 ha (Fig. 14). The reduction of the area of Vjosa - Narta Protected Area and reduced status of Pishe Poro is not what this area really deserves, listed also in EMERALD and IBA networks (AKZM/NAPA 2022b; BirdLife International, 2023), as well as IPA (Radford *et al*., 2011).

Meanwhile, from the Vlora Airport master plan, MIE documents (2019a,b,c) and the Vjosa-Narta development plan (PDZRK, 2021a&b), it seems that in the future, besides the Airport already under the construction (!), probably there will be other interventions within the protected area for tourism (Fig. 15). Undoubtedly, these will cause the decrease of ecological integrity, habitats' fragmentation, leading to their loss, as well as the loss of species in the near future.

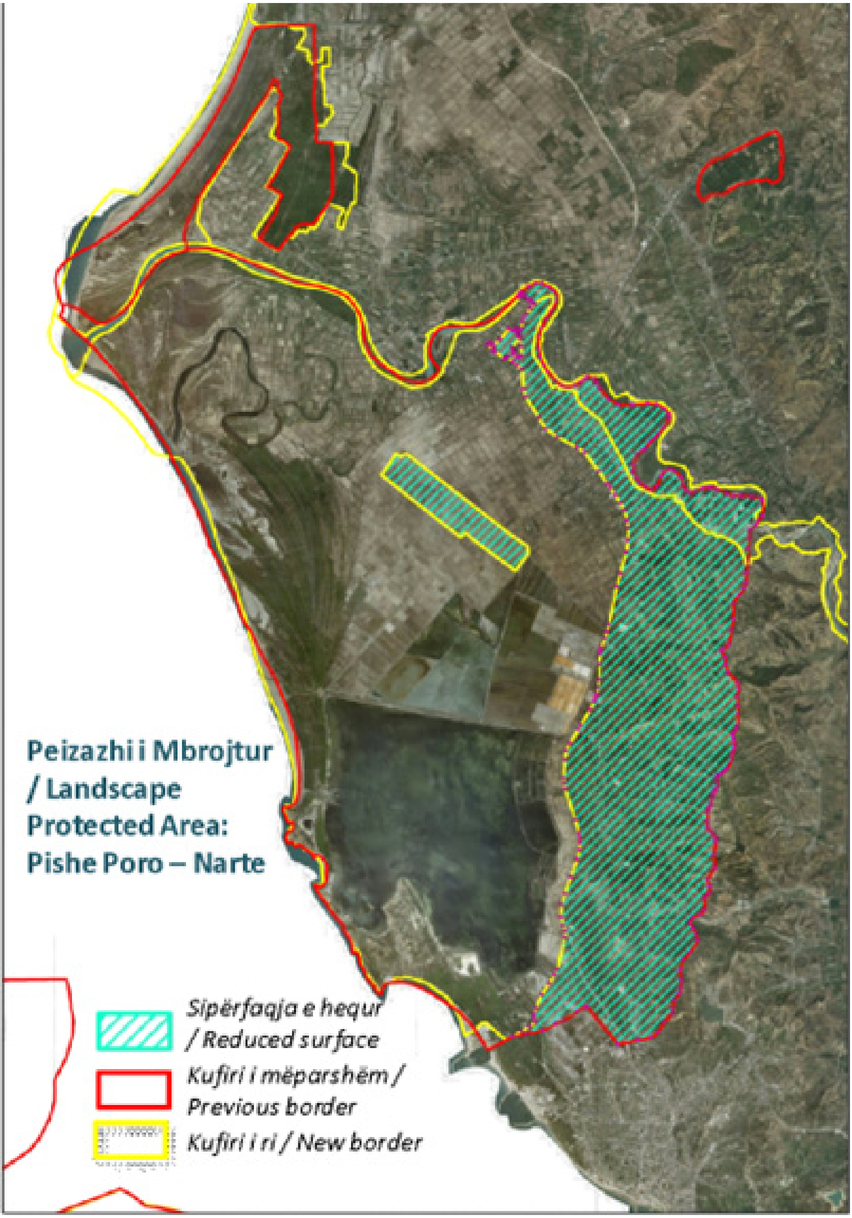

Figure 14.
The previous (in red) and new (in yellow) borders of the Protected Landscape Pishe Poro – Narte (Category V). (elaborated after VKM/DCM 694/2022: Annex 3)

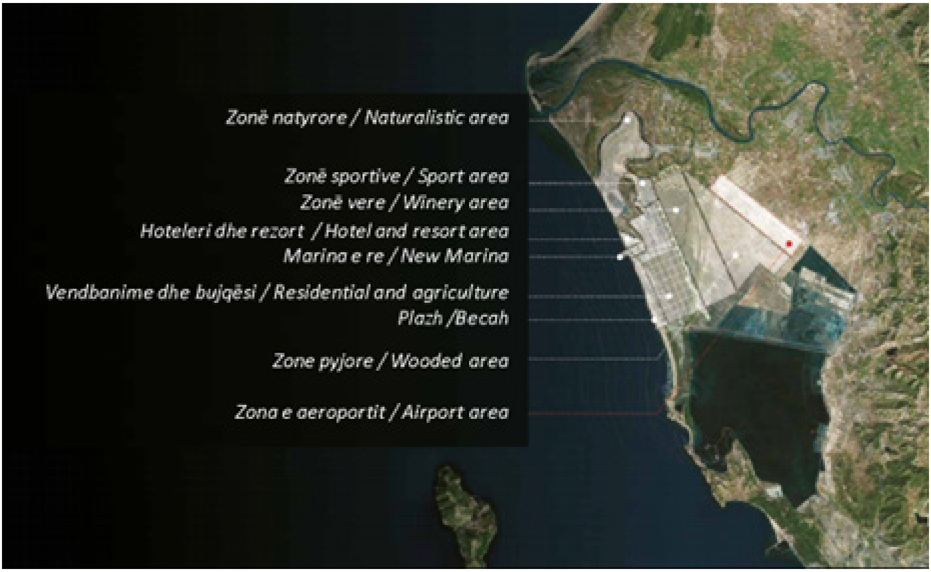

Figure 15.
Map showing the eventual plans for tourist infrastructure in the future within the Protected Landscape Pishe Poro- Narta. (after MIE 2019b)

For Vlora Delta part some management plans were drawn up (2005), and recently a development plan (PDZRK, 2021b), and other documents from the National Agency of Protected Areas (AKZM/NAPA, 2022a,b) and the Ministry of Infrastructure and Energy (MIE, 2019a, b, c). The expert opinion is that the assessment of the present situation is insufficient and not properly done according to international standards, regarding the main environmental issues, the human impact, and what would be the eventual trends after the implementation of the ongoing development plans. Moreover, **even the safety of infrastructure investments is not clear within a very dynamic Delta due to galloping marine erosion, with rapid changes in its extent and contours.** The forming of abandoned traces of construction within this area cannot be merely imaginary. Vlora still has such abandoned traces in the vicinity of this area from a not so distant past (Fig. 13)!

All these cannot be in the spirit of the declaration of the Vjosa Wild River NP; contrary, it contradicts the true values of this Park. Moreover, these plans are in conflict with the implementation of EU standards, the Birds and Habitats Directives, the Water Framework Directive (WFD, 2000), and the EU strategy to stop the loss of biodiversity, and all international organizations concerned with the protection of such coastal areas (Ramsar, Berne, and Barcelona Conventions, IUCN, WWF, etc.).

Tourism development vs. environmental sustainability

On the other hand, the friendly balance between the development and conservation, and sustainable use of natural resources has not been easy in the last 70-80 years in Albania. Despite the efforts and progress towards the protection and related legal acts, the nature and the natural resources are seriously impacted, especially in the last 30 years of the economic transition. The Protected Areas (PAs) are not saved either, as it is with the Vjosa Delta, under the threat unfriendly urbanization of the mass tourism we mentioned above (Fig. 15).

As mentioned for Vjosa Delta, some DCMs, 59/2022, 60/2022 and 694/2022, and others in the process, intervened into the reduction of the area of some important PAs, especially of the coastal wetlands, even with international values and protection.

Figura 16.
Above, view of Limopuo lagoon (***left***) and Zverneci beach (***right***), Vlora; ***below***, view of the Darzeza/ Poro forest, Fieri, burned in October 2023 (!); these are part of the protected area, under the pressure of tourism development (April 2024)..

Lastly, the Parliament, through the Law 21/2024 amended the Law 81/2017 on PAs; after that, all PA categories, even in their core areas can be developed for “infrastructure and hospitality activities, with highest architectural and environmental standards for supporting tourism of excellence (with 5 stars) and the related infrastructure’; the PA zoning was repealed too; moreover, the new amendments sanction that the Natural Monuments (NM) are not surrounded by a buffer zone of up to 200 meters width from the Monument’s perimeter (repealed Point 3, Article 17, Law 81/2017); it means that the Monument’s buffer area can be exposed by law to the infrastructure development.

According to INSTAT Albania was visited by more than 10 million tourists at the end of the past year (2023), with an expected income in this sector up to 4 billion Euros, twice as high as in 2022 (Latifi, 2023); it is up to 8.3% of the estimated GDP(PPP) (51.8 $USD; WEO, 2022). A large part of tourists visit the coast for summer holidays, where the Vlora region is among the most frequented. According to the World Tourism Organization (UNWTO), tourism is one of the fastest-growing industries, contributing more than 10% to the global GDP (Baloch *et al*., 2023).

But together **with the tourism growth the environmental pollution has been witnessed around the globe in different regions.** A substantial large-scale tourism industry is most likely to cause environmental impact along with its positive effects on employment, economic wealth. It may include air emissions, noise, solid waste, littering, sewage, oil and chemicals, architectural/visual pollution, heating, car use, and many more. Tourism is considered a threat to deforestation, and air and water pollution, endangering biodiversity and ecosystem resilience (Baloch *et al*., 2023; Sun *et al*., 2021; Azam *et al*., 2018; etc.).

Therefore, the awareness of the impact of tourism development upon environmental sustainability is urgently needed for the Vjosa Delta. A balance between business and environmental interests in maintaining the integrity of the ecological system is strongly suggested.

About the Science Weeks in the Delta of Vjosa

That's why the Vjosa Delta has been under the attention and concern of environmentalists and experts from the academic world, local and international, and from important international institutions. The last recommendation of Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) for the Albanian Government emphasize to '*suspend the construction of Vlora International Airport until a new and sufficient Environmental Impact Assessment (EIA) procedure will be conducted as well as a Proper/Appropriate Assessment*' (https://rm.coe.int/2023-rec-219e-vlora-airport/1680ac7963).

The aim of the two **Science Weeks in the Vjosa Delta** during April, 2023 and April, 2024, was to be familiar with the actual state, collect data on biodiversity, geology, geography, etc. In April 2023, about 40 experts and students participated (Fig. 17), from important Albanian institutions (UT, UPT, UBT, AMBU, ARM Fier, AdZM Fieri & Vlora, etc.). In April 2024, about 60 experts and students participated from Albanian universities (UT, PUT, AUT, etc.), ERA Fieri, etc., as well as from the Region, Austria, Italy, Bulgaria, Greece, etc.

Figure 17.
Experts and students who participated in the Science Week in the Pishë Poro- Narta Protected Landscape in April 24-28, 2023.

The whole Delta area was visited, from Soda Forest, Narta, Kallenga & Limopuo Lagoons, Zverneci Peninsula and related sand dunes, Saline Dam, Dead River (Zhuka), related marshes and dunes, in Vlora, the marshes and dunes in northern part of the Delta in Fieri, including the Dead River in Darzeza (Fig. 18).

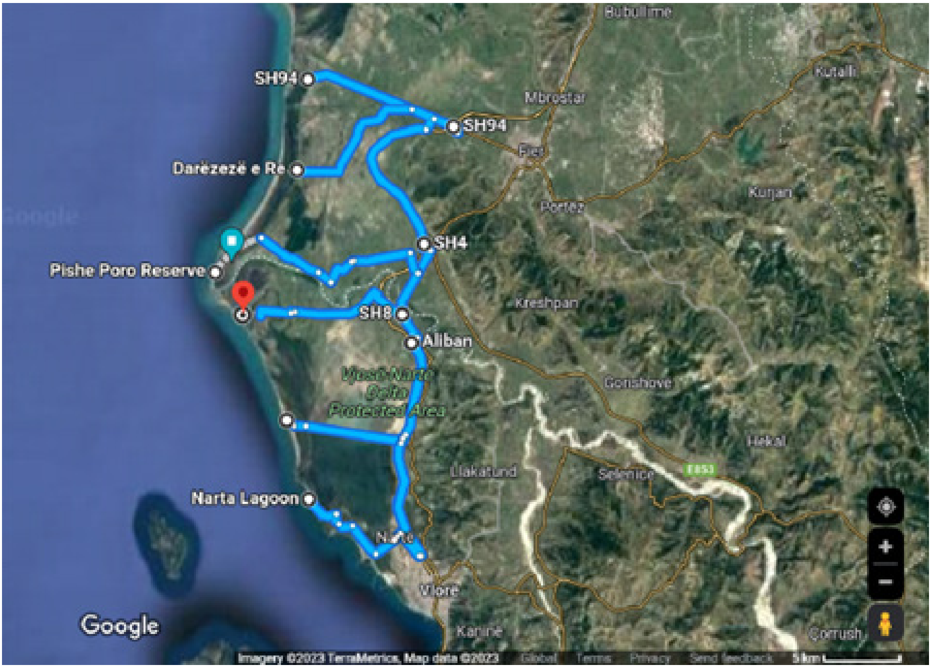

Figure 18.
Itinerary followed during the Science Week in the Protected Landscape Pishe Poro- Narta during April 24th-28th, 2023 (elaborated after Googlemaps 2023).

We made efforts to summarize the data in this bilingual **Special Volume**, with a people science view. Beside the scientific data, recommendations are given, about the sensitivity and threats to habitats and species.

Distinguished colleagues from the University of Vienna (Austria), the University of Salento (Italy), the Institute of Anthropological and Spatial Studies, Slovenia, etc. contributed to this Volume, too. They reported here the best experience from the Mediterranean Region and beyond regarding the conservation and sustainable management of transitional coastal ecosystems.

Worth saying that the area of the Vjosa Delta in years has been a field lab for researchers (Figs. 11, 19 & 20), for diploma or doctorate work. Most of the data has been published and presented at various scientific events in the country and abroad (i.e. Xhulaj, 2008; Miho *et al*., 2013; Xhaferri, 2021; etc.).

Figure 19.
Working moments in different sites of Delta of Vjosa, on April 24-28, 2023.

Figure 20.
Working moments in different sites of the Vjosa Delta, on April, 2023 (***above***) and April 2024 (***middle & below***).

Figure 21.
Moments from the International Vjosa Delta Symposium- An Ecosystem in Transition was held in Vlora, on October 27-28th 2023.

Vjosa Delta Symposium

The International Vjosa Delta Symposium - An Ecosystem in Transition was held in Vlora, on October 27-28th 2023 (Fig. 21), where 45 scientists from Albania and the region (Austria, Italy, Slovenia, Greece) participated. About 20 presentations were held in total, 13 dedicated to the Delta, geological diversity, ecological condition and biodiversity, their condition and threats. Experts from the region brought their experience on the importance of transitional ecosystems, their services, the standards that must be met for sustainable development, etc.

Representatives of central and local government institutions were also invited to this event to present their opinions.

The Symposium followed the efforts and concerns of the academia from our institutions together with national and international environmental organizations regarding the main attitude towards the Vjosa Delta area.

An **Open Letter** was signed by experts and sent to the Albanian Prime Minister and the most relevant central and local representatives. There was strongly suggested:

— Facilitate for an **interdisciplinary study of Vjosa Delta** focused on its conservation and sustainable management, based on scientific evidence.

— The **whole Vjosa Delta must be preserved**, left untouched by large-scale tourism; instead, it should wisely be used for nature-based tourism projects.

— It is now the right moment for the **Pishe Poro - Narta Protected Landscape to be declared National Park (IUCN category II)** as an indivisible part of Vjosa Wild River National Park.

***

Despite transformations in years since the first data on algae were given by Protic (1907), **the Vjosa Delta area is still distinguished throughout the Mediterranean (*Schwarz, here*)**, for its undisturbed habitats, high and special biodiversity. The construction of the airport within the area, and the further urbanization, will undoubtedly cause the further decrease of natural values, habitat integrity, their fragmentation and biodiversity loss, weakening the ecosystem resilience, and reducing ecosystem services.

Our aim is to help the decision-making, policy-making, investors, and other stakeholders, to protect this area as an inseparable hydrodynamic and ecological part of the National Park of the Vjosa Wild River.

We strongly suggest an interdisciplinary study of the whole Vjosa Delta focused on its conservation and sustainable management, based on scientific evidence. The common opinion is that this area should be left free, untouched by construction of large-scale tourism projects. Moreover, it is the right moment for the Protected Landscape Pishe Poro - Narta to be declared a National Park, and the infrastructure interventions of mass tourism to be prevented in the future.

Note: This Chapter is an update of the Miho et al. (2023b), printed for the International Symposium: Vjosa Delta - An ecosystem in transition, Vlora, October 2023.

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Geographical overview and geomorphological evolution of the Vjosa Delta

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Introduction

The delta, formed by the continuous depositional activity of the river and sea waves, and shaped by the wind, has been called the **land of the river, the sea and the wind.** It is an ancient and ever new land; it has no borders, nor can it have, because river and sea water design and redesign its profile every day.

The formation, evolution and very fast dynamics of deltas, their morphology, numerous values and ecosystems with significant biodiversity are conditioned especially by the liquid and solid flows of the river, their regime; these are related to the relief morphology of the basin, valley and river bed; with its climate and geological composition; with human activity in its basin; etc. Therefore, we will begin the geographical overview of the Vjosa delta with the analysis of the general characteristics of the basin of this river.

At the same time, deltas, with all the complexity of their processes, factors and values, are also related to marine activity, which is conditioned by the morphology of the coasts, the bathymetry of the sea, by waves, sea currents and tides. These factors will be addressed in the second part, where the evolution and present-day features of the delta are discussed.

1. General characteristics of the Vjosa/Aoos basin

1.1. General geographical data

Vjosa/Aoos constitutes a river corridor, a living natural hydro-morphodynamic model, and, therefore, very rich in threatened habitats of European importance (Schiemer *et al*., 2020).

Vjosa/Aoos, the largest river in South Albania and among the main rivers of the country, originates outside the border, in the Pindus mountains (Greece), at an altitude of about 2600 m, flows through a delta into the Adriatic Sea, north of the Narta lagoon. The total area of its basin is 6,799 km^2, of which 4,536 km^2 lie within the borders of Albania, while the rest in Greece. The total length of the river is 275 km, of which 190 km flow in Albanian territory. Average annual flow: 60 m^3/s in the upper part of the river and 176 m^3/s in the lower part, while in the estuary 195 m^3/s (Selenica & Saliaj, 2014).

1.2. Extent in administrative units of the basin

The Vjosa basin spreads over 5 counties: Gjirokastra, Korça, Berati, Vlora, Fieri, and in 14 municipalities: Kolonja, Permeti, Kelcyra, Libohova, Dropulli, Gjirokastra, Tepelena, Skrapari, Memaliaj, Selenica, Mallakastra, Himara, Vlora and Fieri (Fig. 1A). The largest extent is in: Selenica (about 14%), Permeti (about 12%), Gjirokastra and Dropulli (10%), Kolonja (9%), Tepelena (8%), etc.

1.3. Morphology and natural diversity of the basin

The shape of the Vjosa basin is elongated and extends SE-NW. Even the basins of its main tributaries (Drino, Shushica, etc.) are elongated. Whereas, many basins of small tributaries have a circular or almost circular shape, especially in terrigenous territories; they, also for this reason, are distinguished by large fluctuations in flows, swelling and immediate reduction of their levels.

The basin is distinguished by a marked natural diversity of landscapes and ecosystems: mountains, hills, valleys, plains, rivers, lakes, wetlands; great diversity of plants and animals and their habitats; different soil types, residential centers, urban and rural, agricultural, industrial, tourist landscapes, etc.

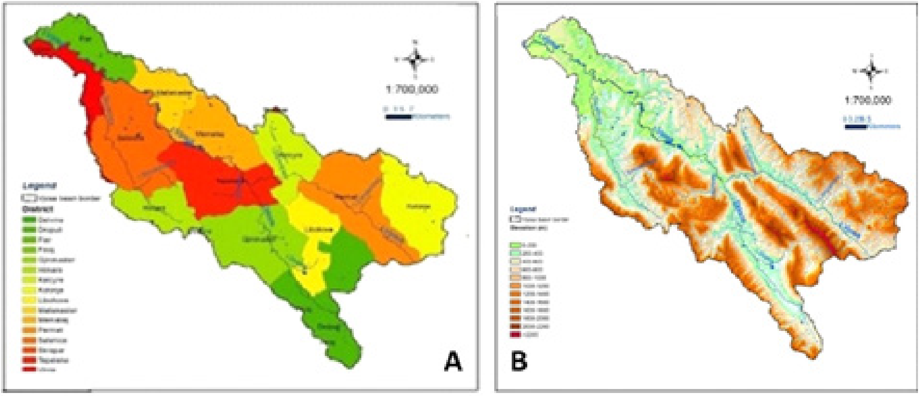

Figure 1.
A, Map of the extent of the Vjosa basin in administrative units.
B, Physical map of the Vjosa basin. (Selenica & Saliaj, 2014)

Geological composition

The basin is built from Mesozoic carbonate, magmatic and evaporitic formations; Paleogene and Neogene terrigenous (flysch and molasses) and new quaternary marine, lake, swamp, wetland and alluvial deposits (ISPGJM, 2022); these are found especially in the lower sector, but also in the river terraces of some valleys in the middle sector and less in the upper sector. Karst has developed in the limestone rocks, in Këlcyra gorge, Dhembeli, Kurveleshi, Poçemi, etc. Especially in the Lengarica canyon, about 10 km of underground karst voids were discovered in 1 km² (Palmisano, 2023).

Morfografia dhe morfometria

Morphography and morphometry

The relief is also very diverse (Qiriazi, 2019; Doka & Qiriazi, 2022): mountainous in the upper sector, hilly-mountainous in the middle sector and plain in the lower sector. The Vjosa Valley from Tre Urat to near to Mifoli has the shape of the letter U. Continuing to the sea, only the wide, shallow, winding bed with islands appears.

In the lower sector there are completely flat fields, at the same height as the sea or very slightly above its level; wetlands of considerable extent, abandoned Vjosa beds, or dead rivers. In the middle sector there are low, medium and high hills, composed of terrigenous, very fragmented by erosion, which has degraded and even desertified the landscapes on many slopes; but in the middle sector and, especially in the upper part, there are high mountains with often steep slopes and ridges, fragmented by erosion in the terrigenous territories and karst in the limestone and evaporite territories. There are many degraded, even desertified, landscapes. In the heights of the mountains (Nemeçka, Dhembeli, etc.), there are also relict glacial forms: cirques, troughs, moraines, etc.

There are valleys of various shapes in this sector, among them also narrow gorges and very deep and long canyons, karst landscapes with karst forms (funnels, uvala, karstic fields, caves, wells, etc.). In the surroundings of these landscapes, there are large karst springs with a flow of up to several m³/s. There are thermo-mineral springs and explosions of hot sulfurous vapors (Postenani, Leskoviku).

According to the **hypsometric** map (Fig. 1B) and the hypsometric curve graph (Fig. 2), the average elevation of the basin is 855 m. The following hypsometric levels are distinguished: 0-200 m that occupies 4.4% of the total area of the basin; 200-1400 m, occupying 74.2%; 1400 - 2000 m occupying 20.5% and hypsometric floor over 2000 occupying 0.9% of the basin. The greatest extent is at altitudes of 200-1400 m and the smallest at altitudes above 2000 m. These data show that the relief of the basin is mainly hilly-mountainous

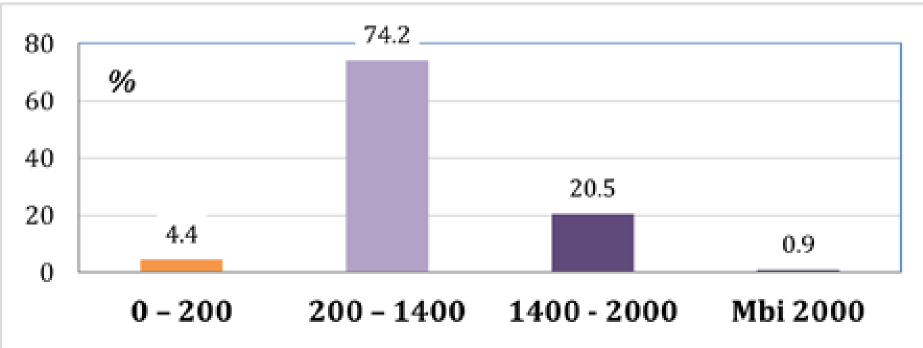

Figure 2.
Percentage of territories of the Vjosa basin, according to altitudes.

According to the **relief fragmentation density** map (QSGJ, 1990), the basin is distinguished by a high degree of refraction in its upper and middle sectors, and by very small values of this morphometric parameter in the lower sector.

According to the corresponding map (QSGJ, 1990), the basin has high values of **the depth of relief fragmentation** in the upper and middle sectors, and small values in the lower basin.

According to the corresponding map (QSGJ, 1990), the basin has high **slope values** in the upper sector, medium values in the middle sector and very small values in the lower sector.

1.4. The characteristics of the valley and bed of Vjosa and its tributaries

Due to the change in the geological composition, the geological structures in which it develops longitudinally or transversely and the character of the differentiating neotectonic movements, **the bed and valley of Vjosa and its branches have extremely diverse morphologies** (Qiriazi, 2019; Doka & Qiriazi, 2022): times very narrow and quite deep (canyons) in the upper and partly middle sector; there are very irregular flows with unstable beds, gritty filled with very thick material. While in the lower sector, the bed of Vjosa widens and shallows, it branches, forming islands. Characteristic for this part of the bed are numerous meanders (twists) with a radius of up to several km.

This bed appearance, in this sector, is related to the reduction of the bed slope and the numerous solid accumulations of the river. The average turbidity of the Vjosa waters reaches 1040 g/m^3, the suspended alluvium transported reaches 6.7 million m^3/year, which occupies 14% of the solid suspended flow of the hydrographic network of Albania, while the module of suspended alluvium reaches 1000 t/km^2 /year (IHM, 1985).

In the lower sector of Vjosa basin, the mainly clay composition of the soils and the very small slopes, condition the standing of water on the surface, which create transitional wetland ecosystems (lakes, marshes, swamps), which constitute habitats of waterfowl and other living things . The lower sector of the basin is constantly flooded by Vjosa, which increases the area of wetlands and changes their extent.

1.5. Evolution of the river bed in years and the historical-morphological interpretation

The bed deepening, lateral and depth erosion is found in the middle and especially the upper sector with a large slope and involved by neotectonic lifting movements. Due to numerous alluvial deposits, but also frequent floods, the lower bed sector has constantly changed its shape and extent, direction and mouth. By comparing the oldest maps from the 14th, 15th, and 16th centuries (Map of Xh. Bastalid, 1560) and later ones, it is established that the Vjosa once flowed into the sector of today's beach of Vlora; in the future, it was displaced in the north direction, up to the present position of the estuary with a rather large delta. The Vjosa estuary, like all other rivers flowing into the Adriatic, undergoes a pendular movement, from south to north and vice versa.

Even in the Myzeqe plain, the Vjosa bed has changed direction several times (Fig. 3). Archaeological data (Ceka, 1958) show that the ancient city of Apollonia (5th century BC) until late in the Roman period was connected to the sea via Vjosa, while currently the river flows far from the ruins of the ancient city.

On the riverbed banks of the lower sector, two processes take place, erosion and landslides. Erosion is higher on the concave banks of bed meanders, where the water impinges with greater force. Therefore, they are steeper and the river near them is deeper. In the opposite wing, the myst, accumulation occurs. Therefore, the banks here have a small slope and the river is shallow, while the profile of the bed is asymmetrical, which creates unequal conditions for aquatic life.

Concave banks evolve faster, retreating continuously until the neck of the meander snaps. This has two consequences: the direction of the bed and forming of the so-called '***dead rivers***' in the meander loop, which lose connections with the main river (Fig. 4). They are supplied with water by rainfall and by small lateral discharges, while they lose water by evaporation and by any possible human use. In their ecosystem, a special living plant and animal world develops.

Their lifespan also depends on the ratio between water supply and consumption. But they gradually become shallower and turn into longitudinal lakes, marshes and swamps, thus creating special wetland habitats. Currently, in the active area of Vjosa, these 'dead' rivers are in different stages of their life: extended lakes, marshes and swamps. There are also cases when they are completely dry or hold water for a short time. In the current relief, they stand out more as negative forms, where hygrophilous vegetation is still found.

The spread of soft flysch formations in the middle and upper basin and many other factors (morphological, climatic, hydrological, floristic, anthropogenic), as it was said, condition the numerous landslides and intense erosion, the transport and large deposition of alluvium on her field bed.

Landslides and the often large erosion of riverbanks are connected with their clay composition, with the activation of the erosion process in depth and on the sides. Erosion in depth is found especially in the middle sector and especially in the upper part of the river with large slopes and involved by the neotectonic lifting movement. Lateral erosion is mostly found in the middle sector and especially in the lower sector (as was said in the evolution of the meanders of the river bed). This is associated with the continuous change in the morphology of the banks of the river bed.

Intense erosion brought about large deposition of alluvium. These processes are related to the filling of the river bed, which made it shallower and transformed into an island, raising it above the level of the Myzeqes plain. This created conditions for the exit of the river's waters, the frequent flooding of the Vjosa and the continuous change of its bed, which turned its lower plain flow into a 'wandering' river.

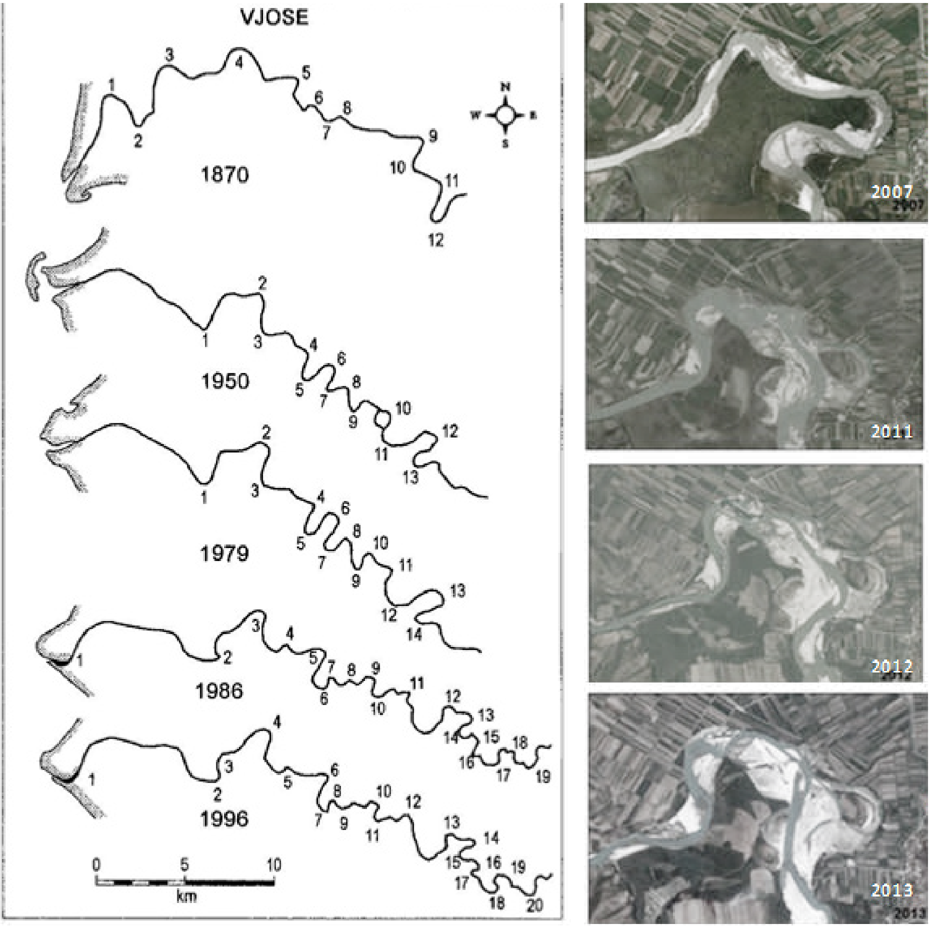

Figure 3.
Left, change of bed configuration in the the lower sector of Vjosa (1870-1996) (Ciavola *et al*., 1999); ***right***, the morphological evolution of the bed of the river Vjosa in Varibobi (2007-2013).

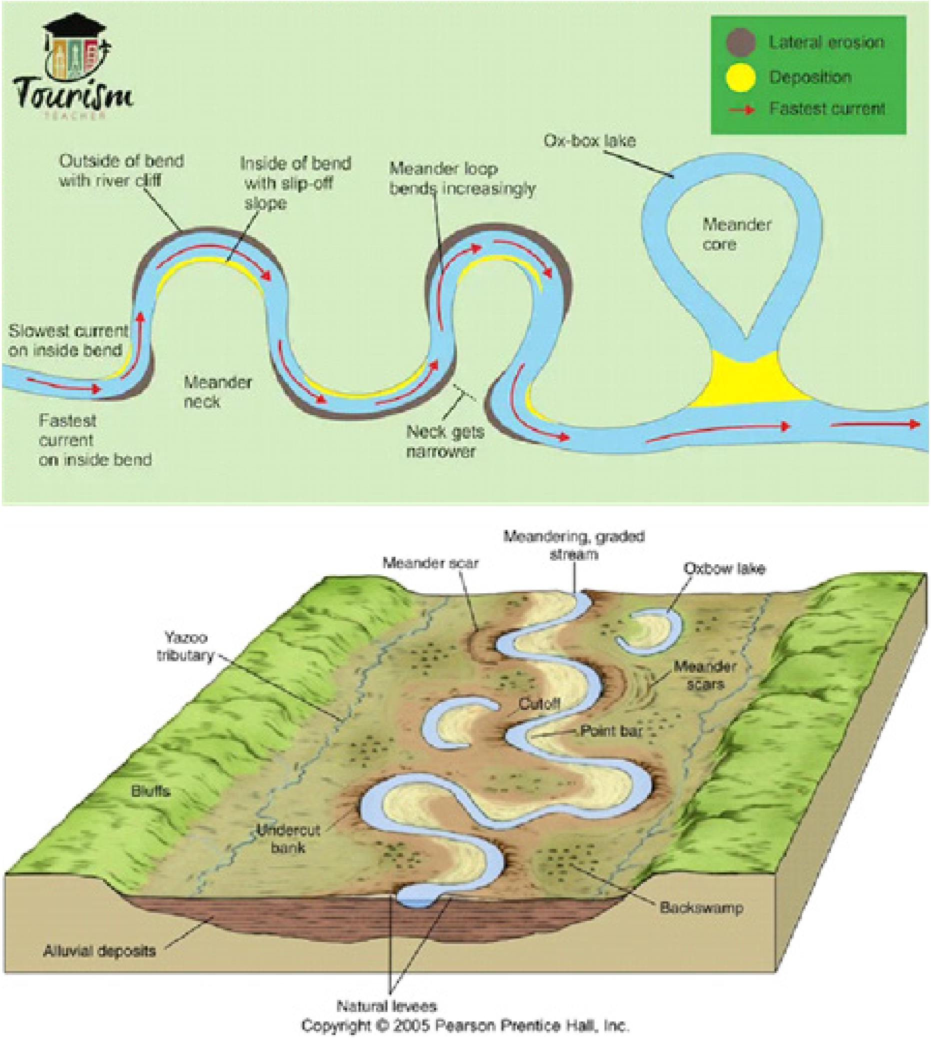

Figure 4.
Above, how are meanders formed? ***Below***, floodplain evolution and its associated landforms (https://tourismteacher.com/how-are-meanders-formed/ & http://thebritishgeographer.weebly.com/river-landforms.html).

In the 1960s, works were carried out to protect against the floods of Vjosa (deepening and straightening of the bed, raising embankments on both sides of it) and reclamation of large wetland areas (main and secondary drainage canals were built, pumping stations were built for the mechanical lifting of stagnant waters and their discharge into the sea). These interventions were accompanied by significant modifications of the bed of the main natural river and its tributaries. Bed direction increased flow velocity, which increased the water and alluvial carrying capacity of these river beds, homogenizing the bottom of the bed and creating other conditions for aquatic life. In addition to drainage and soil cultivation, irrigation canals were built, etc. Agricultural land was gained from this activity, which is cultivated with cereals, vegetables, etc., once also with cotton and rice. The conditions were created for the development of intensive agriculture, for the construction of roads and the urbanization of the territory. All this work modified and changed so much the morphology of the natural bed of the Vjosa, up to its delta; now it is not easy to find the traces of the former flow. Of them, only the remains of recent positions can be more clearly distinguished in the form of 'dead' rivers, wetlands, marches, hygrophilous vegetation, etc.

Due to the numerous solid deposits and the abandonment of works for the maintenance of the drainage system and the hydraulic regulation of the bed of Vjosa, in recent decades, large floods have reappeared and increased in extraordinary hydrometeorological events.

1.6. Klima e basenit

Klima e basenit është mesdhetare. Në sektorin e sipërm, klimë mesdhetare malore (dimër i ftohtë dhe verë e freskët); në sektorin e mesëm, mesdhetare paramalore e kodrinore (dimri më pak i ftohtë dhe vera më pak e freskët); në sektorin e poshtëm, klimë mesdhetare fushore (dimër i lagësht e i butë, verë e nxehtë dhe e thatë) (Tab. 1 & Fig. 5A).

Table 1.
Monthly temperature (°C) distribution in some stations of Vjosa Basin (IHM, 1980).

Months	1	2	3	4	5	6	7	8	9	10	11	12	Year
Frasher	2.2	3.3	5.4	8.8	14.1	17.3	19.6	19.7	16.6	11.8	7.6	3.8	10.9
Goranxi	5.3	6.8	9.2	12.6	16.8	20.8	23.0	23.1	19.7	14.7	10.2	6.6	14.1
Gjirokaster	5.4	6.9	9.3	12.8	17.2	21.2	23.5	23.6	20.1	15	10.3	6.7	14.3
Nivice	4.3	4.8	6.7	9.3	14.4	18.5	20.6	20.7	17.5	12.9	8.3	5.4	12.0
Orikum	8.7	9.5	10.9	13.6	17.2	21.0	22.8	22.9	20.6	16.8	13.5	10.4	15.7
Permet	5.5	7.1	9.6	13.3	17.7	21.7	24.1	24.4	20.9	15.6	10.6	5.8	14.8
Polican	4.1	5.1	7.1	10.2	15.3	18.7	21.4	21.4	18	13.3	9.2	5.7	12.5
Kuç	5.7	6.6	8.3	11.3	15.9	19.9	22.8	23.3	19.8	15.2	11	7.5	13.9
Selenice	7.9	9.0	10.9	13.9	17.8	22.0	24.1	24.3	21.3	17.3	13.0	9.5	15.9

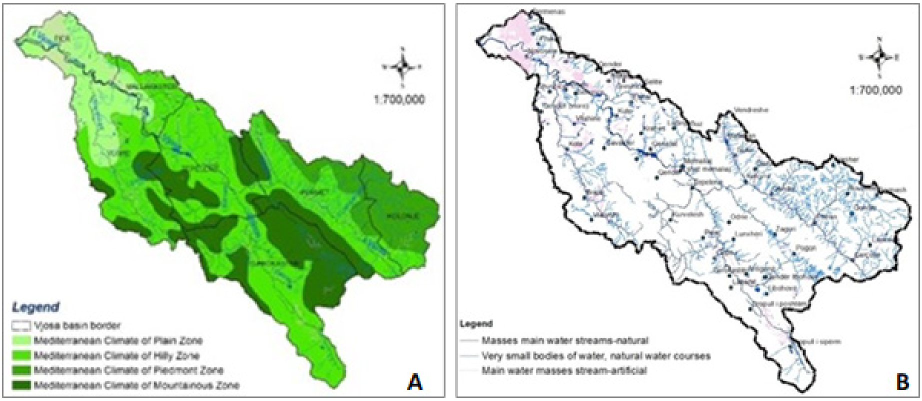

Figure 5.
A, map of climatic zones of the Vjosa basin (IHM, 1975).
B, Map of the hydrographic network of the Vjosa basin (Selenica & Saliaj, 2014).

Table 2.
Monthly distribution of precipitation (mm) in some stations of Vjosa Basin (IHM, 1980).

Station / Month	1	2	3	4	5	6	7	8	9	10	11	12	year (mm)
Arez	121.2	108.9	113	92.3	96.2	67.6	42.2	37.7	41.7	87.2	177.9	150.2	1136
Brataj	293.8	243.8	200	142.3	94.5	47.9	25.3	44.1	101.7	222.6	362.9	353.9	2132.8
Carshove	187.1	145.5	141.1	124.9	74.5	36.1	19.7	34.4	82.2	194	233.5	220.2	1493.2
Erind	232.5	193.1	143.4	105.4	81.8	41.9	24.5	23.3	84.0	166.0	282.1	257.0	1635.1
Frasher	108.8	95.8	74.2	76.3	80.7	53.8	33.2	35	57.6	99.8	140.8	127.1	983.1
Goranxi	279.1	220.9	154.1	125.7	81.9	34.1	20.0	32.7	87.2	182.8	301.4	322.7	1842.6
Gjirokaster	280.6	237.3	168.3	119.4	77.2	33.7	19.8	32.2	93.8	196	324.1	346.5	1928.9
Jorgucat	259.7	216.3	147.4	126.7	82.8	42.9	17.8	31.9	83.0	172.9	278.8	277.7	1737.9
Nivice	336.6	298.8	231.6	171.6	118.9	54.2	37.7	41.9	115	227.6	390.9	399.7	2424.5
Llongo	271	273.7	193.1	147	103.6	45.6	23.9	42	78.6	198.5	306.8	382.0	2065.8
Polican	283.2	254.0	184.8	143.4	98.4	48.9	29.2	40.0	101.4	198.1	310.2	345.0	2036.6
Permet	163.6	151.2	102.5	89.2	67.9	40.6	25.7	29.3	59.6	138.2	221.4	218.4	1307.6
Kuç	363.1	301.8	213.8	156.2	106.1	43.1	30.1	42.0	119.3	225.2	389.4	393.2	2383.3
Selenice	113.7	94.4	83	70.3	63.7	24.8	27.3	33.1	50.2	97.5	145.1	120.6	923.7

The rainfall regime is quite irregular, Mediterranean (Tab. 2 & Fig. 6), expressed in: their concentration mainly in the cold half of the year, especially in November and December; in summer the rainfall is quite scarce, only about 10% of the annual amount, where the July and August are noted; high intensities: from 250 to 300 mm/24 hours in the middle sector (Gjirokastra, Drino valley, Poliçani, Nivica, Kuçi, etc.) to 100 to 150 mm/24 hours in the upper sector (Frasheri, Përmeti, etc.) and the lower part of the basin (Selenica, Vlora, etc.); marked uncertainty of the average amount, i.e. in the large changes from year to year.

The very irregular rainfall regime conditions change Vjosa flow, the frequent floods and inundations of the lands and inhabited centers (see below).

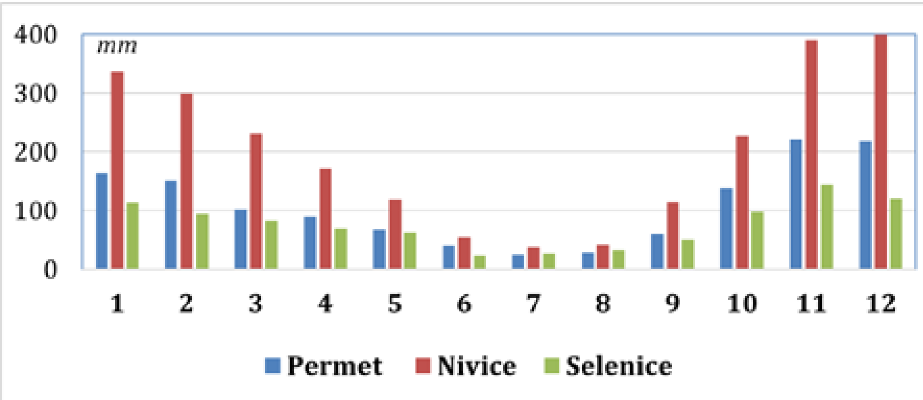

Figura 6.
Shpërndarja mujore e reshjeve (mm) në disa stacione të pellgut të Vjosës (IHM, 1980).

1.7. Hydrographic feature of the basin

The Vjosa basin has great water resources, expressed in: length, density of the hydrographic network and high water content (high values of the annual volume, the coefficient, the modulus of the flow layer) (Selenica & Saliaj, 2014). It is traversed by a fairly dense network of streams and rivers, its tributaries: the average is 2.3 km/km² (Mifoli), varies from 2 km/km² (Biovizhde) to 2.5 km/km² (Ura e Lekli), while the Drino basin has the smallest value, 1 km/km² (Fig. 5B and Tab. 3).

Table 3.
Principal characteristics of Vjosa basin (Pano, 2015).

Site	Watershed surface, A (km^2)	Mean altitude, H (m)	River length, L (km)	Embankment slope, I (%)	Density of hydrographic system, D (km/km^2)	Width of basin, B (km)
Biovizhdë	2,170	1,220	90	27	2	24
Petran	2,420	1,190	110.2	28	2	21.9
Permet	2,810	1,160	120	28	2.1	23.5
Kelcyrë	3,060	1,130	136.2	28	2.2	22.5
Dragot	3,470	1,090	149.7	29	2.2	23.2
Ura e Leklit	1,300	748	80.3	28	2.5	16.2
Dorzë	5,420	963	182.8	29	2.3	29.7
Poçem	5,570	947	203.2	29	2.3	27
Drashovicë	587	618	62.5	31	2.1	9.4
Mifol	6,680	858	253.8	28	2.3	26.3

The rainfall is the principial supplier of the Vjosa, but in the high regions it also snows, which, together with underground water, make up 31% of the river's supply. Therefore, the minimum flows of Vjosa are not as pronounced as in other rivers of Albania.

The flow module reaches 26 $l/s/km^2$, while the average annual flow: 60 m^3/s in the upper part of the river; 176 m^3/s in the lower part and 195 m^3/s at the mouth; runoff layer from 297 mm to 2,550 mm/year, while the average is 917 mm; the annual volume of Vjosa flows reaches 5,550 million m^3 of water; the ratio between the flow of the most watery month (February) and the least watery month (August-September) reaches 7.3. In exceptional events, Vjosa is distinguished by large flows, from 2,000-3,000 m^3/s in the upper part to about 5,000-6,000 m^3/s in the lower part (5,570 m^3/s, Mifol, probability 1%). The difference is related to the different physical-geographic features of the basin. Minimum flow 27 m^3/s (95% probability) (Tab. 4). It belongs to the first subtype of the typical Mediterranean river regime. The main characteristics of the Vjosa basin are given in table 3 (Pano, 2015), and average monthly and annual flows of the Vjosa river and some of its tributaries in table 4 (IHM, 1987).

Large flows cause floods and inundations, larger and more frequent in the lowland, more densely populated sector, and in the river delta. The waters of the floods continue for several days and even weeks, causing considerable economic damage: thousands of hectares of agricultural land, even flooded settlements.

Table 4.
Maximum and minimum discharges (m³/s) in Vjosa River, with different probabilities (IHM, 1987).

Rivièr	Station	Surface (km²)	Maximum discharge with probability:			Discharge for the driest month with probability:		
			1%	2%	5%	75%	90%	95%
Vjosa	Biovizhdë	2,170	1,510	1,369	1,176	11.5	9.32	8.14
Vjosa	Petran	2,420	1,660	1,490	1,250	12.5	9.85	8.52
Vjosa	Përmet	2,810	2,143	1,897	1,562	15.2	13.0	11.7
Vjosa	Dragot	3,470	2,561	2,246	1,837	18.5	16.4	15.1
Vjosa	Dorzë	5,420	4,360	3,940	3,370	30.6	26.6	24.5
Vjosa	Mifol	6,680	5,570	5,040	4,340	34.6	29.6	27.0
Drino	Hormovë	1,300	1,641	1,464	1,218	4.04	2.98	2.52
Shushica	Vodicë	587	1,473	1,273	1,010	3.02	2.44	2.13

The flood map shows that the entire lower part of the Vjosa basin and especially in the continuation of Mifoli is completely flooded (Fig. 7). They are related to the intense and frontal rainfall, the dominant broken relief of the basin, with its vegetation, only 22% covered with forests (Hasenauer *et al*., 2022). At the same time, as we pointed out, the floods have caused continuous changes in the bed, morphology, delta and mouth of the river. These change the living conditions and habitats of plant and animal life.

Efforts have been made to alleviate the flood situation by building protective dams and creating reservoirs upstream.

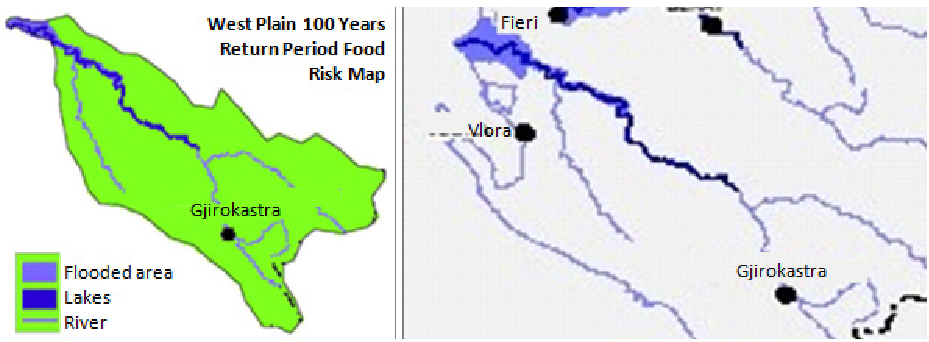

Figure 7.
Flood maps in the Vjosa basin (UNDP, 2002).

The period of minimum flows in the Vjosa river occurs in July, August and September, when the flows are 7-10 times smaller than in the wet period of the year (Tab. 5). However, compared to the other rivers of Albania, the Vjosa basin is rich in underground water, mainly in the form of springs, of which 47 are the main ones: Viroi (about 17 m^3/s), Black Water (about 7-8 m^3/s), Tepelena Cold Water, etc. (Qiriazi, 2019).

Table 5.
Average monthly and annual flows in the Vjosa River and some of its tributaries (IHM, 1987).

River	Station	Discharge (m^3/s)												
		J	F	M	A	M	J	J	A	S	O	N	D	A
Vjosa	Biovizhde	85.4	92.6	82.0	110	85.3	43.5	22.5	15.0	15.2	23.1	53.3	86.4	60.2
Vjosa	Petran	99.3	99.2	94.1	94.3	75.1	40.5	20.5	16.8	16.6	30.4	60.2	100	62.2
Vjosa	Permet	102	106	104	117	83.5	42.5	22.5	17.2	17.3	31.8	63.4	103	67.5
Vjosa	Dragot	117	158	123	117	138	59.2	32.9	23.3	22.6	47.7	130	128	91.4
Vjosa	Dorze	280	259	223	224	167	92.1	53.8	38.3	37.0	65.2	170	285	158
Vjosa	Mifol	328	314	250	123	164	83.9	50.9	45.6	46.4	80.3	206	312	176
Drino	Hormova	84.6	82.5	61.2	44.2	26.1	13.8	8.75	6.22	6.10	13.1	44.9	76.3	39.0
Shushica	Vodice	39.6	34.5	25.3	22.5	16.1	8.24	4.99	4.20	4.81	11.7	25.9	32.5	18.9

The mean sediment concentration in Vjosa waters reaches 1040 g/m^3, while the suspended alluvium is 6.7 million m^3 per year; the alluvium module is 1,000 tons/km^2/year. As a consequence of the limestone predominance in the basin, the flow and solid flow modules are low: respectively: from 36.4 kg/s (Petrani) to 190 kg/s (Poçemi) and 1,070 tons/km^2/year (Mifoli), while Drino river (488 t/km^2/year) (Pano, 2015).

The waters have average mineralization (200-600 mg/l). The exception is the waters of the Lengarica branch with higher mineralization (2,100 mg/l), which are sometimes classified as bicarbonate and sometimes as chloride waters, while the waters of Vjosa are bicarbonate, included in the calcium group (Puka, 1994).

The Vjosa is clean in the upper part of the flow. Its pollution starts mainly in the plain area, from where it grows progressively towards the sea. Water quality, due to little industrial activity, is generally good. Some high values of iron content or hardness were observed in the main flow of Vjosa and of chlorine content in Langarica. But overall the basin has good water quality. Solid waste treatment remains a problem. The high content of phosphorus and ammonium in the Vjosa River is the result of sewage discharge. Uncontrolled wastewater and landfills are sources of pollution (Miho *et al*., 2005).

In the hydrographic network of Vjosa there are: several small natural lakes in its abandoned beds and wetlands in the lower sector and many artificial lakes in the middle and upper sector built for irrigation during the communist period; irrigation canals that take water from Vjosa and its tributaries.

1.8. Soil characteristics

In the basin of Vjosa, there are four main types of soils, which are known in Albania: brownish soil, brown soil, gray brown soil and mountain meadow. The largest extent has brown soils with extremely advanced degrees of degradation due to very intense erosion, the main risk of soil degradation. In the terrigenous territories, rich in clay and water, landslides of different sizes and types are frequent, reactivating from time to time in extremely wet periods, etc. They are associated with economic damage and accelerate the erosion and degradation of the landscape (Qiriazi, 2019).

Agricultural lands have a greater extent in the lower sector, where they form open landscapes composed of large plots, located next to each other with drainage and irrigation canals as borders. In these lands, agriculture is applied with the tendency of its intensification. Cereals, fodder, vegetables, etc. are cultivated; more cattle are bred. They decrease in extent and as the size of the plots in the middle and especially the upper sector, where they take the form of small plots on slopes, often quite steep, where degraded and desertified lands meet. Agriculture with several branches is applied, in efforts to survive. The areas Dangelli-Shqeri, Dishnica, etc. are distinguished. (Qiriazi, 2019).

1.9. Features of flora and fauna

In the lower sector of the basin, the natural vegetation has a very limited extent, because it has been replaced by man over the years. It is preserved only in wetland ecosystems. In the middle sector, the extent of the natural plant formations increases, consisting of the Mediterranean scrub of the maquis, the shiblak and the oaks. Their landscapes are highly damaged, especially by anthropogenic activity. At altitudes above 1000 m in the upper sector, forest formations of conifers appear, represented especially by the Bulgarianian fir (*Abies borisii-regis*) in the Hotova Fir National Park, in Zhej, Sotire, Kardhiq, etc. This vegetation belt is also quite damaged by man. Above the heights of 1600 - 1800 m are the alpine pastures with quite dense herbaceous vegetation, used by cattle farmers as summer pastures for their cattle.

The diversity of geographical environments: marine and coastal, lagoons, marshes, swamps, lakes, rivers, Mediterranean shrubs and broad-leaved, coniferous and mixed forests, alpine meadows and pastures, etc.; the fragmented relief with lots of hidden niches, the climatic diversity and the wealth of water and the variety of water objects (sea, lagoons, rivers, lakes, springs, etc.) have created conditions for the diversity of the animal world (see the corresponding paragraph).

1.10. Natural heritage of Vjosa basin

The diverse nature of the basin is associated with a great wealth of natural heritage. Several natural heritage sites have been declared in this basin: national parks (Vjosa River, Hotova Fir), about 80 natural monuments; natural parks (Firs of Kardhiqi, Germenji, Sotira, Zhulati and Zagoria) and the Landscape Protected Pishe Poro - Narta. In addition to them, Upper Vjosa and the territories around it have been declared a Cross-Border Ecomuseum, managed by a joint Albanian-Greek council.

1.11. Human and Social Background

Population

Based on INSTAT data (2011), the population of the Vjosa basin was: 184,781 inhabitants, while the average density was 40.7 inhabitants/km² (much lower than the country's average of 97 inhabitants/km²). In the upper sector, about 30% of the population lives (density 10-20 inhabitants/km²). In the lower sector, 70% of the population lives (density 100-250 inhabitants/km²). The lowest density is found in the basins of the branches of the upper sector: Lemnica, Lengarica, etc., about 10 inhabitants/km².

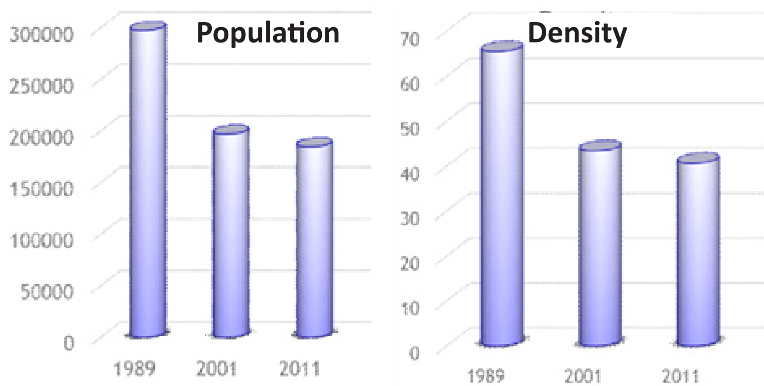

Figure 8.
Evolution of the population in Vjosa basin after 1990. Note: Due to missing the most recent data, we were forced to use the 2011 Census, as more reliable.

After 1990, firstly, due to mass migration, but also birth rate declining, etc., the population of the basin and its density have decreased and this trend continues today (Fig. 8). It has influenced and still influences many natural phenomena of the basin: the state of the living world, biodiversity, reduction of environmental and water pollution, etc.

The other major demographic problem of the Vjosa basin is related to the rapid aging of the population (Fig. 9), firstly conditioned by the mass migration of the population and especially of the reproductive age. At the same time, the continuous reduction of births, the economic situation, etc., have a significant impact.

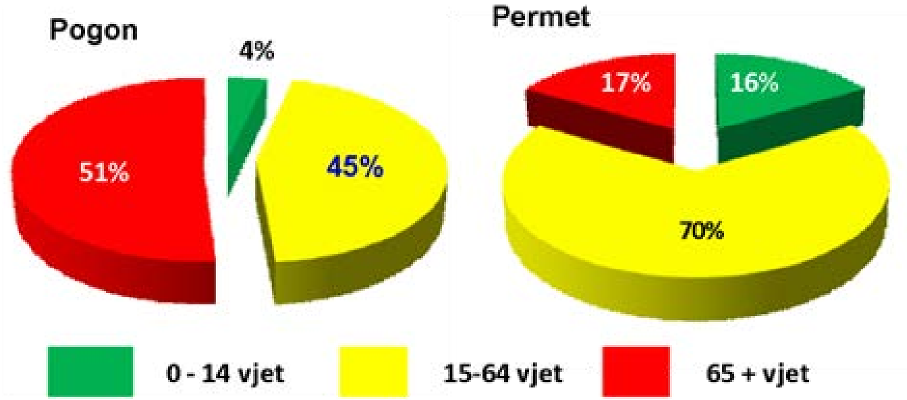

Figure 9.
The age structure of the population of Pogoni and Permeti (INSTAT, 2011).

This phenomenon has different natural impacts: most of the lands that were once cultivated, now abandoned, are being exposed to intense erosion; the natural vegetation, with different degrees of degradation in other territories, in the absence of human use and for grazing, is being revitalized at a considerable rate. Even the animal world and biodiversity in these territories are increasing.

Economic activity

Over 80% of people live in rural areas. Agricultural land occupies about 23% of the basin (Corine, 2006). The main economic activity is agriculture, which, together with the gravel extraction in the river beds (in 2000: in Vjosa 26 sites, in Shushica 16, in Drino 14 sites), the construction of hydropower plants and, recently, the increase of tourism, strongly influence the development of the processes of the natural features of the Vjosa delta, the river beds and ecosystems, the landscape features of the entire basin; the natural vegetation in many sectors of the basin has been completely transformed by human impact. The land of vineyards, fruit trees and vegetables has increased to 3.5% (4,500 ha). There are deforested areas replaced with field plants and fruit trees. Irrigated land has increased to 1%.

2. General characteristics of the Vjosa Delta

2.1. Delta of Vosa - a rare value of Albanian nature

The Vjosa Delta, with its fascinating territories (land, sky and sea), is a paradise of rare natural beauty, whose surreal, dreamlike, almost mythological charm allows you to enjoy the overwhelming sweetness of the landscape, the silence of nature; to discover the mysterious interplay: salty, brackish, freshwater environments, belts of land, waterways, marshes, lagoons, seas, reeds, forests, bushes, meadows, full of diverse animal life, fossil and active dunes, sandy beaches; you are surprised by the uncertain progress of the land in the sea, seemingly without end; you are surprised by the wonderful sunset.

River deltas are ecosystems of great importance, shelter of many species of animals and plants, very complex environments, where the continuity of marine and continental biocenosis is ensured, often with special adaptations. In the Vosa delta there are different environments, water and land (Fig.10).

Figure 10.
Aerial view of the Vjosa Delta, part of the Pishe Poro – Narta Protected Landscape (Category V) (©https://www.balkanrivers.net/).

In the first, there are: river environments, with a variety of algae, high freshwater plants, invertebrates, fish, amphibians, reptiles and mammals; littoral cordons, highly dynamic and populated by plant species able to withstand stressful conditions; marshes with rich biodiversity: primary producers (phytoplankton, algae and higher plants), primary consumers (zooplankton) and secondary, fauna of fish, amphibians and reptiles, such as marsh turtles, etc.; also with extraordinary development of bird life; lagoons, with great development of plankton and their consumers, organisms adapted to large fluctuations in salinity, with resident fish species, catadromous, moving to the sea for reproduction, or vice versa, anadromous, living mainly in the sea and moving in inland waters for reproduction, sedentary and migratory birds, mammals, etc.

In terrestrial environment there are: meadows, bushes, forests, dunes with different types of halophytic, hygrophilous, xerophilic, freshwater, etc., and animals of different orders, among them also species that provide the life needs in water and on land; the coast (the beaches and the belt behind them) with plants that vary depending on the distance from the sea line, which is related to the salt content and the degree of formation of the soil profile. Therefore, on the beaches, the first generation, the young one, near the sea line, is distinguished, which is sterile, without vegetation; the second generation, with rare halophilous and psammophilous pioneer herbaceous plants and the third generation, with rare shrubs at the beginning, which continue with denser and more developed shrubs. The belt behind the beaches, protected from the salt, has tall trees, which also form forests, most of them cultivated, and shrubs, developed especially on the crest of the dunes.

2.2. Features of our coast of the low accumulative type of the Adriatic evolution and relief forms

This type of coast is found in most of our coastline, mainly on the Adriatic coast. It is undergoing marine modeling and river deposits. However, an important role in this modeling has been played by neotectonic and present-day lowering and raising movements, as well as longitudinal and transverse tectonic detachments (Hysenaj, 2010). The two largest bays of this coast are also connected with these movements and tectonic fractures: Drini and Durrës and Vlora, which were partially drained by river deposits, forming the beaches.

As a result of the complicated evolution with repeated advances and retreats of the sea, numerous forms of coastal relief have been created, with a height of up to several meters, such as: underwater weirs and lidos, littoral arrows and cordons, large-sized beaches, deltas, lagoons and dunes.

Our low Adriatic coast is distinguished by great dynamism, expressed in the large and very rapid changes of the coastal forms and the general configuration of the coastline. This dynamism is related to two opposite processes: in some sectors, the advance of the land towards the sea and vice versa, the advance of the sea towards the land, in other sectors. Previously, it was a Dalmatian-type coast, with bays and islands, but, as a result of a series of processes, it changed to a low-type coast. Our coastal plain was formed behind it.

This dynamism is expressed in the pronounced instability of the special forms of the low coastal relief, which have changed, even disappeared, to be formed again under the action of repeated natural and human factors; it is also expressed in the pendular and continuous oscillation of river estuaries. These oscillations are the consequence of large solid streams in their mouths; of the shallowness of the sea; of lifting movements and the small slope of the field. Studies (Boçi, 1981) show that our river estuaries, within their zone of influence (the boundary between the northern and southern ends of the estuarine swing), undergo pendulum movements from north to south and vice versa. Semani has the largest area of influence (24 km), Buna has the smallest 4 km, while Vjosa has about 20 km (Boçi, 1981).

These changes of river mouths are natural, the result of the mentioned causes. But man has also intervened in this natural evolution, through the construction of embankments, the opening of drainage channels, etc. Rivers accumulate more when their estuary has a northwest direction (Boçi, 1981). Therefore, **in order to increase and protect the benefited land, the estuaries should be artificially maintained in this direction.**

Historical, cartographic and geomorphological data show that even during the most recent historical period, there are significant changes in the rate of advancement of the coastline. This progress has been greater in the southern part (coasts of Myzeqe), where from the 15th century until today the annual speed of progress has been about 6-8 m per year (Boçi, 2002; Nikolli, 2010), etc. This was conditioned by: the lifting movements of the structural foundation of this sector and the large solid streams of Semani, Vjosa and Shkumbini.

According to measurements (Boçi, 2002), during the period 1916-1978, the Western Lowlands grew by 3,530 ha, i.e. an average of about 60 ha per year. At the same time, about 1,200 ha were eroded, an average of about 20 ha per year, so the ratio between accumulation and erosion was 3:1. In the following period, the rates of coastline progress in the areas affected by each river, for the same periods of time, are neither equal nor sustainable. This rate changes from 2 to 6 m/year, while the average accumulation-erosion ratio has decreased to 2.4:1. In the last decades, many sectors of the accumulative coasts were involved by intensive erosion with rates up to 35 m/year (see beach crisis) (Boçi, 2002). The advance of the land towards the sea is related to: the formation of river deltas and beaches; with the evolution of arrows, littoral cordons, lagoons and with the formation of tombolos (QSGJ, 1988; Qiriazi, 2011).

-***The rapid formation of river deltas and beaches i***s related to the large solid flows of the rivers, which exceed 3 times the washing capacity of the sea; with the small depth of the sea near the coast (100 m isobath goes 50 km from the coast); with the small amplitude of the tides (up to 30-40 cm); with the predominance of lifting movements of the structural foundation. The exception here is, as we said, the Drini gulf, whose structural foundation was involved by the subsidence movements. The delta of Buna, Semani, Shkumbini and Vjosa grows at a high speed (up to several tens of meters per year) (Boçi, 1981; Fauche, 2001; Nikolli, 2010).

Deltas constantly change their size, contours and character. It is related to the pendular movements of river estuaries, the erosive and accumulative activity of the sea and rivers. They are mostly simple, crossed by a river flow (Ishmi, Erzeni, Vjosa). There are also complicated deltas, traversed by several river flows: Buna, Drini of Lezha, Mati, Shkumbini and Semani.

-***The advance of the land through the formation of arrows, littoral cords and lagoons*** is characteristic in the sectors between the deltas. When waves and marine currents strike the shoreline at an angle other than 90°, accumulation of materials begins. As a result of the shallowness of the sea, the wave breaks and weakens, the material is neither pulled into the depths of the sea nor thrown ashore. They are thus formed near the deltas of underwater barriers and lidos. The advance of the two neighboring deltas towards the sea creates sea bays, which soon turn into marine lagoons. This is related to the formation and growth of littoral cordons, which begin at the capes or the remnants of old river deltas and, growing in the opposite direction to each other, transform the bay into a coastal lagoon. In the littoral cordon, there remain several natural channels, in which the exchange of water between the lagoon and the sea takes place.

The further progress of the deltas towards the sea creates conditions for the formation of new cordons and, as a result, new sea bays and lagoons in front of the existing ones. Old lagoons lose their connection to the sea, gradually become swampy, marshy and dry (Qiriazi, 2019; Qiriazi *et al*., 1999). This natural evolution can be seen more clearly in the Laçi-Patoku plain, where longitudinal strips of land higher than the plain are still preserved. In front of the lagoons of Patoku and Karavasta, the new cordon and lagoons are being formed, while the old ones, behind them, are evolving towards marshland. By reclamation of swamps and marshes, man has accelerated the process of advancing the land towards the sea.

The large extent of lagoons gives our accumulating coast of the Adriatic a lagoon character, while the considerable extent of wetlands in the form of wetlands (swamps, swamps, abandoned or active river beds, etc.) gives this coast a character of swamp type, with very rich biodiversity. Among the current lagoons, the following are distinguished: Karavasta, Narta (*see* below), etc. In the river deltas there are several small lagoons, which constantly change their contours and sizes.

-Land progress through the formation and evolution of tombolas is observed in the Cape Rodoni-Cape Lagji sector and in the Narta-Vlora sector. In the first, the tombola is threefold (Geço, 1963). It has turned the former islands (Palla Cape and Durresi Mount) into peninsulas, connecting them to each other and to the continent. The same is happening in the Narta-Vlora sector (see below).

Aeolian landforms are found on several wide beaches with large sand accumulations, mostly in the form of dunes of different sizes (see the dunes of the Vjosa delta).

Limited sectors with high, abrasive coast. In this type of coast, several forms of relief are found, such as: living cliffs, often vertical (Rodoni, Durresi Mountain, Triporti hills, etc.), but also dead ones, rocky shores with a painful appearance (Kavaja Riviera), etc. The modeling factors of this type of coast are complex (see Vjosa delta).

2.3. Sea beaches and their crisis

They have the greatest extent on the lower coast. Beaches are massive accumulations of sand, often with a length of several kilometers to several tens of kilometers, while their width reaches several tens of meters, even, in some cases, several hundreds. The beaches are formations of the post-glacial period. They are found in the river mouths, in the bays between the capes, on the shores of the littoral cordons and tombolas. The beaches have great touristic values, some also have special scientific and ecological values, which have received the status of natural monuments, such as: Rëra e Hedhur, Kallmi Beach, Shënpjetri, etc. (Qiriazi & Sala, 2006).

Currently, there is a great contradiction: on the one hand, sea coasts constantly endangered by the beach crisis and other major coastal hazards (slides, landslides; sea waves and waves, tsunamis; floods, etc.), on the other hand, the tendency to continuous increase in the marineization of human society, which is invading the coasts for beaches and sand, ports, the construction of large industrial works, etc. The coastal area is among the most inhabited.

Currently, the low sea coasts of the world are facing the so-called ‘beach crisis’, which with its ever-increasing rates, is bringing great economic, ecological, etc. damage. Globally: 70% of coasts are eroding; 20% are in equilibrium and only 10% of them in accumulation (Paskoff, 1992). A big problem is the protection of sea coasts from erosion. Therefore, the attention of researchers is focused on the study of causes, trends and finding effective protection measures. They point out that the balance between the solid flows of the rivers into the sea and the ability of the latter to wash this material and deposit it in its depth has been broken. When the first prevails (solid river flows) the beaches grow continuously and the opposite, when the second dominates (marine erosion) the beaches erode rapidly. Analyzing this balance, the causes of its deterioration have been determined, which are: general and local, natural and human.

The first group includes:

-***Decreasing the solid flow of rivers due to natural and human causes.*** Today's beaches were formed after the last glaciation. Melting of the last ice sheets 15,000 years ago raised the level of the world ocean 100-120 m, while today's sea level stabilized 5,000-6,000 years ago (Paskoff, 2011). It was at that time that the easily eroded material, created by the crushing of the bedrock, by the powerful physical alteration, during the Würm Ice Age, was very large. Therefore, solid flows at this time were much greater than the washing capacity of the sea. The large beaches were thus formed and at once the rapid progress of the land into the sea was marked. But now, after all that time, the easily eroded material was washed away by erosion, the bedrock, much more resistant to erosion, has come to the surface. The process of alteration, in the current climatic conditions, develops at slower rates. Consequently, rivers erode and deposit less than the flushing ability of the sea. But the reduction of the solid flow of rivers is also related to human activity, such as: anti-erosion measures, afforestation, dams, change of mouths and riverbeds, etc.

-***The continuous rise in the level of the planetary ocean,*** due to the melting of polar and mountain ice from global climate warming, which also leads to the expansion of sea water. Different authors give different values of this rise: 15 cm during the last 100 years (Paskoff, 2011). The 2014 IPCC report (Intergovernmental Panel on Climate Change) predicts that during the century XXI, the rise will be from 26 cm to over 98 cm; According to the latest NASA (2018) study based on 25 years of satellite data, in recent decades, the rise of the average world ocean level has been progressively accelerating, from less than 2 mm/year during the last century to more than 3 mm/year at the end of this century, while, during the last 25 years, the level of the planetary ocean rose over 8 cm or 3.2 mm/year. Also, it is emphasized that, if this continues, until the year 2100, the sea level will rise 65 cm. It would be a disaster for humanity, because many plains and coastal cities would be covered by the sea, thousands of islands would disappear; all the western coastal part of our plains and their coastal cities; ecosystems and their biodiversity would disappear, etc.

In the second group, local causes differ from one coast to another. They are natural (tectonic subsidence movements, changes in river mouths, etc.) and humans that act on the watershed, the riverbed, its mouth, on the beaches and the seabed (more specifically about the action of these causes, see below).

2.4. The crisis of beaches in Albania

In the last decades, like other beaches of the world, our beaches are facing the beach crisis. Currently, the accumulation-erosion ratio is going from 3:1 to 1:1 and even 1:2 in some sectors. Sea erosion has destroyed the Semani and Patoku beaches, and not small beach sectors of Kune, Tale, Rrushkulli, Karpeni, Darzeza, Zhuka Poro, the left delta of Mati, Vjosa, etc. The trend is towards increasing the rates of this erosion, which endangers many beaches, bringing economic, ecological damage, etc.

There are cases of replacement of accumulation by erosion and vice versa, related to the position of river mouths: marine erosion in abandoned deltas, accumulation in the current mouth. This makes it difficult to accurately determine the sectors or beaches in erosion, balance or undercutting.

Different indicators have been used to highlight the sectors of beaches under erosion, such as: measurements on maps and satellite photos from different periods; field measurements, generally few; comparison for different periods of the position of different objects in relation to the coastline (Fig. 11).

Figure 11.
A, Artillery bunkers (third row) on the beach New Darzeza – Eel Channel (Hoxhara Channel) (2001). B, Water depot north of this line (2006) (©P. Qiriazi).

The comparison of the current position of the bunkers, located in the 70s of the last century, about 50-100 m from the water's edge (first row), 150-200 m (second row) and about 250-300 m the third row of artillery bunkers. After about 40-50 years, their position, always in relation to the coastline, is not the same. In some sectors (Kune, Rrushkulli, Patoku, Semani, Zhuka, Poro, etc.) these bunkers are located: the first row, about 400 m into the sea; the second row, at the edge of the beaches, while the third row, consisting of large bunkers, at the water's edge (Darzeza beach – Eel Channel, etc.) (Fig. 11). Calculations of the change in the position of the bunkers in relation to the coastline show that this line has advanced towards the land about 250-400 m, so the rate of beach erosion exceeds 10-20 m/year. Boçi (2002) gives the maximum annual rate of 35 m/year.

As it was emphasized, the causes of the beach crisis, as a phenomenon of the planetary scale, are general and local, natural and anthropogenic. Naturally, they act together and simultaneously. Current studies have not yet been able, on our shores, to determine the priorities of these causes. But we emphasize that the consequences are greater when, to the constant action of general causes, the action of local, natural and anthropogenic causes is added. Here, emphasizing the same action on our beaches of general factors, we will talk about the local natural and anthropogenic causes that act on these beaches. The consequences of these local causes are: the reduction of the solid flow of the rivers at their mouths and the disruption of the natural balance of the beaches.

About the problems of our maritime coasts, studies have been carried out by cartographers, geographers, geomorphologists, geologists, etc., which have enlightened their phenomena. But the big problems of our sea coasts require the deepening studies.

Among the local natural causes of beach erosion, we emphasize:

- **Lowering neotectonic movements of the structural foundations,** even with a large amplitude, in some sectors: Shengjini-Ishmi, especially in the mouth of the Drini of Lezha and Mati, in the bay of Vlora, etc. In these sectors, the advance of the sea towards the land increases.

- **The continuous change of river mouths,** which, as it was said, breaks the balance in the sedimentary budget; it brings erosion in the old mouths and accumulation in the new ones.

The local anthropogenic causes of beach erosion are related to action in the watershed and river bed, on beaches and marine reefs. Human activity in the watershed and riverbeds is intense and not the same. Among them we emphasize:

- **Anti-erosion works** in the second half of the century. XX (afforestation, mountain systems, etc.);

- **Formation of artificial water reservoirs** (about 700 of them, for irrigation) and dams of the hydropower lakes on Drini, Mati and Devolli. All the solids in water flows are deposited in these reservoirs.

- **Artificial diverting of riverbeds and estuaries:** the Drini of Lezha was all diverted into Buna, the diverting of the estuary of Ishmi into the Patoku lagoon; it caused almost the destruction of the Patoku beach, etc.

- **The river mining** (as it was said in the river beds of Vjosa, Shushica and Drino, 56 construction sites operated in 2000); it forces the river to fill the holes created in its bed and carry less alluvium to the sea. In addition, this much more intensive activity, after 1990, has disturbed the equilibrium of the river beds and damaged the road infrastructure, etc.

- The abandonment, after 1990, of **the systematization of the river beds of the lower flows** influenced the increase of floods and the reduction of their solid flows into the sea; not a small amount of solid flows remains in the bed and in flooded soils.

- **Human activity on the beaches and in the marine shallow water** appears in different forms: sand removal from the beaches, which has impoverished them and intensified their erosion (case of the Old Beach of Vlora, etc.); the constructions on the beaches and in the shallow water marine environments, numerous and without criteria (port pilings with filling, see below, drainage canals, embankments, tourist resorts, etc.) have enhanced erosion processes on the beaches; beach maintenance works and especially the removal of seaweed deposited on the sand, which helped to reduce the erosive force of sea waves, etc.

The protective measures applied so far in the world and in Albania, through the stone blocks throwing on the coastline or the pile construction parallel or vertical to the shore, with different shapes, in the marine area, proved ineffective: they have transmitted marine erosion to the neighbor sectors; they have denatured the beaches and, obstructing the water circulation, have increased its pollution degree. These have severely damaged the ecological and touristic values of the beaches. Therefore, it is recommended that the beaches are artificially supplied with sand taken from past deposits in the interior of the continent. Of course, this is expensive.

As can be seen, the crisis of beaches is a big and very complex problem. Its solution, above all, requires in-depth studies on the rules of the beach's formation and evolution; strategies and work programs, including long-term ones. These measures **and coastal management should aim at establishing and maintaining a balance between economic, social and environmental factors. Economic and social activities should never encourage or cause marine erosion. Otherwise the consequences will be catastrophic.**

2.5. Geomorphological features of the Vjosa delta

The delta area starts from the Mifoli Bridge, and expands in the coastal area from the Narta lagoon in the south to the Hoxhara channel in the north, where its border almost merges with the Semani delta (Xhaferri, 2021). But, due to the gradual merging of the delta in the fields and its surrounding environment, related to natural and especially anthropogenic factors (reclamations, accompanying bed embankments and its systemization and agricultural lands, etc.) and the great dynamism of the its elements is difficult to give the exact limits of the extension of the Vjosa delta and especially its beginnings in the east. It would require detailed studies and surveys in the field, on maps, satellite images, or aerial photos; analysis of morphological, sedimentological changes, soils, vegetation, etc.

The delta has a classical triangle shape, divided into two almost symmetrical parts by the main river course. In the north and south of it there are estuaries and old deltas, where the soils are salty and the vegetation is halophytic. Due to the transversal tectonic fractures that cross the Neogene structure, covered by Quaternary deposits, its morphological evolution is complicated, expressed in the continuous southward displacement trend of the river mouth. In the last 25 years, the delta of Vjosa has progressed into the sea about 20-30 m/year, but it has a tendency to decrease, due to the increase in the depth of the seabed, the inert's use in the Vjosa River bed, etc. Many of its sectors, in recent years, have been affected by marine erosion.

Coastal landforms

Among the relief forms of the delta, arranged from the sea coast to the east, the following are distinguished: beaches, littoral cords, deltaic arrows, tombolas, dry depressions or depressions filled with water temporarily or permanently, current and abandoned beds, bed meanders, lagoons, dunes, etc. (Fig. 12).

The beaches

They stretch, in the form of a belt, along the delta sea coast. They consist of fine, gray sand. Their width ranges from several tens of meters to over 200 - 500 m. The rising beaches have a regular profile and a gradual slope towards the sea. While the profile of the eroding beaches has a scale near the water line and non-uniform slope. Depending on the position of the Vjosa estuary, some sectors of the beaches are in rapid decline. But there are also beaches, where rapid erosion has appeared, which, apparently, will continue. The detailed survey in the field would accurately determine the sectors in erosion, balance and accumulation. The main beaches are divided into: beaches north of the Vjosa estuary and south of it.

Figure 12.
Satellite images of the Vjosa delta from different periods.

- **In the north there are Povelça - Pishe Poro beaches,** which lie on the right side of the Vjosa delta. It is quite large in size:

Povelça beach stands out, with an increase towards the sea of 400-500 m in the last decade or 40-50 m per year. The bunkers, located about 100 m from the coastline, are now located about 600 m away from this line. The beach is almost flat, without dunes and a large width of the new belt, sterile, without vegetation. Meanwhile, towards its north, marine erosion appears and increases, up to several tens of meters per year. Tourist use of these beaches is in its beginning.

-In the south are the beaches of the Vjosa estuary - the Old Port of Vlora, with different characteristics and dynamics. Here are distinguished:

- **The beach between the Vjosa mouth and the Old River** (Dead River), whose width decreases towards the south, due to marine erosion, caused by the change of the bed of the Vjosa.

- **The beaches between the Old River mouth and the northern end of the Triporti low hill range;** it consists of several beaches formed on the littoral cordons, which separate the small lagoons and the northern part of the Narta lagoon from the sea; due to the earlier age of the cordon and this lagoon, the greater width of the beach and forest to its east is noted.

- **The beaches on the west coast of the hill ridge,** formed in tombolos that connected the former islands to each other; hence, these are located in bays, are small, consist of coarse sand to gravel, and are combined with a high-type coast on the western side of the hills, with vertical living cliffs or sandy rocky shores.

- **The beaches between Narta and the port of Vlora harbor;** it is formed on the west coast of tombolo that connected the former island (now Dajlani hill) to the mainland and closed the Narta lagoon from the south. There are two beaches, Narta and Vlora's Old Beach. The first (Narta), extending to the pilots of the New Harbor of Vlora, 1985 (now the Fishing Harbor) and the Albanian-Italian Petrolifera harbor. The construction with filling piles of these harbors prevented the transport of solid alluvium of Vjosa towards the south, which fed the Old Beach of Vlora; it caused two effects: the appearance of the rapid beach erosion to the north of the piles in question and less in the part another of Narta beach; and in the occurrence of strong marine erosion on the Old Beach of Vlora to the south of them; so much so that now even the Soda forest is being destroyed very quickly, and the erosion is reaching the Vlora Harbor.

Littoral cordons

As said, littoral cordons (barrier beaches) connect the ends of river deltas, separating marine bays from the sea and transforming the latter into lagoons. They begin as deltaic arrows, growing in the opposite direction, transforming into littoral barriers, which have an elongated shape and consist of sand deposits. The width ranges from a few to tens of meters (the young ones on the western shores of the small lagoons, especially on both sides of the Vjosa estuary) to a few kilometers on the western littoral cordons of the earliest Narta lagoon. In the Vjosa estuary, a new littoral arrow without vegetation is forming, constantly changing its shape, extent and size. More stable are the large littoral cordons, with plants growing up to the stage of forests (littoral cordon of Narta, etc.).

Tombolos

As stated, tombolos are accumulative forms of low coastal relief that connect islands to each other and to the mainland. Such are the tombolos that connected the former islands to each other, which lay to the west of today's Narta lagoon, forming here the low hilly ridge, with a width of several tens of meters in the north, up to 700 m in the south (Plaka Hill), in a NW-SE direction for about 5 km in length (Balla, 2015). Its hills are separated from each other by sand belts (tombolos), where the mentioned small beaches are formed. **The molasic hills of Zverneci** were declared a Natural Monument (VKM/DCM 303/2019).

The hills of Triporti, Dajlani (47 m) and Plaka (81 m) at the southern end of the said ridge joined the continent through a larger, earlier tombolo; there are many eolian forms (dunes) and vegetation developed, up to the forest stage. Over time, the part of the sea, separated from the tombolos, turned into wetland and salt marshes; they were reclaimed in the 70s of the last century. For a long time, human activity has been developed and is developing on this tombolo (reclamation, opening of drainage and irrigation canals, agricultural, industrial activity, afforestation, etc.); this has changed and, in most cases, denatured landscapes and ecosystems.

Depressions

They are numerous, and of different sizes, shapes and extents: most are longitudinal (remains of the abandoned beds of Vjosa), circular or elliptic, created between former beds; due to the alluvium accumulation, rose above the field level. During the Vjosa floods, they were filled with water, which, in some was dried up, or remained in others, distinguished by their shape, new deposits and hygrophilous vegetation. Along with other aquatic and terrestrial environments, they are transitory ecosystems with great scientific, ecological, cultural, touristic, etc. values.

Abandoned river beds

There are many, most of them dry, distinguished especially for the hygrophilous vegetation; temporarily and continuously with water. Even today there are abandoned traces of the river in Zhukë (Vlora) and Darëzeze (Fieri), known as the ‘dead river’. The largest is the Old River, which lies between the village of Dellinje in the north, Zhuke - Poro, in the east, while crossing through the Delisuli village in the south. There is continuous water. It is distinguished by its numerous meanderings and very large radius. It was the neck breaking of a great meander that caused its abandonment by Vjosa. Its mouth is blocked by sand deposits. It is supplied with rainfall water and by some small flow, consumed by evaporation or by some limited human use. It is distinguished by its rich living world, which has adapted to the conditions of stagnant water.

Riverbed meanders

For the reasons mentioned, the plain Vjosa bed, like other rivers, is meandering (Fig. 3). It keeps this feature even when it crosses the body of its delta. But, being here much younger, the meanders are at the beginning. Very soon they will evolve, increasing the curvature arc, the neck formation and its rupture, which brings about the change of the Vjosa bed. It is clearly visible in the Old River, the former bed of Vjosa, where, as we said, the meanders are numerous and very large. Between the meanders and on both sides of the Vjosa bed, the lands have been reclaimed and systematized in regular agricultural plots, separated by roads, drainage and irrigation canals. In the west, agricultural lands are bordered by wetlands with salty or brackish waters and soils.

The residential centers, most of them new, built or expanded after reclamation in the second half of the last century, are organized and with regular urban planning in separate blocks (Dellinja, Bishani, Fitore, Delisuli, etc.) or with extensions longitudinal along the motorways (Ferrasi, Pishe Poro, Qarri).

Lagoons

There are many, with different sizes and shapes: small and large, old, new and under-forming. As said, their formation is related to littoral cordons and tombolos. They maintain connections with the sea through one or several natural channels, where the water, due to tides, changes direction every six hours. In many cases, the channels are blocked and the lagoons are asphyxiated due to the oxygen consumption. It brings harm to the biota. Therefore, **tide channels must be kept artificially open**. The Narta lagoon, the earliest, the largest, and the new lagoons are distinguished.

- **The Narta lagoon** (about 42 km²), has a depth from a few centimeters to about 2 m, average 1.2 m; was formed between the Vjosa delta in the north and the Neogene molasses hill belt, in the west, which separates it from the sea. As it was said, the hills of this belt were once islands, which were united between them and with the land through tombolas, created from the deposits of Vjosa and the sea. Between the beaches, on the western slopes of the hills, marine abrasion has formed steep cliffs that fall 20-40 m above the sea. Only two small islands (Manastiri or Zverneci and the very small island near it, Karakonjishti); they were not connected to the rest and the mainland. In the widest and highest part of Triporti, there is the village of Zverneci.

The southern extension of this ridge forms the **Triporti hill and cape**, where the great tombolo began, closing the Narta lagoon from the south and connecting the Triporti hill to the mainland. Tombolo consists of fine sand (Kavalona beach west of Narta, etc.).

There are opinions that this lagoon was formed in antiquity (Fauche, 2001). It is connected to the sea with two natural channels, southern and northern. The southern channel is 200 m long, 6-48 m wide and 0.2-1.8 m deep, while the northern channel is 800 m, 11-60 m and 0.3-0.5 m, respectively. The flows, during the sea-lagoon exchange, are scarce, 2.2-4.3 m^3/s (Pano, 2015). Therefore, the lagoon water level changes only by a few centimeters. When the amount of freshwater decreases in the summer, and when the canals are blocked by fillings, about 1000 ha dry up and about 800 ha become shallow up to a few cm. The average water temperature in January reaches 5°C, while in August up to 25°C (QSGJ, 1990); while the salinity varies according to the seasons and between its eastern and western parts (Pano, 2015): during the summer the eastern part (near the land) has maximum salinity (over 75‰), while during the winter this part of the lagoon has minimum salinity (15-30‰); it is related to the freshwater flow into the lagoon.

During the second half of the last century, the configuration of the lagoon changed; it is related not only to natural factors, but also to powerful human interventions during this time, until the reclamation of a lagoon part. As a result of the change of the Vjosa estuary and the growth of its delta, the northern and eastern border of the lagoon's extent has often changed, while the southern border has changed more due to human intervention: reclamation and the forming of the **Skrofotina Saline**. As a result, these coasts are straight.

The northern part of the lagoon transformed into a salt pan in the early 1950s. Saline (about 1,500 ha) is separated from the lagoon by an embankment. It consists of many shallow pools and small islands, suitable for nesting waterfowl. There are also two small lagoons, part of the Narta lagoon: Kallenga (450 ha) and Limopuo, near the village of Zverneci, natural monument (VKM/DCM 303/2019).

The new or forming lagoons are small and very dynamic. The most pronounced, largest and most evolved are on the left side of the current Vjosa estuary, which, due to the lack of recognition of their name, from north to south, we are naming them with numbers: 1, 2, 3.

- **Lagoons 1 and 2** lie south of the mouth of the Old River. They have common features. Between them they are separated by a new littoral and wetland belt. Both constitute the largest lagoons with the most advanced evolution. They are separated from the sea by a new and narrow littoral cord; are connected to the sea by natural channels, which are often blocked. To their east lies one or several old littoral cordons, with a wetland character that separate the lagoons in question from the former lagoon, which, isolated from the sea, has acquired a marshy and swampy character. Further, towards the east, bands of dry or temporarily dry land (probably dune ranges) are interspersed with elongated valleys with water between them. Under these conditions, a much more diverse and rich living world develops, up to the forests on its eastern edge.

- **Lagoon 3** lies on the southern extension of the coast. Narrowing, it continues to the drainage channel, which passes to the south of the salt flat. After its water rises from the recently reconstructed pumping station, it flows into the sea. Although it is separated from the sea by a narrow littoral cordon, this lagoon is in the stage of swamping and marshing. Apparently, it is related to the filling of the canals, which isolated it from the sea. This lagoon is also surrounded to the east by the continuation of the same environment, where wet and dry zones are combined.

Dunes

Dunes are found on large and wide sandy beaches, where the transport and accumulation activity of continuous winds, often powerful and with a dominant western direction, have created these aeolian accumulation forms of different sizes: height 1-6 m, while length up to several tens or hundreds of meters. They are of a simple type and often take the form of dune ranges parallel to the coast. New, forming and early dunes are distinguished. The first two, near the coastline, constantly change shape and extent. They lack vegetation or the rare pioneer herbaceous plants have just begun to appear. Further inland from the beaches or behind them, the dune crests are curved and shallow towards the sea, which is related to the progradation of the coastline towards the west (Ciavola *et al.*, 1999). They are covered by vegetation, which becomes denser and more diverse towards the east. Vegetation increases stability. Between the dunes there are troughs (‘struga’, as the inhabitants call them) with water and hygrophilous vegetation.

The dunes have the largest extent on wide and open beaches, such as the case of Povelça, with a beach width of over 400-500 m, which continues to expand. Large dunes are also found on the beach north of New Darzeza, affected by erosion, which has reached the dunes, destroying them. The earliest ones are found in the east of the belt behind the beaches, where they are covered with vegetation. Many of them have been flattened during the systematization of agricultural lands. They appear in some cases (Beçovo, etc.) as remnants in the form of low and elongated hills, covered by forest vegetation, mostly cultivated.

Dunes have ecological and scientific values. Therefore, some of them have received the status of a natural monument (Qiriazi & Sala, 2006; VKM/DCM 303/201), such as: **Narta Dunes**, west of the lagoon with a height of 5-6 m and a width of 20-30 m; **Semani Dunes**, northwest of Povelça, a group of dunes, about 1 km long, 15 m wide and 3-6 m high; they are captured by marine erosion near Eel Channel. On them there is herbaceous vegetation, bushes, and pine planted more than 60 years ago.

2.6. Geomorphological evolution of the Vjosa delta

Researchers confirm that 2/3 of the delta is the result of the changes of the last 500 years (Durmishi *et al*., 2018). They add that its mouth has moved from the bay of Vlora (where the lagoon of Narta was created) to the foot of the ridge of Frakulla (Fieri), less than 1 km southwest of the ancient city of Apollonia (Durmishi *et al*., 2018).

The complete analysis of the evolution of this delta would require: more detailed surface and deep sedimentological studies, accompanied by laboratory analyzes to determine the relative and absolute age of the sediments; detailed surveys on maps, aerial photos and satellite images, detailed surveys on the ground of relief forms, water bodies, soils, plant cover, archaeological and historical traces and current and past human activity, up to early times, etc. For this reason, the evolution of this delta is divided into two periods: before 1870 and after this year.

Delta evolution before 1870

Due to the lack of concrete data, it will be discussed relying more on the evolution rules of low-accumulative sea coasts and less on concrete geological and geomorphological, cartographic, archaeological and historical data, current and past, until early human activity, etc.

Starting from the evolution of the entire Western Lowland, as a sedimentary plain, from east to west, as a result of massive river accumulations, the Vlora and the Small Myzeqe, as part of it, have progressed towards the sea. Here, this progress was conditioned by: the formation and development of the Vjosa deltas, the continuous change of its estuary, the formation of littoral cordons and tombolos, the formation and evolution of lagoons, and sandy beaches.

According to archaeological data (Ceka, 2014), in the bay protected by Triporti Cape, in the c. VI BC, the port-city of Triport was founded. This ancient city, due to its special geographical position, flourished in the following centuries, also serving as the port of Bylys. It lost its importance from the end of the century I BC. It was caused by the great earthquake of 59 AD, which destroyed the city and the port, and by the movement of the coastline, as a result of the change in the Vjosa bed. Then the port and city of Aulona (Vlora) developed, the remains of which can be found at Flag Square. According to the Turkish chronicler Evliya Celebi, who visited Aulona in the c. XVII, the Ottoman fortress of the city was built with stones from the former Triport, while in the west of this city there were many swamps and marshes.

Based on these data, we can come to some conclusions: in the fall of the ancient port-city of Triporti, the main role was played by Vjosa, which, apparently, changed the estuary towards the south, arriving somewhere near Vlora . Sedimentological data also speak for this. With its solid currents, Vjosa formed the delta, littoral cordons, tombolas and filled the bay of Triporti, removing the port from the sea. (*Without denying the role of the earthquake, we emphasize the fact that Durresi, as far back as antiquity, was affected by several catastrophic earthquakes, but continued its life until our days.*)

Apparently, in that period, most of the lagoons created in this area, as a result of the separation of parts of the sea from the littoral cordons and tombolos mentioned above, were in the stage of swamping and marshing. The size of the lagoons (Narta, etc.) began to decrease, when the Vjosa estuary gradually moved north. This reduction was accompanied by swamps and marshes around it, which, at that time, were more numerous. But the wetlands, of course with a more limited extent, existed until the second half of the last century, when quite a few of them were reclaimed. In the territories freed from the wetlands, to the left of the lower Vjosa flow, the fields of **Vlora Myzeqe** (Novosela, Akernia, Zhuke-Grykepisha, Poro, etc.) were formed, while to the right of it the fields of **Small Myzeqe** (Frakulla, Roskoveci, Bubullima, Fieri, Hoxhara, etc.).

The displacement of the Vjosa estuary towards the north was accompanied by the activation of marine erosion, which brought the rapid progress of the sea towards the land to its current position.

Delta evolution after 1870

Here we are talking about the new delta, formed by the Vjosa, when its estuary was moved to the north. The analysis of this evolution is based on old maps of the period from 1870 to 1968 (Figs. 3 & 14), and on satellite images for the years 1990 and 2020 (Fig. 13) (Fauche, 2001).

On the 1870 map, it appears that the Vjosa flowed south of the new delta. Therefore, due to the large accumulation, the land has progressed towards the sea, while further north and south of this estuary, the opposite happens, there is strong marine erosion. The position of the mouth of the Old River also speaks for this.

On the 1918 map, the estuary started to move southward, causing the sea to advance towards the land. But apparently, this position did not last long.

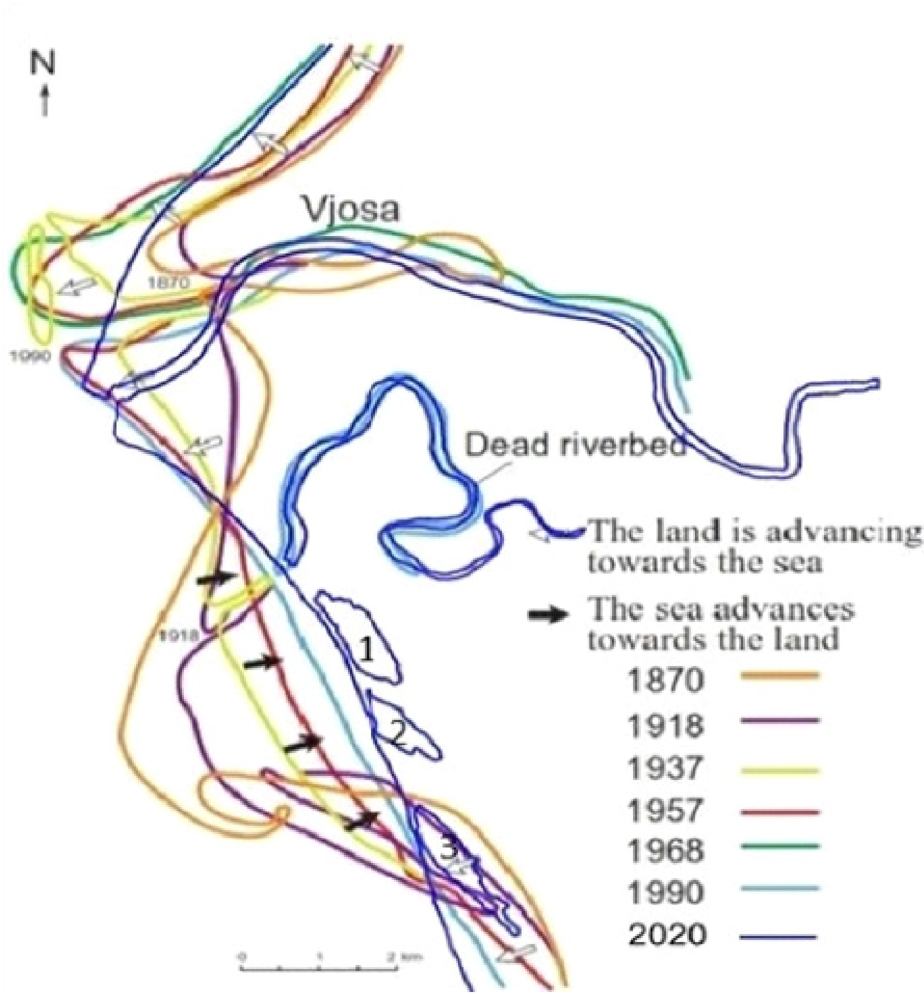

Figure 13.
Evolucioni i deltës së Vjosës në periudhën 1870-2020 (Fouche, 2001, përditësuar nga Nikolli, 2023).

Figure 14.
Map of the southern part of the Vjosa delta in 1945 (NID, 1945).

In the maps of 1937, 1957, 1968 and in the satellite images of the years 1990 and 2000, it appears that the entire Vjosa lower course is displaced northward, abandoning the previous bed by the rupture of the meander neck. The abandoned bed today constitutes a dead river (Old River, Zhuke). It brought strong marine erosion, the land withdrawal to its current position and the formation of three lagoons, 1, 2, 3. Meanwhile, in the north of the mouth of the Dead River, a large accumulation happen, with the formation of beaches and the progress of the land towards the sea.

On the 1937 map, in front of the estuary, a sandy island is clearly visible; it disappeared in the following years, as a result of its change from its normal position southward the sea, where it continues to be today. This is the reason that there is land progress. As said, a new littoral cordon is being formed in continuation of the right of the current delta.

In the map of 1945 (Fig. 14) several changes can be noticed: not long ago, the deviation of the Vjosa bed to the north and the formation of the Old River took place; a lagoon has been formed south of the mouth of the Old River, while a littoral cordon is separating the other lagoon south of it; the lagoon of Narta, with irregular contours, is surrounded by numerous wetlands.

Human activity in the river basin and bed played a special role in the evolution of the delta. Thus, the rapid growth of the delta in the 70s of the last century was caused by the reclamation and systematization of the Vjosa bed, and by the opening of numerous terraces on the slopes of the hills and mountains in the Vjosa basin.

As a result, the erosion intensified, which increased the river alluvium; these, passing through the systemized and directed bed, reached the estuary in large quantities. It increased the growth rates and dynamism of the delta. In the last decades, forests are being damaged and bed systematization is abandoned. It makes the delta dynamics and the Vjosa bed more complex.

As we can see, the Vjosa delta, part of the Protected Landscape Pishe Poro – Narta (Vth Category), stands out for the pronounced dynamism expressed by: the constant change of the estuary, the formation of many accumulative forms; it is expressed by marine erosion and accumulation, which replace each other depending on its position, etc.

The Vjosa estuary is predicted to advance into the sea about 1 km, at a rate of 5-10 m/year (Balla, 2015), while north of the Narta lagoon, in a 4 km long sector, erosion will be intense at a rate over 30 m/year. With the exception of a sector to the west of the Narta lagoon, which will be strongly accumulative at a rate of 25-30 m/year, the entire other sector of the coast, starting from Zverneci in the north to Vlora in the south, will be under the erosion.

It makes the ecosystems values of this protected area and constructions of a touristic nature or other types completely uncertain. This dynamism, as said, is related to a multitude of general and local, natural and human causes. Therefore, **detailed multidisciplinary studies are needed, on the basis of which strategies and programs with short-term and long-term protective measures can be built.**

2.7. Threatening risks of delta values

The complexity of the delta environment makes it particularly fragile and exposed to several risks, among which stand out:

a. Hydrogeological instability, which disrupts ecological balances. This phenomenon is related to:
-Frequent and, not infrequently, very large, even **catastrophic floods**, which can cause the diversion of water channels, modifying the configuration of the delta and the morphology of the coast, changing the ecological and edaphic conditions, which harm the living world, etc.

-It is related to **pronounced and prolonged droughts and high temperatures**, so frequent in recent years, which reduce the river flow; it leads to a marked reduction of freshwater, replaced by salty sea water, which penetrates the body of the delta, severely damaging the living world. These weather conditions are also associated with frequent and large fires that destroy everything.

b. Global warming is causing the polar ice caps to melt, and the average sea level to rise. As a result, many lower sectors of the delta will be flooded and not only. It has dramatic effects for the natural environment and human activities. Another serious impact would be the further increase in the salinization of coastal waters and the increase in the infiltration of salty waters into the freshwater layers of the coastal belt.

c. The beach crisis, which, for the reasons mentioned above, is constantly intensifying, eroding the beaches and causing the sea advance at very fast rates in the river bed and the delta body (the case of the last years: 20-30 km from the river Po mouth, Italy); it destroys ecosystems and biodiversity, beaches and tourist infrastructure, closing the perspective of tourism development.

d. The impact of human activity in the basin, the riverbed and the body of the delta, among them are distinguished:

-**enhancing of the beach crisis**;
-**inorganic and organic pollution,** from industrial, agricultural and zootechnical activities, from residential centers, intensive and chaotic tourism, etc. in the basin, in the Vjosa bed and in the delta body;
-**fragmentation and disap-pearance of entire ecosystems of protected areas** by chaotic and large-scale constructions, such as the case of Vlora Airport in the wetlands of the Pishe Poro - Narta Protected Landscape, other eventual large touristic constructions;
-**increasing the salt water penetration into the delta body** from the use of underground water (Eftimi, 2023) and from the restarting the exploitation of natural gas and oil south of Darzeza; it is eventually discovered a few years ago west of the Narta lagoon; as we said, it would bring great harm to the living world.

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Mediterranean Deltas: Assessment of general intactness by hydromorphology and land use obstruction – In focus the Vjosa Delta

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Introduction

Deltas are dynamic riparian-coastal landscapes composed of various habitats driven by river discharges, sediment supply, the permanent fight between land and wave-powered seashore, and dune development leading to different delta types (Fig. 1). In this context, river sediment input from the upstream catchments and sea level changes plays an essential role in the delta development. The most extensive delta expansion can be observed where mountainous, sediment-rich catchments with high precipitation meet shallow coastal reaches. Those preconditions prevailed in the many northern Mediterranean countries, supporting the development of broad coastal plains within only a few millennia.

In total **258 deltas and river mouths were assessed by us around the Mediterranean basin (Fig. 2)** (*see* also Schwarz, 2024); only some 80 are larger than 1,000 ha in size. Deltas are represented by several types (*compare* deltas in figure 1), various catchments and river sizes.

For **the assessment of intactness**, the understanding of the development of deltas and its various habitats, phases of progression and regression as well as man-made degradation is essential (Anthony *et al*. 2014; 2021). Deltas strongly depend on the sediment transport which is altered by land cover, dams, sediment exploitation and river regulation. As deltas are subject of deep landuse changes and threats the assessment of their intactness is highly needed.

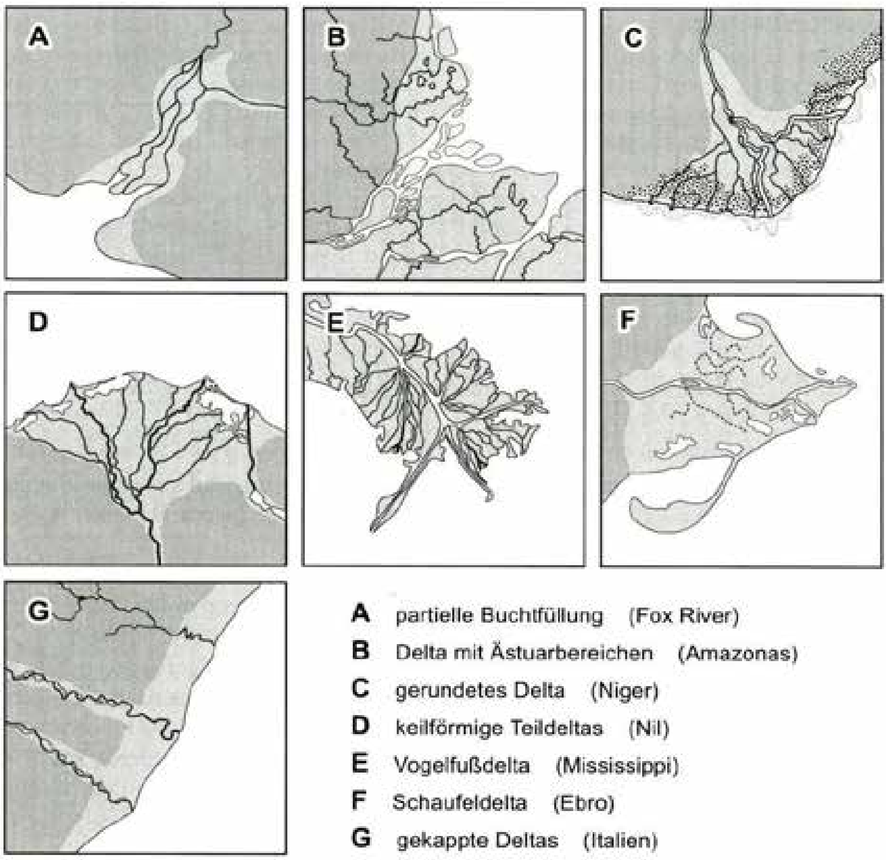

Figure 1.
Different types of deltas and namely Mediterranean Deltas (D, F, G): A) partial bay filling; B) delta with estuarine areas; C) rounded delta; D) wedge-shaped partial deltas; E) Bird's Foot Delta; F) Shovel Delta; G) capped deltas. (*After Ahnert*, 2001).

Approach I: Assessing the intactness of deltas

For the comparative assessment of the intacness of deltas, four steps were implemented. The first two steps focussed on the conditions in the river basin forming the delta. In steps three and four, attention was paid to the status of the delta itself. Previous studies on the locations of hydropower plants along rivers and their hydromorphological assessment in the Mediterranean Basin (Schwarz, 2020a), as well as studies concerning the landscape development for Adriatic deltas (Schwarz, 2020b), delivered important base data.

1. Identification of dams in the catchment. Dams are indicators for a significantly altered sediment transport throughout the deltas. The number, size and position of those dams (on main rivers and tributaries, in middle/ lower course, relevant for sediment transport) were recorded and combined with the deltas.

2. Analysis of the overall hydromorphological status of main rivers and tributaries in the catchment, following the CEN Standard (CEN, 2010).

3. Rough assessment of hydromorphological conditions in the delta regarding the channels, banks and adjacent riparian zone of the delta river branches and the shoreline.

4. Assessment of floodplains and wetlands (including lagoons) located in the deltas. The loss and assessment of deltaic wetlands is of great importance to understand the overall level of degradation of the delta area.

Approach II: Scoring

Të gjitha deltat u vlerësuan mbështetur në katër kriteret e sipërpërmendura dhe u sistemuan në tre klasa pikësimi kryesore (mirë, mesatare & keq) si tregohet në tabelën 1.

Table 1.
Scoring classes for the four main criteria (Images: GE 2023); Hymo, Hydromorphology.

Score	1 Dams in the catchment (number/ size and location)	2 Hymo main rivers and tributaries in the catchment	3 Hymo delta channel, banks and adjacent riparian	4 Hymo delta floodplain and wetlands (e.g. lagoons)	Integrative assessment ∑ scores [1-4] = [4-12]
Score 3 (best)	No major dams (> 10 MW) or chain of smaller dams 1-10 MW) in relevant river sections	Hymo classes 1-2 (near-natural, slightly modified)	No river regulation works and free shift of channels (no lateral obstructions)	No significant reduction of core delta area and provision of typical habitats including lagoons and swamps	

Score	1 Dams in the catchment (number/ size and location)	2 Hymo main rivers and tributaries in the catchment	3 Hymo delta channel, banks and adjacent riparian	4 Hymo delta floodplain and wetlands (e.g. lagoons)	Integrative assessment ∑ scores [1-4] = [4-12]
Score 2 (moderated)	Only smaller dams (1-10 MW) in relevant river sections	Hymo class 3 (moderately modified)	Moderate regulation of channels, including shorter meander cut-offs	Significant reduction of typical delta habitats, namely wetlands and obstructions and agricultural usages	
Score 1 (worst)	Major dams on relevant river sections	Hymo class 4-5 (extensively and severely modified)	Extensive or total regulation and rectification of channels	Loss of most of the typical delta habitats and wetlands, intensive land use, not only agriculture but also settlements and touristic development	

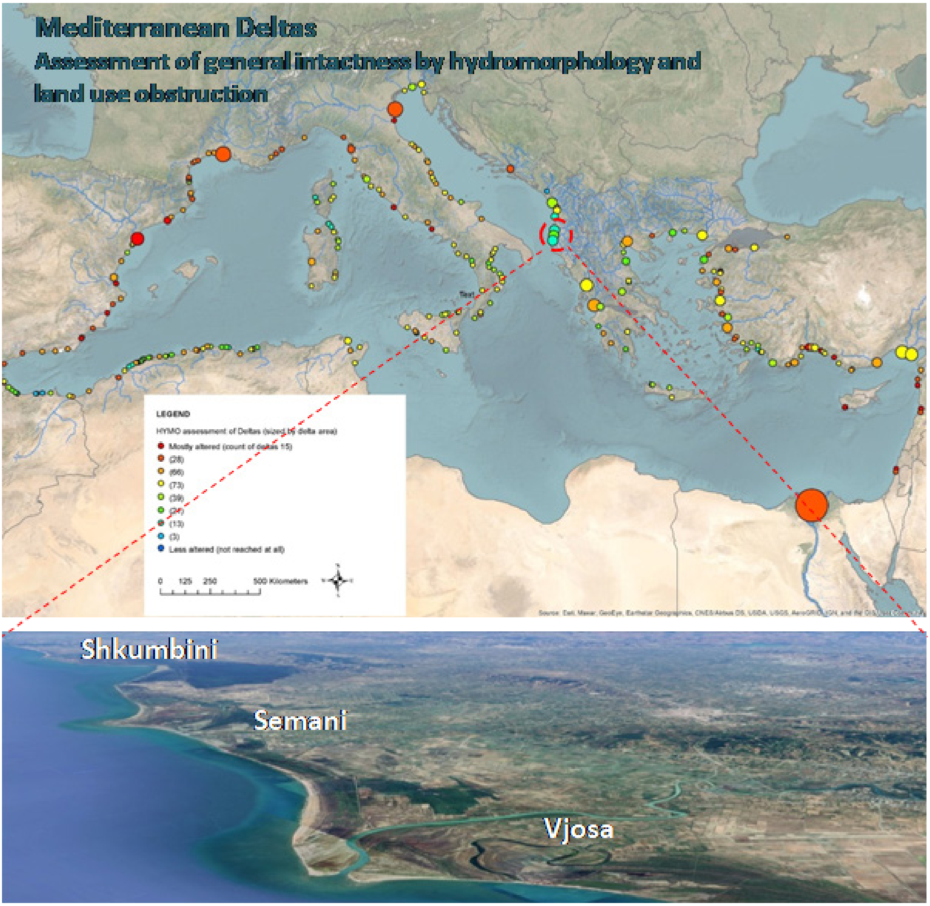

Figure 1.
Above, Mediterranean Deltas: Assessment of general intactness by hydromorphology and land use obstruction. ***Below***, Mediterranean Deltas: Vjosa-Semani-Shkumbini - Triple deltas (AL), highest score (10-12) (Image: GE 2023).

Table 2.
Assessment table for the largest deltas (>10,000 ha); Hymo, Hydromorphology. 1, Dams in the catchment (number/ size and location); 2, Hymo main rivers and tributaries in the catchment; 3, Hymo delta channel, banks and adjacent riparian; 4, Hymo delta floodplain and wetlands (e.g. lagoons).

Name	**Country**	**Area in ha**	**Ass1 Dams**	**Ass2 Hymo River**	**Ass3 Hymo Delta Channel**	**Ass4 Hymo Delta Wetlands**	**Ass Delta Total**
Shkumbini	AL	16,628	1	3	3	3	**10**
Vjosa	AL	23,690	2	3	3	2	**10**
Nestos	GR	9,588	1	2	3	3	**9**
Semani	AL	20,413	1	2	3	3	**9**
Agios Georgios	GR	12,753	2	3	1	2	**8**
Buna-Bojana	AL-ME	16,424	1	2	2	3	**8**
Atachthos	GR	42,391	1	2	2	2	**7**
Seyhan	TR	65,129	1	1	3	2	**7**
Ceyhan	TR	63,592	1	1	2	3	**7**
Gediz	TR	32,958	1	2	2	2	**7**
Evros-Meric-Maritsa	GR	32,436	1	2	2	2	**7**
Acheloos	GR	50,243	1	1	2	2	**6**
Axios-Vardar	GR	27,546	1	2	2	1	**6**
Meander	TR	26,366	1	2	1	2	**6**
Göksu	TR	18,943	1	2	2	1	**6**
Turia-Poyo	ES	10,037	2	2	1	1	**6**
Arno	IT	14,000	1	1	1	2	**5**
Nile	EG	2,768,143	1	1	2	1	**5**
Po	IT	86,491	1	2	1	1	**5**
Rhone	FR	126,931	1	1	1	2	**5**
Ebro	ES	41,901	1	1	1	1	**4**

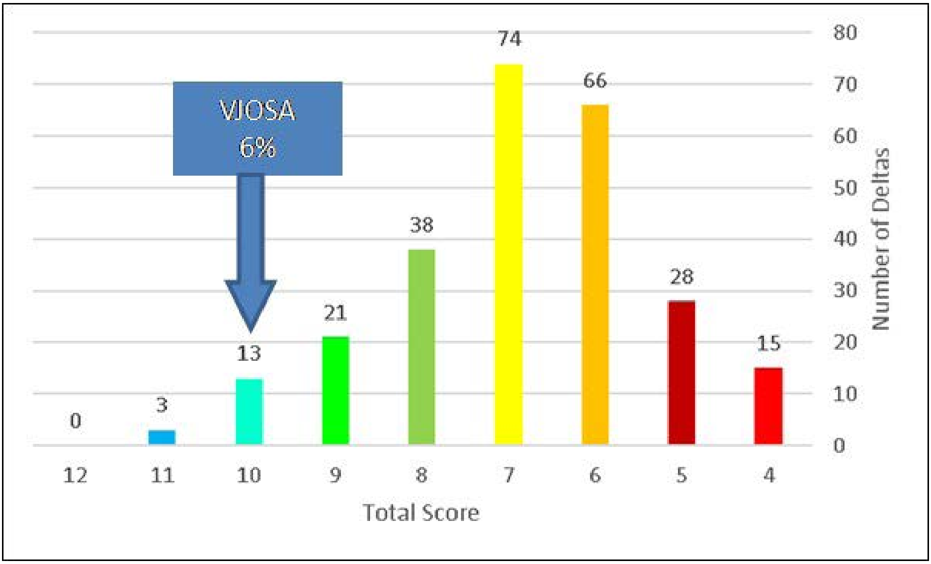

Figure 3.
Mediterranean Deltas: Scoring class distribution.

Overall Results

Out of 258 assessed deltas, none received the full score of 12, and only three smaller deltas fell in the second-highest scoring, 11.

Thirteen deltas are attributed to very good conditions, receiving a score of 10. Vjosa and Shkumbini deltas are also in this group (Tab. 2, and Fig. 2). It's important to highlight that most deltas with scores of 10 and 11 are relatively small.

Only 6% of deltas by number (Fig. 3) and 5% by size (Fig. 4) (*without the Nile delta due to the extraordinary size) remain in the best classes 10-12 (Tab. 2). Vjosa and Shkumbini Deltas, Albania, belong to the best classes.

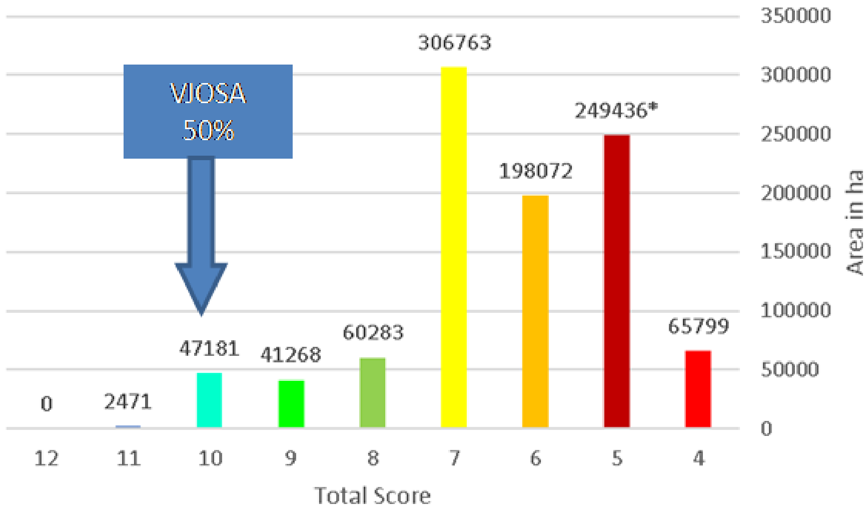

Figure 4.
Mediterranean Deltas: Size distribution (The Vjosa Delta size is about 50% of the best class deltas 10-12).

Representative results

While large deltas in the northwestern countries Spain, France and Italy receive constantly low values central and eastern Balkan rivers namely in Albania and partially in Greece scored best. In Turkey only a few deltas remain in better shape. Figures 5 to 7 show examples for the three main score groups (compare also further examples below the Vjosa case).

Vjosa Delta

In Albania most remarkable is the concentration of three relatively intact adjoining deltas ("triple-deltas") situated along the southern Adriatic coast - the Vjosa, Semani, and Shkumbini river deltas (Fig. 7). These deltas, spanning 24,000 hectares (Vjosa), 20,000 hectares (Semani), and 17,000 hectares (Shkumbini) (Tab. 2), fall into the category of large deltas with expansive coastal plains. Various lagoons, extensive deltaic dunes, and stretches of coastal swamps shaped by river sediments and the forces of waves and wind, characterise all three deltas.

-Vjosa, Semani and Shkumbini deltas built a unique "Triple delta" (Fig. 2).

-Vjosa Delta: Intact catchment, but dredging in lower course and land reclamation in delta area.

-Semani Delta: River impacted by hydropower dams on Devolli river.

-Shkumbini Delta: Protected, but land reclamation north of the delta.

Figure 5.
Mediterranean Deltas: Evros/Mariza (GR/TR), medium score (7-9) (Image: GE 2023).

Figure 6.
Mediterranean Deltas: Arno (IT), lowest score (4-6) (Image: GE 2023).

Figure 7.
Satellite views of Shkumbini, Semani and Vjosa deltas (Images: GE 2023).

The Vjosa delta mouth provides the most discharge and sediment load of all three deltas (Figs. 8-9). The Vjosa Delta still hosts a remarkable delta front and a highly dynamic small lagoon system, particularly on the southern delta area. On the other hand, agricultural use has spread into the delta area, and now, fishery activities and impacts of keeping water in the lagoons deteriorate and endanger the site protected as Pishe Poro - Narta Protected Landscape.

Figure 8.
Satellite view of the Vjosa Delta and the lower catchment with the lower part of the Vjosa Wild River national park (Image: GE 2023).

Delta examples

The following delta images mëposhtme (Figs. 10-15) should highlight the high degree of alteration due to various usages in many deltas in the Mediterranean.

Figure 9.
View of the Vjosa Delta from the air (Images: Upper two: provided by riverwatch.org, below: GE 2023).

Figure 10.
Satellite view of the Tagliamento Delta (IT), indicating a strong touristical usage of the delta area (Image: GE 2023).

Figure 11.
Satellite view of the the Var River Delta (FR), highlighting the construction of airports in deltas and deltaic plains across the entire project area (Image: GE 2023).

Figure 12.
Satellite view of the the Evrotas River Delta (GR), showing strong river and delta regulation (Image: GE 2023).

Figure 13.
Satellite view of the Gönen Cayt River Delta (TR), indicating the high pressure of agricultural usages in delta areas (Image: GE 2023).

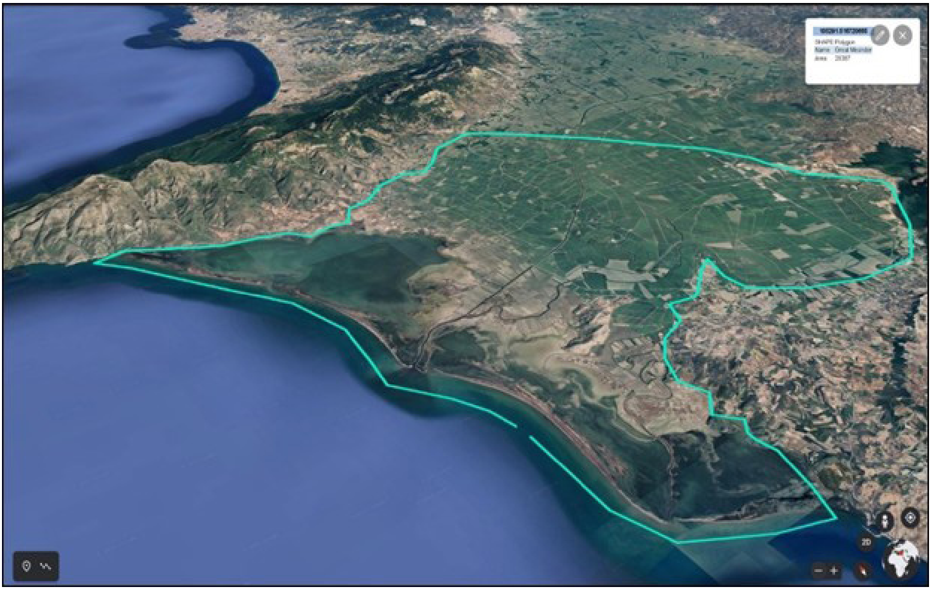

Figure 14.
Satellite view of the Great Meander River Delta (TR), another example for strong river regulation (meander cut-off) and intensive agricultural usage of the delta plain (Image: GE 2023).

Conclusions

- Only 6% of all Mediterranean deltas can be addressed as "intact to a large extent"; here, namely the Vjosa, Semani and Shkumbini deltas in Albania build a unique "Triple delta".

- In most cases deltas are obstructed by river regulation, flood control and land reclamation for various purposes (agriculture, settlements, commercial, even industrial sites, harbors, airports, touristic resorts with golf courses, or for seawater desalination plants).

Figure 15.
Satellite view of the Belek River Delta (TR), covered by intensive touristic resort development with golf courses (Image: GE 2023).

- Deltas strongly depend on their catchments, therefore the assessment of dams in the middle and lower courses as well as river regulation along the main rivers must be considered!

- Deltas show a clear trend towards degradation, superimposed by raising sea water levels.

- The effective protection of deltas and sustainable management of the catchments is highly needed!

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Dynamic landscapes of the Vjosa Delta: An intersection of remote sensing and ethnographic research

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1.Introduction

The river Vjosa is characterised by continuous, dynamic nature throughout its almost 300 km long course, with parts of wide gravel bars and a rich biohabitat. Its Delta is a transitional wetland complex and is therefore subject to constant changes and shifts influenced by a combination of many natural and anthropogenic factors. It is considered an important ecosystem on the Albanian coast and the Adriatic Sea.

Wetlands are important factors for biodiversity as they help regulate, capture and store greenhouse gases, enable nutrient cycling, mitigate flooding, store, treat and purify water (Kingsford & Basset, 2016). However, due to anthropogenic activities, climate and environmental changes, almost half of the world's wetlands are undergoing accelerated change, resulting in abrupt alteration or even loss of habitat (O'Connell, 2003; Xiong *et al*., 2023). **This also applies to the Vjosa Delta, a transitional wetlands that could be affected by drainage projects and urbanisation due to the construction of Vlora International Airport and the Vlora Marine tourist resort.**

This paper examines the dynamic environments of this wide region, stretching from the Hoxhara Channel in the northwest, through the Pishe Poro (Fieri), the Vjosa Estuary, the Kallenga and Narta Lagoons, coastal dunes, and the Vlora town in the southwest. Through the intersection of big remote sensing data (RS) and thick ethnographic data, we observe and explore the dynamic reconfigurations of landscape structure between 1984 and 2023. We specifically address temporal changes in land use land cover (LULC), coastal shifts, urban sprawl, and attempt to link these Earth Observation (EO) data to specific political, economic and social realms that directly or indirectly accelerate changes in the landscape.

Due to its geophysical characteristics, such as the Mediterranean climate and vegetation, the geological features with a flat relief in the depression, the predominant marine clayey silts and sandy deposits (Xhaferri *et al*., 2020), the tides and waves that cause an abrupt shift in the coastline, **this dynamic area is potentially susceptible to constant changes.** At the same time, the anthropogenic interventions of the last decades contribute to the accelerated changes of the Vjosa Delta and the coastline in this area. Because of the expansion of the Narta Saline and the international Harbour of Vlora, the construction of the Thermal Power Plant in Zverneci, Petrolifera crude oil deposits, the construction of the Vlora-Fier gas pipelines, the urban Waste collection point in Zverneci, these changes are more frequent and discontinuous, as the preliminary study shows.

In summary, the results of this intersectional study are twofold. One is to map and explain how geophysical features, together with anthropogenic interventions, have reconfigured the landscape structure in the wider area of Vlora. The other result explains why the use of the intersectional approach - combining RS and anthropology - is important for the study of the landscape dynamics of the transitional wetland complex of the Vjosa Delta.

2. Study area and background

2.1 Brief description of the study area

The extent of our preliminary analysis is the wider Vlora-Fieri area, which covers about 350 km² (Fig. 1) and stretches from the Hoxhara Channel, with Darzeza, Pishe Poro wetlands and coastal dunes in the northwest (Fieri), the Vjosa River estuary, the Kallenga and Narta Lagoons, coastal dunes, saline, etc. to the Vlora city in the southwest. In the northeast, it extends to the Mifoli Bridge. Less than half of this area, about 160 km², is located within the Pishe Poro - Narta Protected Landscape (Vlora & Fieri) (Vth Category) (VKM/DCM 694/2022). The use of a defined polygon (with fixed outer coordinate boundaries) for all four observation times allows us to analyse the LULC changes within this fixed area.

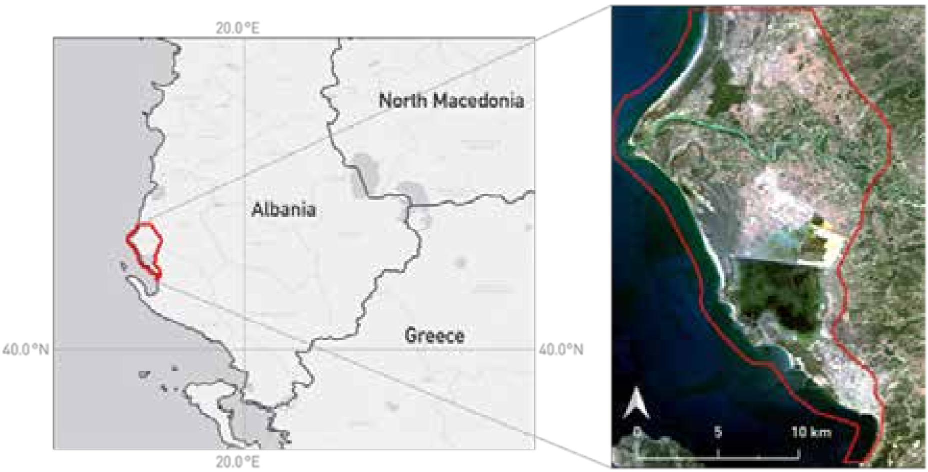

Figure 1.
The study area- the defined polygon- is marked in red and is located in southern Albania (*left*). On the right is the Landsat 8 satellite image of the study area from July 2023.

2.2 Dynamic environments

According to the Ramsar Convention, wetlands are "*areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land or where the land is covered by water*" (Ramsar Convention, Paper No. 1). Wetlands are thus dynamic ecosystems, as their transitory environments are constantly changing between terrestrial and aquatic landscapes (Kaplan & Avdan, 2018). Wetlands are of great importance for hydrological and ecological processes (Kaplan & Avdan, 2018), therefore they have been protected by the Ramsar Convention since 1971. They are considered essential to mitigate the effects of greenhouse gases, protect water quality and prevent erosion. They are subject to continuous but steady dynamics, altered in recent centuries by anthropogenic interventions whose pressures affect wetland condition, ecology and valuable ecosystem services (Newton *et al*., 2020). The latter also applies to the transitional wetlands of Vjosa Delta whose coastline and estuary are not only subject to constant erosion due to their geophysical characteristics, but are also endangered by the anthropogenic interventions of recent decades.

The Mediterranean climate and vegetation combined with geomorphological features make Albania one of the most erosion-prone countries in Europe (Grazhdani & Shumka, 2005). In recent decades, Albania's more than 400 km long coastline has been abruptly eroded. The most severe erosion has been observed along the 150 km long northern coastline (from the Buna River to the Bay of Vlora) with up to 10 m per year; the southern rocky coastline (from Vlora to the Bay of Ftelis in Greece) is subject to moderate erosion of up to 20-50 cm per year (Qiriazi & Sala, 2000). The reasons for accelerated coastal erosion are related to the interaction between anthropogenic (e.g. urbanisation, expansion of agricultural and pastoral areas, removal of inert material from riverbeds and the coastline, unplanned construction, infrastructural interventions) and geophysical (e.g. terrigenous material on the coast, steep slopes, river deposits, erratic rainfall) processes. Despite annual monitoring of coastal and soil erosion in Albania (Agjencia Kombëtare e Mjedisit, 2014; Hoxha *et al*., 2012; Prifti e*t al*., 2013; Sallaku *et al*., 2010), there are few legal regulations and even fewer decrees for the effective protection of these areas.

2.3. Urbanisation

Due to its strategic location by the sea, the city of Vlora was already settled in antiquity (6th century BC). Since then, the city has continued to expand in different historical periods. In this article, we briefly explain the social and historical context of the city's expansion for the period between 1984 and 2023, for which EO data are available.

In the period between 1945 and 1991, Albania was ruled by a communist regime, often described as one of the strictest totalitarian regimes in Europe (along with Romania), with political and economic centralisation and draconian restrictions on the economy and social life in general. With the formal completion of the agrarian reform in 1946, most private land ownership was placed in the hands of cooperatives, with peasants making up the majority of the Albanian population (Lelaj, 2012).

After 1960, the industrialisation reform was implemented, driving the "modernisation and development" of the country and the proletarianisation of the peasant population in the urban areas of Albania. During this period, the city of Vlora expanded through the construction of several factories. The most important were Soda and Polyvinyl chloride (PVC) plants (Wiki, 2020), and with them the Lamp factory, the Oil depot in Zvernec, Cement, Textile and Food factories in Vlora, which were built between 1967 and 1978.

To alleviate the pollution caused by the aforementioned factories, the communist elite arranged for the pine trees to be reforested in the area now called Soda forest. During the same period, the coastal dunes from Pishe Poro (Vlora) to Pishe Poro (Fieri) were reinforested with pine trees (QSGJ, 1990). This was done to protect against flooding in the area that was becoming prosperous for agriculture as a result of the agrarian reform.

In the course of this reform numeruous agricultural plots were expanded and a dense network of drainage and irrigation canals was built. The latter is stll in place today. Four pumping hydrostations were built to protect this drainage network from flooding: Vlora, Gorrica, Akerni (Vlora), and Hoxhara-Darzeza (Fieri) (*see Miho et al., in this volume; Non Vascular Plants*).

Due to industrialisation, the city of Vlora needed new labour, for which the communist government used the strategy of internal immigration. Thus, many people who lived in rural areas were encouraged to move to Vlora, where they found work in the above-mentioned factories. The military airport in the village of Akerni (near the Narta lagoon) was also built during this period. Due to the political isolation of the country, it was not frequently used and after the collapse of the regime it remained abandoned until recently.

In 1988, natural gas extraction began in the village of Povelça (Fieri), which was abandoned after the 1990s. In the same year, the village of New Darzeza was founded in this area, to which the inhabitants from the village of Darzeza in the Gramshi area (central Albania) were resettled due to the flooding from the Banja reservoir on the Devolli river (Gorica, 2016).

The fall of the regime in 1991 and the subsequent political, economic and social crisis in the country led to massive migrations. According to academic literature in during 1991 and 2000, migrations reached "epic proportions" (King & Vullnetari, 2007), as more than ⅓ of the population fled to Italy and Greece, as well as to other countries in Europe and the United States of America. The latter had a significant impact on Albanian politics, economy and society, as well as on the local landscape (Vullnetari, 2012). As described in detail elsewhere, remittances and other material and immaterial flows are an important social institution in Albania and nowadays also a driving force for the economic and social enrichment of the country (Gregorič Bon, 2017a, b, 2022; see also King & Vullnetari 2007, Vullnetari & King 2011).

Internal migration has left to the depopulation of many rural areas while many cities, including Vlora, have been subject to urban sprawl. Against this backdrop, many areas on the outskirts of cities, such as Akerni, Radhima and Orikumi, have expanded due to internal migration.

After 2000, the number of migration stabilised, while the number of remittances increased sporadically. Remittances were often the main source of income for many households and economies in Albania (Vullnetari & King, 2011) and influenced the rapid urbanisation of Vlora and other cities (Tirana, Durres, Saranda). Between 2004 and 2005, remittances contributed about 14% to Albania's GDP (Vullnetari & King, 2011: 55). Although this share dropped to 9% in 2009 due to the economic and financial crisis in Europe and the United States, they are still three times the value of Albania's exports abroad and thus cover a relatively large part of the country's GDP (*ibid*.: 55). In Vlora, the development of tourism and massive urbanisation have led to the expansion of suburbs such as Radhima, Orikumi and partly Zverneci, which are now major tourist attractions in the summer months.

Against the backdrop of neoliberal extraction policies, several infrastructural investment projects have been carried out in Vlora in recent decades. These included the expansion of the international Harbour of Vlora, the extension of the Narta Saltworks, the construction of the Thermoelectric Power Plant (TPP) in Zverneci (on the outskirts of Vlora) as well as gas pipelines (TAP) and the associated corridor VIII. Other planned interventions in the wetland (between the Vjosa Estuary and the Narta Lagoon) are also underway. These include the construction of the international Airport on the site of the former military airport in Akerni and the construction of the Vlora Marine tourist resort planned nearby on the coast. All this may lead to significant environmental pressures on the transitional wetlands of the Vjosa Delta and introduce a discontinuity in its changes.

3. Material and methods

3.1 Data sources Data sources

The data sources used in this study come from the intersection of anthropological research and RS analysis. While the anthropological data is based on extensive ethnographic fieldwork (from 2004), the EO data consists of four Landsat satellite images from 1984 (Landsat 5), 1992 (Landsat 4), 2000 (Landsat 5) and 2023 (Landsat 8). These years coincide with periods of great political, economic and social change in Albania:

- 1984-1990 – period of communist regime (1945-1991) and prohibition of emigration abroad, highly restricted and controlled emigration at home; agrarian reform in 1946 and industrial reform in the 1960s.

- 1991-2000 – end of the communist regime and subsequent massive emigration (mainly to Greece, Italy and the USA).

- 2001-2023 – period of remittances (2000-2007) and associated urbanisation; return migration (2008-2010); infrastructural interventions in Zvernec and a renewed increase in migration.

All satellite images were acquired during the same period (month of July) when vegetation is at its phenological peak. Therefore, pixel values are generally stable during this green period and the Vjosa River is in its driest month (Ndini & Demiraj, 2011). The downloaded Landsat data are Level 1 standard data that have been geometrically corrected or orthorectified by the provider. The preprocessed output data contains surface reflectance values, the only data suitable for land surface change studies. Finally, the images were cropped to the desired geospatial extent corresponding to our study area, as mentioned in the previous chapter.

3.2. Methods

The individual steps developed and applied in this research are illustrated in the synthesis workflow shown in the figure 2.

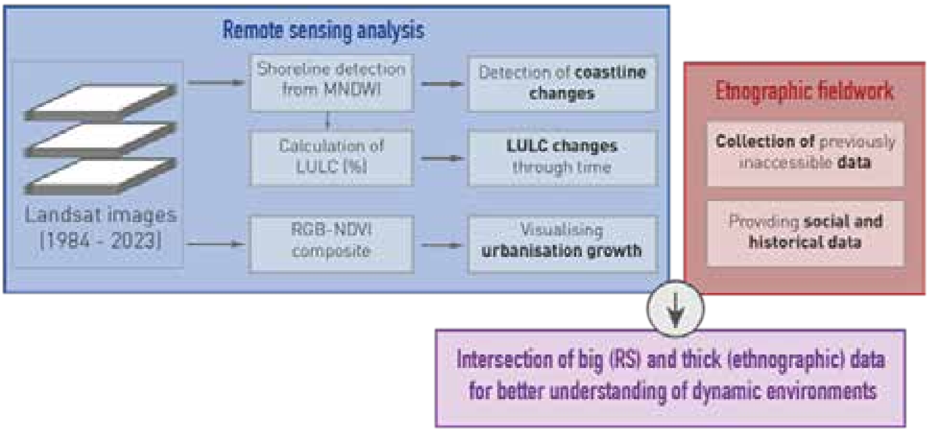

Figure 2.
The workflow of this intersectional study, which is a combination of remote sensing and anthropological approaches.

3.2.1 Landscape changes from remote sensing data

The key question of this study is whether the changes in the LULC, coastal erosion and urban sprawl are related to the reconfiguration or transformation of the wider Vlora area. The mentioned landscape changes in the area were identified using optical remote sensing data. We therefore used four different satellite image time slots (1984-1992-2000-2023).

In order to obtain details about the long-term changes, we first performed a LULC classification and identified five main classes using an automatic procedure on satellite images: land, sea, river, lagoon and salt pans. A robust and repeatable automatic procedure was developed to identify the land and water areas on Landsat optical imagery of the selected years.

The main objective was to classify the pixels of a given image into two classes, the background (land) and the segments of interest (water), by defining the threshold in an image histogram (Gonzalez & Woods, 2002). The Modification of Normalised Difference Water Index (MNDWI) (McFeeters, 1996) was used for automatic delineation of open water based on a histogram. This modified index has become a common method for mapping surface waters on Landsat imagery (e.g. Ji *et al*., 2009; Lu *et al*., 2011; Soti *et al*., 2009), as it can significantly improve the classification of open waters compared to NDWI. Namely, MNDWI uses a MIR band instead of a near-infrared (NIR) band (Li *et al*., 2013; Xu, 2006), especially on water surfaces mixed with fluvial sedimentation where spectral values are more similar to land features, e.g. lagoons (Gregorič Bon *et al*., 2018). For an illustration of the steps required to classify the images, see Figure 3. For a detailed explanation of the MNDWI-based classification method and its validation, see Gregorič Bon *et al*. (2018).

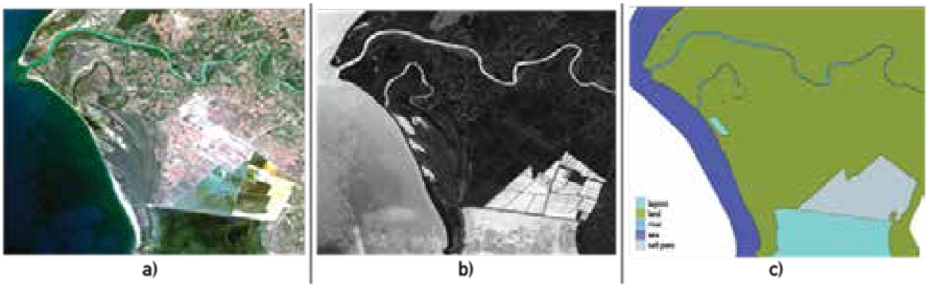

Figure 3.
The section of our study area, shown as an original Landsat 8 image from the year 2023 (a), as an MNDWI derivative (b) and as a result of automatic classification (c).

After vectorisation, the MNDWI results for each year were classified into the five land cover categories listed above, with the sea, river, lagoon and salt pan classes manually reclassified from an automatic dichotomous classification between land and water classes. The percentage of each land cover class in all four images analysed (see Table 1 below) was calculated.

In addition to LULC changes, we also attempted to map the coastline of the Vjosa Delta to show dynamic changes over time. We delineated the land/sea area from three points in time (1984-2000-2023) to mark the line of a coastal area. As we mentioned in our previous work, these changes are the result of the interplay between a river's sediment discharge, erosion from tidal and wave energy, and possible anthropogenic removal of coastal sediments (for details see Kanjir & Gregorič Bon, 2015).

For the third landscape change, the urban growth of the city of Vlora, we used a simple visual method called RGB-NDVI colour composite. With a basic understanding of additive colour theory and the use of the NDVI (Normalised Differential Vegetation Index) calculated on three Landsat images, we visualised and assimilated the spatial and temporal trends of change in an urban landscape. For details on the RGB-NDVI methodology, see Kanjir *et al*. (2022).

This study is also inspired by the results of the project 'RIVERINE ENVIRONMENTS' (2020 -2022), in which we compared two riverine landscapes of Mura (Slovenia) and Vjosa, using the intersection of remote sensing, anthropological and geographical research. The results of this comparative study (*see* https://riverchange.zrc-sazu.si/; ZRC SAZU 2022) show how intensive infrastructural interventions (such as the construction of hydropower plants, various industries, severe management of the river in its upper and middle sections) have affected Mura over the years. Based on these results, RIVERINE ENVIRONMENTS presumes how the planned infrastructural interventions on the Vjosa might also lead to transformations of its riverine and delta landscapes.

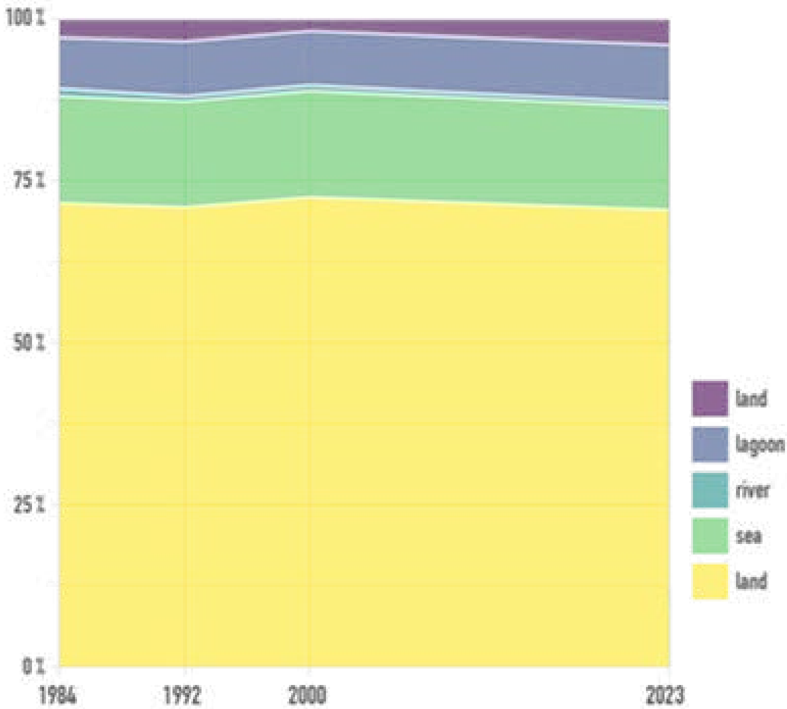

Figure 4.
The figure accompanying Table 1 shows the LULC changes of land and four different water classes over time for four selected years (1984, 1992, 2000 and 2023).

4. Results and discussion

4.1. LULC and coastline changes

The use of Landsat data allowed us to study the impact of coastal and inland dynamics and to identify recent LULC changes and geomorphological evolution of the transitional wetlands of the Vjosa Delta, especially at its estuary. Table 1 shows the acquisition time and sensors of the Landsat data used to calculate the percentage of the five land cover types in the selected study area in the four selected years, as also shown graphically in Figure 4. Since the spatial resolution of the satellite images used is 30 m (for all three sensors – Landsat 4, 5 and 8), the tidal effect was taken into account in this study but was considered insignificant.

In considering the main changes in the landscape under study, we have focused on the coastline and its changes in the Vjosa Delta. In order to measure the extent of changes, we took satellite images of the Vjosa Delta in four different phases: at the beginning of the measurements (1984), at the midpoint (1992 and 2000) and at the last measurement in 2023.

Table 1.
Selected Landsat images and their LULC distribution.

	1984 (Landsat 5)	1992 (Landsat 4)	2000 (Landsat 5)	2023 (Landsat 8)
Land	71.59%	70.92%	72.50%	70.51%
Sea	16.45%	16.31%	16.41%	15.84%
River	1.19%	0.85%	0.84%	0.71%
Lagoon	7.87%	8.46%	8.34%	8.92%
Salt pans	2.90%	3.46%	1.91%	4.02%

As can be seen in Figure 5, the Vjosa mouth has changed by more than 1200 m between 1984 and 2023.

The changes in the coastline are the result of sediment movements in the littoral zone and the dynamic nature of water levels at the coastal boundary (e.g. waves, tides, groundwater). In this particular area, tides vary vertically between 20 and 30 cm (Simeoni *et al*., 1997), which does not affect the 30 m resolution satellite images used in this case. This drastic change in the Vjosa estuary (more than 1.2 km between 1984 and 2023) is consistent with the statement of Fouache *et al*. (2001) that the course of the river Vjosa and the shifts of the delta estuaries have changed since the 16th century.

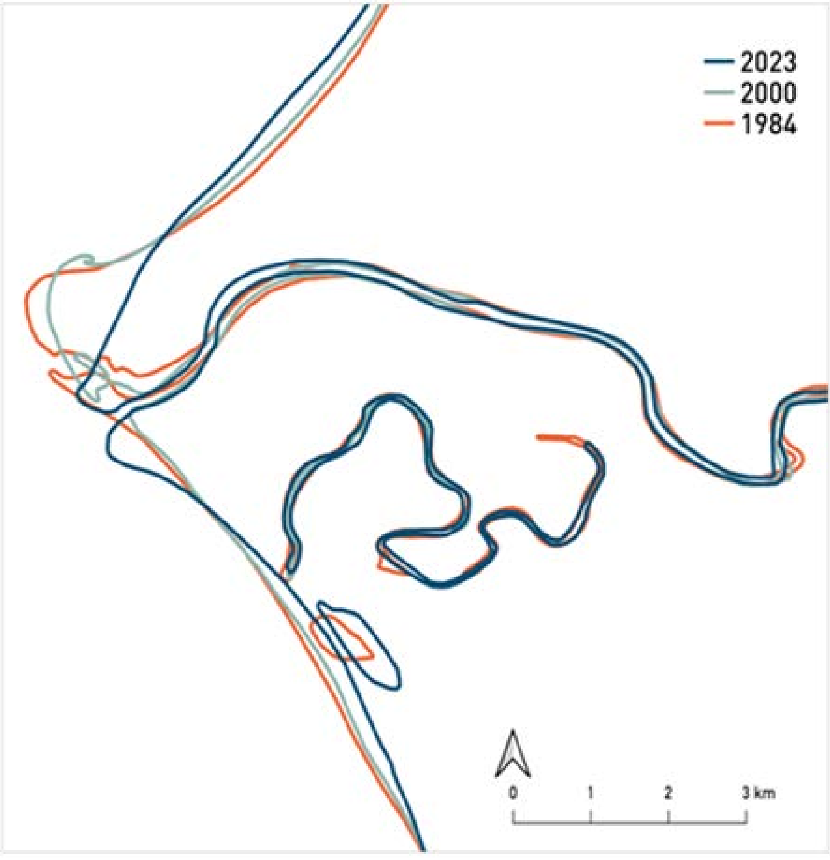

Figure 5.
Development of the coastline around the mouth of the Vjosa between the years 1984 and 2023. The Kallenga lagoon and abandoned mouth of the river in the south, which was still active in 1918 (Fouache *et al*., 2001) are still visible today.

4.2. Urban sprawl of Vlora city

In addition to the changes in the LULC and the coastline in the Vjosa Delta, significant changes can also be observed in the extent (northwest and southwest) of the city of Vlora. Figure 6 shows two satellite images from 1985 and 2023 and a composite image from RGB-NDVI. One can even see with the naked eye how the city of Vlora has been subjected to urban sprawl and has thus grown considerably in size over time. The increase in built-up areas is shown in light pink/red on the right side of Figure 6, especially along the coast. All this is the result of strong urban growth around the city, reinforced by the increasing population in the region (due to in-country and out-country migrations), which rose steeply until 2000 (Gregorič Bon *et al*., 2016).

Apart from mentioned, in Zverneci, a village north of Vlora, there was an increase in land deposition due to the natural accumulation of material when the construction of the harbour affected the physics of water movements. In addition, the results show that the construction of a breakwater in the port, which was extended deep into the sea in the mid-1980s, caused an increase in the amount of sediment by up to 0.5 km² between 1985 and 2023. Port infrastructure and other infrastructural interventions often stimulate erosion processes and the transport of longshore sediments (Pranzini *et al*., 2015).

Figure 6.
Urbanisation growth of the city of Vlora between 1985 and 2023, with a NDVI RGB composite of three NDVI bands showing urbanisation growth in pink/red (*right*).

Conclusions

This paper is part of a preliminary study that examines the key parameters for the changes observed in the Vjosa Delta, and the city of Vlora; it can be detected from a bird's eye view through the analysis of satellite images over the last 40 years. The study attests that **these dynamic environments are highly susceptible to changes that are constantly taking place due to the geophysical characteristics and anthropogenic interventions in the greater Vlora area.** These changes are then placed in a temporal context where we suggest ways in which they can be further explored and brought into greater focus.

In this study, we departed from the intersection between anthropological research and RS techniques, as we were interested in how changes in landscape structure evolve through time and space. Based on the EO data available for our study area and long-term anthropological research, we defined three parameters that are most important for accelerating changes in landscape structure: LULC changes, coastal erosion and urban sprawl in Vlora city. Our preliminary study has shown that the landscape structure in the whole Delta area have been reconfigured due to geophysical conditions and anthropogenic interventions in the period between 1984 and 2023. This means that **the transitional wetlands of Vjosa Delta has not yet undergone major transformations.** Thus, when analysing the RS data, no severe alterations in the landscape structure of the wetland have been detected so far. The situation is different in the city of Vlora, where the NDVI composites show many changes due to urban sprawl after the 1990s, as the landscape structure has transformed.

As already mentioned in the section on Urbanisation (see § 2.3.), the Delta zone, despite its continuous dynamics, has not been intensively managed after the collapse of the communist regime. This is also shown by LULC's analysis that shows how **the area is gradually returning to its 1984 state** when the communist party invested in the construction of the military airport, the oil reserve, the PVC factory and other factories in Zverneci.

However, as this study partly shows, the planned infrastructural interventions - **the construction of the Vlora International Airport and especially the planned tourist resort to be built directly in the Pishe Poro - Narte Protected Landscape - could potentially accelerate the dynamics of wetlands and lead to sudden and unexpected alterations in the landscape structure**. These interventions could also increase coastal erosion and lead to abrupt changes in wetland biota and in the long term contribute to the current global climate and environmental changes. Accelerated erosion could potentially jeopardise the safety of these infrastructural investments and, above all, lead the dynamics of the transitional wetland of Vjosa Delta from continuous to discontinuous changes.

In other words, **Vjosa Delta transitional zone is still subject to a sustainable policy so far, which could be overridden by an extractive policy due to the imminent construction of the airport and tourist resort**. Similar extractive policies are widespread in many parts of the world and, as numerous studies show, lead to accelerated climate and environmental changes.

As **the Vjosa Delta is prone to continuous changes, we need to look at the phenomena from more than one disciplinary angle**. In this study, we have approached the subject through the intersection of anthropology and RS. The latter allowed us to look at, analyse and interpret the EO data in a particular social and cultural context in Albania. We consider this crucial to better understand how in what ways and why landscape structure is reconfigured or transformed over time and space.

Acknowledgements

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Non vascular plants from the Vjosa Delta, floristic and ecological view

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Summary

The Vjosa River is distinguished in the whole Mediterranean for its wide and quite active Delta, at the southernmost end of the Eastern Adriatic; it extends from the Mifoli Bridge in the coastal area of Vlora Myzeqe, from the Narta Lagoon in the southern part, to the Hoxhara Channal in the northern part (Small Myzeqe, Fieri) (ca. 350 km²). About 160 km² has recently been re-declared a Protected Landscape (Category V). Aquatic habitats cover ca. 40% of the whole area, mainly lagoons and marshes, of priority in the EU Habitats Directive (code 1150). They belong to transitional ecosystems also under priority protection for many other conventions or directives. Despite the development of the last 100 years, their natural condition is good, and the water quality is not significantly affected.

These aquatic ecosystems are distinguished by a high productivity, where algae have the major contribution, in phytoplankton, phytobenthos and macrophytes. An overview is reported here, of what is known so far about the diversity and quantity of algae, and what conditions their growth. In total, about 580 species of non vascular plants have been known so far, where diatoms dominate with about 420 species, green algae with ca. 50, charophytes with 36, dinoflagellates with ca. 30, cyanobacteria with ca. 15 known species and 28 species of mosses. Also 70 species of higher fungi (including 2 lichens) are reported here. Narta lagoon is among the richest ecosystems with ca. 350 species, 96 of them in phytoplankton. It is worth saying that among them there are also some toxic species belonging to *Halamphora, Oscillatoria* or dinoflagellates.

Studies in the topic summarized here extend from Protic (1907) to the present days. Most of them belong to the Delta of Vlora. An overview of aquatic habitats and their physico-chemical quality, nutrients or human impact is presented, too. It is illustrated with photos from the area or algal microscopic photos. The cheklist of algal species is reported at the end.

Further development plans in Delta area, on both sides of the Vjosa estuary, will undoubtedly affect the natural state of aquatic habitats, their fragmentation, pollution and eutrofication. It can disturb strongly the species diversity and the healthy productivity; as well enhance the toxic algal blooms. All in synergy may impact the aquatic livings and the human health itself, but also decreasing the recreational tourism values.

We suggest qn interdisciplinary study of the whole Vjosa Delta focused on its conservation and sustainable management, based on scientific evidence. And Nonvascular plants sensu lato (algae, mosses, lichens and fungi) should be important part of it.

Brief view on algae

Algae form a large and diverse group of photosynthetic, eukaryotic organisms. Many distinct groups embrace species from microscopic unicellular algae, such as diatoms, to multicellular forms of brown algae. Most are aquatic and lack many of the distinct cell and tissue types. The most complex freshwater forms are Charophyta, a group of green algae that includes, for example, Spirogyra and Chara (https://en.wikipedia.org/wiki/Algae).

Why are algae important? Through photosynthesis, algae fix CO_2 and produce organic matter, once releasing O_2 into the atmosphere. They, produce yearly a significant portion of the Earth's biomass and oxygen. Cyanobacteria are able to fix nitrogen from the atmosphere. Algae help to 'purify' water by absorbing nutrients and pollutants from the water. They are the basis of most aquatic food webs, and can be valuable indicators of environmental bioquality (i.e. diatoms).

As primary producers, algae are essential to wetland ecosystems and their food webs. They grow underwater attached to the bottom and other submerged substrates (microscopic or macrophyte algae), or remain suspended in the water column (phytoplankton). Transitional ecosystems, such as the Vjosa delta, are the backbone of life on earth; they host many habitats and high biodiversity; microscopic algae in phytoplankton are basic in the food webs; these environments play an important role in nutrient recycling and gas exchange (Mayor, 2023).

A relatively rapid increase in the population of (usually) **phytoplankton** algae in an aquatic system can lead to **algal blooms** and the undesirable condition of **eutrophication**. Certain species in an algal bloom (especially among the dinoflagellates, cyanobacteria, diatoms) can produce toxins that cause adverse effects on other aquatic life, including humans. (**HAB, Harmful Algal Blooms**) (Heisler, 2008).

The main groups of algae *s.l.* found in transitional waters are the diatoms (Bacillariophyta), dinoflagellates (Dinophyceae), green algae (Chlorophyta), stoneworts (Charophyta), red algae (Rhodophyta), blue-green algae (Cyanobacteria) etc. (*See* Annex I).

Wetland habitats of the Vjosa Delta

The Vjosa River has formed a wide and very active Delta in the Adriatic Sea; from Mifoli Bridge it expands to the coastal area of Vlora Myzeqe, from Narta Lagoon in its southern part, to Hoxhara Channel in the northern part (Small Myzeqe, Fieri), where its border is almost merged with the Delta of the Semani River (see Map of Fig. II.3.2.3 in Xhaferri, 2021).

The wetland habitats of Delta are of particular importance, up to 40% of the whole area (VKM/DCM 694/2022). They include the permanent marshes represented by the lagoons of Narta and Kallenga, the marshes Limopuo, the salt marshes of Akerni and the Dead River (Zhuke). The Vjosa River from Mifoli to Estuary separates this area of Vlora, with the Fieri area on the northern side of the Delta (Fig. 1). There are also other shallow wetlands with brackish water (Tab. 2), river traces left by the meandering of the Vjosa bed over the centuries that extend up to the Hoxhara Channel. The entire Delta area is also crossed by many artificial habitats, such as drainage and irrigation channels, salt evaporation ponds and temporary ponds with fresh or brackish water.

The Narta Lagoon is the main water body in the entire Delta area (Pano *et al*., 2005) (Fig. 2, left); it covers an area of 2,900 ha, average depth of 1.2 m (minimum 1.08 m and maximum up to 2.08 m); it communicates with the sea through two artificial tide channels: the southern one is 200 m long, 6-48 m wide and 0.2-1.8 m deep; the northern channel (Big Dajlani) is 800 m long, 11-60 m wide and 0.3-0.5 m deep (flow of 2.2-4.3 m^3/s) (MIE, 2019a).

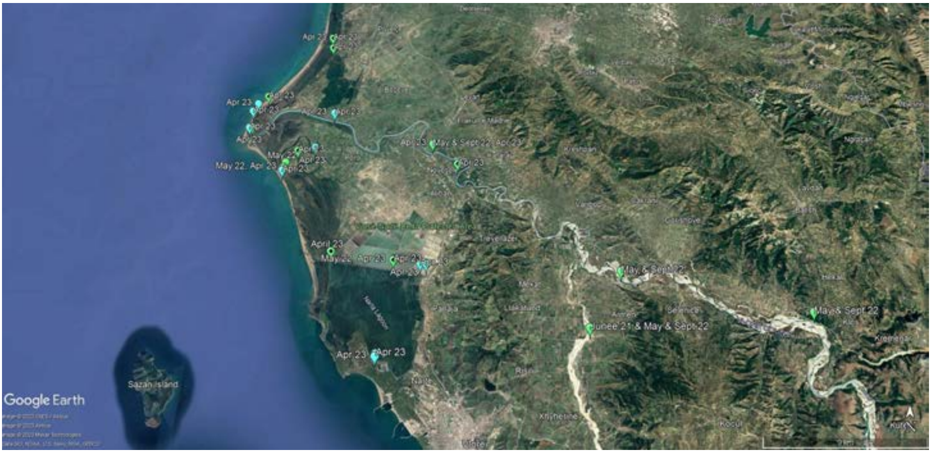

Figure 1.
Satellite map of Vjosa Delta where the sampling (periphyton or fitoplankton) places are indicated, collected in May and September, 2022, and April 2023. Blue labels show the places where physicochemical parameters are measured.

After Peja *et al*. (1996) the mean monthly depth is 28 cm, but this is strongly influenced by the alternate northerly and southerly winds and varies from 12 cm to 41 cm. In summer more than a third of the lagoon dries out. The salinity varies according to evaporation and rainfall, and can rise to 78.9‰ in summer. The catchment area of the lagoon covers some 7,300 ha.

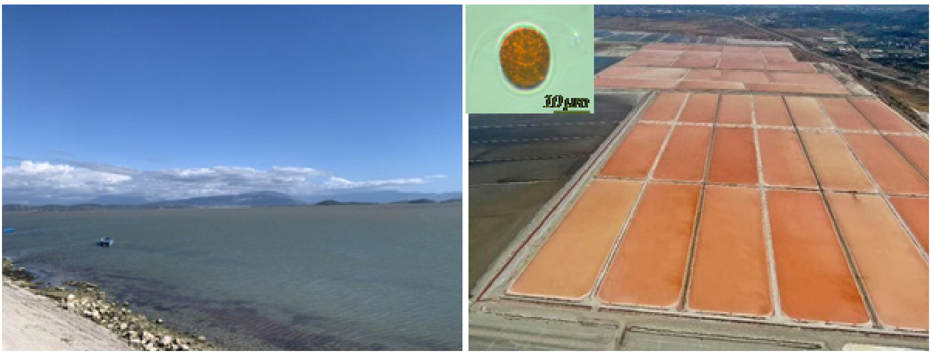

Figure 2.
Left, view of the Narta Lagoon from the Dam. **Right**, view of Saline in summer (Saracini, 2022). The reddish color is caused by the bloom of the unicellular green alga *Dunaliella salina*, a halophilic species often found in hypersaline waters (salt lakes or evaporation ponds); *top left*, microscopic photo of a cell from Saline, July 2023 (500x).

A **Dam** of ca. 8 km separates the Narta Lagoon from the **Skrofotina Saline** basins (Fig 2, right), covering ca. 1.5 ha. Saline represents a special habitat with many shallow ponds and many ridges and small islands in their interior that make them interesting for nesting waterfowl (MIE, 2019a).

Parallel to the Dam, an artificial drainage channel collects the waters to the **Akerni Hydrostation** (Fig. 4), in the northwestern part of the lagoon complex. The station has a pumping capacity of 11,000 L/s and it drains an area of 6,500 ha in the eastern part of the complex. The main part of the water is discharged into the sea through an artificial channel, and a small part is sent to Narta Lagoon in its eastern part. **The Gorrica Hydrostation** is also situated to the east of the Lagoon; it has a capacity of about 16,000 L/s, and is the only fresh water supplier, draining an area of 1,000 ha (MIE, 2019b). The **Vlora Hydrostation**, to the south of the lagoon complex, has a capacity of about 16,000 L/s; it drains ca 1,000 ha, and discharges the waters into the sea (Dea Studio, 2016). The Fieri Delta part is drained by the Hoxhara-Darzeza **Hydrostation** (cnown also as Fieri-Vlora Pumping station), which drain an area of more than 31,000 ha, discharging the waters into the sea.

A dense irrigation network run through the Delta area, based mainly on the Vjosa River, and also on some small reservoirs. The Vjose-Levani-Fieri Channal cross the Small Myzeqe plain (the northern part of the Delta), with an irrigation capacity of 15,000 ha. The Vlora Myzeqe fields (southern Delta) were fed by the irrigation system supplied by Vjosa through a water station in Mifoli, with a capacity of 4,000 L/s; it crossed through the Akerni fields (about 1,100 ha) and the fishing reservoirs in Gorrica (Narta). The agricultural lands of the Center are supplied by the Panaja reservoir, with a water capacity of 1.4 million m³, irrigating an area of 300 ha (PDZRK, 2019).

Figure 3.
Left, view of Salty lake, Akerni. **Right**, view of Kallenga Lagoon, Zhuke.

Several other lagoons have been formed along the coastline to the north-west of the Narta-Saline lagoon complex. **Kallenge Lagoon** (Fig. 3, *right*) is the biggest, a shallow water body of 450 ha, formed originally as the mouth of the Vjosa River. It is artificially connected to the sea through a channel that was opened only recently. The lagoon is used for fishing with nets, while recently a weir was built at the mouth of the canal (MIE, 2019a). Such ponds are also found in the northern part of the Poro Delta (in Fieri) (Fig. 1; Fig. 5).

Tabela 1.
Mean values of some physical-chemical parameters measured in Narta lagoon (three stations) and in Saline (one station), in November 2004 (nutrients comprised) and April 2005. t, temperature in °C; C, conductivity in µS/cm²; TDS, total dissolved solid in g/L; S, salinity in ‰; DO, dissolved oxygen in %: O_2, oxygen in mg/L (data after INTERREG IIIB CADSES project) in Miho *et al*. (2013).

Stations	*t, °C*	*C, µS/cm²*	*TDS, g/L*	*S, ‰*	*DO, %*	*O_2, mg/L*	*pH*	*NO_3, µM/L*	*NO_2, µM/L*	*NH_3, µM/L*	*PO_4, µM/L*
November 2004											
Narta	6.73	60,566	39.37	39.98	125.2	11.78	7.96	2.26	0.13	2.88	0.25
Saline	7.5	79,135	51.43	54.17	120.9	10.16	8.04	2.19	0.16	1.8	0.12
April 2005											
Narta	16.6	44,958	29.59	29.18	83.27	6.81	8.59	-	-	-	-
Saline	24	71,800	47.24	49.6	161.8	9.72	9.32	-	-	-	-

Figure 4.
Left, view of the Akerni Hydrostation, and its connecting channal to the sea (**right**).

Fishing is the most important service of the aquatic ecosystem. During yrs. 1975-1990 the annual fish catches in Narta were about 55 kg/ha (or 1,590 kv/year), with a maximum of 70 kg/ha (2,023 kv/year) during 1980-87. About 30% consisted of crab (*Carcinus aestuarii*). According to MIE (2019a), the fishermen number and catches have decreased, up to 50 people, and 46 kg/ha (or 1,340 kv/year in 2003). In Novosela there is also a **frog processing** and trading factory, operating for 30 years; during the last 10 years, the average amount of collected production is nearly 2,700 kv/year (MIE, 2019a). The **salt pan** and the whole existing drainage network were built and are operating since 1958. During 1975-1985, the annual salt production of reached a peak of 140,000 tons (Peja *et al.*, 1996).

Physico-chemical data on aquatic habitats of Delta and human impact

In this extense wetland complex, the **salinity changes throughout the space and during the seasons, just as their size and depth also change**. In temporary swamps above low depressions without running water they dry up every year. Salinity is usually low during winter, caused by heavy rainfall (MIE, 2019a).

Generally mild winters, and abundant rainfall, while summers are hot and dry in Delta. Precipitation falls mainly in the form of rain. The average annual value of solar radiation is 1,540 kwh/m². The average annual temperature varies from 15.4°C to 16.3°C (maximum in July/August with 30°C and minimum in January with 4.8°C). The average rainfall in the area is about 892 mm per year; 80% of precipitation falls during the wet period of the year (October-May) and only 20% during the dry period. The average annual value of evaporation is 1,173 mm (56% during the hot period of the year). This value shows that evaporation is higher than precipitation; it shows clearly that the ecosystem needs water flow and good water exchange (MIE, 2019a).

Figura 5.
Left, marshes in the northern part of the Vjosa River Estuary (Poro). **Right**, view of the Dead River, Darzeze (Fieri).

Let's stress again that the Narta Lagoon is the most important ecosystem of the whole wetland Delta complex. The limited water exchange significantly affects the living world of the Lagoon, its eutrophication and decrease in productivity. This is also promoted by pollution with organic matter or other pollutants of urban, agricultural or industrial origin.

Table 2.
Average values (from 2-6 parallel measurements on site) of the physic-chemical data measured on site during April 24th-28th, 2023, with the multiparametric probe AQUAREAD (courtesy from A. Zhori and colleagues, AMBU).

Station / Parameter	Date	T, °C	pH	*DO, %*	*O_2, mg/L*	EC, uS/cm @25C	TDS, mg/L	*S, ‰*
Vjose (Mifoli)	4/25/2023	15.65	8.6	106.78	10.53	486.4	315.8	0.18
Vjose (Dellinje)	4/25/2023	16.26	8.5	119.28	11.62	352.2	228.4	0.11
Vjose (Estuary, Poro, Fieri)	4/24/2023	17.1	8.16	105.05	10.5	2,000	1,300.5	1.01
Small pond (Poro, Fieri)	4/24/2023	19.4	9.13	114.5	10.22	8,592	5,579	4.78
Big pond (Poro, Fieri)	4/24/2023	18.56	9.65	114.32	10.35	10,991.8	7,144.2	6.22
Dead River (Darzeze, Fieri)	4/28/2023	19.36	8.3	115.13	10.18	17,211.8	11,187	10.11
Dead River (Zhuke, Vlora)	4/25/2023	21	8.56	132.4	11.26	15,243.5	9,908	8.86
Dead River Estuary (Kallenge)	4/25/2023	19.4	8.79	124.47	10.33	36,440.7	23,686	22.99
Temporary pond 1 (Narta Dam, East)	4/26/2023	16.95	8.48	108.25	10.35	2,133.5	1,386	1.08
Temporary pond 2 (Narta Dam, East)	4/26/2023	17.73	8.31	192.07	17.62	11,579.3	7,526	6.58
Narta Lagoon (Dam, middle)	4/26/2023	17.66	8.86	114.63	9.83	38,338.7	24,920	24.33
Drainage Chanel (Dam, middle)	4/26/2023	17	9.14	110.95	10.38	10,492.5	6,819.5	5.91
Pond (Soda Dump, south)	4/27/2023	19.49	8.31	101.77	9.25	2,987	1,941	1.54
Soda Dump (Shën Thanas)	4/27/2023	17.41	9.29	117.47	10.06	42,570.7	27,671	27.35

Due to the limited depth, the thermal water regime of the Narta Lagoon is similar to the air temperature. The sea water entering the lagoon has a great influence on the thermal regime, especially near the tide channels. The average annual temperature of the Lagoon waters is 14.9°C.

The lagoon's water exchange with the sea tends to slow down (especially in summer); there are many factors acting together here: excessive evaporation; the sea waves action; heavy sediments from the Vjosa River; scarce water inflows from the basin; the use of Lagoon water to feed the Saline pans; etc.

The Skrofotina Saltworks, built up since the 1960s, pumped 5.8 million m^3 of seawater every year for the production of up to 120,000 t of salt per year, mainly used for industrial purposes (Peja *et al*., 1996). The salt flat today receives salt water from the Lagoon, causing additional stress on it. All of them tend to block the connecting channels to the sea and prevent water exchange. About 1000 ha of the Lagoon dries up during the summer; while the depth for the rest of about 800 ha drops down to 10 cm (MIE, 2019a). From the Lagoon, about 12.9 x 106 m^3 is discharged into the sea per year and the average water exchange is 1.83 m^3/s (MIE, 2019b), which is relatively low.

Peja *et al*. (1996) provide data on the main morphometric, physical and chemical features of Albanian lagoons and their fish production, including the Narta lagoon. General features of the complex are also summarized by Gjiknuri (1995), and Miho *et al*. (2013), or Çomo *et al*. (2018. Pano *et al*. (2005) report that the hydrochemical characteristics of the Narta Lagoon during July 2001 varied widely in space and time: O2 from 3.45 mg/L to 8.19 mg/L and salinity from 44.60 to 62.73 ‰. Table 1 provides data on the average values of some physico-chemical parameters measured in the Narta lagoon (three stations) and in Saline (one station), in November 2004 and April 2005 (Xhulaj, 2008). Moreover, in table 2, the latest data are given, measured during the Scientific Week (April 24-28, 2023). The measurement points are shown on the map in figure 1 in blue.

Data related to nutrients content (N & P) in Delta waters are scarce and not easy to identify the relevant analytical data. Xhulaj (2008) gives data on phosphates, nitrates, nitrites and ammonia measured at 3 stations in the Narta lagoon and 1 in the salt pan (Tab. 1). Kane *et al*. (2015) provide data on the state of the Narta and Orikum lagoons conducted in February 2013. Worth to mention here the phosphorus (PO_4-P) value, 45 µg/L (1.45 µmol/L PO_4), measured in the northeast of the lagoon. Heavy metals were not of concern; the **waters were slight-moderately contaminated with Hg and slightly with Zn.** Beqaj (2023) also provides data on nutrients in the Narta Lagoon, measured in December 2018, May and October 2019, but without concern data.

Although sporadic, from these data it seems that the nutrient values of the Narta Lagoon waters are generally low. However, in Kane *et al*. (2015) its is observed that **phosphorus values tend to exceed 1.1 µmol/L PO_4 for 'bad' water quality**, based on EEA criteria for nutrient levels in transitional, coastal and marine waters (Crouzet *et al*., 1999). Phosphorus is a nutrient element for livings; but in high content it is harmful as it promotes the algal blooms and the eutrophic state of wsters. Consequently, the increasing of phosphates to natural waters is today one of the most serious environmental concerns.

Bakaj *et al*. (2022) report data on faecal coliforms (MPN/100 ml) for seven peripheral stations (S1-S7) of the Narta Lagoon, for the period December 2017-November 2018. From the graphs in their figures 3 & 4 it can be seen that **urban pollution is not negligible. The most polluted period was March, August, September and November 2018; FC were more than 1000 CFU/100 ml**: in S3 & S4 in March 2018; in S3 – S7 in July and August 2018; and in S4 in November 2018. Stations near Narte village (S4) and Gorrica Hydrostation (S5) were the most polluted, up to 2,400 MPN/100 ml in S4 in March, July and August, and in S5 in August. According to the EU Standard for *E. coli* for coastal and transitional waters (ETC/ICM, 2021), the overall water quality can be considered 'good', but with a clear trend towards 'sufficient' quality in the lagoon habitats near the Narte village and Gorrica hydrostation. But according to the limit values given by Kavka *et al*. (2001) in their table 2, the above values of FC measured in Narta belong to quality class III, or to critical pollution.

Delta area covers transitional and marine coastal ecosystems

The area of the Vjosa Delta with over 350 km², or about 30% of all Albanian transitional ecosystems, is one of the most important and naturally preserved on the whole Adriatic Coast. Let's mention here that the deltas of Buna, Drini, Lezha, Mati and Semani are heavily transformed today in their natural aspects by human impact, either in their river watersheds or in the corresponding coastal area.

Worth noting that such transitional ecosystems (estuaries, lagoons, coastal lakes) host rich and protected habitats for biodiversity, preserving within a very limited space numerous species of freshwater, but also marine and brackish waters. It is for their productivity is among the highest on the Planet, ranking after the tropical rain forest; net plant productivity in wetlands is up to 2200 g/m²/year (220 kv/ha/year) (Salisbury & Ross, 1991); in addition to the abundant assimilation of carbon dioxide and the abundant release of oxygen, they also help in the circulation of other nutrients (especially in the reduction of nitrogen); therefore, these ecosystems help significantly in mitigating the climate and global warming. For these and many other services we invite the reader to see USGS (2023) or with Newton *et al*. (2023), etc.

Therefore, their knowledge, and proper use, conservation and protection is prioritized by national legislation and international conventions, including the Water Framework Directive (WFD, 2000), the Ramsar Convention, the Bern Convention, the Barcelona Convention, IUCN, WWF, etc.

Due to its natural and biodiversity values, good part of of the Delta of Vjosa has been protected for years, either from Vlora and Fieri. Last year, the whole **natural/wetland ecosystem of the Vjosa Delta, Pishe Poro - Narte (16,124.61 ha), was re-declared Protected Landscape (Category V)** (VKM 694/2022). The protection status is not really what this area deserves, known also as part of the EMERALD and IBA network (AKZM/NAPA 2022b). According to AKZM/NAPA (2022), the area shelter up to 18 habitats, listed in Natura 2000; 6 habitats are prioritary, meaning that they require special conservation measures. Plant and animal life flourish in these habitats, with many rare and threatened species.

According to VKM/DCM 694/2022, within the protected area there are: 119.6 ha of water surface, 2,540.1 ha of swamps and 3,471.8 ha of marine water area (perhaps lagoon area is understood here!); hence, **6,131.5 ha in total, or 38% of the whole protected area, are aquatic habitats**, with salt, brackish or fresh water. Worth noting that these are priority habitats (code 1150) in the EU Habitats Directive (EEA, 2019). The Narta Lagoon is among the largest and most important ecosystem, not only on the Albanian coast, but in the whole Adriatic. This Lagoon is the second most important in the country for waterfowl, and an important IBA area.

The **algae**, the further topic of this review, grow precisely in these habitats.

Algae from Delta of Vjosa: floristic and ecological view

Algae rapresent aquatic eukaryotic organisms, belonging to various taxonomic groups (Charophyta, Chlorophyta, Rhodophyta, Bacillariophyta, etc.). They carry out photosynthesis, absorbing CO_2 and producing organic matter, as well as enriching the water with O2; with prokaryotic Cyanobacteria and some higher submersed plants, they are the main primary producers and the basis of most aquatic food webs; in addition cyanobacteria are able to fix nitrogen from the atmosphere. Algae help to ‘purify’ the water by absorbing nutrients, heavy metals and other pollutants transported by streams and rivers. Furthermore, algae can be good indicators of environmental quality (bioquality). (https://www.doc.govt.nz/).

By a careful check at the studies on algal flora of the Vjosa Delta area, about 580 species have been found in total, mostly in Vlora part. The species number of according to main groups and to habitats is reported in table 3; the checklist of all species is given in Appendix 1 at the end, with the related habitats and the corresponding authors. Scientific names are updated according to Aglaebase (Guiry & Guiry, 2022). 158 microscopic photos representing 96 species are given in PLATES I-XII (ANNEX II), where 2 species belong to dinoflagellates, 1 chlorophyte, 5 centric diatoms, and others pennatae diatoms.

The most abundant species are siliceous algae (diatoms; Bacillariophyceae) with 420 species, followed by green algae (Chlorophyta) with 49 species, charophyta (Charophyta) with 36 species, dinoflagellates (Dinophyceae) with 31 species and cyanobacteria (Cyanophyceae) with 14 species. Other groups are with scarce species or little known to date. **The Narta lagoon is among the richest ecosystems, with 349 species (96 species in phytoplankton);** followed by Mifoli ponds with 117 species, Saline with 112 species and Vjosa River (Mifoli) with 86 species.

Data about authors, related species number, respective habitats and period are reported in table 4. The botanist and limnologist from Sarajevo, Georg Protic is the first researcher, whose findings cover most of the principal algal classes. Protic (1907) observed 11 mud and water samples collected by the the Austrian historian and archaeologist Karl Patsch, in April and May of 1900 in the area of Mifoli, Novosela, Saline, Vlora, Dukati, and in the two corresponding lakes, Narta (in the paper it is written Arta!) and that of Dukati (Orikumi). Not much explanation is given on the specific station, the collection or preservation methods.

Protic (1907) reports in his paper a checklist of 196 species. More than 180 species seem to belong to the habitats of the Vjosa Delta; siliceous algae (diatoms) prevail with 108 species, sharophytes and green algae with 30 species each, cyanobacteria with 13 species, etc. Some subspecies today have the species state. The mentioned abundant species are marked in red in the Annex I.

Many species, especially diatoms, were mentioned by other authors recently, while other species were not observed. Of course, after a period of over 120 years the area is heavily transformed, starting from large-scale reclamation in the 1960s, to the slightly chaotic urbanization of today. The lack of chlorophyte *Ulva* species found today in abundance both in the Narta lagoon and in the drainage canals, is easy evidence. They together with *Cladophora* species, known as nitrophilous species (Tsiamis *et al*., 2013), also abundant in the lagoon are evidence of the relatively high nutrient load (N & P) from the watershed, as discussed above, based also on the few data from Kane *et al*. (2015).

Xhulaj (2008) in his PhD work on the phytoplankton of some Albanian lagoons reports about 290 species of microscopic algae from the Narta lagoon. 96 species were found in phytoplankton: 25 wer centric diatoms, 44 pennatae diatoms and 31 dinoflagellates. Species from other groups in the phytoplankton were relatively abundant, but given often at the genus level (eg Oscillatoria) or as indeterminates (eg cryptophytes).

Based on biological indicators in paralic ecosystems (Guelorget & Perthuisot, 1984), Xhulaj (2008) confirm that that Narta lagoon belongs mainly to zone V, considering the high growth of phytoplankton, almost in all stations and both seasons; such exosystems can be exploited mainly extensively, for the growth of fish and shrimp (Dutrieux & Guelorget, 1988). In Xhulaj's PhD (2008), about 230 species of diatoms (27 circular types and the rest feathered) are additionally reported from periphyton samples of the Narta lagoon. The majority, about 86 species, belong to marine and brackish water environments, mainly coastal. Some data are also reported by Xhulaj & Miho (2008).

Other data, mainly for siliceous algae (diatoms) in sporadic samples, were also provided by Dedej (2006) and finally by us (Miho,-) for different habitats of the Delta. Kupe (2006) and some diploma theses provide also data on diatoms in periphyton samples from the Vjosa River to the Mifoli Bridge and someone in Vjosa Mouth. Most of the data are also mentioned by Miho & Witkowski (2005), Kupe & Miho (2007), Miho *et al*. (2013) or Miho *et al*. (2018).

The ecological quality is calculated for Vjosa River, based on several diatom indices (SI, TIDIA, IPS). Hence, the water quality was I-II, oligomesotrophic, of the class quality 'Good', for samples of May 2004, October 2006, April 2012, and March 2015 (Miho *et al*., 2018).

More than 9 species of algae present in phytoplankton or periphyton are known to be toxic, according to Hallegraeff *et al*. (2004). Let's mention here the diatoms *Conticribra weissflogii* and *Skeletonema costatum* (both centric), and Halamphora coffeiformis and *Pseudo-nitzschia seriata (pennate). H. coffeiformis* was also found relatively abundant by us in some habitats of Delta, and is also mentioned as abundant by Protic (1907).

From dinoflagellates we mention *Dinophysis fortii, Prorocentrum cordatum, P. lima and Scrippsiella acuminata. P. cordatum*, known to be very toxic, has been found abundant in the phytoplankton of the lagoon. As for the cyanobacteria, species of the genus *Oscillatoria* known as toxic, are often present, or even blooming in the phytoplankton of the Narta lagoon or the Hidrostation drainage Channel of Akerni.

In summer, the salt pans take on a pink color, caused by the bloom of the *Dunaliella salina*, a halophilic, unicellular, green alga, found often in hypersaline waters (salt lakes or evaporation ponds) (Fig. 2, *right*). It is a meaningful example of how life flourishes even in these extreme habitats of the Delta.

Table 3.
The distribution of species according to the main groups of non vascular plants s.l., and according to the main habitats.

Main groups – Class (Phylum)	Species	Main groups – Class (Phylum)	Species
Charophyta		**Dinophyceae (Miozoa)**	31
– Charophyceae	6	**Euglenophyceae**	1
– Zygnematophyceae	30	**Florideophyceae**	2
Chlorophyta		**Ochrophyta**	
– Chlorophyceae	27	– Xanthophyceae	5
– Trebouxiophyceae	1	– Dictyochophyceae	1
– Prasinophyceae	1	**Phaeophyceae**	2
– Pyramimonadophyceae	1	**Coccolithophyceae**	1
– Ulvophyceae	8	**Cyanophyceae**	14
Bacillariophyta		**Bryopsida**	27
– Bacillariophyceae - centric	40	**Marchantiopsida**	1
– Bacillariophyceae - pennate	383	**Fungi (Lichens)**	70
Habitats	**Species**	**Habitats**	**Species**
Narte (Lagoon)	363	Kallenge (Lagoon & Swamp)	52
Vjose (Mifol)	86	Dead River (Zhuke)	29
Vjose (Mouth)	32	Bishan (Pond)	22
Narte (Phytoplankton)	96	Vlore (Pond)	48
Saline (Pond)	112	Darzeze (Pond)	3
Mifol (Pond)	117	Pishe Poro (Forest)	11
Novosele (Pond)	63	Sode (Forest)	13
		Zvernec (Forest)	27

Table 4.
Data on authors, species number, related habitats and period.

Authors	Species	Habitats	Period
Protic, 1907	181	Narte (Lagoon), Saline, Mifol, Novosele, Vlore	April & May 1900
Miho & Witkowski, 2004	74	Narte (Lagoon)	March 1993; June 1994; November 1995
Dedej, 2006	57	Narte (Lagoon))	June 1994; November 1995
Kupe, 2006	28	Vjose (Mifol)	May 2004
Jaupaj, 2007	8	Vjose (Mifol)	September 2006
Xhulaj, 2008	290	Narte (Lagoon)	November 2004; April 2005; November 2005; April 2006; November 2006; April 2007
Meço, 2013	24	Vjose (Mifol)	April 2012
Ngjela, 2016	50	Vjose (Mifol)	March 2015
Nderjaku, 2019	70	Vjose (Mouth & Mifol)	October 2016 (Mouth); October 2016 (Mifol); April 2017 (Mifol)
Kashta *et al.*,-	8	Lagoon (Nartë); Saline; Vjosa (Mouth); Kallenge; Salty Lake; Limopuo (Lagoon)	April, May 2013; April 2015 & 2016; August 2019; May 2020
Kashta,-	8	Dead River (Zhuke); Saline (Narte); Lagoon (Narte); Poro (Fier); Darzeze	April 2023
Miho,-	159	Narte (Lagoon); Saline (Pond & Channel); Kallenge (Lagoon & Sawamp); Bishan (Pond)	April, 2012, May 2022, April & Septembre 2023

The Narta lagoon suffers from eutrophication, due to the scarce water exchange with the sea, the water intake from the salt flats, the scarce fresh water flows, the discharge of sewage, industrial organic pollutants, etc. (PDZRK, 2019; Peja *et al*., 1996). Together, these can be the reason for the heavy growth of filamentous cyanobacteria of the genus *Oscillatoria*, as well as of dinoflagellates (*Prorocentrum* and *Dinophysis*), some of them very toxic. The cyanobacteria bloom was noticed in November 2004, near the discharge of sewage from the Narte village (Xhulaj, 2008). Recently (September 2023), zoological colleagues noticed an algal bloom in Narta, represented by the high presence of *Prorocentrum lima*, and *Oscillatoria* sp. (Fig. 6), both potentially toxic species. This is evidence of the stressing state that the lagoon suffer during this period.

Data on macrophyte algae are reported by Kashta & Miho, (2016), Miho *et al*. (2013), Kashta *et al*.,-, and by Kashta,-. Peja *et al*. (1996) evidenced that beds of *Zostera noltii* were abundant, and associations of halophytes such as *Salsola sodae* growed around the lagoon's margins.

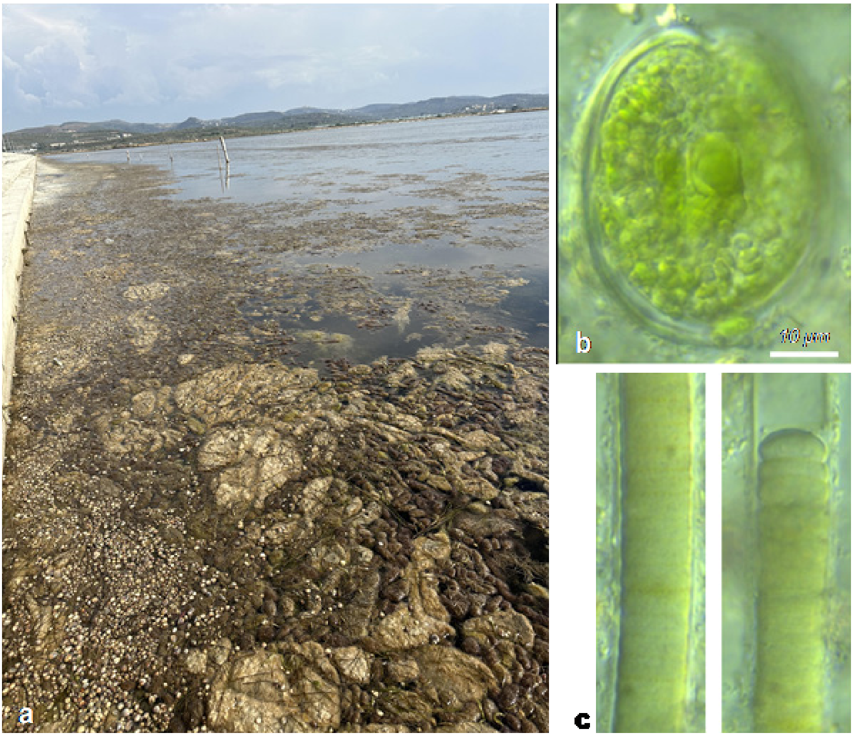

Figure 6.
View of the foaming waters of the Narta lagoon in the Dam part on September 29, 2023 (photo by S. Ruci); two potentially toxic species *Prorocentrum lima* (b) and *Oscillatoria* sp. (c), abundant in this bloom.

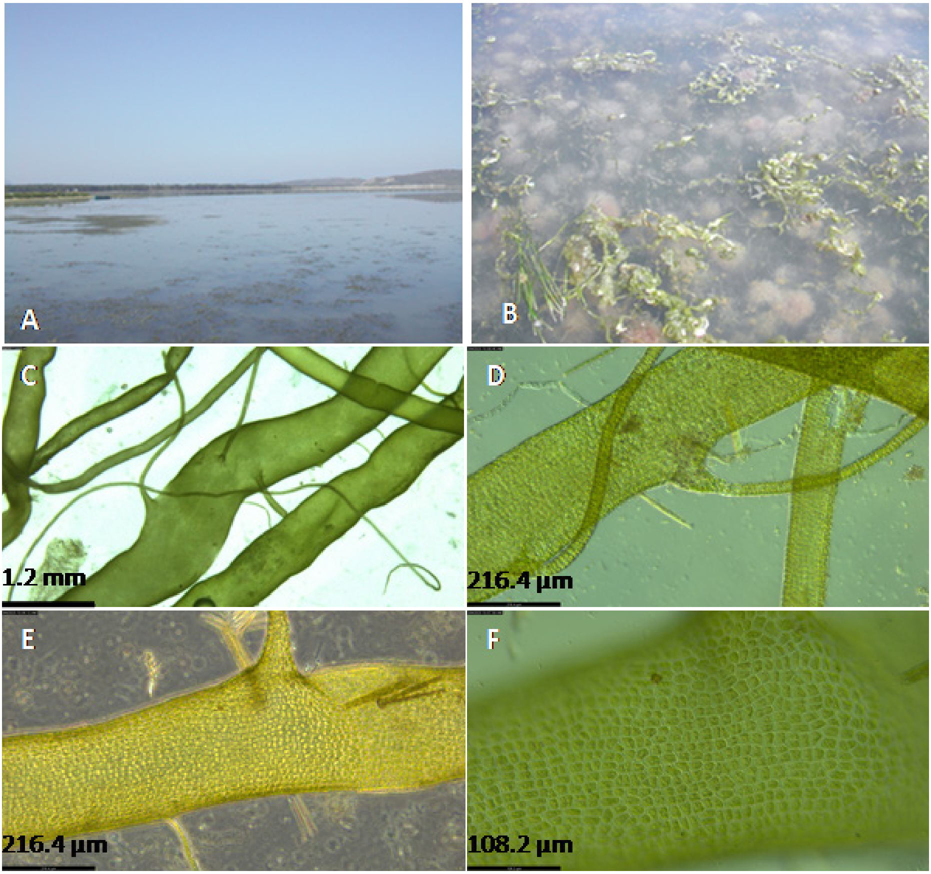

Figure 7.
A, evident high trophy level of Narta lagoon, especially close to Narta village; **B**, intense growth of submersed macrophytes of *Ulva* (*Ulva* (*Enteromorpha*) intestinalis), etc. can be easily observed. **C-F**, Views of *Ulva* (*Enteromorpha*) *clathrata* from Drainnage Channel, Saline, April 2023.

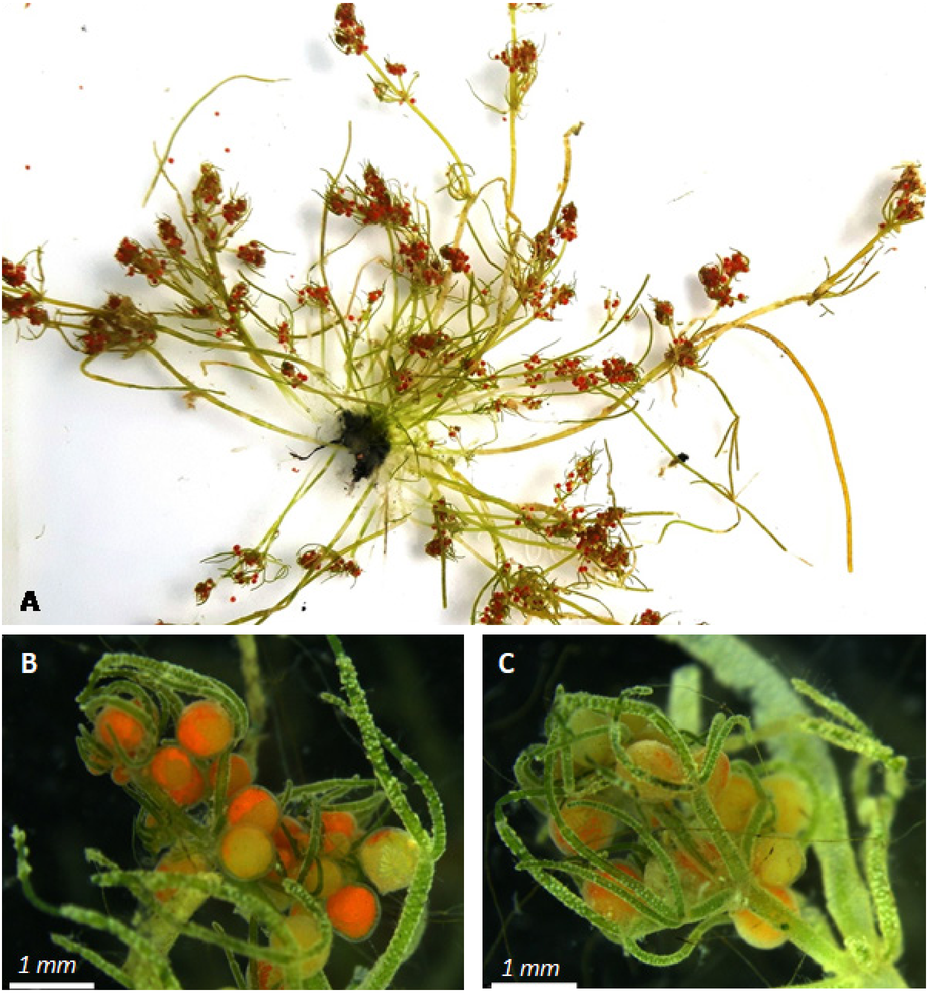

Figure 8.
Views of *Tolypella hispanica* from a temporary pond with brackish water (1-6.5‰; Tab. 2) between Narta lagoon and Saline, April 2018 (**A**) and April 2023 (**B** & **C**).

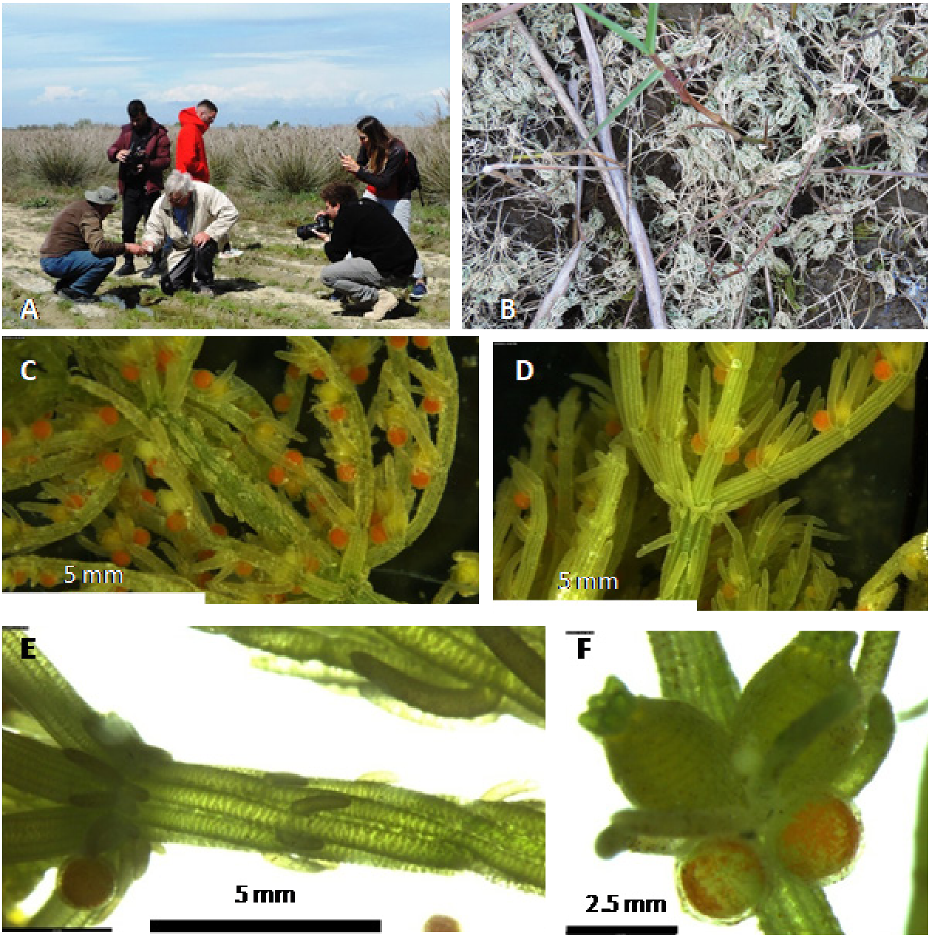

Figure 9.
A, Temporary ponds with *Chara vulgaris*, Zhuke. **B**, Dried pond with *C. vulgaris*, in Darzeze, April 2023. **C-F**, Views of *C. vulgaris* from temporary ponds, Poro and Darzeze.

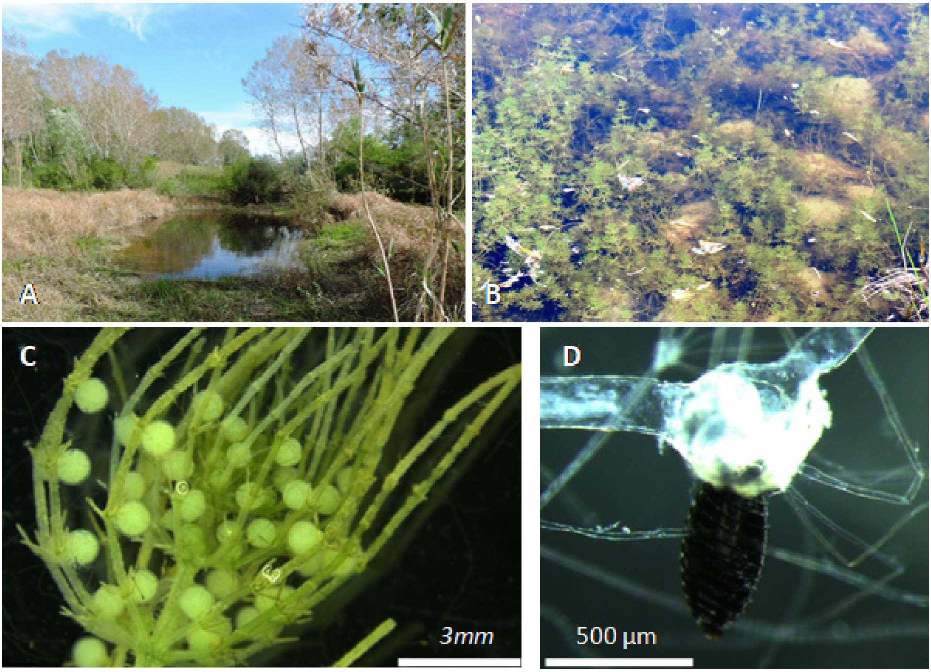

Figure 10.
A & B, Temporary pond with *Chara aspera* (**C & D**), Zhuke, April 2023.

Figure 11.
Chara galioides in a temporary pond between Narta Lagoon and Saline, April 2013.

Figure 12.
A, Swamps near Kallenga with *Lamprothamnium papulosum* (**B**), May 2022.

The soft bottoms of the Narta lagoon and other smaller lagoons on both sides of the Delta are covered by submerged meadows of *Ruppia cirrhosa* and *Zostera noltii. R. cirrhosa* grows best in shallow, sheltered areas, which often have a higher freshwater content. *Cymodocea* nodosa is rarely found near channels of water exchange with the sea. *Chaetomorpha linum*, a filamentous green alga, grows in dense populations at depths of 0.3 to 1 m. Other macrophyte algae belong to the genera *Ulva* (Fig. 7) and *Cladophora, Chara* (Fig. 8-11), *Lamprothamnium* (Fig. 13), *Polysiphonia* (Fig. 13), etc. They grow abundantly during spring and summer.

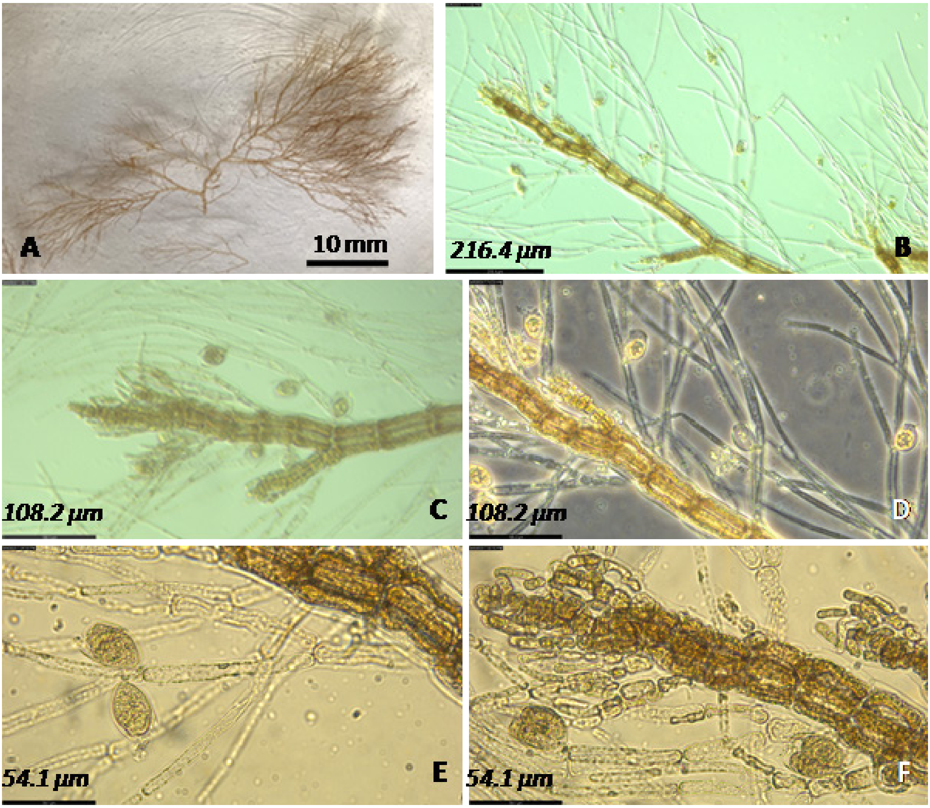

Figure 13.
Views of *Polysiphonia* sp. from Narta Lagoon, April 2023.

Briefly on other groups (mosses and higher fungi, including lichens)

Data about some not well-known groups among plants *sensu lato* (s.l.) will be reported here, such as **mosses** and **lichens** (almost unknown for Albania), as well as data on cap **mushrooms**. Regardless of our level of knowledge, these living groups always remain important for the normal functioning of ecosystems and biodiversity and man.

Mosses: Are an important plant group, not only as an integral part of the biodiversity of natural ecosystems, but also for their practical interest. Mosses grow in habitats where other plants cannot grow, fixing CO_2 and releasing O_2, often in extreme conditions (Cenci, 2008). Some mosses are used today in landscape architecture (e.g. Moss Lovers, 2021), as well as the assessment of the environmental bioquality, air quality (Carballeira *et al*., 2002; etc.), or even water quality (Saxena & Harinder, 2004).

Marka (2014) provides data on the distribution of about 417 taxa of mosses for the whole of Albania; **28 taxa of the phylum Bryophyta were reported for some of the habitats of the Delta (Vlora part)** (Annex I), collected in year 2007 (Zverneci and Poro) and 2010 (Narta and Zvrneci). Three of them are rare for Southeast Europe, such as: *Sematophyllum substrumulosum* (rare for SE Europe), *Syntrichia laevipila* (VU for Bulgaria; CR for Romania) and Tortella humilis (CR for Bulgaria; NT for Romania).

Recently, Kashta *et al*. (2023), provide data on Riella *macrocarpa* found in a temporary pond and an abandoned saltwork pond close to Narta Lagoon (Fig. 14). This is an aquatic hepatic of the phylum Marchantiophyta very rare for the Eastern Mediterranean region.

Lichens are composite organisms, where algae or cyanobacteria grow among filaments of multiple fungi species in a mutualistic relationship. Morphologically, some lichens have a leafy appearance (*foliose*), others cover the substrate like scales (*crustose*), others take a branched (*fruticose*) shape (Fig. 15), and others have a jelly appearance.

Lichens uptake water and minerals mainly from the atmosphere, through rain and dust. In some cases, minerals are taken by the fungus from the substrate where they grow (stones, wood, soil, etc.). The alga reduces atmospheric carbon dioxide to sugars and thereby feeds itself and its companion fungus. In cases where cyanobacterial algae also participate in the association, they also help the lichen to reduce atmospheric nitrogen.

Many lichens are sensitive to environmental disturbances. Therefore, they are useful for assessing air pollution, ozone depletion and heavy metal pollution. Lichens can be used for the production of dyes, perfumes and in folk medicine. Lichens constitute an almost unknown group for Albania. In the Delta they are abundant in the trunks of the pine forests of Soda and Zverneci (Fig. 15) and elsewhere, but their diversity remains almost unknown-

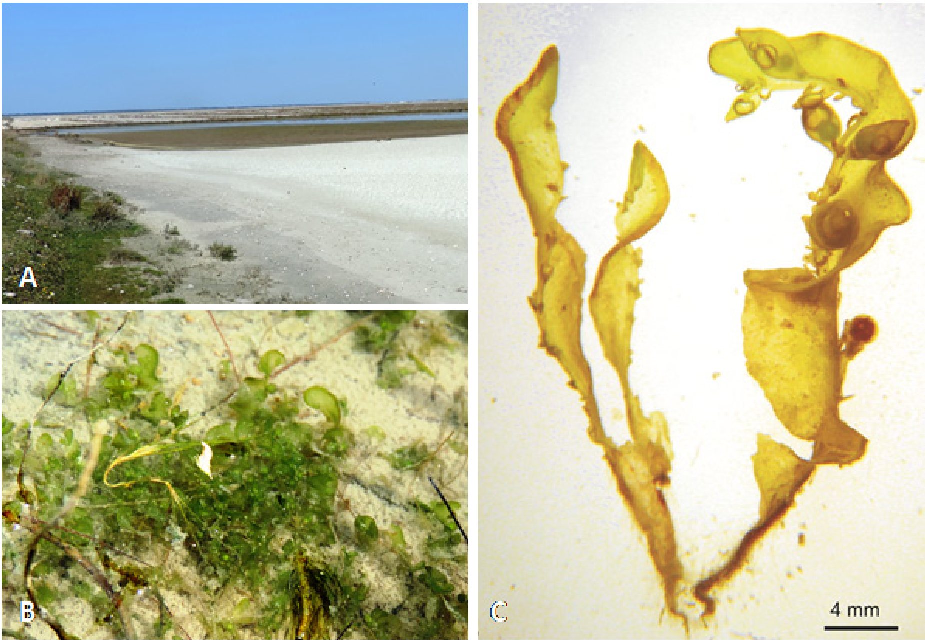

Figure 14.
A, View of the abandoned saltworks pond close to Narta Lagoon where Riella macrocarpa was found dense few centimeter underwater (B); **C**, general view of both male (**left**) and female (**right**) plant. (Kashta *et al*., 2023).

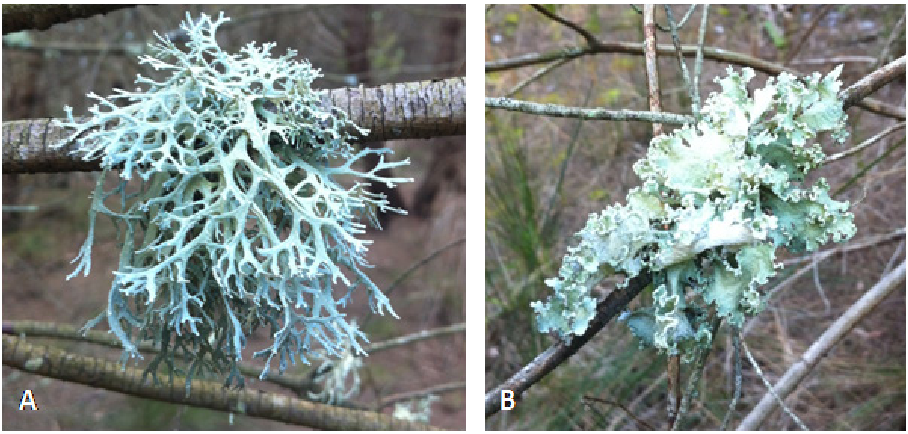

Figure 15.
Fruticose (*Ramalina cf. farinacea*) (**A**) and foliose (*Parmotrema cf. hypotropum*) lichens (**B**) in Soda Forest (April 2012; Vlora) (Fotot nga / Photos from O. Nika, in Miho *et al*., 2013).

Figure 16.
Mushrooms from the Vjosa Delta, collected in the forest of Pishe Poro, Fieri, in October 2020: A-C, *Cantharellus* sp.; D-E, *Suillus* sp. (Photos from M. Meco)

Fungi: Fungi are eukaryotic organisms with cell walls, mostly chitinized. They feed heterotrophically, feeding on living tissue (parasites) or dead organic matter (saprotrophs). Fungi usually have multicellular filamentous structure (hyphae). This kingdom includes the familiar **mushrooms** (Basidiomycota & Ascomycota), **molds** and **yeasts**.

Even these biodiversity groups are scarcely studied in Albania, despite their importance for ecosystems and man. Even for the Vjosa Delta, the data are scarce, and further research is needed. Xhulaj (1992) report data on the distribution of about 590 species of higher fungi (Macromycetes). About 17 species were reported for several Vlora Delta habitats found during several visits in the years 1980-1990 in Soda-Zverneci, and in Pishe Poro forests (Vlora) (Annex I). Most of them belong to the division Basidiomycota (16 species) and the rest to the division Ascomycota, of the subkingdom of higher fungi (with hat) (Fig. 16).

It is worth noting that *Inocybe geophylla* is known as a poisonous species. **In the Management Plan for Vjosa - Narta Landscape Protected Area is reported that some 68 higher mushrooms are recorded (MoE, 2009)**, but we were not able to find the related species list. Perhaps here are also included 3 endangered species (En) according to IUCN that are mentioned by Miho *et al*. (2013) for the Vjosa-Narta area: *Cantharellus cibarius*, *Clathrus ruber* and *Agaricus aridicola* (=*Gyrophragmium dunalii*).

Concluding remarks

From the 1900s when the algae data were first given by Protic (1907) that the situation has changed, compared to the former natural state. It is due to the reclamation, urbanization and all other activities in the basin. But the whole area still seems to be distinguished by its diversity of species and habitats, even though the area of the Fieri Delta still remains almost unknown The construction of the airport within the area, further urbanization, undoubtfully will cause the decrease of natural values, of the integrity of habitats, their fragmentation and biodiversity loss.

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ANNEX I: Species checklist of non-vascular plants s.l. (algae, mosses & tall fungi together with lichens) found in years by various authors and by us (Miho,-) in different habitats of the Vjosa Delta.

Class, Species name (Synonyms)	Habitats	Author/s
Bryopsida (Bryophyta)		
Barbula convoluta Hedwig	Narte	Marka, 2014
Barbula sardoa (Schimper) Frahm (=*Barbula convoluta* var. *sardoa* Schimper)	Poro	Marka, 2014
Barbula unguiculata Hedwig	Narte	Marka, 2014
Brachythecium rutabulum (Hedwig) Schimper	Zvernec	Marka, 2014
Bryum capillare Hedwig	Poro	Marka, 2014
Didymodon acutus (Bridel) K. Saito	Narte, Poro, Zvernec	Marka, 2014
Hypnum cupressiforme Hedwigh	Poro	Marka, 2014
Kindbergia praelonga (Hedwig) Ochyra	Zvernec	Marka, 2014
Leptodon smithii (Hedwig) F.Weber & D.Mohr	Zvernec	Marka, 2014
Orthotrichum diaphanum Schrader ex Bridel	Zvernec	Marka, 2014
Orthotrichum tenellum Bruch ex Brid.	Zvernec	Marka, 2014
Pleurochaete squarrosa (Bridel) Lindberg	Narte, Poro, Zvernec	Marka, 2014
Pseudoscleropodium purum (Hedwig) M.Fleisch	Zvernec	Marka, 2014
Rhynchostegiella litorea (De Notaris) Limpricht	Poro	Marka, 2014
Rhynchostegium confertum (Dicks.) Schimper	Zvernec	Marka, 2014
Rhynchostegium megapolitanum (Blandow ex F.Weber & D.Mohr) Schimper	Poro, Narte	Marka, 2014
Scleropodium touretii (Bridel) L.F. Koch	Poro, Narte, Zvernec	Marka, 2014
Scorpiurium circinatum (Bruch) M.Fleisch. & Loeske	Zvernec	Marka, 2014
Sematophyllum substrumulosum (Hampe) E.Britton	Zvernec	Marka, 2014
Syntrichia laevipila Bridel	Zvernec	Marka, 2014
Syntrichia virescens (De Notaris) Ochyra	Zvernec	Marka, 2014
Tortella flavovirens (Bruch) Brotherus	Narte	Marka, 2014
Tortella humilis (Hedwig) Jennings	Poro	Marka, 2014
Tortella inclinata (R. Hedwig) Limpricht	Poro	Marka, 2014

Class, Species name (Synonyms)	Habitats	Author/s
Tortella tortuosa (Hedwig) Limpricht	Narte	Marka, 2014
Trichostomum crispulum Bruch	Zvernec	Marka, 2014
Zygodon rupestris Schimper ex Lorentz	Zvernec	Marka, 2014
Marchantiopsida (Marchantiophyta)		
Riella macrocarpa (P. Allorge) Puche, Segarra-Moragues, Sabovlj., M. Infante et Heras	Kripore (Pellg)	Kashta *et al.* (2023)
Ascomycota (Fungi)		
Helvella leucomelaena (Pers.) Nannf. (=*Paxina leucomelas* (Pers.) Kuntze)	Sode	Xhulaj M. (1992)
Ramalina farinacea (L.) Ach. (cf.) (Lichen)	Sode-Zvernec	Miho, -
Parmotrema hypotropum (Nyl.) Hale. (cf.) (Lichen)	Sode-Zvernec	Miho, -
Basidiomycota (Fungi)		
Agaricus aridicola Geml, Geiser & Royse ex Mateos, J.Morales, J.A.Muñoz, Rey & C.Tovar (=*Gyrophragmium dunalii* (Fr.) Zeller)	Vjose-Narte	Miho *et al.*, 2013
Amanita vaginata (Bull.) Lam.	Vlore	Xhulaj M. (1992)
Cantharellus cibarius Fr.	Vjose-Narte	Miho *et al.*, 2013
Clathrus ruber P.Micheli ex Pers.	Vjose-Narte	Miho *et al.*, 2013
Clitocybe nuda (Bull.) H.E.Bigelow & A.H.Sm. (=*Rhodopaxillus nudus* (Bull.) Maire)	Sode	Xhulaj M. (1992)
Cyathus olla (Batsch) Pers.	Vlore	Xhulaj M. (1992)
Inocybe geophylla (Sowerby) P. Kumm.	Zvernec	Xhulaj M. (1992)
Lactarius deliciosus (L. ex Fr.) S.F.Gray	Sode-Zvernec	Xhulaj M. (1992)
Lactarius sanguifluus (Paulet) Fr.	Sode-Zvernec	Xhulaj M. (1992)
Marasmius oreades (Bolton) Fr	Vlore	Xhulaj M. (1992)
Russula adusta (Pers.) Fr.	Sode-Zvernec	Xhulaj M. (1992)
Russula sororia Fr.	Sode	Xhulaj M. (1992)
Stropharia rugosoannulata Farlow ex Murrill	Zvernec	Xhulaj M. (1992)
Suillus granulatus(L.) Roussel	Vlore	Xhulaj M. (1992)
Suillus luteus (L.) Roussel	Sode	Xhulaj M. (1992)
Tricholoma portentosum (Fr.) Quél.	Sode, Zverneci	Xhulaj M. (1992)
Tricholoma saponaceum (Fr.) P.Kumm.	Sode, Zverneci	Xhulaj M. (1992)
Tylopilus felleus (Bull.) P.Karst.	Sode	Xhulaj M. (1992)
Charophyceae		

Class, Species name (Synonyms)	Habitats	Author/s
Chara aspera Willdenow	Zhuke (Pond)	Kashta & Miho, 2016; Kashta,-
Chara canescens Loiseleur	Limopuo (Lagoon)	Kashta *et al.*, -
Chara galioides De Candolle	Saline (Pond)	Kashta *et al.*, -
Chara vulgaris L. (=*Chara foetida* A.Braun)	Novosele (Pond), Darzeze (Pond)	Protic, 1907; Kashta,-
Lamprothamnium papulosum (Wallroth) J. Groves	Kallenge (Swamp), Salty Lake, Limopuo (Lagoon), Saline (Pond)	Kashta *et al.*, -
Tolypella hispanica Nordstedt ex T.F.Allen	Saline (Pond)	Kashta *et al.*, -
Zygnematophyceae (Charophyta)		
Closterium acerosum Ehrenberg ex Ralfs	Mifol, Narte, Novosele	Protic, 1907
Closterium ehrenbergii Meneghini ex Ralfs	Saline	Protic, 1907
Closterium leibleinii Kützing ex Ralfs	Saline	Protic, 1907
Closterium lunula Ehrenberg & Hemprich ex Ralfs	Mifol	Protic, 1907
Closterium striolatum Ehrenberg ex Ralfs	Mifol	Protic, 1907
*Cosmarium bi*oculatum Brébisson ex Ralfs	Saline	Protic, 1907
Cosmarium botrytis Meneghini ex Ralfs	Mifol, Novosele	Protic, 1907
Cosmarium crenatum Ralfs ex Ralfs	Saline, Narte	Protic, 1907
Cosmarium margaritiferum Meneghini ex Ralfs	Mifol, Novosele	Protic, 1907
Cosmarium meneghinii Brébisson ex Ralfs	Saline, Narte	Protic, 1907
Cosmarium naegelianum Brébisson	Mifol, Novoselë	Protic, 1907
Cosmarium subcostatum var. *beckii* (Gutwinski) West & G.S.West (=*Cosmarium beck*ii Gutwinski)	Saline	Protic, 1907
Euastrum binale Ehrenberg ex Ralfs	Mifol	Protic, 1907
Euastrum didelta Ralfs	Vlore	Protic, 1907
Euastrum elegans Ralfs	Mifol	Protic, 1907
Micrasterias rotata Ralfs	Saline	Protic, 1907
Penium digitus Brébisson ex Ralfs	Mifol	Protic, 1907
Sirogonium sticticum (Smith) Kützing	Mifol	Protic, 1907
Spirogyra affinis (Hassall) Petit	Saline, Narte, Mifol	Protic, 1907

Class, Species name (Synonyms)	Habitats	Author/s
Spirogyra decimina var. *elongata* (Vaucher) Petlovany (=*Spirogyra communis* (Hassall) Kützing)	Saline, Narte, Mifol	Protic, 1907
Spirogyra longifissa Wei	Mifol, Novosele	Protic, 1907
Spirogyra porticalis (O.F.Müller) Dumortier(=*Spirogyra quinina* (O.F.Müller) Dumortier)	Vlore	Protic, 1907
Spirogyra tenuissima (Hassall) Kützing	Saline	Protic, 1907
Spirogyra weberi Kützing	Novosele	Protic, 1907
Spirogyra sp.	Vjose (Mouth)	Miho,-
Staurastrum dilatatum Ehrenberg ex Ralfs	Mifol, Narte, Novosele	Protic, 1907
Staurastrum furcatum Brébisson	Mifol, Narte	Protic, 1907
Staurastrum muticum Brébisson ex Ralfs	Mifol, Narte, Novosele	Protic, 1907
Zygnema cruciatum (Vaucher) C.Agardh	Saline	Protic, 1907
Zygnema stellinum (O.F.Müller) C.Agardh	Narte	Protic, 1907
Chlorophyceae		
Chaetophora elegans (Roth) C.Agardh	Mifol (Pond)	Protic, 1907
Chaetomorpha linum (O.F.Müller) Kützing	Narte (Lagoon)	Miho *et al.,* 2013; Meço *et al.,* 2023
Chaetophora pisiformis (Roth) C.Agardh	Novosele (Pond), Vlore (Pond)	Protic, 1907
Chlamydomonas reinhardtii P.A.Dangeard. (=*Chlamydomonas pulvisculus* Ehrenberg, nom. illeg.)	Mifol	Protic, 1907
Chlamydopodium sieboldii (A.Braun) P.M.Tsarenko (=*Characium sieboldii* A.Braun)	Narte	Protic, 1907
Chlorococcum infusionum (Schrank) Meneghini (=*Protococcus infusionum* (Schrank) Kützing)	Mifol, Novosele, Narte, Vlore	Protic, 1907
Dunaliella salina (Dunal) Teodoresco	Saline	Kashta,-; Miho,-
Coelastrum naegelii Ralfs	Narte	Protic, 1907
Cylindrocapsa involuta Reinsch	Vlore	Protic, 1907
Gonium pectorale O.F.Müller	Saline	Protic, 1907
Microspora amoena (Kützing) Rabenhorst	Mifol, Vlore	Protic, 1907
Oedogonium ciliatum Pringsheim ex Hirn	Vlore	Protic, 1907

Class, Species name (Synonyms)	Habitats	Author/s
Oedogonium tumidulum Wittrock ex Hirn	Mifol, Novosele, Vlore	Protic, 1907
Oedogonium undulatum A.Braun ex Hirn	Mifol, Novosele	Protic, 1907
Pandorina morum (O.F.Müller) Bory	Saline, Mifol	Protic, 1907
Pediastrum duplex Meyen (=*Pediastrum pertusum* Kützing)	Mifol, Novosele	Protic, 1907
Pseudopediastrum boryanum (Turpin) E.Hegewald (=*Pediastrum boryanum* (Turpin) Meneghini)	Narte, Saline	Protic, 1907
Scenedesmus obtusus Meyen	Mifol, Novosele	Protic, 1907
Scenedesmus quadricauda (Turpin) Brébisson (=*Scenedesmus caudatus* Corda)	Mifol, Novosele	Protic, 1907
Schizochlamys gelatinosa A.Braun	Saline	Protic, 1907
Sorastrum spinulosum Nägeli	Mifol, Novosele	Protic, 1907
Stauridium tetras (Ehrenberg) E.Hegewald (=*Pediastrum ehrenbergii* (Corda) A.Braun)	Novosele	Protic, 1907
Tetraspora gelatinosa (Vaucher) Desvaux	Mifol, Novosele	Protic, 1907
Ulothrix aequalis Kützing	Saline, Mifol	Protic, 1907
Ulothrix zonata (F.Weber & Mohr) Kützing	Mifol	Protic, 1907
Volvox globator Linnaeus	Mifol	Protic, 1907
Willea rectangularis (A.Braun) D.M.John, M.J.Wynne & P.M.Tsarenko (=*Staurogenia rectangularis* A.Braun)	Saline	Protic, 1907
Trebouxiophyceae (Chlorophyta)		
Botryococcus braunii Kützing	Novosele	Protic, 1907
Prasinophyceae (Chlorophyta)		
Pterosperma sp.	Narte	Xhulaj, 2008
Pyramimonadophyceae (Chlorophyta)		
Pyramimonas sp.	Narte	Xhulaj, 2008
Ulvophyceae		
Cladophora fracta (O.F.Müller ex Vahl) Kützing	Saline, Novosele	Protic, 1907
Cladophora glomerata (Linnaeus) Kützing	Vjose (Mifol)	Kashta & Miho, 2016;
Cladophora glomerata var. *crassior* (C.Agardh) C.Hoek (=*Cladophora crispata* (Roth) Kützing)	Mifol	Protic, 1907
Chladophora sp.	Darzeze	Miho,-

Class, Species name (Synonyms)	Habitats	Author/s
Ulva (Enteromorpha) clathrata (Roth) Greville	Saline (Dam)	Miho,-
Ulva (Enteromorpha) prolifera J. Agardh (cf.)	Kallenge, Narte (Dam)	Miho,-
Ulva (Enteromorpha) intestinalis (Linnaeus) Nees	Kallenge, Narte (Dam), Saline (Dam), Dead River (Zhuke)	Miho,-
Rhizoclonium hieroglyphicum (C.Agardh) Kützing	Saline	Protic, 1907
Bacillariophyceae - Centric		
Actinocyclus normanii (Gregory) Hustedt	Narte	Xhulaj, 2008
Actinocyclus octonarius Ehrenberg	Narte	Xhulaj, 2008
Chaetoceros dadayi Pavillard	Narte	Xhulaj, 2008
Chaetoceros decipiens Cleve	Narte	Xhulaj, 2008
Chaetoceros rostratus Lauder	Narte	Xhulaj, 2008
Chaetoceros simplex Ostenfeld	Narte	Xhulaj, 2008
Chaetoceros tenuissimus Meunier	Narte	Xhulaj, 2008
Conticribra weissflogii (Grunow) Stachura-Suchoples & D.M.Williams *(=Thalassiosira weissflogii* (Grunow) Fryxell & Hasle)	Narte	Xhulaj, 2008
Coscinodiscus radiatus Ehrenberg	Narte	Xhulaj, 2008
Cyclostephanos dubius (Fricke) Round	Narte	Xhulaj, 2008
Cyclotella choctawhatcheeana Prasad	Narte	Xhulaj, 2008
Cyclotella cyclopuncta Hakansson & Carter	Narte	Xhulaj, 2008
Cyclotella distinguenda Hustedt	Vjose (Mifol)	Miho *et al.*, 2018
Dactyliosolen fragilissimus (Bergon) Hasle	Narte	Xhulaj, 2008
Dactyliosolen mediterraneus (H.Peragallo) H.Peragallo *(=Leptocylindrus mediterraneus* (H.Peragallo) Hasle)	Narte	Xhulaj, 2008
Ellerbeckia arenaria (Moore ex Ralfs) Crawford	Narte	Xhulaj, 2008
Hemiaulus hauckii Grunow	Narte	Xhulaj, 2008
Hyalodiscus scoticus (Kützing) Grunow	Narte	Xhulaj, 2008
Leptocylindrus danicus Cleve	Narte	Xhulaj, 2008
Lindavia radiosa (Grunow) De Toni & Forti *(=Cyclotella radiosa* (Grunow) Lemmermann)	Narte	Xhulaj, 2008

Class, Species name (Synonyms)	Habitats	Author/s
Lindavia tenuistriata (Hustedt) T.Nakov *et al.* (=*Cyclotella glabriuscula* (Grunow) Håkansson)	Vjose (Mifol)	Ngjela, 2016
Melosira moniliformis (O.F.Müller) Agardh	Narte	Xhulaj, 2008
Melosira nummuloides (Dillwyn) C.A. Agardh	Narte	Xhulaj, 2008
Melosira varians C.Agardh	Mifol, Vlore, Narte, Vjose (Mifol)	Protic, 1907; Xhulaj, 2008; Miho *et al.,* 2018; Nderjaku, 2019
Odontella aurita (Lyngbye) Agardh	Narte	Xhulaj, 2008
Pantocsekiella comensis (Grunow) K.T.Kiss & E.Ács *(=Cyclotella comensis* Grunow in Van Heurck)	Vjose (Mifol), Narte, Kallenge, Saline (Dam), Bishan	Xhulaj, 2008; Miho et al., 2018; Miho,-
Pantocsekiella ocellata (Pantocsek) K.T.Kiss & Ács *(=Cyclotella ocellata* Pantoscek)	Narte, Vjose (Mouth)	Xhulaj, 2008, Nderjaku, 2019
Plagiogramma minus var. nanum (W. Gregory) Chunlian Li, Ashworth & Witkowski *(=Dimeregramma minus var. nanum* (W.Gregory) Van Heurck (Gregory) Van Heurck)	Narte	Xhulaj, 2008
Pleurosira laevis (Ehrenberg) Compère	Narte	Xhulaj, 2008
Shionodiscus oestrupii (Ostenfeld) A.J.Alverson, S.-H.Kang & E.C.Theriot (=*Thalassiosira oestrupii* (Ostenfeld) Proshkina-Lavrenko ex Hasle)	Narte	Xhulaj, 2008
Skeletonema costatum (Greville) Cleve	Narte	Xhulaj, 2008
Skeletonema subsalsum (Cleve-Euler) Bethge	Narte	Xhulaj, 2008
Stephanocyclus meneghinianus (Kützing) Kulikovskiy, Genkal & Kociolek (=*Cyclotella meneghiniana* Kützing)	Narte	Xhulaj, 2008
Stephanodiscus alpinus Hustedt	Narte	Xhulaj, 2008
Stephanodiscus hantzschii Grunow	Narte	Xhulaj, 2008
Stephanodiscus medius Håkansson	Vjose (Mifol)	Jaupaj, 2007; Meço, 2013
Stephanodiscus parvus Håkansson	Vjose (Mifol)	Ngjela, 2016
Stephanodiscus rotula (Kützing) Hendey	Narte	Xhulaj, 2008
Thalassiosira visurgis Hustedt	Narte	Xhulaj, 2008
Thalassiosira sp.	Narte	Xhulaj, 2008
Bacillariophyceae - Pennales		

Class, Species name (Synonyms)	Habitats	Author/s
Achnanthes adnata Bory *(=Achnanthes brevipes* Agardh)	Narte, Kallenge, Dead River (Zhuke), Saline (Dam)	Xhulaj, 2008; Miho,-
Achnanthes armillaris (O.F.Müller) Guiry (=*Achnanthes longipes* Agardh)	Narte	Xhulaj, 2008
Achnanthes lemmermannii Hustedt	Narte	Xhulaj, 2008
Achnanthes sancti-pauli (Heiden in Heiden & Kolbe) Kobayasi & Swatari	Narte	Xhulaj, 2008
Achnanthidium biasolettianum (Grunow) Lange-Bertalot, *nom. illeg.* (=*Achnanthes biasolettiana* Grunow)	Vjose (Mifol)	Nderjaku, 2019
Achnanthidium exile (Kützing) Heiberg (=*Achnanthes exilis* Kützing)	Vlore, Narte	Protic, 1907
Achnanthidium minutissimum (Kützing) Czarnecki (=*Achnanthes minutissima* Kützing)	Vlore, Narte, Vjose (Mouth & Mifol), Saline (Dam)	Protic, 1907; Dedej, 2006; Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019; Miho,-
Achnanthidium pusillum (Grunow) Czarnecki (=*Achnanthes pusilla* Grunow) (cf.)	Vjose (Mifol)	Nderjaku, 2019
Amphipleura pellucida (Kützing) Kützing	Kripore, Narte, Vjose (Mifol)	Protic, 1907; Dedej, 2006; Miho *et al.*, 2018; Nderjaku, 2019
Amphiprora pseudoduplex (Osada & Kobayasi) Hällfors (=*Entomoneis pseudoduplex* Osada & Kobayasi) *(cf.)*	Kallenge	Miho,-
Amphora aequalis Krammer	Narte	Xhulaj, 2008
Amphora affinis Kützing (=*Amphora ovalis* var. *affinis* (Kützing) Van Heurck)	Lagoon, Saline	Protic, 1907
Amphora cimbrica Østrup	Narte	Xhulaj, 2008
Amphora commutata Grunow	Lagoon, Saline	Protic, 1907
Amphora copulata (Kützing) Schoeman & Archibald	Narte	Xhulaj, 2008
Amphora helenensis Giffen *(cf.)*	Saline (Dam)	Miho
Amphora inariensis Krammer	Narte	Xhulaj, 2008
Amphora libyca Ehrenberg	Bishan	Miho,-

Class, Species name (Synonyms)	Habitats	Author/s
Bacillariophyceae - Pennales		
Amphora lineolata Ehrenberg, *nom. illeg*.	Saline, Narte	Protic, 1907; Dedej, 2006; Miho *et al.,* 2018
Amphora ovalis (Kützing) Kützing	Narte, Vjose (Mifol)	Xhulaj, 2008; Miho *et al.,* 2018; Nderjaku, 2019
Amphora pediculus (Kützing) Grunow (=*Amphora ovalis* var. *pediculus* (Kützing) Van Heurck)	Lagune, Narte, Saline, Vjose (Mouth & Mifol)	Protic, 1907; Dedej, 2006; Xhulaj, 2008; Miho *et al*., 2018;; Nderjaku, 2019
Aneumastus tusculus (Ehrenberg) D.G.Mann & A.J.Stickle (=*Navicula tuscula* (Ehrenberg) Grunow, nom. illeg.)	Lagoon, Narte, Saline	Protic, 1907; 2005; Dedej, 2006; Miho *et al.,* 2018;
Anomoeoneis sphaerophora Pfitzer	Narte	Xhulaj, 2008
Ardissonea fulgens (Greville) Grunow ex De Toni	Narte	Xhulaj, 2008
Astartiella bahusiensis (Grunow) Witkowski, Lange-Bertalot & Metzeltin	Narte	Xhulaj, 2008
Asterionella formosa Hassall	Narte	Xhulaj, 2008
Asterionellopsis glacialis (Castracane) Round	Narte	Xhulaj, 2008
Berkeleya rutilans (Trentepohl) Grunow	Narte, Vjose (Mouth), Kallenge	Xhulaj, 2008; Nderjaku, 2019; Miho,-
Berkeleya scopulorum (Brébisson) Cox	Narte	Xhulaj, 2008
Brachysira aponina Kützing *(cf.)*	Vjose (Gryke), Kallenge	Nderjaku, 2019; Miho,-
Brachysira neoexilis Lange-Bertalot	Narte, Vjose (Mouth & Mifol)	Xhulaj, 2008; Nderjaku, 2019
Brachysira serians (Brébisson) Round & D.G.Mann (=*Navicula serians* (Brébisson) Kützing)	Mifol, Narte	Protic, 1907
Brebissonia lanceolata (Agardh) Mahoney & Reimer (=*Cymbella lanceolata* (C.Agardh) Kirchner, *nom. illeg*.)	Mifol, Novosele, Vlore, Lagoon, Saline	Protic, 1907
Caloneis aequatorialis Hustedt	Vjose (Mifol)	Meço, 2013
Caloneis amphisbaena (Bory) Cleve	Narte	Xhulaj, 2008

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Caloneis amphisbaena var. *subsalina* (Donkin) Cleve (=*Navicula amphisbaena* var. *subsalina* (Donkin) Van Heurck)	Lagoon, Saline	Protic, 1907
Caloneis bacillum (Grunow) Cleve	Narte	Xhulaj, 2008
Caloneis crassa (Gregory) R. Ross	Narte	Xhulaj, 2008
Caloneis limosa (Kützing) R.M.Patrick (=*Navicula limosa* Kützing)	Novosele	Protic, 1907
Caloneis molaris (Grunow) Krammer	Narte	Xhulaj, 2008
Caloneis ventricosa F.Meister (=*Navicula ventricosa* Ehrenberg)	Mifol, Narte	Protic, 1907
Campylodiscus neofastuosus Ruck & Nakov *(=Surirella fastuosa* (Ehrenberg) Ehrenberg)	Narte	Xhulaj, 2008
Campylosira cymbelliformis (A.W.F.Schmidt) Grunow ex Van Heurck	Lagoon	Protic, 1907
Cocconeiopsis sp.	Saline (Dam)	Miho,-
Cocconeis dirupta Gregory	Narte	Xhulaj, 2008
Cocconeis disculus (Schumann) Cleve *(cf.)*	Saline (Dam)	Miho,-
Cocconeis lineata Ehrenberg *(=Cocconeis placentula var. lineata* (Ehrenberg) Van Heurck)	Narte, Vjose (Mifol), Dead River (Zhuke), Saline (Dam)	Xhulaj, 2008; Meço, 2013; Nderjaku, 2019; Miho,-
Cocconeis neodiminuta Krammer	Vjose (Gryke), Vjose (Mifol)	Nderjaku, 2019
Cocconeis pediculus Ehrenberg	Mifol, Vlore, Lagoon, Narte, Saline, Vjose (Mouth & Mifol)	Protic, 1907; Miho & Witkowski, 2005; Xhulaj, 2008; Nderjaku, 2019
Cocconeis placentula Ehrenberg	Mifol, Vlore, Lagoon, Narte, Saline, Vjose (Mifol)	Protic, 1907; Dedej, 2006; Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019
Cocconeis placentula var. euglypta (Ehrenberg) Cleve	Narte, Kallenge, Dead River (Zhuke), Saline (Dam)	Xhulaj, 2008; Miho,-

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Cocconeis pseudolineata (Geitler) Lange-Bertalot *(=Cocconeis placentula* var. *pseudolineata* Geitler)	Narte	Xhulaj, 2008
Cocconeis scutellum Ehrenberg	Narte, Kallenge	Xhulaj, 2008; Miho,-
Cocconeis stauroneiformis (W.Smith) Okuno	Narte	Xhulaj, 2008
Cosmioneis eta (Cleve) Witkowski, Lange-Bertalot & Metzeltin	Narte	Xhulaj, 2008
Craticula ambigua (Ehrenberg) Mann	Narte	Xhulaj, 2008
Craticula cuspidata (Kutzing) D.G.Mann *(=Navicula cuspidata* (Kutzing) Kutzing)	Bishan	Miho,-
Craticula halophila (Grunow) D.G.Mann *(=Navicula halophila (*Grunow) Cleve) *(cf.)*	Saline (Dam), Bishan, Kallenge	Miho,-
Ctenophora pulchella (Ralfs ex Kützing) D.M.Williams & Round (=*Fragilaria pulchella* (Ralfs ex Kützing) Lange-Bertalot)	Vjose (Mouth)	Nderjaku, 2019
Cylindrotheca closterium (Ehrenberg) Reimann & J.C.Lewin *(=Nitzschia closterium* (Ehrenberg) W.Smith)	Narte	Xhulaj, 2008
Cymatopleura elliptica (Brébisson) W.Smith	Novosele, Lagune	Protic, 1907
Cymbella affinis Kützing	Vjose (Mouth & (Mifol), Dead River (Zhuke), Saline (Dam)	Kupe, 2006; Miho *et al.,* 2018*; Nderjaku, 2019; Miho,-*
Cymbella amphicephala Naegeli	Narte	Miho & Witkowski, 2005; Dedej, 2006; Xhulaj, 2008
Cymbella aspera (Ehrenberg) Cleve (=*Cymbella gastroides* (Kützing) Brébisson & Godey)	Mifol, Novosele, Vlore, Lagoon, Saline	Protic, 1907
Cymbella cistula (Ehrenberg) O.Kirchner	Saline, Mifol, Novosele, Narte, Vjose (Mifol)	Protic, 1907; Ngjela, 2016
Cymbella compacta Østrup	Narte	Xhulaj, 2008
Cymbella cymbiformis C.Agardh	Saline, Mifol, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006

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Cymbella helvetica Kützing	Saline, Mifol, Narte, Vjose (Mifol)	Protic, 1907; Miho & Witkowski, 2005; Miho *et al.*, 2018; Nderjaku, 2019
Cymbella hustedtii Krasske	Narte	Xhulaj, 2008
Cymbella lanceolata (Ehrenberg) Van Heurck	Narte	Miho & Witkowski, 2005; Dedej, 2006; Xhulaj, 2008
Cymbella tumida (Brébisson) Van Heurck	Lagoon, Narte, Saline, Vjose (Mifol)	Protic, 1907; Miho & Witkowski, 2005; Xhulaj, 2008; Miho *et al.*, 2018;
Cymbopleura amphicephala (Nägeli ex Kützing) Krammer (=*Cymbella amphicephala* Näegeli ex Kützing)	Vjose (Mifol)	Ngjela, 2016
Cymbopleura inaequalis (Ehrenberg) Krammer (=*Cymbella ehrenbergii* Kützing)	Vlore, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
Delicatophycus delicatulus (Kützing) M.J.Wynne (=*Cymbella delicatula* Kützing)	Mifol, Novosele, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
Denticula tenuis Kützing	Mifol, Narte, Vjose (Mifol)	Protic, 1907; Miho & Witkowski, 2005; Miho *et al.*, 2018; Nderjaku, 2019
Diadesmis contenta var. biceps (Grunow) P.B.Hamilton (=*Diadesmis biceps* G.A.Arnott ex Cleve, *nom. inval.)*	Narte	Xhulaj, 2008
Diatoma ehrenbergii Kützing	Vjose (Mifol)	Ngjela, 2016
Diatoma moniliformis (Kützing) D.M.Williams	Narte, Vjose (Mouth)	Kupe, 2006; Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019
Diatoma tenuis C.Agardh	Narte	Xhulaj, 2008
Diatoma vulgaris Bory	Mifol, Lagoon, Saline, Vjose (Mifol)	Protic, 1907; Xhulaj, 2008; Miho *et al.,* 2018; Nderjaku, 2019

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Diatoma vulgaris var. *tenue* Proschkina-Lavrenko (Mindat.org)	Lagune	Protic, 1907
Diatoma vulgaris var. tenuis (C.Agardh) Kutzing	Narte	Dedej, 2006
Diploneis boldtiana Cleve	Narte	Xhulaj, 2008
Diploneis didymus (Ehrenberg) Ehrenberg	Narte, Kallenge	Xhulaj, 2008; Miho,-
Diploneis elliptica (Kützing) Cleve (=*Navicula elliptica* Kützing)	Lagoon, Saline	Protic, 1907
Diploneis interrupta (Kützing) Cleve	Narte	Xhulaj, 2008
Diploneis krammeri Lange-Bertalot & Reichardt	Narte	Xhulaj, 2008
Diploneis marginestriata Hustedt	Narte	Xhulaj, 2008
Diploneis oblongella (Nägeli) Cleve-Euler	Vjose (Mifol)	Nderjaku, 2019
Diploneis parma Cleve	Narte	Xhulaj, 2008
Diploneis petersenii Hustedt	Vjose (Mouth)	Nderjaku, 2019
Dorofeyukea kotschyi (Grunow) Kulikovskiy, Kociolek, Tusset & T.Ludwig (=*Navicula kotschyi* Grunow)	Narte	Xhulaj, 2008
Encyonema lacustre (C.Agardh) Pantocsek (=*Cymbella lacustris* (C.Agardh) Cleve)	Vjose (Mifol)	Nderjaku, 2019
Encyonema leibleinii (C.Agardh) W.J.Silva, R.Jahn, T.A.V.Ludwig, & M.Menezes (=*Encyonema prostratum* (Berkeley) Kützing)	Mifol, Novosele, Vlore, Lagune, Saline	Protic, 1907
Encyonema minutum (Hilse) D.G.Mann	Vjose (Mifol)	Nderjaku, 2019
Encyonema leibleinii (C.Agardh) W.J.Silva, R.Jahn, T.A.V.Ludwig, & M.Menezes (=Encyonema prostratum (Berkeley) Kützing)	Narte, Vjose (Mifol)	Dedej, 2006; Miho *et al.*, 2018
Encyonema silesiacum (Bleisch) D.G.Mann	Vjose (Mifol)	Meço, 2013
Encyonema ventricosum (C.Agardh) Grunow (=*Cymbella ventricosa* Agardh)	Mifol, Novosele, Vlore, Saline, Narte, Vjose (Mifol)	Protic, 1907; Dedej, 2006; Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019
Encyonopsis cesatii (Rabenhorst) Krammer	Narte	Xhulaj, 2008
Encyonopsis microcephala (Grunow) Krammer *(=Cymbella microcephala* Grunow)	Narte, Vjose (Mouth), Vjose (Mifol)	Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019
Entomoneis alata (Ehrenberg) Ehrenberg *(cf.)*	Kallenge	Miho,-

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Entomoneis paludosa (W.Smith) Reimer	Narte, Dead River (Zhuke)	Xhulaj, 2008; Miho,-
Epithemia adnata (Kützing) Brébisson (=*Epithemia zebra* (Ehrenberg) Kützing)	Mifol, Novosele, Vlore, Saline, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
Epithemia gibba (Ehrenberg) Kützing (=*Navicula stauroptera* Grunow)	Kripore, Novosele, Narte	Protic, 1907
Epithemia sorex Kützing	Mifol, Novosele, Vlore, Saline, Narte	Protic, 1907; Xhulaj, 2008; Miho *et al.*, 2018.
Epithemia turgida (Ehrenberg) Kützing	Mifol, Novosele, Vlore, Saline, Narte	Protic, 1907; Miho & Witkowski, 2005; Xhulaj, 2008
Eunotia arcus Ehrenberg	Vlore, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
Eunotia lunaris (Ehrenberg) Grunow	Mifoli, Narte	Protic, 1907
Eunotia minor (Kützing) Grunow	Narte	Xhulaj, 2008
Eunotia pectinalis (Kützing) Rabenhorst	Saline, Narte	Protic, 1907; Miho & Witkowski, 2005;
Eunotia flexuosa (Kützing) J.B.Petersen.	Vjose (Mifol)	Nderjaku (2019)
Fallacia balnearis (Grunow) Witkowski, Lange-Bertalot & Metzeltin	Narte	Xhulaj, 2008
Fallacia cassubiae Witkowski	Narte	Xhulaj, 2008
Fallacia forcipata (Greville) Stickle & D.G. Mann	Narte	Xhulaj, 2008
Fallacia lenzii Lange-Bertalot *(=Navicula lenzii* Hustedt)	Vjose (Mifol)	Miho *et al.,* 2018;
Fragilaria austriaca (Grunow) Lange-Bertalot	Vjose (Mifol)	Nderjaku (2019)
Fragilaria capucina Desmazières	Mifol, Novosele, Vlore, Lagoon, Narte, Saline, Vjose (Mifol)	Protic, 1907; Xhulaj, 2008; Miho *et al.,* 2018
Fragilaria cassubica Witkowski & Lange-Bertalot	Narte	Xhulaj, 2008
Fragilaria crotonensis Kitton	Narte	Xhulaj, 2008

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Fragilaria vaucheriae (Kützing) J.B.Petersen *(=Fragilaria capucina* var. *vaucheriae* (Kützing) Lange-Bertalot)	Narte, Vjose (Mifol)	Xhulaj, 2008, Nderjaku, 2019
Fragilariforma mesolepta (Rabenhorst) Kharitonov *(=Fragilaria capucina var. mesolepta* (Rabenhorst) Rabenhorst	Narte	Xhulaj, 2008
Fragilariforma virescens (Ralfs) D.M.Williams & Round (=*Fragilaria virescens* Ralfs)	Mifol, Novosele, Vlore, Lagoon, Narte, Saline	Protic, 1907; Xhulaj, 2008; Miho *et al*., 2018;
Geissleria acceptata (Hustedt) Lange-Bertalot & Metzeltin	Narte	Xhulaj, 2008
Geissleria decussis (Østrup) Lange-Bertalot & Metzeltin	Narte	Xhulaj, 2008
Gomphonella olivacea (Hornemann) Rabenhorst *(=Gomphonema olivaceum* (Hornemann) Ehrenberg)	Narte, Vjose (Mouth), Vjose (Mifol)	Dedej, 2006; Xhulaj, 2008; Miho et al., 2018; Nderjaku, 2019
Gomphonema acuminatum Ehrenberg	Narte, Vjose (Mifol)	Dedej, 2006; Xhulaj, 2008; Miho *et al.,* 2018;
Gomphonema angustatum (Kützing) Rabenhorst	Mifol, Novosele, Vlore, Lagoon, Narte, Saline, Vjose (Mifol)	Protic, 1907; Dedej, 2006; Miho *et al.,* 2018; Nderjaku, 2019
Gomphonema clavatum Ehrenberg	Vjose (Mifol)	Kupe, 2006*;* Miho et al., 2018;
Gomphonema constrictum Ehrenberg	Narte	Protic, 1907
Gomphonema gracile Ehrenberg cf.)	Bishan	Miho,-
Gomphonema intricatum Kützing	Saline, Novosele	Protic, 1907
Gomphonema micropus Kützing	Vjose (Mifol)	Ngjela, 2016
Gomphonema minutum (Agardh) Agardh agg.	Vjose (Mifol)	Kupe, 2006; Nderjaku, 2019
Gomphonema occultum Reichardt & Lange-Bertalot	Narte	Xhulaj, 2008

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Gomphonema parvulum (Kützing) Kützing	Mifol, Narte, Vjose (Mifol), Bishan	Protic, 1907; Miho & Witkowski, 2005; Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019; Miho,-
Gomphonema pseudotenellum Lange-Bertalot *(cf.)*	Vjose (Mifol)	*Kupe, 2006; Nderjaku, 2019*
Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot	Vjose (Mifol)	Miho *et al.*, 2018; Nderjaku, 2019
Gomphonema tergestinum (Grunow) Fricke	Narte, Vjose (Mifol)	Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019
Gomphonema truncatum Ehrenberg	Vjose (Mifol)	Ngjela, 2016; Nderjaku, 2019
Grammatophora angulosa Ehrenberg	Narte	Xhulaj, 2008
Grammatophora hamulifera Kutzing	Narte	Xhulaj, 2008
Grammatophora marina (Lyngbye) Kützing	Narte	Xhulaj, 2008
Grammatophora oceanica Ehrenberg	Narte	Xhulaj, 2008
*Grunowia tabellaria (*Grunow) Rabenhorst *(=Nitzschia sinuata var. tabellaria* (Grunow) Grunow)	Narte	Xhulaj, 2008
Gyrosigma acuminatum (Kützing) Rabenhorst	Narte, Kallenge	Xhulaj, 2008; Miho,-
Gyrosigma attenuatum (Kützing) Cleve	Narte	Xhulaj, 2008
Gyrosigma balticum (Ehrenberg) Rabenhorst	Narte	Xhulaj, 2008
Gyrosigma fasciola (Ehrenberg) J.W.Griffith & Henfrey	Narte	Xhulaj, 2008
Gyrosigma nodiferum (Grunow) Reimer	Narte, Vjose (Mifol & Mouth)	Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019
Gyrosigma scalproides (Rabenhorst) Cleve	Narte, Vjose (Mifol), Kallenge	Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019; Miho,-
Gyrosigma wansbeckii (Donkin) Cleve	Kallenge	Miho,-
Halamphora acutiuscula (Kützing) Levkov *(=Amphora acutiuscula* Kützing)	Narte	Xhulaj, 2008
Halamphora borealis (Kützing) Levkov *(=Amphora borealis* Kützing) *(cf.)*	Vjose (Mouth)	Nderjaku, 2019

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Halamphora coffeiformis (C.Agardh) Mereschkowsky (=*Amphora salina* W.Smith; *Amphora coffeaeformis* (Agarth) Kützing)	Lagoon, Kallenge, Dead River (Zhuke), Saline (Dam)	Protic, 1907; Xhulaj, 2008; Miho,-
Halamphora holsatica (Hustedt) Levkov *(=Amphora holsatica* Hustedt)	Narte, Vjose (Mouth), Kallenge, Dead River (Zhuke), Saline (Dam)	Xhulaj, 2008; Nderjaku, 2019; Miho,-
Halamphora hybrida (Grunow) Levkov (=*Amphora angularis* var. *lyrata* (W.Gregory) Van Heurck)	Lagoon, Saline	Protic, 1907
Halamphora luciae (Cholnoky) Levkov (=*Amphora luciae* Cholnoky) *(cf.)*	Kallenge, Dead River (Zhuke), Saline (Dam)	Miho,-
*Halamphora montana (*Krasske) Levkov *(=Amphora montana* Krasske)	Narte	Xhulaj, 2008
Halamphora subholsatica (Krammer) Levkov	Dead River (Zhuke), Saline (Dam)	Miho,-
Halamphora veneta (Kützing) Levkov *(=Amphora veneta* Kützing)	Narte, Bishan	Xhulaj, 2008; Miho,-
Hantzschia amphioxys (Ehrenberg) Grunow	Lagoon, Vjose (Mifol), Narte, Bishan	Protic, 1907; Xhulaj, 2008; Miho *et al.,* 2018; Miho,-
Hantzschia marina (Donkin) Cleve	Narte	Xhulaj, 2008
Hantzschia virgata (Roper) Grunow	Bishan	Miho,-
Haslea crucigera (W.Smith) Simonsen	Narte	Xhulaj, 2008
Haslea spicula (Hickie) Lange-Bertalot	Narte	Xhulaj, 2008
Haslea stundlii (Hustedt) Blanco, Borrego-Ramos & Olenici *(=Navicula duerrenbergiana* Hustedt*, nom. inval.)*	Vjose (Mouth)	Nderjaku, 2019
Hippodonta caotica Witkowski, Lange-Bertalot & Metzeltin *(cf.)*	Saline (Dam)	Miho,-
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski	Narte	Xhulaj, 2008
Hippodonta costulata (Grunow) Lange-Bertalot, Metzeltin & Witkowski	Narte, Saline (Dam)	Xhulaj, 2008; Miho,-
Hippodonta hungarica (Grunow) Lange-Bertalot, Metzeltin & Witkowski	Narte	Xhulaj, 2008

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Humidophila contenta (Grunow) R.L.Lowe & *al.* (=*Diadesmis contenta (*Grunow) D.G.Mann)	Narte	Xhulaj, 2008
Iconella biseriata (Brébisson) Ruck & Nakov (=*Suriraya biseriata* (Brébisson) Pfitzer)	Narte, Vlore	Protic, 1907; Dedej, 2006; Miho *et al.,* 2018
Iconella spiralis (Kützing) E.C.Ruck & T.Nakov *(=Surirella spiralis* Kützing)	Narte	Miho & Witkowski, 2005; Dedej, 2006
Iconella splendida (Ehrenberg) Ruck & Nakov (=*Surirella robusta* var. *splendida* (Ehrenberg) Van Heurck)	Mifol, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
*Karayevia amoena (*Hustedt) Bukhtiyarova (=*Achnanthes amoena* Hustedt)	Narte	Xhulaj, 2008
Karayevia nitidiformis (Lange-Bertalot) Bukhtiyarova *(=Achnanthes nitidiformis* Lange-Bertalot*) (cf.)*	Kallenge	Miho,-
Licmophora abbreviata C.Agardh *(cf.)*	Kallenge	Miho,-
Licmophora dalmatica (Kützing) Grunow	Lagune	Protic, 1907
Licmophora flabellata (Greville) C.Agardh	Narte, Kallenge	Xhulaj, 2008; Miho,-
Licmophora gracilis (Ehrenberg) Grunow var. *gracilis*	Narte	Xhulaj, 2008
Licmophora paradoxa (Lyngbye) C.Agardh	Narte	Xhulaj, 2008
Luticola mutica (Kützing) D.G.Mann (=*Navicula mutica* Kützing)	Lagune, Saline, Vjose (Mifol), Bishan	Protic, 1907; Xhulaj, 2008; Miho *et al.,* 2018; Miho,-
Luticola muticopsis (Van Heurck) D.G.Mann (=*Navicula muticopsis* Van Heurck)	Narte	Xhulaj, 2008
Luticola nivalis (Ehrenberg) D.G. Mann	Narte	Xhulaj, 2008
Luticola paramutica (W.Bock) D.G.Mann	Vjose (Mifol)	Kupe, 2006
Lyrella abrupta (Gregory) D.G. Mann	Narte	Xhulaj, 2008
Lyrella approximatoides (Hustedt) D.G.Mann	Narte	Xhulaj, 2008
Mastogloia angulata Lewis	Narte	Xhulaj, 2008
Mastogloia braunii Grunow	Lagoon, Narte	Protic, 1907; Dedej, 2006; Miho *et al.,* 2018;
Mastogloia crucicula (Grun.) Cleve	Narte	Xhulaj, 2008
Mastogloia danseyi (Thwaites) Thwaites ex W.Smith	Narte, Lagoon	Protic, 1907

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Mastogloia elliptica (C.A. Agardh) Cleve	Narte	Xhulaj, 2008
Mastogloia exigua Lewis	Narte	Xhulaj, 2008
Mastogloia ovalis A. Schmidt	Narte	Xhulaj, 2008
Mastogloia pumila (Grunow) Cleve	Narte, Kallenge, Dead River (Zhuke)	Xhulaj, 2008; Miho,-
Mastogloia pusilla (Grunow) Cleve	Narte	Xhulaj, 2008
Mastogloia smithii Thwaites	Narte, Vjose (Mifol & Mouth)	Xhulaj, 2008; Nderjaku, 2019
*Mayamaea permitis (*Hustedt) K.Bruder & Medlin *(=Navicula atomus var. permitis* (Hustedt) Lange-Bertalot)	Bishan	Miho.-
Mastogloia vasta Hustedt	Narte	Xhulaj, 2008
Meridion circulare (Greville) C.A.Agardh	Narte, Vjose (Mifol)	Xhulaj, 2008; Ngjela, 2016;
Navicymbula pusilla (Grunow) Krammer (=Cymbella pusilla Grunow)	Kallenge	Miho,-
Navicula ammophila Grunow (cf.)	Narte	Xhulaj, 2008
Navicula antonii Lange-Bertalot *(=N. menisculus var. grunowii* Lange-Bertalot)	Vjose (Mifol), Dead River (Zhuke)	Miho *et al.,* 2018; Miho,-
Navicula arenaria var. rostellata Lange-Bertalot	Kallenge, Dead River (Zhuke)	Miho,-
Navicula capitatoradiata Germain	Narte, Vjose (Mifol)	Xhulaj, 2008; Miho *et al.,* 2018; Nderjaku, 2019
Navicula cari Ehrenberg	Narte	Xhulaj, 2008
Navicula caterva Hohn & Hellerman	Vjose (Mifol), Bishan	Miho *et al.,* 2018; Nderjaku, 2019*;* Miho,-
Navicula cincta (Ehrenberg) Ralfs	Narte, Kallenge	Xhulaj, 2008; Miho,-
Navicula cryptocephala Kützing	Lagune, Mifol	Protic, 1907; Miho & Witkowski, 2005; Xhulaj, 2008
Navicula cryptotenella Lange-Bertalot	Narte, Vjose (Mifol)	Xhulaj, 2008; Miho *et al.,* 2018
Navicula cryptotenelloides Lange-Bertalot	Vjose (Mifol)	Nderjaku, 2019
Navicula dealpina Lange-Bertalot	Vjose (Mifol)	Miho & Witkowski, 2005; Dedej, 2006; Miho et al., 2018

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Navicula denselineolata (Lange-Bertalot) Lange-Bertalot *(=Navicula pseudolanceolata var. densilineolata* Lange-Bertalot) *(cf.)*	Kallenge	Miho,-
Navicula digitoconvergens Lange-Bertalot	Narte	Xhulaj, 2008
Navicula digitoradiata (W.Gregory) Ralfs	Saline, Narte, Vjose (Mouth)	Protic, 1907; Xhulaj, 2008; Nderjaku, 2019
Navicula directa (W.Smith) Brébisson	Narte	Xhulaj, 2008
Navicula distans (W.Smith) Brébisson	Lagoon	Protic, 1907
Navicula duerrenbergiana Hustedt*, nom. inval.*	Vjose (Mouth), Kallenge	Nderjaku, 2019; Miho,-
Navicula erifuga Lange-Bertalot	Vjose (Mouth)	Nderjaku, 2019
Navicula gregaria Donkin	Narte, Kallenge	Xhulaj, 2008; Miho,-
Navicula hamiltonii Witkowski, Lange-Bertalot & Metzeltin *(cf.)*	Kallenge	Miho,-
Navicula hofmanniae Lange-Bertalot	Narte	Xhulaj, 2008
Navicula libonensis Schoeman	Narte	Xhulaj, 2008
Navicula menisculus Schumann	Narte	Xhulaj, 2008
Navicula meniscus Schumann	Narte	Xhulaj, 2008
Navicula microcari Lange-Bertalot *(cf.)*	Dead River (Zhuke)	Miho,-
Navicula microdigitoradiata Lange-Bertalot	Narte	Xhulaj, 2008
Navicula minima Grunow	Vjose (Mifol)	Nderjaku, 2019
Navicula neowiesneri Chaudev & Kulikovskiy *(=Navicula wiesneri* Lange-Bertalot)	Narte	Xhulaj, 2008
Navicula normaloides Cholnoky *(cf.)*	Kallenge	Miho,-
Navicula oblonga (Kützing) Kützing	Saline, Novosele, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
Navicula oligotraphenta Lange-Bertalot & Hofmann	Narte, Vjose (Mifol)	Xhulaj, 2008; Ngjela, 2016;
Navicula palpebralis Brébisson ex W.Smith	Narte	Xhulaj, 2008
Navicula paul-schulzii Witkowski et Lange-Bertalot	Narte	Xhulaj, 2008

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Navicula pavillardii Hustedt	Narte, Kallenge, Dead River (Zhuke)	Xhulaj, 2008; Miho,-
Navicula peregrina (Ehrenberg) Kützing	Lagoon	Protic, 1907
Navicula perminuta Grunow	Kallenge, Dead River (Zhuke), Saline (Dam), Bishan	Miho,-
Navicula phyllepta Kützing	Narte	Xhulaj, 2008
Navicula phylleptosoma Lange-Bertalot	Narte, Kallenge, Dead River (Zhuke)	Xhulaj, 2008; Miho,-
Navicula radians Héribaud	Mifol, Novosele, Vlore, Saline	Protic, 1907
Navicula radiosa Kützing	Narte, Vjose (Mifol)	Xhulaj, 2008; Miho *et al.,* 2018; Nderjaku, 2019
Navicula ramosissima (C.Agardh) Cleve	Narte, Dead River (Zhuke)	Xhulaj, 2008; Miho,-
Navicula rhynchocephala Kützing	Lagoon, Saline, Narte	Protic, 1907; Miho & Witkowski, 2005
Navicula rostellata Kützing	Narte	Xhulaj, 2008
Navicula salinarum Grunow	Lagoon, Saline, Vjose (Mouth), Narte, Dead River (Zhuke), Bishan	Protic, 1907; Miho & Witkowski, 2005; Xhulaj, 2008; Nderjaku, 2019; Miho,-
Navicula salinicola Hustedt	Kallenge, Lumi Vdekur (Zhuke)	Miho,-
Navicula slesvicensis Grunow	Narte	Xhulaj, 2008
Navicula subrhynchocephala Hustedt	Narte	Xhulaj, 2008
Navicula termes (Ehrenberg) O'Meara	Mifol, Vlore, Narte	Protic, 1907
Navicula transitans Cleve	Narte	Xhulaj, 2008

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Navicula tripunctata (O.F.Müller) Bory (=*Navicula gracilis* Ehrenberg)	Mifol, Saline, Narte, Vjose (Mifol), Dead River (Zhuke); Kallenge (Swamp)	Protic, 1907; Xhulaj, 2008; Miho *et al.,* 2018; Nderjaku, 2019; Miho,-
Navicula trivialis Lange-Bertalot	Narte, Bishan	Xhulaj, 2008; Miho,-
Navicula upsaliensis (Grunow) Peragallo	Narte	Xhulaj, 2008
Navicula veneta Kützing	Narte, Vjose (Mifol)	Xhulaj, 2008; Miho *et al*., 2018; Nderjaku, 2019
Navicula ventricosa Ehrenberg	Narte	Miho & Witkowski, 2005; Dedej, 2006
Navicula viridula (Kützing) Ehrenberg	Narte	Xhulaj, 2008
Navicymbula pusilla (Grunow) Krammer *(=Cymbella pusilla* Grunow)	Narte	Xhulaj, 2008
Neidium affine (Ehrenberg) Pfitzer (=*Navicula iridis* var. *affinis* (Ehrenberg) O'Meara)	Mifol, Novosele, Narte	Protic, 1907
Neidium affine var. *amphirhynchus* (Ehrenberg) Cleve (=*Navicula iridis* var. *amphirhynchus* (Ehrenberg) Van Heurck)	Mifol, Novosele, Narte	Protic, 1907
Neidium binodiforme Krammer	Narte	Xhulaj, 2008
Neidium dubium (Ehrenberg) Cleve	Narte	Xhulaj, 2008
Neosynedra provincialis (Grunow) Williams et Round	Narte	Xhulaj, 2008
Nitzschia acicularis (Kützing) W.M.Smith	Narte	Xhulaj, 2008
Nitzschia agnita Hustedt *(cf.)*	Bishan	Miho,-
Nitzschia amphibia Grunow	Narte	Xhulaj, 2008
Nitzschia aurariae Cholnoky	Narte	Xhulaj, 2008
Nitzschia clausii Hantzsch *(cf.)*	Kallenge	Miho,-
Nitzschia communis Rabenhorst	Vlora	Protic, 1907
Nitzschia commutata Grunow	Bishan	Miho,-
Nitzschia dissipata (Kützing) Grunow	Narte, Vjose (Mifol)	Xhulaj, 2008; Miho *et al*., 2018; Nderjaku, 2019
Nitzschia filiformis (W.Smith) Van Heurck *(cf.)*	Vjose (Mouth)	Nderjaku, 2019

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Nitzschia frustulum (Kützing) Grunow	Narte, Kallenge, Dead River (Zhuke), Saline (Dam)	Xhulaj, 2008; Miho,-
Nitzschia heufleriana Grunow	Mifol	Kupe, 2006
Nitzschia incospicua Grunow	Vjose (Mifol), Bishan	Miho *et al.,* 2018; Nderjaku, 2019; Miho,-
Nitzschia intermedia Hantzsch ex Cleve & Grunow	Narte	Xhulaj, 2008
Nitzschia lacuum Lange-Bertalot	Vjose (Mifol)	Nderjaku, 2019
Nitzschia lanceolata W.M.Smith	Narte	Xhulaj, 2008
Nitzschia linearis (Agarth) W. Smith var. *linearis*	Narte, Vjose (Mifol), Bishan	Miho *et al.,* 2018; Nderjaku, 2019; Miho, -
Nitzschia littorea Grunow *(cf.)*	Kallenge	*Miho,-*
Nitzschia longa Grunow	Narte	Xhulaj, 2008
Nitzschia longissima (Brébisson) Ralfs	Narte	Xhulaj, 2008
Nitzschia media Hantzsch *(=Nitzschia dissipata* var. *media* (Hantzsch) Grunow)	Vjose (Mifol)	Nderjaku, 2019
Nitzschia palea (Kützing) W.Smith	Mifol, Novosele, Vlore, Lagoon, Saline, Vjose (Mouth & Mifol), Narte, Bishan	Protic, 1907; Miho & Witkowski, 2005; Miho *et al.,* 2018; Nderjaku, 2019; Miho,-
Nitzschia paleacea (Grunow) Grunow (=*Nitzschia subtilis* var. *paleacea* Grunow)	Saline, Narte	Protic, 1907
Nitzschia pellucida Grunow	Narte	Xhulaj, 2008
Nitzschia perindistincta Cholnoky *(=Nitzschia fontifuga* Cholnoky*) (cf.)*	Kallenge	Miho,-
Nitzschia perminuta Grunow	Vjose (Mouth)	Nderjaku, 2019
Nitzschia pusilla (Kützing) Grunow	Narte, Vjose (Mifol & Mouth)	Xhulaj, 2008; Nderjaku, 2019
Nitzschia reversa W.Smith	Narte	Xhulaj, 2008
Nitzschia rosenstockii Lange-Bertalot	Narte	Xhulaj, 2008
Nitzschia scalpelliformis Grunow	Narte, Kallenge	Xhulaj, 2008; Miho,-
Nitzschia sigma (Kützing) W.Smith	Lagune	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006

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Nitzschia sigma var. rigidula (H.Peragallo & M.Peragallo) Grunow	Kallenge	Miho,-
Nitzschia sigmoidea (Nitzsch) W.Smith	Narte, Vlore	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006; Xhulaj, 2008
Nitzschia solita Hustedt	Narte	Xhulaj, 2008
Nitzschia subcohaerens var. scotica (Grunow) Van Heurck, *nom. Inval.*	Vjose (Mouth)	Nderjaku (2019)
Nitzschia thermaloides Hustedt	Narte	Xhulaj, 2008
Nitzschia tubicola Grunow	Narte	Xhulaj, 2008
Odontidium anceps (Ehrenberg) Ralfs (=*Diatoma anceps* (Ehrenberg) Kirchner)	Vlora, Narte	Protic, 1907
Odontidium hyemale (Roth) Kützing (=*Diatoma hyemalis* (Roth) Heiberg)	Vlora, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
Odontidium mesodon (Ehrenberg) Kützing *(=Diatoma mesodon* (Ehrenberg) Kützing)	Vjose (Mifol)	Kupe, 2006; Ngjela, 2016
Opephora mutabilis Sabbe & Wyverman, *nom. inval. (=Opephora olsenii* Moeller)	Narte	Xhulaj, 2008
Opephora pacifica (Grunow) Petit	Narte	Xhulaj, 2008
Petroneis humerosa (Brébisson ex W.Smith) Stickle & D.G.Mann	Narte	Xhulaj, 2008
Pinnularia appendiculata (C.Agardh) Schaarschmidt (=*Navicula appendiculata* (C.Agardh) Kützing)	Mifol, Novosele, Vlore, Lagoon, Saline	Protic, 1907
Pinnularia brebissonii (Kützing) Rabenhorst (=*Navicula brebissonii* Kützing)	Mifol, Novosele, Vlore, Lagoon, Saline	Protic, 1907
Pinnularia legumen Ehrenberg (=*Navicula legumen* Ehrenberg)	Mifoli, Kripore, Narte	Protic, 1907
Pinnularia major (Kützing) Rabenhorst (=*Navicula major* (Kützing) Ehrenberg)	Saline, Mifol, Novosele	Protic, 1907
Pinnularia mesolepta (Ehrenberg) W.Smith (=*Navicula mesolepta* Ehrenberg)	Mifol, Vlore	Protic, 1907
Pinnularia nobilis (Ehrenberg) Ehrenberg (=*Navicula nobilis* Ehrenberg)	Saline, Mifol	Protic, 1907

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Pinnularia tabellaria Ehrenberg (=*Navicula tabellaria* (Ehrenberg) Kützing)	Saline, Novosele, Narte	Protic, 1907
Pinnularia viridis (Nitzsch) Ehrenberg (=*Navicula viridis* (Nitzsch) Ehrenberg)	Mifol, Novosele, Vlore, Lagoon, Saline, Bishan	Protic, 1907; Miho,-
Pinnularia viridis var. *commutata* (Grunow) Cleve (=*Navicula commutata* Grunow)	Vlore, Novosele	Protic, 1907
Placoneis dicephala (Ehrenberg) Mereschkowsky (=*Navicula dicephala* Ehrenberg)	Mifol, Novosele, Narte	Protic, 1907
Plagiotropis gibberula Grunow (cf.)	Kallenge	Miho,-
Planothidium frequentissimum (Lange-Bertalot) Lange-Bertalot	Narte	Xhulaj, 2008
Planothidium hauckianum (Grunow) Bukhtiyarova	Narte	Xhulaj, 2008
Planothidium lanceolatum (Brébisson ex Kützing) Lange-Bertalot	Narte	Xhulaj, 2008
Planothidium linkei (Hustedt) Lange-Bertalot	Narte	Xhulaj, 2008
Planothidium rostratum (Østrup) Lange-Bertalot	Narte	Xhulaj, 2008
Pleurosigma angulatum (Quekett) W.Smith	Narte	Xhulaj, 2008
Pleurosigma attenuatum (Kützing) W.Smith	Mifol	Protic, 1907
Pleurosigma elongatum W. Smith	Narte, Kallenge	Xhulaj, 2008; Miho,-
Pleurosigma salinarum (Grunow) Grunow	Dead River (Zhuke), Vjose (Mouth)	Miho,-
Prestauroneis integra (W.Smith) Bruder (=*Navicula integra* (W.Smith) Ralfs)	Saline	Protic, 1907
Prestauroneis protractoides (Hustedt) Q.Liu & Kociolek (=*Parlibellus protractoides* (Hustedt) Witkowski, Lange-Bertalot & Metzeltin)	Narte	Xhulaj, 2008
**Pseudo-nitzschia seriata* (Cleve) H.Peragallo	Narte	Xhulaj, 2008
Pseudostaurosiropsis punctiformis (Witkowski, Metzeltin & Lange-Bertalot) Witkowski, Seddon & Pliński (=*Staurosira punctiformis* Witkowski, Metzeltin & Lange-Bertalot)	Narte	Xhulaj, 2008
Reimeria sinuata (W.Gregory) Kociolek & Stoermer (=*Cymbella sinuata* Gregory)	Vjose (Mifol)	Meço, 2013; Nderjaku, 2019

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Rhoicosphenia abbreviata (C.Agardh) Lange-Bertalot (=*Rhoicosphenia curvata* (Kützing) Grunow)	Vlore, Narte, Vjose (Mouth & Mifol)	Protic, 1907; Xhulaj, 2008; Nderjaku, 2019
Rhopalodia brebissonii Krammer	Narte	Xhulaj, 2008
Rhopalodia constricta (Brébisson) Krammer	Narte, Kallenge, Dead River (Zhuke)	Xhulaj, 2008; Miho,-
Rhopalodia gibba (Ehrenberg) O.Müller (=*Epithemia gibba* (Ehrenberg) Kützing)	Mifoli	Protic, 1907; Xhulaj, 2008
Rhopalodia gibba var. *ventricosa* (Kützing) H.Peragallo & M.Peragallo (=*Epithemia gibba* var. *ventricosa* (Kützing) Grunow)	Mifoli, Bishan	Protic, 1907; Miho,-
Rhopalodia musculus (Kutzing) O.Muller	Narte, Dead River (Zhuke), Saline (Dam)	Xhulaj, 2008; Miho,-
Sellaphora bacillum (Ehrenberg) D.G.Mann (=*Navicula bacillum* Ehrenberg)	Saline, Narte	Protic, 1907; Dedej, 2006
Sellaphora pupula (Kützing) Mereschkowksy	Narte	Xhulaj, 2008
Sellaphora seminulum (Grunow) Mereschkowsky	Narte	Miho & Witkowski, 2005; Dedej, 2006
Seminavis barbarae Witkowski, Lange-Bertalot & Metzeltin *(cf.)*	Dead River (Zhuke)	Miho,-
Skabitschewskia peragalloi (Brun & Héribaud) Kuliskovskiy & Lange-Bertalot (=*Planothidium peragalloi* (Brun & Héribaud) Round & L.Bukhtiyarova)	Narte	Xhulaj, 2008
Stauroneis acuta W.Smith	Mifol, Novosele, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
Stauroneis anceps Ehrenberg	Mifol, Novosele, Vlore, Lagoon, Saline, Bishan	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006; Miho,-
Stauroneis gracilis Ehrenberg	Narte	Xhulaj, 2008

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Stauroneis phoenicenteron (Nitzsch) Ehrenberg	Mifol, Novosele, Vlore, Saline, Narte, Kallenge	Protic, 1907; Dedej, 2006; Miho,-
Stauroneis simulans (Donkin) R.Ross	Narte	Xhulaj, 2008
Staurophora amphioxys (W.Gregory) D.G.Mann (=*Stauroneis gregoryi* Ralfs)	Lagoon, Saline	Protic, 1907
Staurophora anuschkae Witkowski	Narte	Xhulaj, 2008
Staurophora salina (W.Smith) Mereschkowsky (=*Stauroneis salina* W.Smith)	Lagoon, Saline, Narte, Kallenge	Protic, 1907; Dedej, 2006; Xhulaj, 2008; Miho,-
Staurosira binodis (Ehrenberg) Lange-Bertalot	Narte	Xhulaj, 2008
*Staurosira leptostauron (*Ehrenberg) Kulikovskiy & Genkal *(=Fragilaria leptostauron* (Ehrenberg) Hustedt)	Narte	Xhulaj, 2008
Staurosira subsalina (Hustedt) Lange-Bertalot	Narte	Xhulaj, 2008
Striatella unipunctata (Lyngbye) Agardh	Narte, Kallenge, Saline (Dam)	Xhulaj, 2008; Miho,-
Suriraya ovalis var. *minuta* (Brébisson) Gutwinski	Mifol	Protic, 1907
Surirella angusta Kützing	Narte	Xhulaj, 2008
Surirella brebissonii Krammer & Lange-Bertalot	Narte, Vjose (Mifol)	Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019
Surirella librile (Ehrenberg) Ehrenberg (=*Cymatopleura solea* (Brébisson) W.Smith)	Novosele, Lagoon, Narte, Bishan	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006; Miho,-
Surirella minuta Brébisson ex Kützing*, nom. illeg.*	Narte	Xhulaj, 2008
Surirella ovalis Brébisson	Narte	Dedej, 2006; Xhulaj, 2008
Surirella robusta Ehrenberg	Mifol	Protic, 1907
Surirella salina W.Smith (=*Suriraya ovalis* var. *salina* (W.Smith) Gutwinski)	Saline	Protic, 1907
Synedrosphenia crystallina (C.Agardh) Lobban & Ashworth *(=Ardissonea crystallina* (C.Agardh) Grunow)	Kallenge, Saline (Dige)	Miho,-
Tabellaria fenestrata (Lyngbye) Kützing	Mifol, Saline, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006

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Tabellaria flocculosa (Roth) Kützing	Mifol, Saline, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
Tabularia fasciculata (C.Agardh) D.M.Williams & Round *(=Fragilaria tabulata* (C.Agardh) Lange-Bertalot)	Narte, Vjose (Mouth), Kallenge, Dead River (Zhuke), Saline (Dam)	Xhulaj, 2008; Nderjaku, 2019; Miho,-
Tetramphora ostrearia (Brébisson) Mereschkowsky *(=Amphora ostrearia* Brebisson ex Kützing)	Narte	Xhulaj, 2008
Thalassionema nitzschioides (Grunow) Mereschkowsky	Narte	Xhulaj, 2008
Toxarium undulatum J.W.Bailey	Narte	Xhulaj, 2008
Tryblionella angustatula (Lange-Bertalot) Cantonati & Lange-Bertalot *(=Nitzschia angustatula* Lange-Bertalot)	Vjose (Mifol)	Nderjaku, 2019
Tryblionella apiculata W.Gregory *(=Nitzschia constricta* (Kützing) Ralfs)	Narte, Vjose (Mouth & Mifol), Kallenge, Dead River (Zhuke), Saline (Dam)	Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019; Miho,-
*Tryblionella coarctata (*Grunow) D.G.Mann *(=Nitzschia coarctata* Grunow)	Narte	Xhulaj, 2008
Tryblionella compressa (Bailey) Poulin *(=Nitzschia compressa* (Bailey) C.S.Boyer)	Narte, Kallenge	Xhulaj, 2008; Miho,-
Tryblionella compressa (Bailey) Poulin	Vjose (Gryke), Kallenge	*Nderjaku, 2019; Miho,-*
Tryblionella hungarica (Grunow) Frenguelli (=*Nitzschia hungarica* Grunow)	Saline, Narte, Bishan, Vjose (Mouth)	Protic, 1907; Dedej, 2006; Xhulaj, 2008; Miho,-
Tryblionella pararostrata (Lange-Bertalot) Clavero & Hernández-Mariné *(=Nitzschia pararostrata* (Lange-Bertalot) Lange-Bertalot)	Narte, Kallenge, Dead River (Zhuke)	Xhulaj, 2008; Miho,-
Tryblionella punctata var. elongata Grunow *(=Nitzschia compressa* var. *elongata* (Grunow) Lange-Bertalot)	Narte	Xhulaj, 2008
Ulnaria acus (Kützing) Aboal *(=Fragilaria ulna var. acus (*Kützing) Lange-Bertalot)	Vjose (Mifol)	*Kupe, 2006;* Miho *et al.*, 2018;

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Ulnaria biceps (Kützing) Compère *(=Fragilaria biceps* (Kützing) Hustedt)	Vjose (Mifol)	Miho *et al.*, 2018; *Nderjaku, 2019*
Ulnaria capitata (Ehrenberg) Compère (=*Synedra capitata* Ehrenberg)	Mifoli, Saline, Narte	Protic, 1907; Miho & Witkowski, 2005; Dedej, 2006
Ulnaria longissima (W.Smith) Van de Vijver & D.M.Williams (=*Synedra ulna* var. *longissima* (W.Smith) Brun)	Lagoon	Protic, 1907
Ulnaria oxyrhynchus (Kützing) Aboal (=*Synedra ulna* var. *oxyrhynchus* (Kützing) O'Meara)	Vlore, Narte	Protic, 1907
Ulnaria ulna (Nitzsch) Compère (=*Synedra ulna* (Nitzsch) Ehrenberg)	Mifol, Novosele, Vlore, Lagoon, Saline, Vjose (Mouth & Mifol), Kallenge, Bishan	Protic, 1907; Kupe, 2006; Xhulaj, 2008; Miho *et al.*, 2018; Nderjaku, 2019; Miho,-
Ulnaria ulna var. *subaequalis* (Grunow) Aboal (=*Synedra ulna* var. *subaequalis* (Grunow) Van Heurck)	Mifol, Novosele, Vlore, Lagoon, Saline	Protic, 1907
Vanheurckia rhomboides f. *crassinervia* Grunow	Mifol	Protic, 1907
Dinophyceae (Miozoa)		
Akashiwo sanguinea (K.Hirasaka) Gert Hansen & Moestrup *(=Gymnodinium sanguineum* K.Hirasaka)	Narte	Xhulaj, 2008
Alexandrium sp.	Narte	Xhulaj, 2008
Amphidinium sp.	Narte	Xhulaj, 2008
Dinophysis caudata Kent	Narte	Xhulaj, 2008
Dinophysis fortii Pavillard	Narte	Xhulaj, 2008
Dinophysis sacculus F.Stein	Narte	Xhulaj, 2008
Gonyaulax diegensis Kofoid	Narte	Xhulaj, 2008
Gymnodinium sp.	Narte	Xhulaj, 2008
Gyrodinium sp.	Narte	Xhulaj, 2008
Heterodinium sp.	Narte	Xhulaj, 2008
Kryptoperidinium triquetrum (Ehrenberg) Tillmann, Gottschling, Elbrächter, Kusber & Hoppenrath (=*Heterocapsa triquetra* (Ehrenberg) F.Stein)	Narte	Xhulaj, 2008
Noctiluca scintillans (Macartney) Kofoid & Swezy	Narte	Xhulaj, 2008
Ornithocercus magnificus F.Stein	Narte	Xhulaj, 2008
Oxyrrhis marina Dujardin	Narte	Xhulaj, 2008
Oxytoxum sp.	Narte	Xhulaj, 2008
Peridinium sp.	Narte	Xhulaj, 2008

Class, Species name (Synonyms)	**Habitats**	**Author/s**
Phalacroma rotundatum (Claparéde & Lachmann) Kofoid & J.R.Michener *(=Dinophysis rotundata* Claparède & Lachmann)	Narte	Xhulaj, 2008
*Prorocentrum cordatum (*Ostenfeld) J.D.Dodge *(=Prorocentrum minimum* (Pavillard) J.Schiller*)*	Narte	Xhulaj, 2008
Prorocentrum dentatum F.Stein	Narte	Xhulaj, 2008
Prorocentrum lima (Ehrenberg) F.Stein	Narte	Xhulaj, 2008; Miho,-
Prorocentrum micans Ehrenberg	Narte, Narte (Dam)	Xhulaj, 2008; Miho,-
Prorocentrum rotundatum J.Schiller	Narte	Xhulaj, 2008
Prorocentrum scutellum B.Schröder	Narte	Xhulaj, 2008
Protoperidinium bipes (Paulsen) Balech	Narte	Xhulaj, 2008
Protoperidinium depressum (Bailey) Balech	Narte	Xhulaj, 2008
Protoperidinium divergens (Ehrenberg) Balech	Narte	Xhulaj, 2008
Protoperidinium pyriforme subsp. breve (Paulsen) Balech *(=Peridinium breve* (Paulsen) Paulsen)	Narte	Xhulaj, 2008
Protoperidinium pyriforme subsp. *breve* (Paulsen) Balech *(=Protoperidinium breve* (Paulsen) Verdugo-Díaz*, nom. inval.)*	Narte	Xhulaj, 2008
Pyrophacus horologium F.Stein	Narte	Xhulaj, 2008
Scrippsiella acuminata (Ehrenberg) Kretschmann, Elbrächter, Zinssmeister, S.Soehner, Kirsch, Kusber & Gottschling *(=Scrippsiella trochoidea* (F.Stein) A.R.Loeblich)	Narte	Xhulaj, 2008
Tripos muelleri Bory *(=Ceratium tripos* (O.F.Müller) Nitzsch)	Narte	Xhulaj, 2008
Florideophyceae (Rhodophyta)		
Jania rubens (Linnaeus) J.V.Lamouroux	Narte	Meço *et al.*, 2023
Polysiphonia sp.	Narte (Dam)	Miho,-
Phaeophyceae (Heterokontophyta)		
Cladostephus verticillatus (Lightfoot) Lyngbye	Narte	Meço *et al.*, 2023
Cystoseira sp.	Narte	Meço *et al.*, 2023
Xanthophyceae (Ochrophyta)		
Ophiocytium majus Nägeli	Saline	Protic, 1907
Tetraëdron trigonum (Nägeli) Hansgirg (=*Polyedrium trigonum* Nägeli)	Mifol, Saline	Protic, 1907
Vaucheria bursata (O.F.Müller) C.Agardh.(=*V. sessilis* (Vaucher) De Candolle)	Mifol, Novosele	Protic, 1907

Class, Species name (Synonyms)	Habitats	Author/s
Vaucheria geminata (Vaucher) De Candolle	Novosele, Vlore	Protic, 1907
Vaucheria hamata (Vaucher) De Candolle	Novosele, Vlore	Protic, 1907
Euglenophyceae (Euglenozoa)		
Euglena sp.	Narte	Xhulaj, 2008
Coccolithophyceae (Haptophyta)		
Helicosphaera wallichii (Lohmann) Okada & McIntyre *(=Coccolithus wallichii* (Lohmann) Schiller)	Narte	Xhulaj, 2008
Syracosphaera pulchra Lohmann	Narte	Xhulaj, 2008
Dictyochophyceae (Ochrophyta)		
Octactis speculum (Ehrenberg) F.H.Chang, J.M.Grieve & J.E.Sutherland *(=Dictyocha speculum* Ehrenberg)	Narte	Xhulaj, 2008
Cyanophyceae (Cyanophyta)		
Anabaena oscillarioides Bory ex Bornet & Flahault	Vlore	Protic, 1907
Anabaena sp.	Narte	Xhulaj, 2008
Chroococcus minor (Kützing) Nägeli	Novosele	Protic, 1907
Chroococcus minutus (Kützing) Nägeli	Vlore, Mifol	Protic, 1907
Cylindrospermum stagnale Bornet & Flahault	Saline	Protic, 1907
Geitlerinema splendidum (Greville ex Gomont) Anagnostidis (=*Oscillaria leptotricha* Kützing, nom. inval.)	Mifol, Novosele, Vlore, Saline	Protic, 1907
Leptolyngbya blennophila Anagnostidis & Komárek (=*Oscillatoria gloiophila* Grunow ex Gomont)	Saline	Protic, 1907
Leptolyngbya tenerrima (Hansgirg) Komárek (=*Oscillaria tenerrima* Kützing, nom. inval.)	Mifol, Novosele	Protic, 1907
Merismopedia glauca (Ehrenberg) Kützing	Mifol	Protic, 1907
Class, Species name (Synonyms)	**Habitats**	**Author/s**
Nostoc carneum C.Agardh ex Bornet & Flahault	Mifol	Protic, 1907
Oscillatoria froelichii Komárek & Anagnostidis, nom. inval. (=*Oscillaria froelichii* Kützing, nom. inval.)	Mifol, Novosele, Vlore, Saline	Protic, 1907
Oscillatoria spp.	Narte	Xhulaj, 2008; Miho,-
Oscillatoria tenuis C.Agardh ex Gomont	Mifol, Novosele, Vlore, Saline	Protic, 1907
Spirulina sp.	Narte	Xhulaj, 2008

ANNEX II: Microscopic algae form Vjosa Delta.

PLATE I:

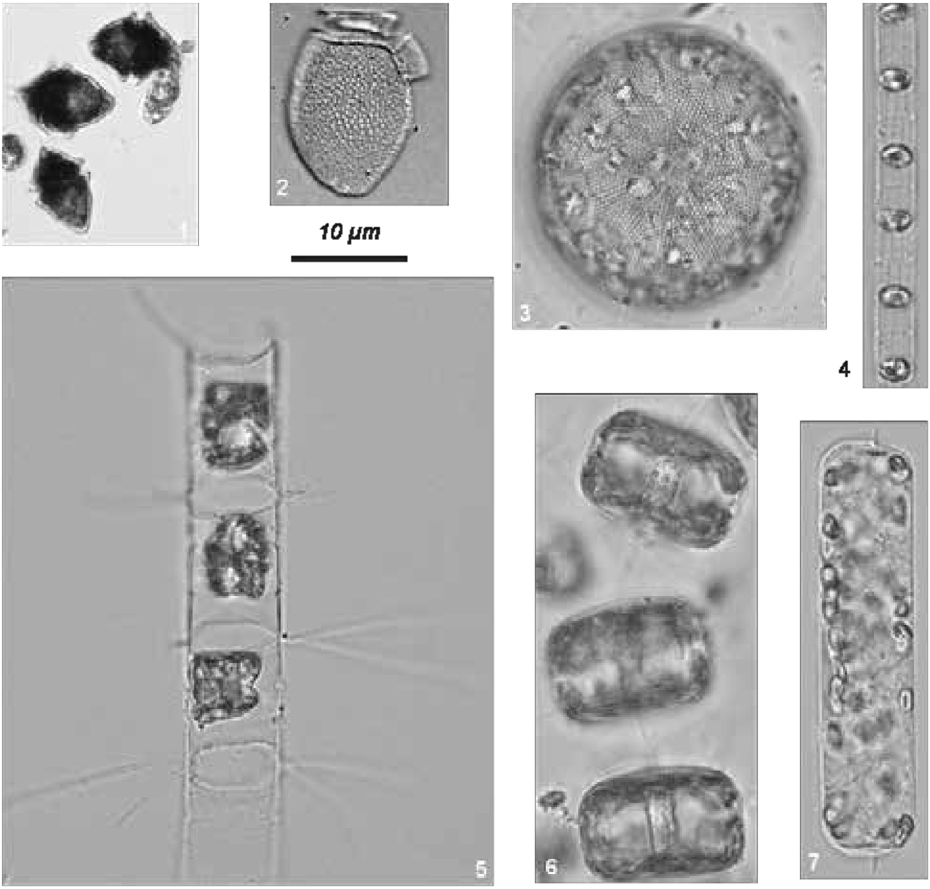

PLATE I:

Microscopic algae from Narta lagoon: **1 & 2**, dynoflagellates: **1**, *Kryptoperidinium triquetrum*; **2**, *Dynophysis sp*.; **3-7**, *diatome rrethore / centric diatoms*: **3**, *Coscinodiscus radiatus*; **4**, Skeletonema costatum; **5**, *Chaetoceros decipiens;* ***6,*** *Thalassiosira sp.;* ***7,*** *Dactyliosolen fragilissimus* (aproximate magnification; photos from Xhulaj, 2008).

PLATE II:

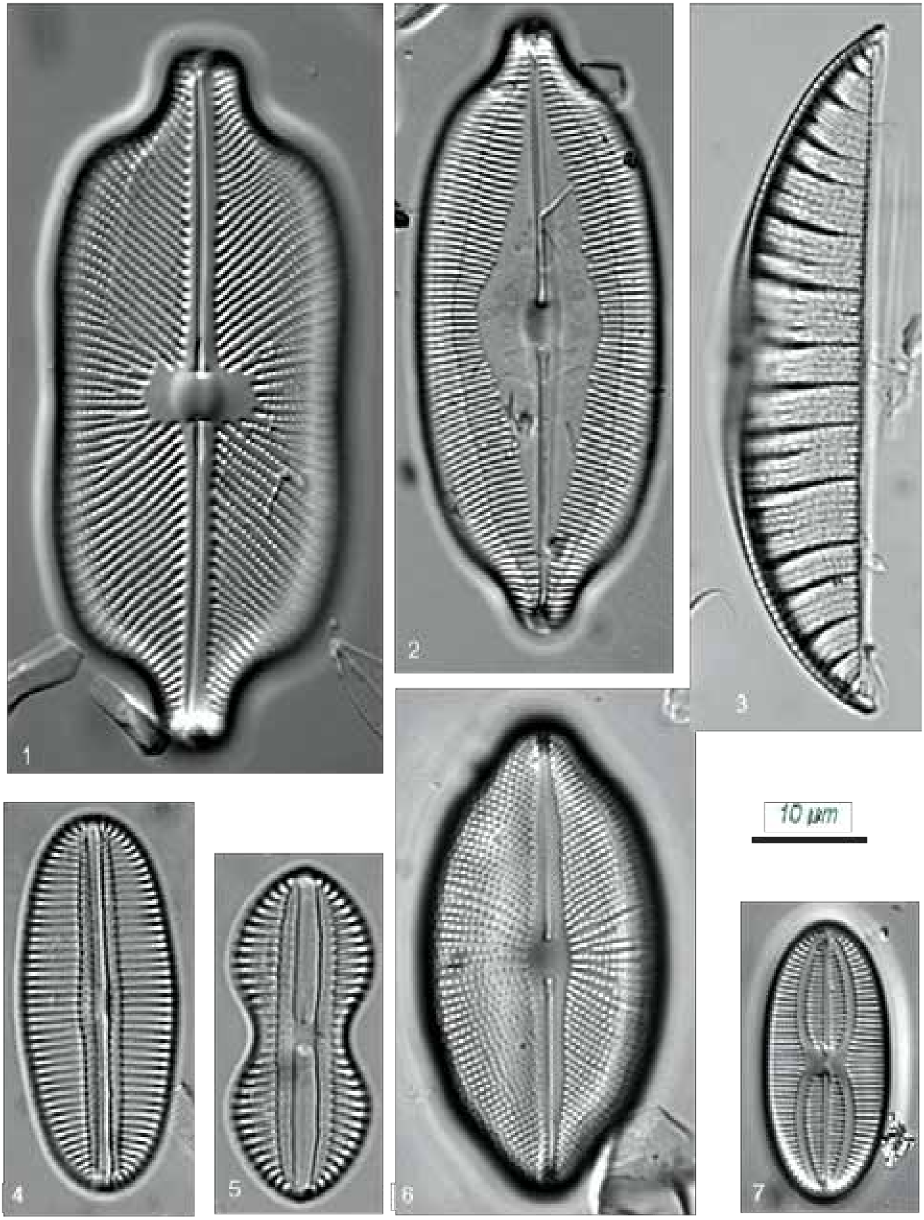

PLATE II:

Microscopic algae (pennate diatoms) from Narta lagoon: **1**, *Petroneis humerosa*; **2**, *Caloneis amphisbaena*; **3**, *Rhopalodia constricta*; **4**, *Diploneis boldtiana*; **5**, *Diploneis interrupta*; **6**, *Cosmioneis eta*; **7**, *Fallacia forcipata* (photos from: Xhulaj, 2008).

PLATE III:

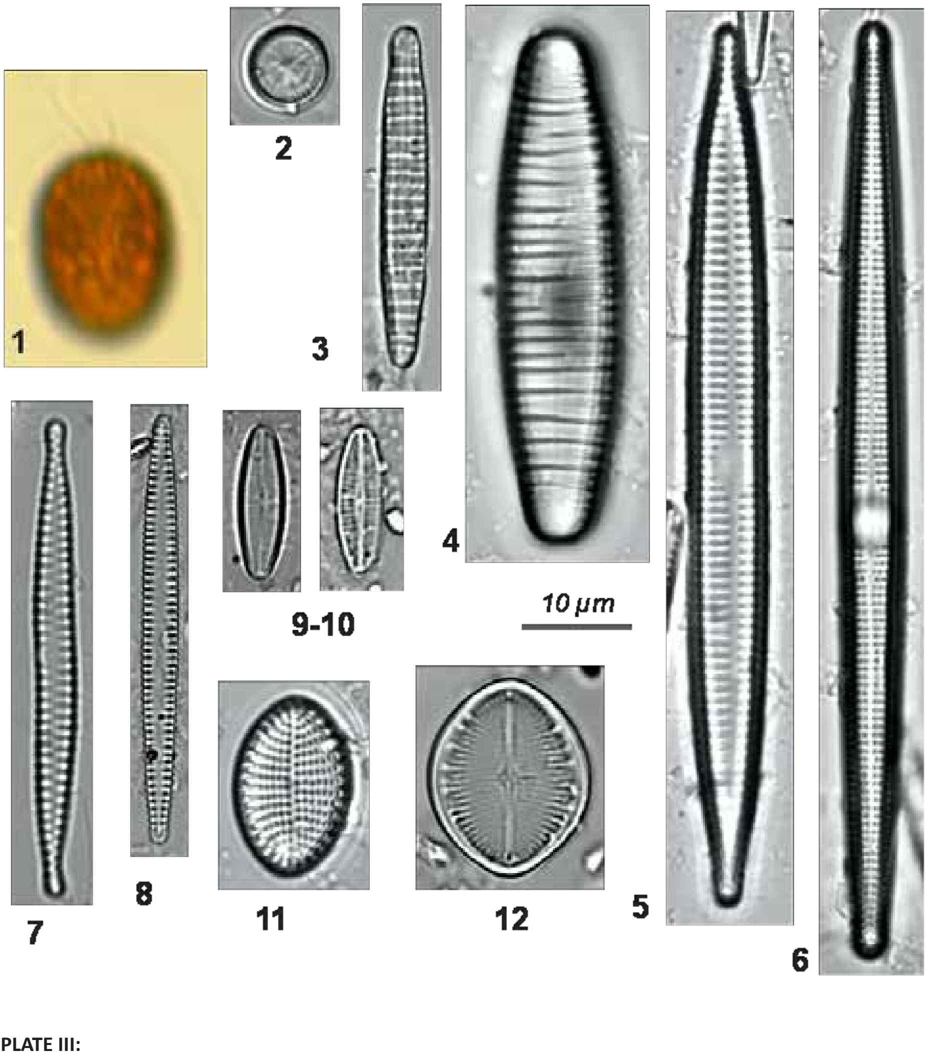

PLATE III:
1, *Dunaliella salina (Chlorophyta)*, Saline, Narte, July 2023; **2**, *Pantocsekiella comensis*, Dead R. (Zhuke), May 2022; **3**. *Diatoma moniliformis*, Delte, October 2016; **4**, *D. vulgaris*, Delte. October 2016; **5**, *Ulnaria ulna*, Delte, October 2016; **6**, *Ctenophora pulchella*, Delte, October 2016; **7**, *Fragilaria vaucheriae*, Mifol (Vjose), April 2017; **8**, *Tabularia fasciculata*, Delte. October 2016; **9-10**, *Achnanthidium biasolettianum*, Delte, October 2016; **11**, *Cocconeis scutellum*, Kallenge, May 2022; **12**, *C. pediculus*, Delte, October 2016 (1500x).

PLATE IV:

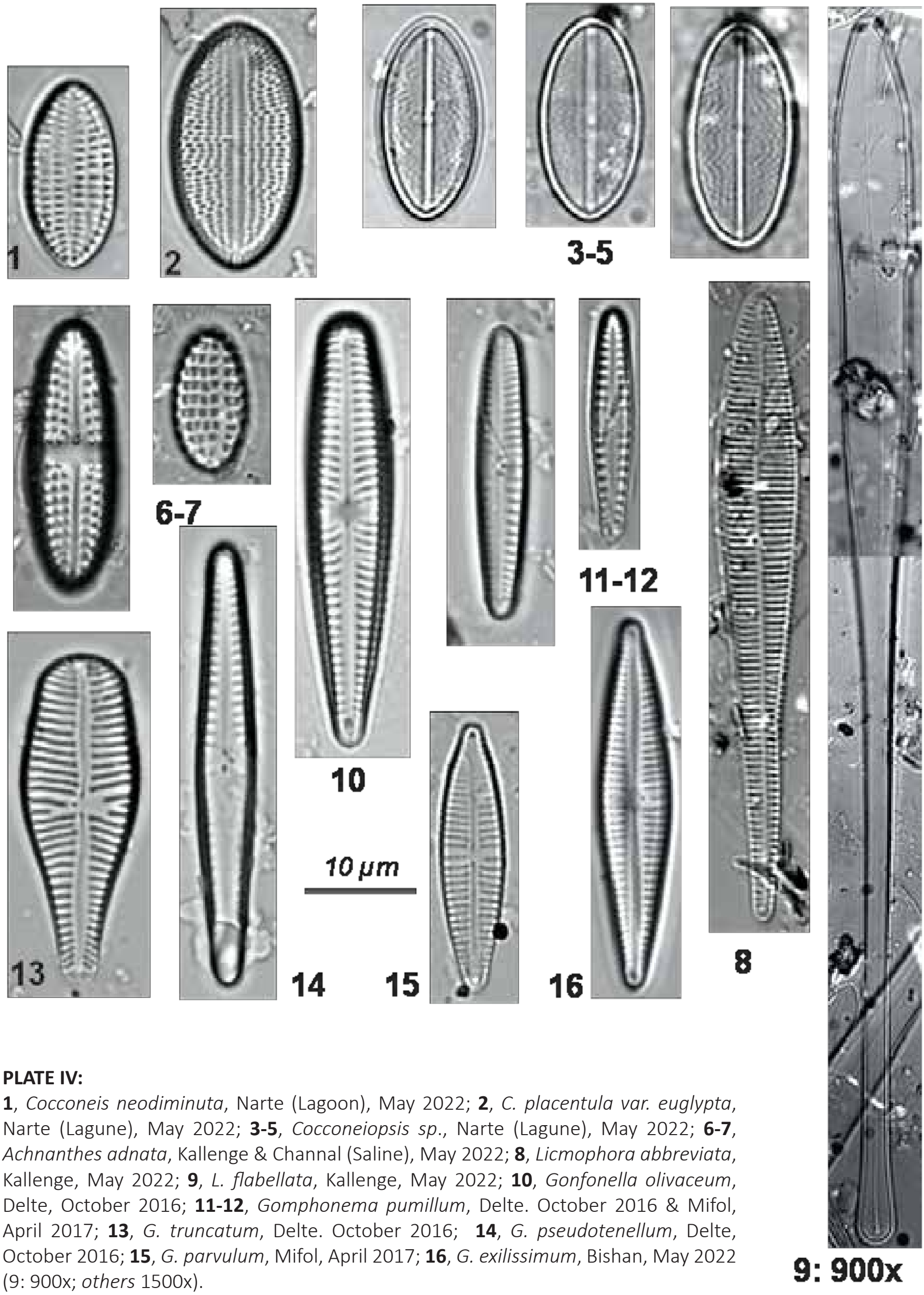

PLATE IV:

1, *Cocconeis neodiminuta*, Narte (Lagoon), May 2022; **2**, *C. placentula var. euglypta*, Narte (Lagune), May 2022; **3-5**, *Cocconeiopsis sp*., Narte (Lagune), May 2022; **6-7**, *Achnanthes adnata*, Kallenge & Channal (Saline), May 2022; **8**, *Licmophora abbreviata*, Kallenge, May 2022; **9**, *L. flabellata*, Kallenge, May 2022; **10**, *Gonfonella olivaceum*, Delte, October 2016; **11-12**, *Gomphonema pumillum*, Delte. October 2016 & Mifol, April 2017; **13**, *G. truncatum*, Delte. October 2016; **14**, *G. pseudotenellum*, Delte, October 2016; **15**, *G. parvulum*, Mifol, April 2017; **16**, *G. exilissimum*, Bishan, May 2022 (9: 900x; *others* 1500x).

PLATE V:

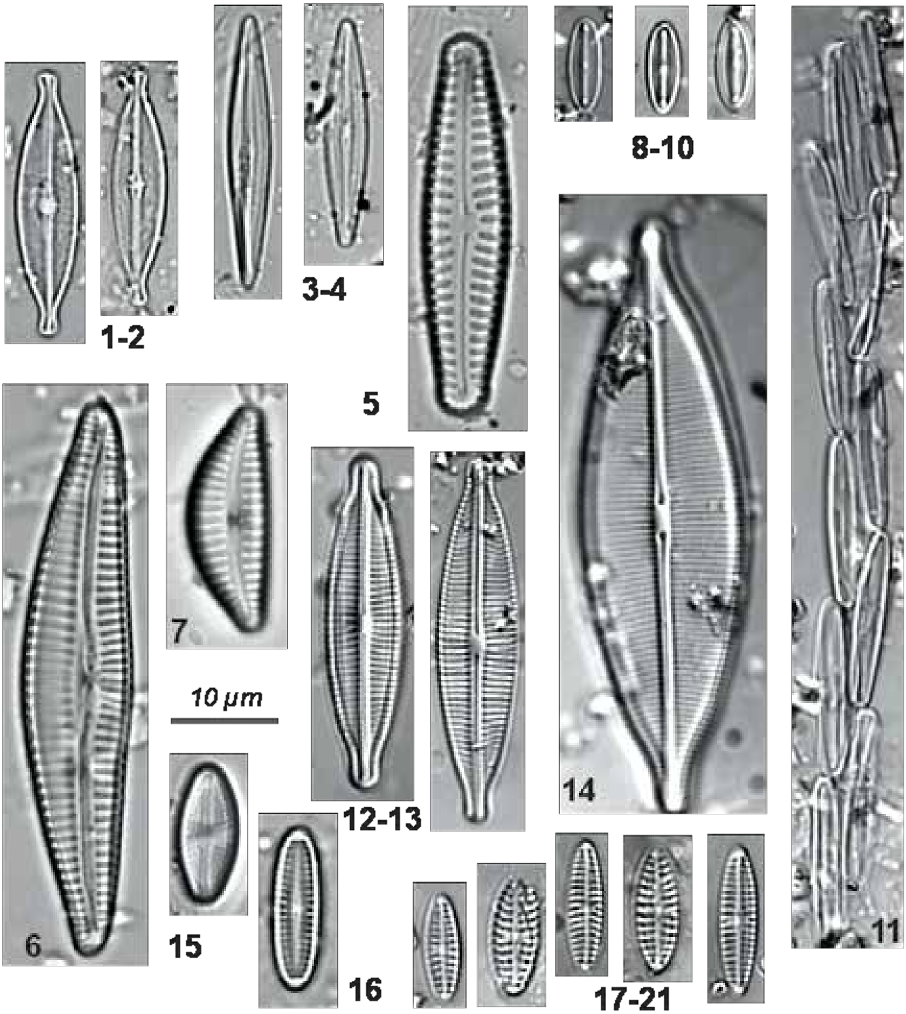

PLATE V:

1-2, *Brachysira neoexilis*, Delte, October 2016; **3-4**, *B. aponina*, Delte, October 2016; **5**, *Encyonema lacustre*, Mifoli, April 2017; **6**, *Cymbella subhelvetica*, Delte, October 2016; **7**, *C. affinis*, Delte, October 2016; **8-10**. *Mayamaea atomus*, Bishan, May 2022; **11**, *Berkeleya rutilans*, Delte, October 2016; **12-13**, *Craticula halophila*, Bishan, May 2022; **14**, *C. cuspidata*, Bishan, May 2022; **15**, *Luticula mutica*, Bishan, May 2022; **16**, *Navicula minima*, Delte, October 2016; **17-21**, *N. perminuta*, Dam (Saline), May 2022 (1500x).

PLATE VI:

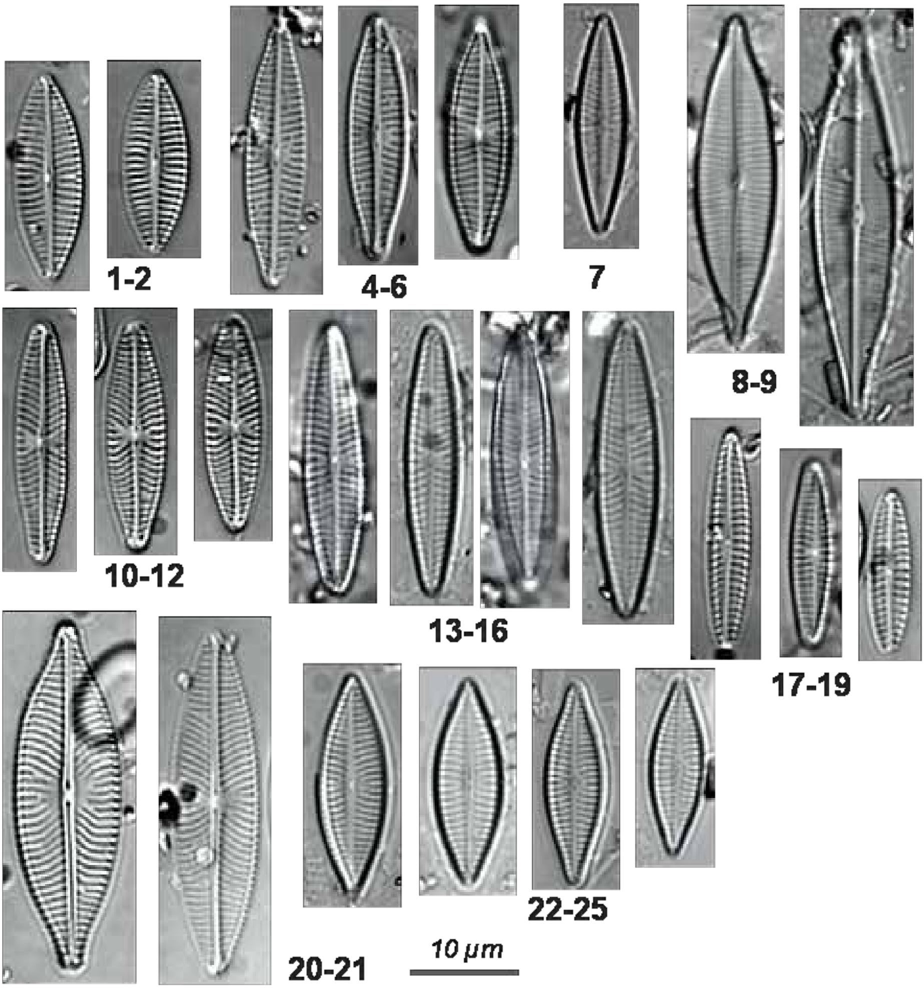

PLATE VI:
1-2, *Navicula antonii*, Dead R. (Zhuke), May 2022; **4-6**, *N. veneta*, Bishan, May 2022; **7**, *N. cryptotenelloides*, Delte, October 2016; **8-9**, *N. gregaria*, Kallenge (Swamp), May 2022; **10-12**, *N. microcari* (*cf.*), Dead R. (Zhuke), May 2022; **13-16**, *Navicula* sp., Kallenge (Swamp), May 2022; **17-19**, *N. salinicola*, Dead R. (Zhuke), May 2022; **20-21**, *N. salinarum var. rostrata*, Kallenge (Swamp), May 2022; **22-25**, *N. phylleptosoma*, Kallenge (Swamp), May 2022; (1500x).

PLATE VII:

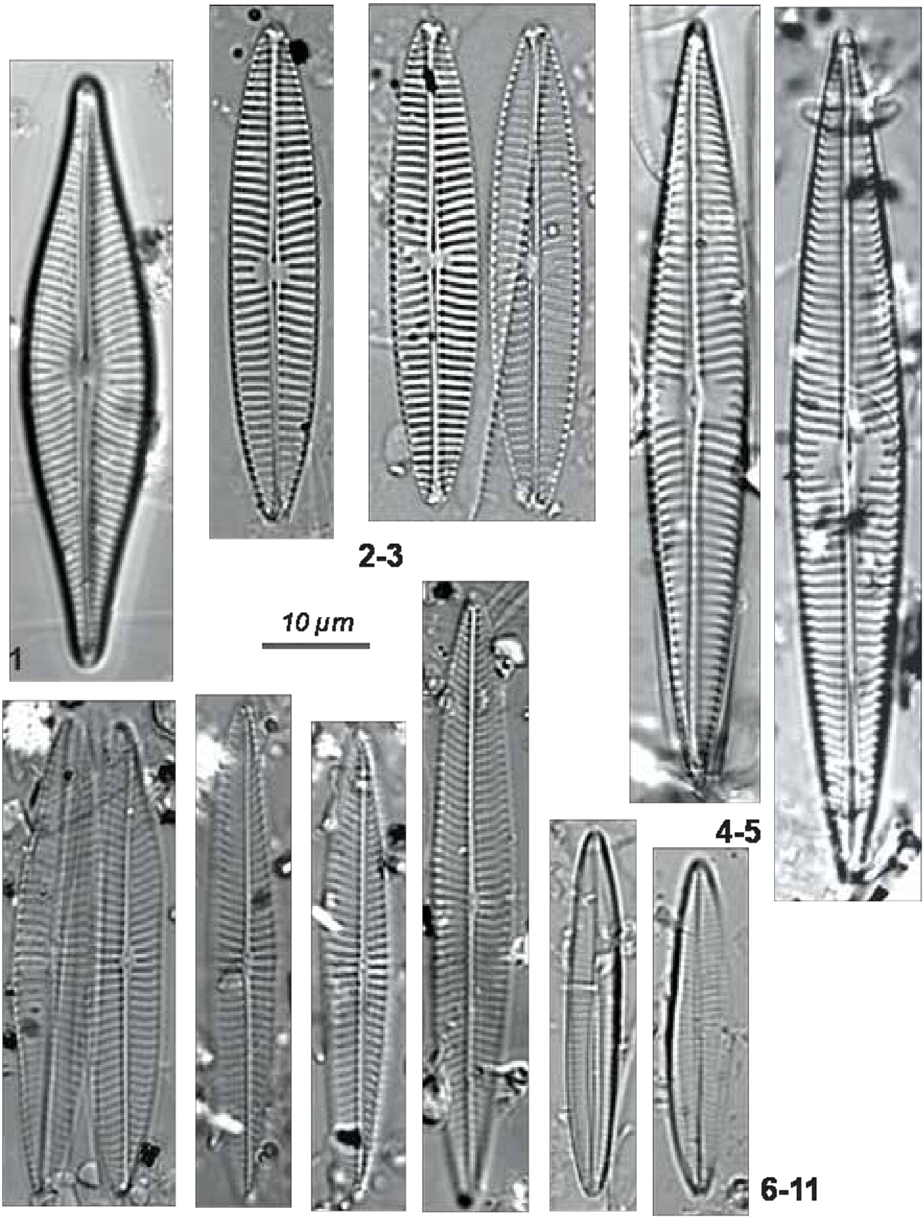

PLATE VII:

1, *Navicula trivialis*, Bishan, May 2022; **2-3**, *N. tripunctata*, Kallenge (Swamp), May 2022 & Mifol, April 2017; **4-5**, *N. arenaria var. rostellata*, Kallenge, May 2022; **6-11**, *Haslea stundlii*, Kallenge, May 2022 & Delte. October 2016 (1500x).

PLATE VIII:

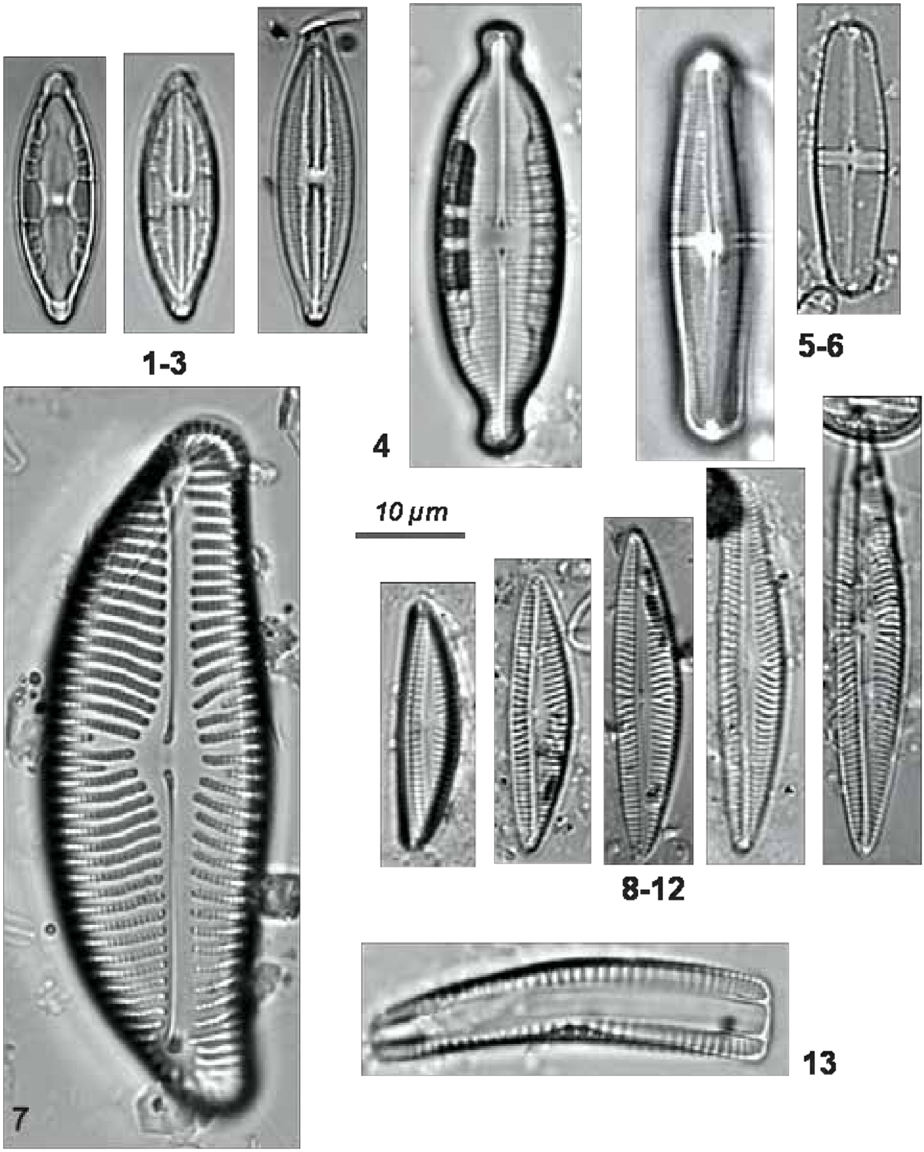

PLATE VIII:

1-3, *Mastogloia pumillum*, Dead R. (Zhuke), May 2022; **4**, *M. smithii*, Delte. October 2016; **5-6**, *Caloneis aequatorialis*, Delte. October 2016 & Mifol, April 2017; **7**, *Encyonema leibleinii*, Mifol (Vjose), April 2017; **8-12**, *Navicymbula pusilla*, Kallenge (Kenete), May 2022; **13**, *Rhoicosphenia abbreviata*, Delte, October 2016 (1500x).

PLATE IX:

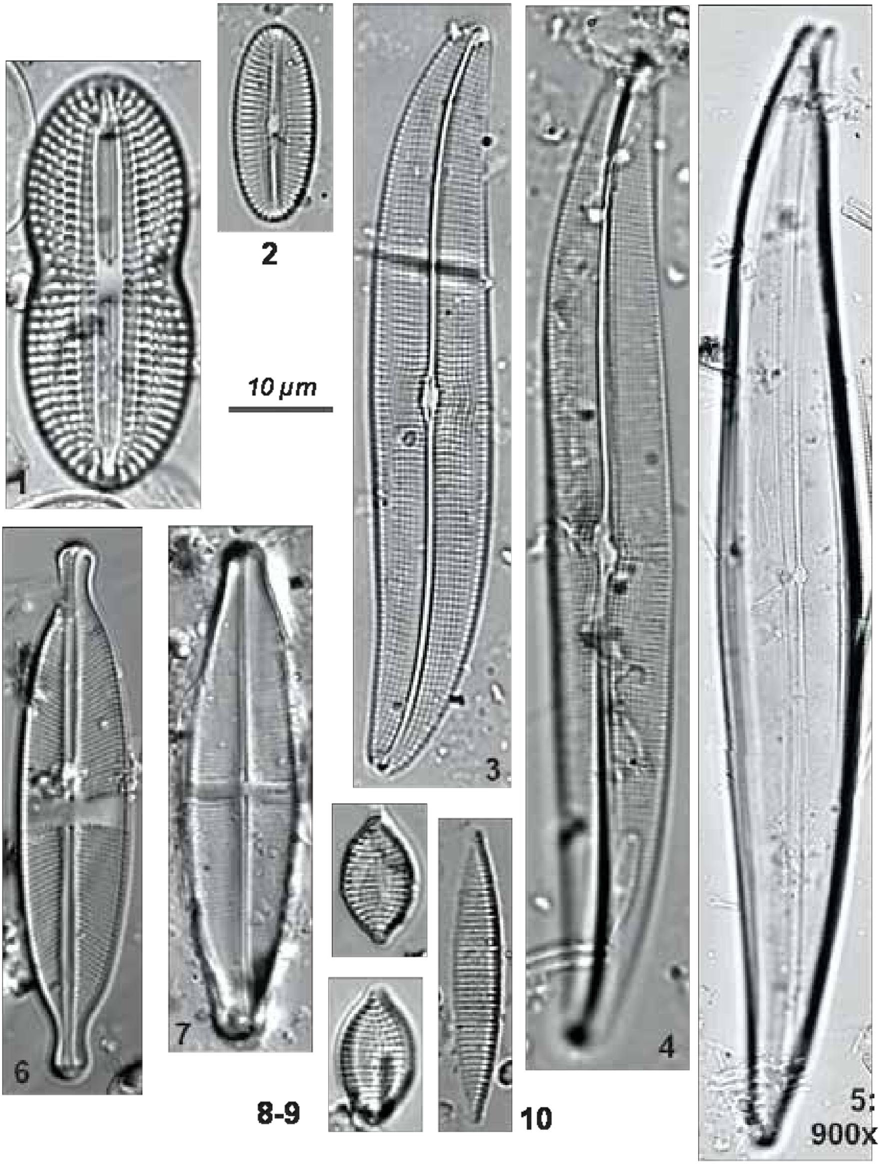

PLATE IX:

1, *Diploneis didymus*, Delte, October 2016; **2**, *D. oblongella*, Delte, October 2016 & Mifol, April 2017; **3**, *Gyrosigma scalproides*, Mifol, April 2017; **4**, *G. nodiferum*, Mifol, April 2017; **5**, *Pleurosigma salinarum*, Delte. October 2016; **6**, *Stauroneis anceps*, Bishan, May 2022; **7**, *S. salina*, Kallenge, May 2022; **8-9**, *Tryblionella pararostrata*, Kallenge & Dead R., May 2022; **10**, *T. angustatula*, Mifol, April 2017 (5, 900x; others 1500x).

PLATE X:

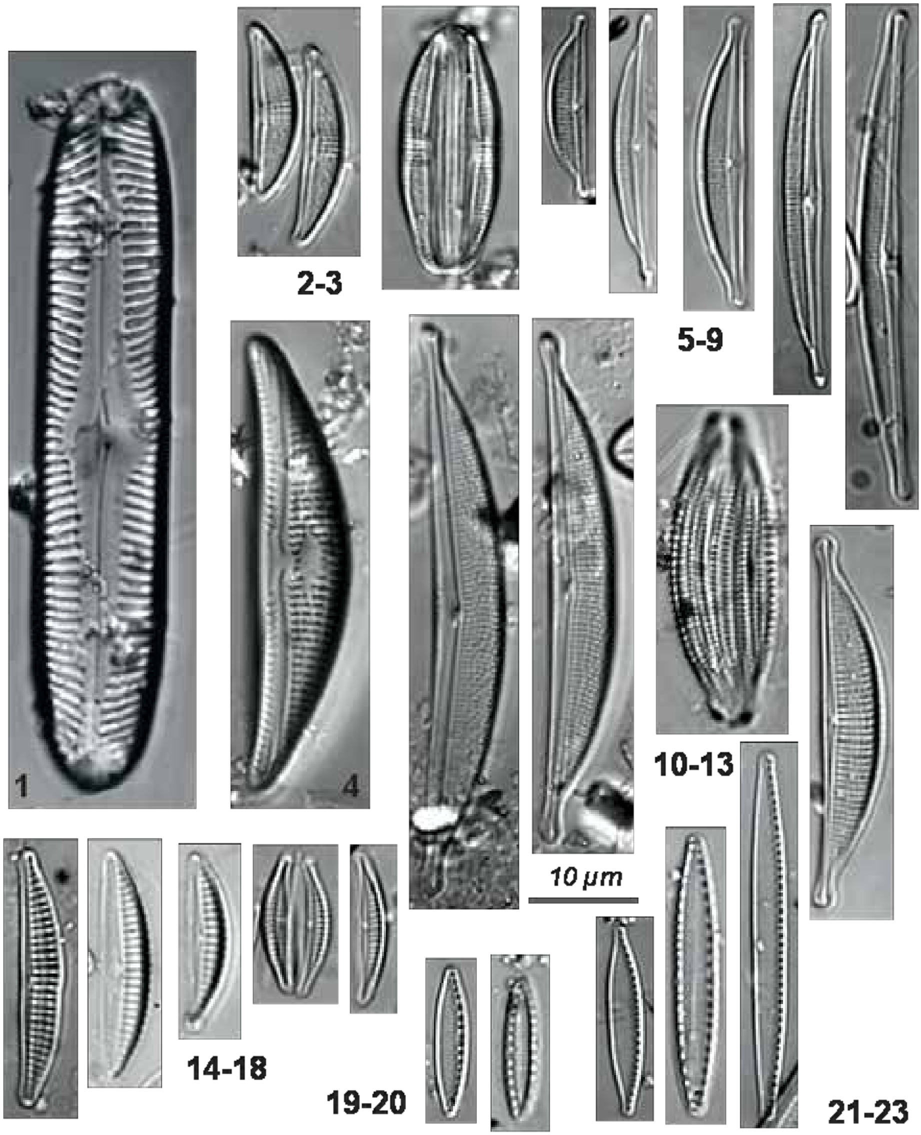

PLATE X:

1, *Pinnularia viridiformis*, Bishan, May 2022; **2-3**, *Amphora veneta*, Bishan, May 2022; **4**, *A. lybica*, Bishan, May 2022; **5-9**, *Halamphora coffeiformis*, Dead R., May 2022; **10-13**, *H. holsatica*, Delte, October 2016 & Dead R., May 2022; **14-18**, *H. luciae (cf.)*. Channel (Dam) & Kallenge (Swamp), Maj 2022; **19-20**, *Nitzschia incospicua*, Bishan, Maj 2022; **21-23**, *N. palea*, Bishan, May 2022 (1500x).

PLATE XI:

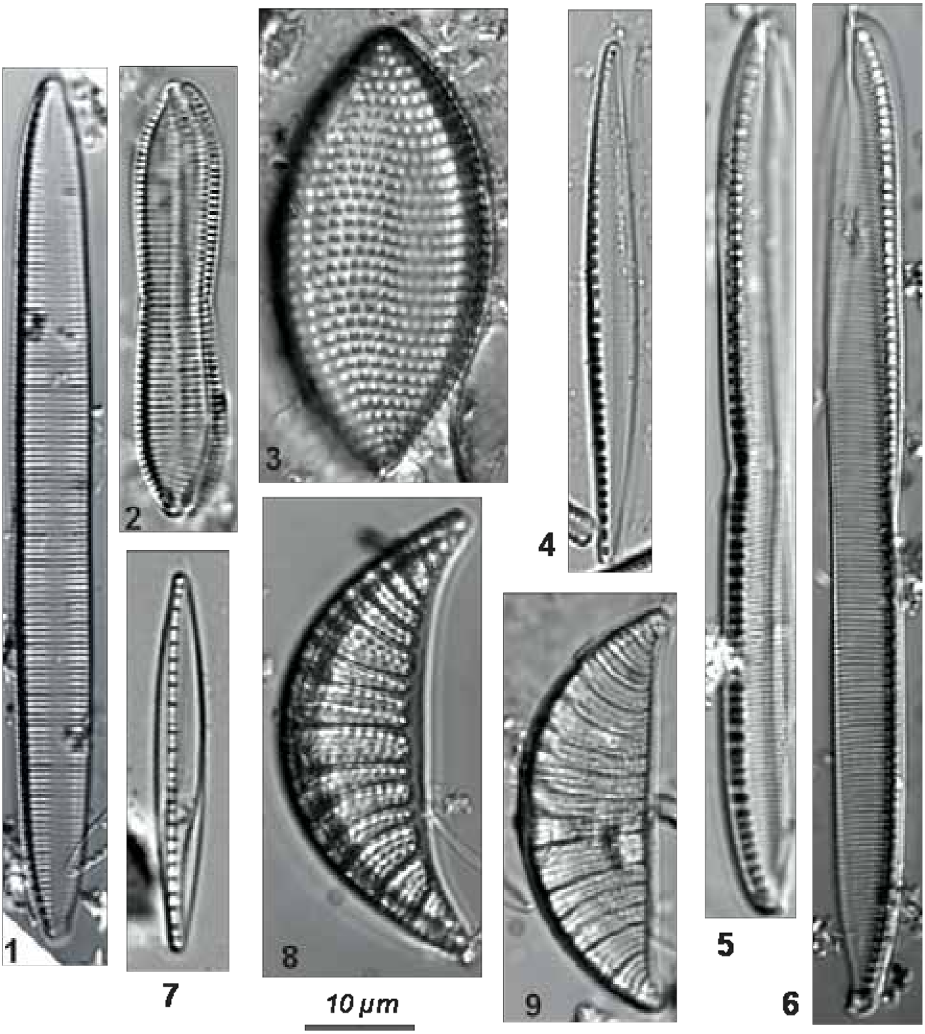

PLATE XI:

1, *Tryblionella hungarica*, Bishan, May 2022; **2**, *T. apiculata*, Delte, October 2016; **3**, *T. compressa*, Kallenge (Swamp), May 2022; **4**, *Nitzschia subcohaerens var. scotica*, Delte, October 2016; **5**, *N. commutata*, Mifol, April 2017; **6**. *N. linearis*, Mifol, April 2017; **7**, *N. dissipata*, Delte, October 2016; **8**, *Rhopalodia musulus*, Dead R. (Zhuke), May 2022; **9**, *R. constricta*, Kallenge (Swamp), May 2022 (1500x).

PLATE XII:

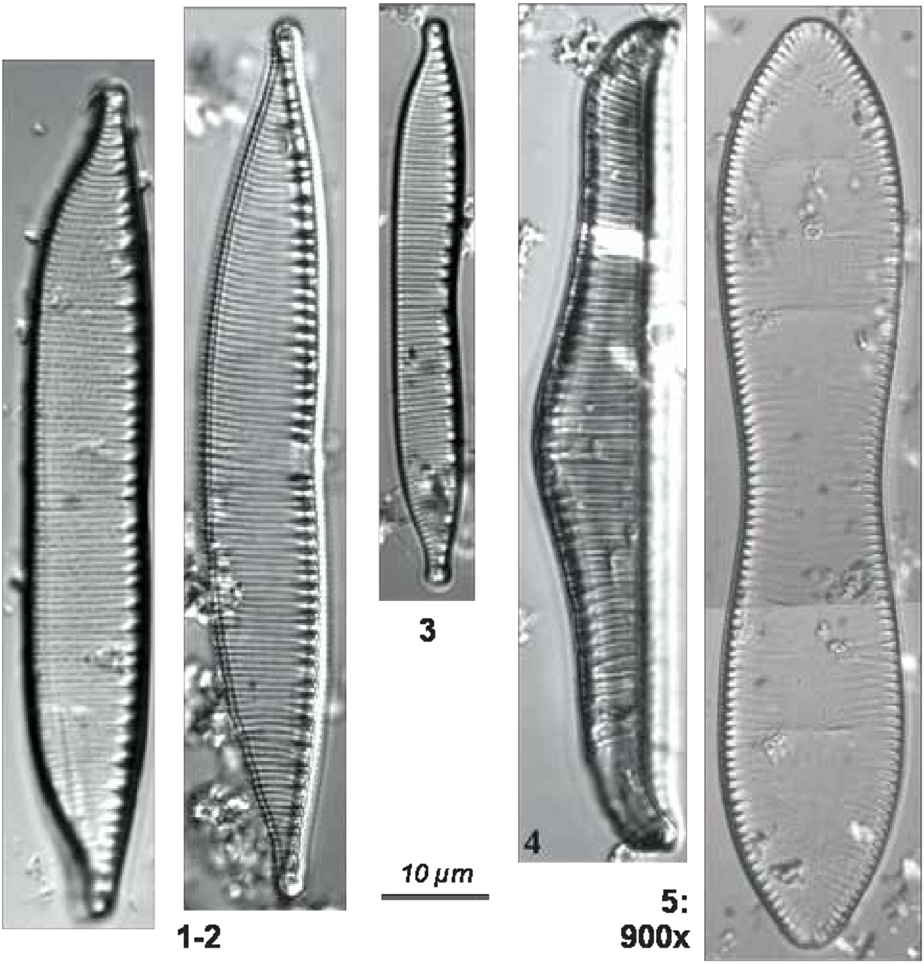

PLATE XII:
1-2, *Hantzschia virgata*, Bishan, May 2022; **3**, *H. amphyoxis*, Bishan, May 2022; **4**, *Rhopalodia gibba*, Bishan, May 2022; **5**, *Surirella librile*, Bishan, May 2022 (5: 900x; others 1500x).

Flora, vegetation and natural habitats of the Vjosa Delta

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Summary

The Vjosa Delta is a wetland complex of international importance that stretches from the dunes and wetlands of Darzeze/Poro, Fieri, to the Narta Lagoon, Vlora; about 160 km² is part of the Pishe Poro - Narta Protected Landscape (Category V, IUCN) (VKM/DCM 694/2022). It is a well-known area for its special flora and diversity of habitats. Some species are very rare for Albania, others have important scientific values, and a high number of species are widely used in the economy as medicinal, aromatic, industrial and decorative plants.

The area's floristic, vegetation and habitats values are presented here, seen from the conservation point of view and sustainable development for the present and future generations. **About 770 species / subspecies and 18 habitats listed in the Habitats Directive, of which 6 are priority habitats (*) are known to date**. Worth to note the high number of national and international importance species. **There are 120 species with a conservation status; 41 have a national status and 99 have international status**. They are widespread in different habitats, i.e. sand dunes, Mediterranean juniper thickets, coniferous forests, water depressions, or in lagoons and canals.

The different plant formations proves that this area is and of great interest for biodiversity and scientific research. However, **the protected landscape of Pisha Poro - Narta is one of the areas with high tourist attraction, which also brings high anthropogenic impact on sensitive habitats. Some of the biggest pressures in the area are: urbanisation, beach cleaning, cutting/burning of trees and spread of non-native and invasive species.**

A short history about the flora and vegetation studies in the Vjosa Delta area

Data on the flora and vegetation of the Delta area are relatively scarce and not easily available. Moreover, they seem to be partial and sporadic, and more focused in the area of the Vlora Delta.

The first floristic data from the Vjosa Delta date from the end of the 19th - beginning of the 20th century. The famous Italian botanist Antonio Baldacci reports the first floristic data from this territory of Albania in 1896 (Baldacci, 1896). About 20 years later, in the spring of 1915, the Italian Captain Alberto Piroli, commander of the Vlora garrison in the Italian army, collected plants in the surroundings of the Vlora city. The plant material was identified and published by the Italian botanist Renato Pampanini (1875-1949), at that time engaged in the Botanical Institute of Florence. The work includes a list of 85 common species from Narta, Zvërneci and the hills around the city (Pampanini, 1915).

From the Albanian researchers, Mullaj (1989) brings data on the Albanian coastal vegetation with geobotanical relevees, including also in the Delta area. The floristic data is given then in general or reporting form by Xhulaj & Mullaj (2002), MoE (2009), Topi *et al*. (2013), MIE (2019a), PDZRK (2019), Imeri *et al*. (2018), etc. In their preliminary report, Topi *et al*. (2013) provide descriptive data on the habitats of the natural ecosystem of Narta, including the vegetation structure. They also provide a general list of 194 species of higher plants, a list of rare species (2 endemic, 8 rare and 66 notworthy species), and a list of 25 threatened species according to the IUCN. Based on existing data, Miho *et al*. (2013) among others provide also an overview of the main habitats and their floristic composition.

Buzo (2000) provides also data on the flora and vegetation of the Vjosa Delta, for the Vlora part. There is no value for the total number of species, but floristic data are given for specific areas: for Poro 571 species, Novosela 465 species, Pine 409 species, and Scrofotina 487 species. It is emphasized that the habitats and flora of the zone are diverse, scientifically and economically important, and under the pressure at the same time. Of particular interest are the species: *Petrosimonia oppositifolia, Sencecio vernalis, Tamarix hampeana, Peucedanum arenarium and Pholiurus panonicus*. In addition, rare, endemic and relict plants such as: *Ephedra distachya, Orchis albanica*, were found on the beaches along the coast. *Marsilea quadrifolia* a relict species was mentioned in wetlands, etc. Other rare and particularly beautiful plants such as: *Narcissus poeticus, Nymphaea alba, Nuphar lutea, Nymphoides peltata* and various genera of *Orchis* sp., *Scilla* sp., etc. were also mentioned (Fig. 1).

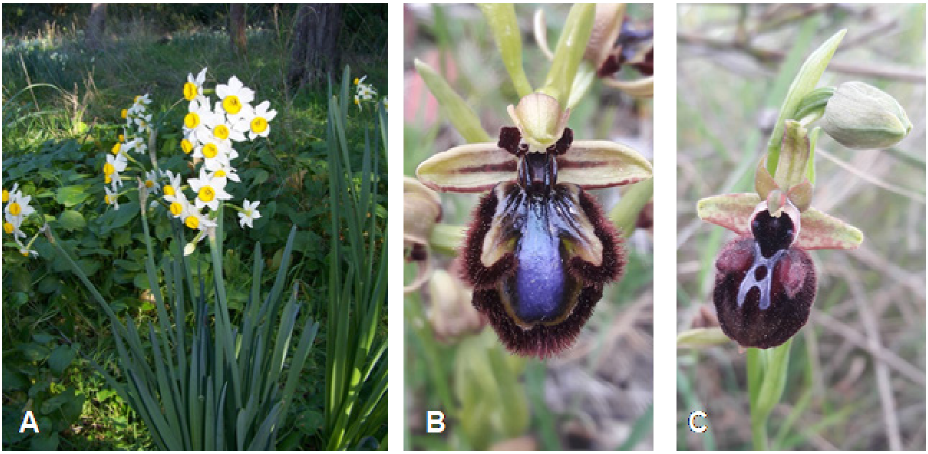

Figure 1.
A, *Narcissus tazetta* from Zverneci Island; **B**, *Ophrys speculum*; **C**, *O. sphegodes* from the Dellinja wetlands. (photos from: A. Miho (A), M. Meço (B&C))

Recently, Meço *et al*. (2023) describe the floristic richness of the Narta - Pishe Poro area, the distribution of the most important species, their values and mapping, human impact and existing threats. These data, in more detail, will be also discussed here.

Richness and floristic values of the Delta

The area of the Vjosa Delta (Darzeza, Fieri to Narta, Vlora) is distinguished by high diversity of flora, vegetation and habitats types, which will be the subject of this review. About 160 km² of this area is part of the Pishe Poro–Narta Protected Landscape (Vlora & Fieri) (V^{th} Category according IUCN) (VKM/DCM 694/2022).

The presence of 770 plant species is known for the Delta area (ca. 20% of Albanian flora). 764 (98%) are phanerogams, 6 species are ferns (1%) (Mullaj, 1989; Corine, 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MoE, 2009; Topi *et al*., 2013; Barina *et al*., 2017; Imeri *et al*., 2018; MIE, 2019; PDZRK, 2019; Mahmutaj *et al*., 2020; Meço *et al*., 2023, etc.). In the Appendix I, the checklist of the higher plant species known to date for the Vjosa Delta area is reported.

120 plant species are with conservation status: 41 species are listed in the Albanian Red List (Urdhër 1280/2013), 99 species are part of IUCN Red List (2016) and 20 species are in both lists (Tab. 1).

Figure 2.
Location where the endangered species in Albanian Red List were found.

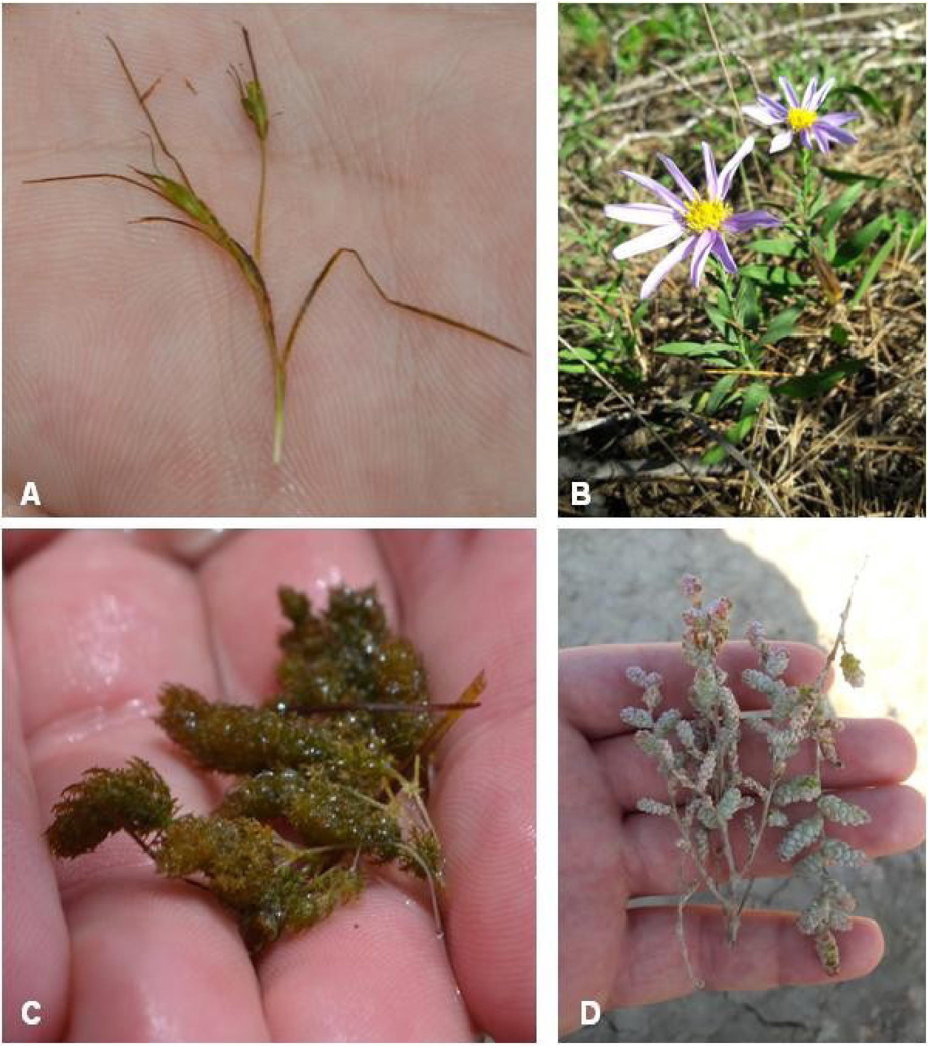

Figure 3.
Rare plants from the Vjosa Delta.
A, *Althenia filiformis*; **B**, *Galatella albanica*; **C**, *Lamprothamnium papulosum*; **D**, *Halopeplis amplexicaulis*. (Photos by: M. Meço).

Table 1.
Checklist of plant species with conservation status in the Vjosa Delta. AL LK / RL, Albanian Red List (2013); IUCN, IUCN Red List (EUNIS, 2019).

Species name	Al RL	IUCN
Polypodiophyta		
Equisetum arvense	-	LC
Equisetum palustre	-	LC
Equisetum telmateia	-	LC
Gymnospermae		
Juniperus communis	VU A1b	LC
Juniperus macrocarpa	-	LC
Pinus pinea	EN A2c	LC
Angiospermae - Eudicotidae		
Adiantum capillus-veneris	-	LC
Aegilops triuncialis	-	LC
Agrimonia eupatoria	-	LR
Alisma lanceolatum	-	LC
Alisma plantago-aquatica	-	LC
Alnus incana	-	LC
Apium graveolens	-	LC
Bidens tripartita	-	LC
Butomus umbellatus	VU A1b	LC
Capparis spinosa	VU A1b	-
Centaurium erythraea	-	LC
Centaurium pulchellum	-	LC
Cephalanthera rubra	-	LC
Cichorium intybus	-	LC
Cyperus flavescens	-	LC
Daucus carota	-	DD
Daucus guttatus	-	DD
Desmazeria marina	VU A1b	NE
Digitalis lanata	LR cd	LR
Hordeum bulbosum	-	LC
Hypericum perforatum	EN A1b	LC
Laurus nobilis	EN A1b	LC
Lemna minor	-	LC
Lepidium ruderale	-	LC
Lotus cytisoides	EN A1b	-
Luzula forsteri	-	DD
Lycopus europaeus	-	LC
Lythrum salicaria	-	LC
Malus sylvestris	-	DD
Medicago lupulina	-	LC
Medicago minima	-	LC
Melilotus officinalis	-	LC
Mentha aquatica	-	LC
Mentha pulegium	-	LC
Nasturtium officinale	-	LC
Origanum vulgare	EN A1b	LC
Petrosimonia oppositifolia	CR A1c	-
Platanus orientalis	VU A2b	LC
Populus alba	VU A2b	-
Populus nigra	-	LC
Potamogeton crispus	-	LC
Potamogeton natans	-	LC
Prunus spinosa	-	LC
Quercus coccifera	-	LR
Quercus ilex	EN A1b	-
Quercus robur	VU A1b	-
Ranunculus peltatus subsp. *baudotii*	-	LC
Salix alba	-	LC

Species name	Al RL	IUCN
Salix amplexicaulis	-	LC
Sambucus nigra	VU A1b	-
Silene vulgaris	-	LC
Sparganium erectum	-	LC
Spyrodela polyrhiza	-	LC
Tamarix hampeana	VU A2b	-
Tamarix parviflora	-	LC
Teucrium scordium	-	LC
Trifolium angustifolium	-	LC
Trifolium nigrescens	-	LC
Trifolium patens	-	LC
Trifolium repens	-	LC
Ulmus campestris	VU A2b	-
Ulmus glabra	VU A1c	-
Ulmus minor	VU A2b	-
Urtica dioica	-	LC
Veronica anagallis-aquatica	-	LC
Veronica beccabunga	-	LC
Vicia bithynica	-	LC
Vicia lutea	-	LC
Vicia sativa	-	LC
Vitis sylvestris	-	LC
Vulpia ciliata	-	LC
Zostera noltii	VU A2d	NE
Angiospermae - Lilianae		
Agrostis stolonifera	-	LC
Allium roseum	-	LC
Althenia filiformis	-	DD
Ammophila arenaria	EN A1b	-

Species name	Al RL	IUCN
Anacamptis laxiflora	VU A1b	LC
Anacamptis pyramidalis	VU A1b	LC
Arundo donax	-	LC
Arundo plinii	-	LC
Asparagus acutifolius	-	LC
Asphodelus macrocarpus	-	LC
Avena fatua	-	LC
Carex distans	-	LC
Cyperus fuscus	-	LC
Cyperus longus	-	LC
Eleocharis palustris	-	LC
Eriophorum angustifolia	-	LC
Gladiolus palustris	LR nt	DD
Holcus lanatus	-	LC
Iris pseudacorus	VU A2b	LC
Juncus articulatus	-	LC
Juncus bufonius	-	LC
Juncus effusus	-	LC
Ophrys apifera	VU A1b	LC
Ophrys bertolonii	VU A1b	LC
Ophrys bombyliflora	VU A1b	LC
Ophrys ferrum-equinum	VU A1b	LC
Ophrys fusca	VU A1b	LC
Ophrys lutea	VU A1b	LC
Ophrys scolopax	VU A1b	LC
Ophrys speculum	VU A1b	LC
Ophrys sphegodes	VU A1b	LC
Ophrys umbilicata	VU A1b	LC
Orchis albanica	EN A1b	NE

Species name	Al RL	IUCN
Orchis coriophora	VU A1b	LC
Orchis morio	VU A1b	LC
Orchis x paparisti	Vu A1b	-
Pancratium maritimum	EN A1b	LC
Phragmites australis	-	LC
Poa pratensis	-	LC
Posidonia oceanica	VU A2d	NE
Ruppia maritima	-	LC

Species name	Al RL	IUCN
Ruscus aculeatus	-	LC
Serapias parviflora	-	LC
Serapias vomeracea	-	LC
Typha angustifolia	-	LC
Typha latifolia	-	LC
Zannichellia palustris	-	LC
Zostera marina	VU A2d	NE

Petrosimonia oppositifolia has the higher conservation status at the national level as "*critically endangered*" (CR). Also, 8 species have the status "*endangered*" (EN), 28 species are "*vulnerable*" (VU) and 2 species are considered as "*least risk*" (LR). Most of the species that have a conservation status according to the IUCN belong to the lowest conservation category and specifically "*low risk*" (LC). There is not enough data for *Gladiolus palustris*, *Luzula forsteri*, *Daucus carota*, *D. guttatus* and *Malus sylvestris*, classified as DD. *G. palustris* and *Anacamptis pyramidalis* are listed in the European Habitat Directive 92/43/EEC (Annex II and IV), too.

The data about the endangerment degree and the conservation status of flora species of the Pishe Poro - Narta Protected Area should be taken into account in any possible conservation and management plan. The distribution of important plant species in Delta area is shown in the map of figure 2, whereas in figure 3 there are photos of some of the rare plants.

The Vjosa Delta lies in a plain, coastal relief, where human presence is almost everywhere. However, in this area, there are rare plant species for the country and beyond. In the area were found sub-endemic species such as: *Galatella albanica, Achillea baldaccii* and *Silene cephallenia*.

The Delta area is also important for sheltering species without any conservation status or with a wide areal in general; but in Albania they occur only in Delta area according to Barina *et al*. (2017), and it is important for our national biodiversity conservation. Such species are: *Halopeplis amplexicaulis, Isoetes histrix, Arthrocnemum perenne, Chamaemelum fuscatum, Euphorbia pinea, Glycyrrhiza glabra, Sphenopus divaricatus, Ononis variegata, Thymelaea hirsuta* (Fig. 3).

Figure 4.
a, Salt pan pond with *Ruppia, Althenia, Zannichellia pedunculata, Lamprothamnium papulosum*, June 20, 2013; **b**, *Althenia filiformis* associated with Riella macrocarpa (*arrows*) in an abandoned salt pan pond, April 19, 2016; **c**, Dam pond with *Ruppia* sp., *Tolypella hispanica*, *Chara galioides*, March 31, 2016; **d**, pond in Zverneci, with *Ranunculus peltatus subsp*. *baudotii* and *Chara aspera*, in April 27, 2023. (Photos by: L. Kashta).

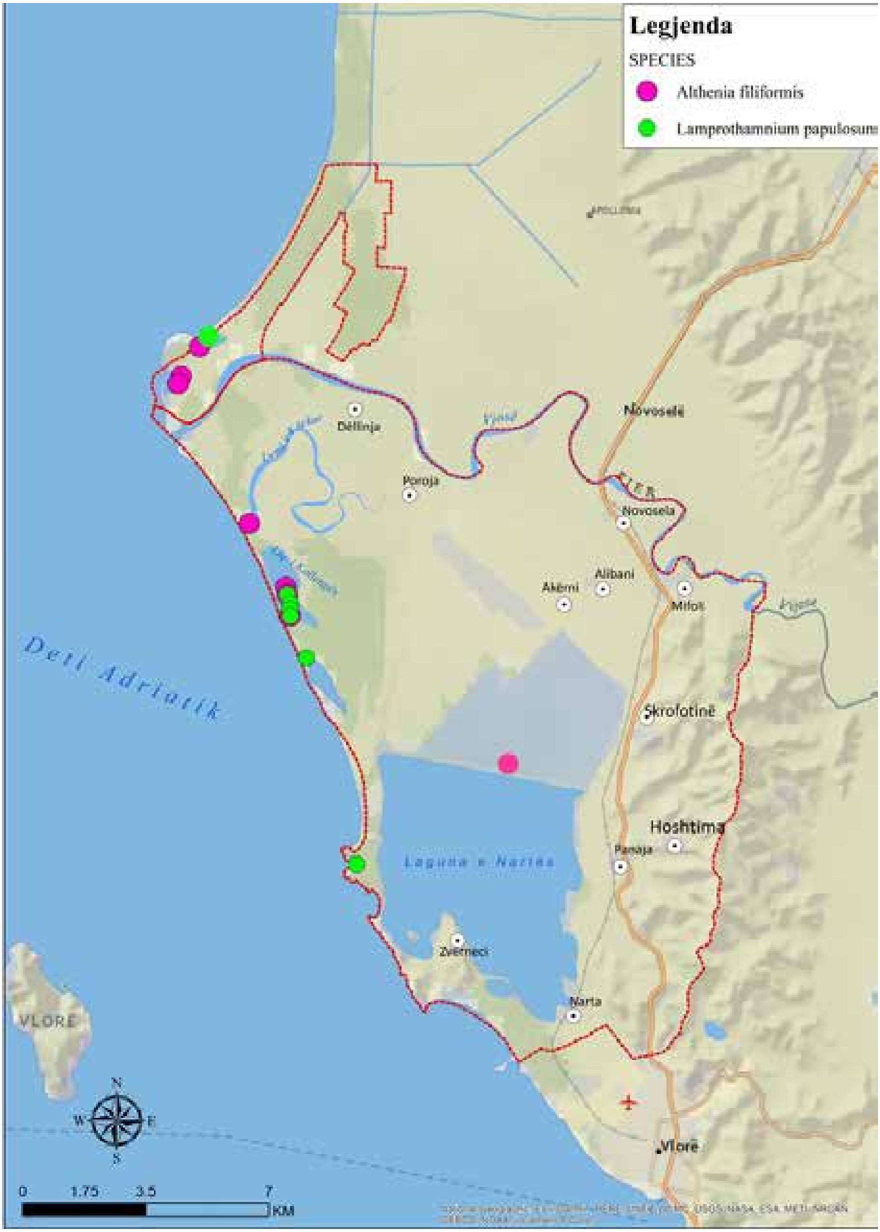

Figure 5.
Places where the endangered species *Althenia filiformis* and *Lamrothamium papulosum* reported by Mahmutaj *et al*. (2020).

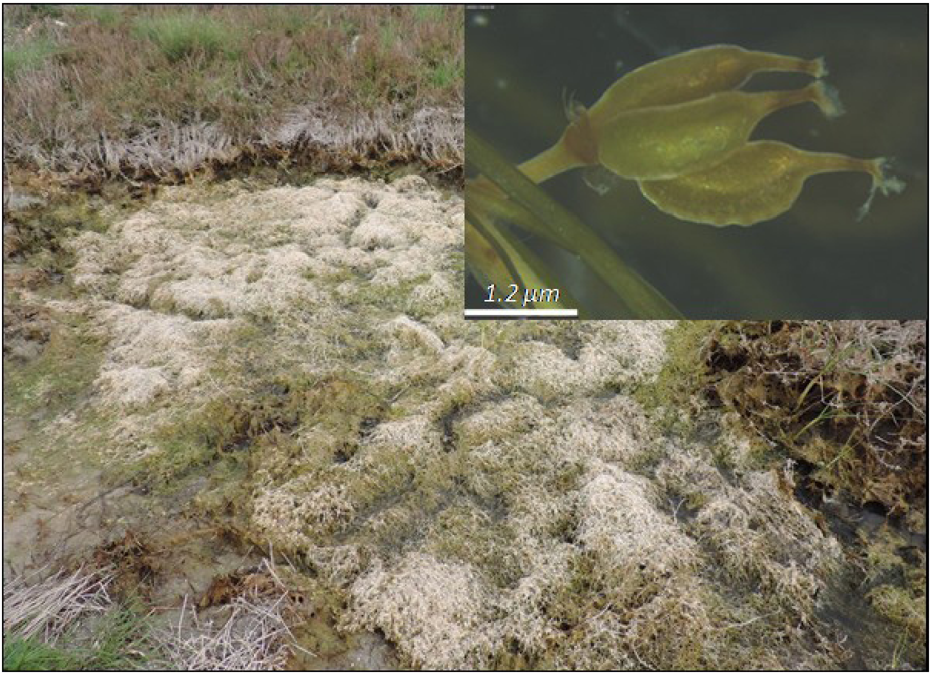

Figure 6.
Temporary pond with brackish water (1-6-5‰) at the Dam with *Zannichellia palustris* (with fruits in stereomicroscope) and with Characeae (i.e. *Tolipella hispanica*) (April 24, 2023) (Photo by L. Kashta).

In their recent publication about the rare hepatic *Riella macrocarpa* in an abandoned brackish water pond of the Narta Salt Pans, Kashta *et al*. (2023) report that together with this aquatic plant, the submerged grasses *Ruppia maritima and Zannichellia pedunculata, Althenia filiformis*, and a few individuals of the charophyte, *Lamprothamnium papulosum* (June 2013) were seen (Fig. 4a).

In an abandoned Saline pond, with muddy-clay bottom and 10 cm deep, was observed a sparse vegetation of *Althenia filiformis, Ruppia maritima* and *Riella macrocarpa* (Fig. 4b; April, 2016). *Zannichellia pedunculata* was also reported by Csiky *et al*. (2017) also for the Fieri part. *Ruppia maritima, Ranunculus peltatus* subsp. baudotii (Fig. 4d), and *R. macrocarpa, Tolypella hispanica, Chara galioides* (March 2016) were also oserved in a brackish temporary pond between Narta Dam and Saline.

In the last visit to Delta (April 2023), *Zannichellia palustris* (Fig. 6) was also found in a brackish temporary pond (1-6.5‰) in the associated Dam and more charophyte plants (e.g. *T. hispanica*). It should be said that *R. maritima, R. peltatus* ssp. *baudotii* and *Z. palustris* have LC conservation status and *Althenia filiformis* DD, according to IUCN (EUNIS, 2019).

The wetlands and lagoons environments shelter important habitats for these rare aquatic species, such as *Althenia filiformis*, and Foxtail stonewort, *Lamprothamnium papulosum*, found only in Delta area (Figs. 4 & 5) and in Divjaka-Karavasta NP. Marsilea quadrifolia, a relict perennial herbaceous fern mentioned to grow in aquatic environments of the Delta by Buzo (2000) has not been found by botanists during recent years' expeditions to the area.

The temporary coastal semi-saline wetlands are their primary habitats for these species. Anthropogenic pressure is the main threat for important plant species and wetland habitats. **Their return to the lagoons for fishing purposes as happened with Kallenga, will seriously risk the important species extinction from the area.**

Medicinal plants of the area

About **90 species from Delta area have different medicinal uses** by the local population. They are mostly hravested for economic benefits (Tab. 2). The most represented families are Rosaceae with 10 species, Fabaceae 9 species, Lamiaceae 7 species, Compositae 6 species, Plantaginaceae 4 species, etc.

Medicinal uses have always put these plant species under the anthropogenic pressure. Some of them have national and international conservation status. 9 of them have a conservation status according to the Red List of Albania (2013) (Fig. 7), of which 5 are VU and 4 EN. 17 species are in the IUCN list with "*low risk*" (LC) status.

Table 2.
Checklist of medicinal plants in the Vjosa Delta.

Gymnospermae	
Pinus halepensis	
Angiospermae - Eudicotidae	
Alnus glutinosa	*Papaver rhoeas*
Agrimonia eupatoria	*Parietaria officinalis*
Althaea officinalis	*Pistacia lentiscus*
Anethum graveolens	*Plantago lanceolata*
Anthyllis vulneraria	*Potentilla micrantha*
Aristolochia clematitis	*Potentilla reptans*
Bellis perennis	*Prunus spinosa*
Borago officinalis	*Punica granatum*
Centaurium erythraea	*Quercus coccifera*
Cichorium intybus	*Quercus ilex*
Clematis flammula	*Quercus pubescens*
Clematis vitalba	*Quercus robur*
Crataegus monogyna	*Reseda lutea*
Crataegus rhipidophylla	*Robinia pseudoacacia*
Cupressus sempervirens	*Rosa canina*
Cyanus segetum	*Rosa gallica*
Datura stramonium	*Rosa sempervirens*
Equisetum arvense	*Rumex conglomeratus*
Erica arborea	*Salix alba*
Ficus carica	*Salix amplexicaulis*
Fumaria capreolata	*Salix elaeagnos subsp. angustifolia*
Galega officinalis	*Salix purpurea*
Galium aparine	*Salvia verbenaca*
Geum urbanum	*Sambucus ebulus*
Hedera helix	*Sambucus nigra*
Humulus lupulus	*Spartium junceum*
Hypericum perforatum	*Taraxacum sect. Taraxacum*
Jacobaea erratica	*Teucrium polium*
Laurus nobilis	*Thymus capitatus*
Limonium oleifolium ssp. oleifolium	*Trifolium pratense*
Limonium sinuatum	*Tussilago farfara*
Limonium vulgare	*Urtica dioica*
Lythrum salicaria	*Verbascum blattaria*
Malva sylvestris	*Verbascum phlomoides*
Matricaria chamomilla	*Verbascum sinuatum*
Melilotus officinalis	*Verbascum thapsus*
Melisa officinalis	*Verbena officinalis*
Mentha pulegium	*Veronica anagallis-aquatica*
Mentha × piperita	*Veronica beccabunga*
Myrtus communis	*Veronica chamaedrys*
Ocimum basilicum	*Veronica persica*
Olea europaea	*Vitis vinifera*
Origanum vulgare	
Angiospermae - Lilianae	
Anacamptis laxiflora	*Orchis x paparisti*
Anacamptis morio	*Ruscus aculeatus*

Figure 7.
Pancratium maritimum medicinal plant of embryonic sand dunes with conservation status "Endagered" (EN A1b) according to the Red List of Albania (2013). (Photos from: M. Xhulaj, in Miho *et al*., 2013)

Plant associations and habitats of the Vjosa Delta

Different plant species coexist in similar environmental conditions, forming a variety of associations. Sandbanks always covered by water, without vegetation or with few marine phanerogams such as *Zostera marina* and *Cymodocea nodosa*, represent the habitat type **1110 - Sandbanks which are slightly covered by sea water all the time.** Starting from the coast towards the continent, the first associations are those of ***Psammophila or sand dunes.*** In general, in this area there is a wide sandy belt, dominated by two types of vegetation. The first one, starting from the sea line to the stable appearance of the species (Fig. 6 to 8), such as: *Cakile maritima, Salsola kali, Xanthium strumarium, Inula crithmoides*, etc. According to the Habitat Directive, these vegetation groups are part of the habitat type **1210 - Annual vegetation of driftlines (Fig. 8).**

The appearance of the species like: *Elymus farctus, Echinophora spinosa, Eryngium maritimum, Ammophila arenaria* etc., up to the forest belt, constitutes the second type of vegetation. In the first type it is observed a low scale of vegetation cover (10-15%), while in the second the vegetation cover is much higher (40-50%).

Figure 8.
Cakile maritima characteristic species of the annual vegetation of the sandy belt, immediately after the deposits of sea plants such as *Cymodocea nodosa* (photos: M. Meço, A. Mullaj).

Figure 9.
Mediterranean embryonic dune with the presence of the species *Euphorbia paralias, Eryngium maritimum, Xanthium orientale (Xanthium strumarium ssp. italicum)* (photos: M. Meço, A. Mullaj).

The dunes height in Vjosa Delta reaches up to 10 m, with significant presence of depressions with vegetation different from the one above such as: *Juncus bufonius, Carex* spp., *Sporobolus pungens*, etc. *Ammophila arenaria* is the dunes typical species on both sides of the Vjosa estuary. It is well noticed the presence of invasive species such as: *Oenothera biennis*, *Aster squamatus, Acacia saligna*, etc., mainly as a result of anthropogenic impact. Urban wastes are a worrying problem along the sandy shores, especially on both sides of the Vjosa estuary, transported from the mainland to the sea.

Figure 10.
Association with: **a**, *Sporobolus pungens*; and **b**, *Pancratium maritimum*, in embryonic sand dunes (photos: M. Meço, A. Mullaj).

Figure 11.
The vegetation of the white Mediterranean dunes, with the presence of the characteristic species *Ammophila arenaria* (photos: M. Meço).

Such plant associations are part of the habitat 2110 - Embryonic shifting dunes and 2120 - Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes) (Figs. 9-11).

After the sand herbaceous layer, the **Mediterranean Coniferous Forest** is found. The Aleppo pine (*Pinus halepensis*) is the dominant species in comparison to the Stone pine (*Pinus pinea*). In the east, these forests are bordered by wetlands, lagoons or agricultural lands, while in the west by the sandy belt. In addition to the coniferous species, in the depressions within the open woodland, also are found the accompanying species such as: *Ulmus minor, Fraxinus angustifolius, Populus alba*, etc. The shrub layer is often poor or absent due to the dense pine canopy that conditions the light.

The herbaceous floor is presented with a more complex composition, where several types of psamophilic, halophilic, hygrophilic, mesophilic and xerophilic vegetation are combined. The highest cover belong to psammophilic species such as: *Vulpia fasciculata, Lagurus ovatus, Alkanna tinctoria, Sporobolus pungens* etc. In addition, it is worth mentioning some halophilic species such as: *Plantogo coronopus, Scirpus holoschoenus, Saccharum ravennae, Schoenus nigricans*; some hygrophilic species such as: *Lythrum salicaria, Agrostis stolonifera, Oenanthe pimpinelloides* etc.

According to the Habitats Directive these plant associations are listed in the priority habitat of **2270 - * Wooded dunes with *Pinus pinea* and/or *Pinus pinaster* (Fig. 12).**

Figure 12.
Coastal forests of sand dunes with *Pinus halepensis, P. pinea* in the Vjosa Delta (photos: A. Mullaj).

Between the sandy dunes and the coniferous forest, a **shrub belt of *Juniperus macrocarpa*** is found. This community is like a fence which prevents the wind and sand penetration inside the forest. In those places with high shading scale the species *J. macrocarpa* is replaced by the myrtle (*Myrtus communis*) with a 70-80% total cover of all the association and sometimes by the Narrow-leaved mock privet (*Phillyrea* *angustifolia*). In the open areas, with poor environmental values and with high erosion scale the shrub floor is completely dominated by "frigana" species *Erica manipuliflora*, *Cistus salvifolius*, *Erica arborea*, etc. Similarly, the species such as: *Pistacia lentiscus* and *Rubus ulmifolius* are spread uniformly, especially in habitats with a high degree of anthropogenic activity. The shrub belt is seriously threatened in the area by the invasive species *Acacia saligna*, which is competing with the spread of *Juniperus macrocarpa* very aggressively. This association is found in the priority habitat **2250 -* Coastal dunes with *Juniperus* spp. (Fig. 13).**

Figure 13.
Plant formation dominated by *Juniperus macrocarpa* on stabilized sand dunes (photo: A. Mullaj, M. Meço).

The halophilic vegetation is mainly spread in the wetlands around the Narta lagoon and some temporary saline ponds near the Vjosa estuary, environments with the area's highest salinization degree. Even within these habitats, depending on the distance from the saline sources a vegetation differentiation is observed. Thus, in environments closer to salty waters, i.e. with a higher degree of salinization, the vegetation is dominated by associations often composed of a single species, or a limited number of them, such as: *Arthrocnemum fruticosum, A. glaucum, Salicornia europaea, Limonium vulgare, Puccinellia festuciformis, Juncus maritimus,* etc. This vegetation is regenerated in a mosaic form even in the abandoned saline lands. According to the Habitats Directive these plant associations are part of the habitat: **1310 - *Salicornia* and other annuals colonizing mud and sand; 1420 - Mediterranean and thermo-Atlantic *halophilous* shrubs (*Sarcocornetea fruticosi*) (Fig. 14).**

Other plant associations are created in areas with a high salinization degree, but in more elevated places, where water stays for a short time. According to the Directive Habitats these associations are part, of the priority habitat **1510 - * Mediterranean salt steppes (*Limonietalia*) (Fig. 15).**

Figure 14.
Halophilic associations of Mediterranean and thermo-Atlantic shrubs north of the estuary and along the Vjosa rivercourse (photos: A. Islami).

Leaving the lagoon shores, these associations gradually are replaced by *Juncus acutus, J. maritimus*. According to the Habitats Directive, these associations belong to habitat type **1410 - Mediterranean salt meadows (*Juncetalia maritimi*) (Fig. 16).**

In areas with a lower degree of salinization, they are replaced by predominantly tamarisk associations (*Tamarix dalmatica, T. hampeana*, etc.). These galleries with tamarisk represent the habitat type ***92D0 - Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae).***

The vegetation changes according to the environment degree of salinization, which is gradually accompanied by a floristic enrichment. The main characteristic of this vegetation group is the presence of succulent species, adapted to survive in these environments with scarce freshwater. This group is in very good state, playing an important role for the preservation and protection of fauna (as shelter and source of food).

Hygro-hydrophilic vegetation spreads mainly along the Vjosa banks, along the canals and also in the depressions found inside the pinus forest. The widespread associations are composed of: *Phragmites australis, Typha angustifolia, Scirpus maritimus, S. lacustris* etc. In the drainage channel of Narta village and Akerni, close to the airport area, there are formations with *Cladium mariscus* (Fig. 17) that belong to the priority habitat, code **7210 - * Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*.**

Figure 15.
Limonium vulgare, characteristic specie of Mediterranean salt steppe (photos: M. Meço, A. Mullaj).

Figure 16.
Mediterranean salt meadows with *Juncus acutus* and *J. maritimus* (photos: M. Meço).

Figure 17.
Drainage channel of the Narta village with formations of *Cladium mariscus* and other aquatic macrophytes, in the part that flows through the Soda Forest, Vlorë (photo: M. Meço).

In the Zverneci swamp, which is divided by a dam from the Narta Lagoon, the vegetation is dominated by reeds with *Phragmites australis, Typha angustifolia* and *T. latifolia*. The vegetation of the free water surface is dominated by *Ranunculus trichophyllus* (Fig. 18). The marsh bottom is covered by a carpet of green algae of the genus *Chara spp*. which represent the habitat type **3140 - Hard oligo-mesotrophic waters with benthic vegetation of *Chara spp*.**

Figure 18.
Zvernec swamp covred by reeds with *Phragmites australis*, *Typha angustifolia, T. latifolia* and free water surfaces with *Ranunculus trichophyllus* (photo: E. Mahmutaj).

In humid interdune depressions and with water on the surface in wet weather periods, the vegetation is dominated by *Erianthus ravennae, Samolus valerandi, Blackstonia perfoliata*, etc., often even *Chara spp*. According to the Habitats Directive, these associations are part of habitat **2190 - Humid dune slacks** (Fig. 19).

Associations with Phragmites australis (Fig. 20) stand out for a high ecological plasticity, so they grow both on shores covered by water and in dry places. Its presence in different ecological conditions is the result of numerous polyploid forms of its dominant species. Reeds with *Phragmites australis, Typha* spp., *Scirpus* spp., etc., is an important habitat, especially as shelter of water birds.

Figure 19.
Humid dune slacks, moist depressions between sand dunes dominated by *Erianthus ravennae, Imperata cylindrica* and *Schoenus nigricans* (photo: M. Meço).

Figure 20.
High helophytic associations along the riverbanks of the Vjosa estuary dominated by *Phragmites australis, Scirpus lacustris and S. maritumus* (photo: M. Meço).

Estuaries and their surrounding habitat types dominated mainly by freshwater plant formations form independent ecological units. In nature conservation point of view these different habitat types are not separated, but studied as a single unit. **The estuary of the Vjo river, according to the Habitats directive, is part of habitat code 1130 – Estuaries** (Fig. 21). It represents important habitats for aquatic fauna and especially birds. Near the Vjosa estuary, between the villages of Dëllenjë and Poro, the belts of *Populus alba* and *Salix alba* start to extend along the Vjosa riverbanks. These riparian galleries represent the habitat type **92A0 - *Salix alba* and *Populus alba galleries*.**

Figure 21.
Habitat 1130 - Vjosa Estuary.
(©https://www.balkanrivers.net/)

Submersed vegetation of the Narta lagoon, the marshes and numerous saltwater ponds that lie in the area aremainly characterized by associations dominated by *Rupia cirrhosa*. It forms wide populations, like "water meadows'', because they cover 40-50% of the muddy bottom stotal surface, up to a depth of about 1 m. But it is most present in shallow places at a depth of 20-30 cm. *Cymodocea nodosa* and *Zostera noltii* are usually found in the tide canals as companion species.

The algae of this association change according to salinity and depth. Macrophyte algae often present are: *Chaetomorpha linum*, *Enteromorpha* sp., *Cystoseira* sp. etc. In shallow wetlands, are also associations of ***Althenia filiformis* with *Lamprothamnium papulosum***, found only in Vjosa Delta wetlands and in Karavasta lagoon.

Temporary coastal lagoons and wetlands are a complex habitat with high biodiversity values; thex represent a priority habitat with code **1150 *Coastal lagoons (Fig. 22)**.

Figure 22.
Wetlands and ponds with salty water near the Vjosa mouth (due to flooding from the Vjosa River) (photo: A. Islami).

Major threats to habitats, flora and vegetation in the Delta area

Meço *et al*. (2023) summarize the major threats to habitats, flora and vegetation in the Delta area. Among the most threatening factors is the **intensive maintenance, cleaning and even occupation with infrastructural objects (tourist, solar panels, etc.) of sand beaches**. The sandy coastline is used for sunbathing and beach activities during summer, and with higher trends for the future (MIE, 2019b; 2019c; PDZRK, 2019). Wrong practices such as flattening or plowing dunes to clear or open new beaches are a major extinction risk for species of conservation interest. It is more threatening in the recently opened beaches wher species of conservation interest, still present in these areas, are in danger of extinction. It is cleare evidence of how the long-term of human activity can be a serious threatening factor.

A second important pressure is **the forestry clearance mostly for orban or tourist infrastructures, mostly in Vlora part but also in Fieri part of the Delta**. The woodcutting and deforestation are a direct threat for woody species with conservation interests, such as *Populus alba*, *Ulmus minor*, *Tamarix hampeana*, etc. Also herbaceous species of the herb layers are impacted, i.e. *Galatella albanica*, *Orchis* sp., *Ophrys* sp., etc. Along Vjosa riverbanks it is attributed to the cutting of *Populus alba* and *Ulmus minor*, species with national and international conservation status (Tab. 1).

Figure 23.
Two alien species from the Vjosa Delta: **A**, *Oenothera speciosa* from Narta area; **B**, *O. parodiana* from sand beach near the pumping station in Akerni. (Photo from: A. Mullaj in Mullaj *et al*., 2017 (A); M. Meço (B))

Fires burn down actively the vegetation. The forest and scrubs are often under the risk of fires. Species of conservation interest, such as *Tamarix hampeana, Populus alba, Juniperus macrocarpa, Ulmus minor*, etc., are under the direct pressure. The most recent is the burning of 700 ha of pine forest in Pishe Poro - Darzeza, at the end of last September (2023).

Invasive or non-native species are an important factor to be considerd and possibly taken under the control. Ca. 45 species (or ca. 6% of all the known plant species) in Delta area are alien (Tab. 3). *Carpobrotus edulis* and *Robinia pseudacacia* are part of the list of the 100 most dangerous invasive species in Europe (*Nentwig et al*., 2018). Also *Acacia saligna* can be considered an invasive threat in the area, in concurrence with *Juniperus oxycedrus* subsp. *macrocarpa*, a species with national and international conservation status, forming also the priority habitat 2250* (Coastal dunes with *Juniperus* spp.). Mullaj *et al*. (2017) report that the alien species *Oenothera speciosa* (Fig. 23) shows invasive features at Narta area. *Oenothera parodianaee*, is a new reported invasive species in the area (Meço *et al*., 2023).

Other presure that can directly or indirectly impact the habitats and their plant diversity are the unsustainable harversting of medicinal and aromatic plants, overgrazing and pollution from urban, industrial areas, harbor activity, aquaculture, and intensive agriculture and livestock in the area or its surrounding. **The given data and comments here would help the local stakeholders for their future development plans and balancing them properly with environmental interests and ecosystem integrity.**

Table 3.
Alien species of the Vjosa Delta area.

Acacia saligna	*Ficus carica*
Acer negundo	*Heliotropium supinum*
Agave americana	*Lemna minuta*
Ailanthus altissima	*Linum usitatissimum*
Allium sativum	*Morus alba*
Amaranthus albus	*Oenathera biennis*
Amaranthus hybridus	*Oenathera parodiana*
Amaranthus retroflexus	*Oxalis pes-caprae*
Amorpha fruticosa	*Paspalum paspalodes*
Arundo donax	*Physalis angulata*
Capsicum annum	*Pinus pinaster*
Carpobrotus edulis	*Portulaca oleracea*
Chenopodium ambrosioides	*Punica granatum*
Conyza bonariensis	*Robinia pseudacacia*
Conyza canadensis	*Sisyrinchium angustifolium*
Coronopus didymus	*Sorghum halepense*
Cupressus sempervirens	*Symphyotrichum squamatum*
Cuscuta campestris	*Xanthium spinosum*
Cydonia oblonga	*Xanthium strumarium*
Datura stramonium	*Zizifus jujuba*
Euphorbia maculate	

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ANNEX I: Checkist of plant species found over years by different authors and in different habitats of Vjosa Delta.

Name of species	Publication
Polypodiophyta	
Equisetum arvense L.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Equisetum palustre L.	Barina *et al.,* 2017
Equisetum ramosissimum Desf.	Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a
Equisetum telmateia Ehrh.	Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Isoetes histrix Bory	Barina *et al.,* 2017
Gymnospermae	
Ephedra distachya L.	Buzo, 2000; Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018
Juniperus oxycedrus subsp. *macrocarpa* (Sm.) Ball	HK; CORINE biotopes 1991; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Juniperus phoenicea L. subsp. *phoenicea*	HK; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Juniperus phoenicea subsp. *turbinata* (Guss.) Nyman	Mahmutaj *et al.,* 2020
Pinus halepensis Mill.	HK; CORINE biotopes 1991; Buzo, 2000; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Pinus maritima Lam. [non Mill.]	Imeri *et al.,* 2018; MIE, 2019a
Pinus pinaster Aiton	Topi *et al.,* 2013; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Pinus pinea L.	HK; Topi *et al.,* 2013; Imeri *et al.,* 2018; MIE, 2019a
Angiospermae	
Abutilon theophrasti Medik.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Acacia saligna (Labill.) H. L. Wendl.	Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Acanthus balcanicus Heywood	Barina *et al.,* 2017
Acanthus spinosus L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Acer campestre L.	CORINE biotopes 1991;
Acer negundo L.	Barina *et al.,* 2017
Achillea baldaccii Degen	Barina *et al.,* 2017
Acinos arvensis (Lam.) Dandy	Barina *et al.,* 2017
Adiantum capillus-veneris L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Aegilops neglecta Req. ex Bertol.	Mahmutaj *et al.,* 2020
Aegilops triuncialis L.	Buzo, 2000; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Aeluropus littoralis (Gouan) Parl.	CORINE biotopes 1991; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017
Agave americana L.	Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Agrimonia eupatoria L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a
Agrostemma githago L.	MPWTT, 2007
Agrostis stolonifera L	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Ailanthus altissima (Mill.) Swingle	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Aira elegantissima Schu	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ajuga reptans L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017

Name of species	Publication
Alcea rosea L.	Pampanini, 1915; Barina *et al.,* 2017
Alisma lanceolatum With.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Alisma plantago-aquatica L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Barina *et al.,* 2017; MIE, 2019a
Alkanna tinctoria L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Allium commutatum Guss.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Allium roseum L.	Barina *et al.,* 2017
Allium sativum L.	MIE, 2019a
Alnus glutinosa L. (Gaerth)	HK; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Alnus incana (L.) Moench	MIE, 2019a
Alopecurus myosuroides Hudson	HK
Alopecurus rendlei Eig	HK
Althaea officinalis L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Althenia filiformis Petit agg.	Barina *et al.,* 2017
Amaranthus albus L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Amaranthus graecizans L.	Barina *et al.,* 2017
Amaranthus hybridus L.	MPWTT, 2007
Amaranthus retroflexus L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Ambrosia maritima L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ammi majus L.	Barina *et al.,* 2017
Ammi visnaga (L.) Lam.	Barina *et al.,* 2017
Ammophila arenaria (L.) Lb.	CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Amorpha fruticosa L.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Anacamptis coriophora (L.) R. M. Bateman, Pridgeon & M. W. Chase	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Anacamptis laxiflora (Lam.)	HK; Pampanini, 1915; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Anacamptis morio (L.) R. M. Bateman, Pridgeon & M. W. Chase	CORINE biotopes 1991; Topi *et al.,* 2013; Barina *et al.,* 2017
Anacamptis morio subsp. *caucasica* (K. Koch) H. Kretzschmar, Eccarius & H. Dietr.	HK; Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a
Anacamptis pyramydalis (L.)Rich.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Anacyclus radiatus Loisel.	Barina *et al.,* 2017
Anagallis arvensis L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Anagallis foemina Mill.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Anchuza azurrea Miller	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Anemone hortensis L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Anethum graveolens L.	MIE, 2019a
Anthemis arvensis L.	Barina *et al.,* 2017
Anthemis chia L.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Anthemis cotula L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Anthoxanthum odoratum L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Anthyllis hermanniae L.	HK; Barina *et al.,* 2017

Name of species	Publication
Apium graveolens L.	Xhulaj & Mullaj, 2002
Arenaria serpyllifolia L.	HK; Barina *et al.,* 2017
Aristolochia clematitis L.	Xhulaj & Mullaj, 2002
Aristolochia rotunda L.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Artemisia annua L.	Barina *et al.,* 2017
Artemisia caerulescens L.	CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Artemisia vulgaris L.	Xhulaj & Mullaj, 2002
Arthrocnemum fruticosum (L.) Moq.	CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Arthrocnemum glaucum (Delile) Ung.-Sternb.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Arthrocnemum macrostachyum (Moric.) K. Koch	Barina *et al.,* 2017
Arthrocnemum perenne (Mill.) Moss	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; MoE, 2009; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Arum italicum Mill.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Arundo donax L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Arundo plinii Turra	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Asparagus acutifolius L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Asparagus maritimus (L.) Mill.	Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Asparagus tenuifolius Lam.	Xhulaj & Mullaj, 2002
Asperula aristata L. f.	Barina *et al.,* 2017
Asphodelus aestivus Brot.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Asphodelus macrocarpus Parl.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Asplenium adiantum-nigrum L.	Barina *et al.,* 2017
Aster squamatus (Spreng.) Hieron.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Aster tripolium L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Asteriscus aquaticus (L.) Less	Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Astragalus hamosus L.	Barina *et al.,* 2017
Astragalus monspessulanus L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Astragalus sesameus L.	Barina *et al.,* 2017
Atriplex patula L.	MPWTT, 2007
Atriplex prostrata Boucher ex DC.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Atriplex rosea L.	Barina *et al.,* 2017
Atriplex tatarica L.	Buzo, 2000; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Avena barbata Pott ex Link	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Avena fatua L.	Xhulaj & Mullaj, 2002

Name of species	Publication
Baldellia ranunculoides (L.) Parl.	HK; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Bellardia trixago (L.) All.	Pampanini, 1915; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Bellevalia romana (L.) Rchb.	Barina *et al.,* 2017
Bellis annua L.	HK; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Bellis perennis L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; MIE, 2019a
Berteroa obliqua (Sm.) DC.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Bidens tripartita L.	Barina *et al.,* 2017
Blackstonia perfoliata (L.) Huds.	Pampanini, 1915; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Bolboschoenus maritimus (L.) Palla	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Borago officinalis L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Brachypodium distachyon (L.) P. Beauv.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Brachypodium pinnatum (L.) P. Beauv.	Barina *et al.,* 2017
Brachypodium retusum (Pers.) Beauv.	HK
Brachypodium sylvaticum (Huds.) P. Beauv.	Barina *et al.,* 2017
Brassica nigra (L.) Koch.	MIE, 2019a; Mahmutaj *et al.,* 2020
Briza maxima L.	Topi *et al.,* 2013
Briza minor L.	Barina *et al.,* 2017
Bromus arvensis L.	Mahmutaj *et al.,* 2020
Bromus hordeacus Beck.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017
Bromus squarrosus L.	Topi *et al.,* 2013
Bromus sterilis L.	HK; Topi *et al.,* 2013; Barina *et al.,* 2017
Bromus tectorum L.	Topi *et al.,* 2013; Barina *et al.,* 2017
Buglossoides arvensis (L.) I. M. Johnst.	MPWTT, 2007; Barina *et al.,* 2017
Buglossoides purpurocaerulea (L.) I. M. Johnst.	Topi *et al.,* 2013; Barina *et al.,* 2017
Bupleurum subovatum Link ex Spreng.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Bupleurum tenuissimum L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Butomus umbellatus L.	Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Cakile maritima Scop.	CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Calamagrostis epigejos (L.) Roth	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013;
Calendula arvensis L.	Barina *et al.,* 2017
Calepina irregularis (Asso) Thell.	Barina *et al.,* 2017
Calystegia sepium (L.) R. Br.	Xhulaj & Mullaj, 2002

Name of species	Publication
Calystegia soldanella (L.) R.Br.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Capparis spinosa L.	Barina *et al.,* 2017
Capsella bursa- pastoris (L.) Med	Xhulaj & Mullaj, 2002; MPWTT, 2007; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Capsicum annum L.	MIE, 2019a
Cardamine graeca L.	Barina *et al.,* 2017
Cardamine hirsuta L.	HK; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Carduus pycnocephalus L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Carex distachia Desf.	Barina *et al.,* 2017
Carex distans L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Carex divisa Huds.	HK; Barina *et al.,* 2017
Carex divulsa Stokes	Barina *et al.,* 2017
Carex echinata Murray	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Carex elata All.	Buzo, 2000
Carex extensa Gooden.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Carex flacca Schreb.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Carex hallerana Asso	Barina *et al.,* 2017
Carex muricata L.	Xhulaj & Mullaj, 2002
Carex pendula Huds.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Carex praecox Schreb.	Barina *et al.,* 2017
Carlina corymbosa L.	Barina *et al.,* 2017
Carlina lanata L.	Barina *et al.,* 2017
Carpinus orientalis Mill.	CORINE biotopes 1991; Topi *et al.,* 2013; Barina *et al.,* 2017
Carpobrotus edulis (L.) N. E. Br.	Barina *et al.,* 2017
Centaurea calcitrapa L.	Barina *et al.,* 2017
Centaurea cyanus L.	MPWTT, 2007;
Centaurea jacea L.	Barina *et al.,* 2017
Centaurea sonchifolia L.	HK; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Centaurium erythraea Rafn	Topi *et al.,* 2013; Barina *et al.,* 2017
Centaurium pulchellum Swartz.	Topi *et al.,* 2013
Centaurium spicatum (L.) Fritsch	Topi *et al.,* 2013; Barina *et al.,* 2017
Centaurium umbellatum (Swarz)Druce.	Xhulaj & Mullaj, 2002
Cephalanthera longifolia (L.) Fritsch	HK; Barina *et al.,* 2017
Cephalaria transylvanica (L.) Roem. & Schult.	Barina *et al.,* 2017
Cerastium brachypetalum Pers.	Topi *et al.,* 2013
Cerastium ligusticum Viv.	Barina *et al.,* 2017
Ceratophyllum demersum L.	Xhulaj & Mullaj, 2002

Name of species	Publication
Cercis siliquastrum L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Cerinthe major L.	HK; Barina *et al.,* 2017
Chamaemelum fuscatum (Brot.) Vasc.	Barina *et al.,* 2017
Chamaemelum mixtum (L.) All.	Topi *et al.,* 2013; Barina *et al.,* 2017
Chamomilla recutita (L.) Rauschert	MPWTT, 2007; Barina *et al.,* 2017
Chenopodium album L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Chenopodium ambrosioides L.	Barina *et al.,* 2017
Chenopodium murale L.	Barina *et al.,* 2017
Chenopodium opulifolium Schrad. ex W. D. J. Koch & Ziz	Barina *et al.,* 2017
Chenopodium vulvaria L.	MPWTT, 2007
Chondrilla juncea L.	Barina *et al.,* 2017
Chrozophora tinctoria (L.) A. Juss.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Chrypsis aculeata (L.) Aiton	Topi *et al.,* 2013
Chrysopogon gryllus (L.) Trin.	Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Cichorium intybus L	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a
Cirsium creticum (Lam.)	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Cirsium vulgare (Savi) Ten.	Barina *et al.,* 2017
Cistus incanus L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Cistus salvifolius L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Cladium mariscus (L.) Pol.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Clematis flammula L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Clematis vitalba L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Clematis viticella L.	Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Clinopodium vulgare L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Colutea arborescens L.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Consolida regalis Gray	Xhulaj & Mullaj, 2002
Convolvulus althaeoides L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Convolvulus arvensis L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Convolvulus lineatus L.	Barina *et al.,* 2017
Conyza canadensis (L.) Cronquist	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Coris monspeliensis L.	Barina *et al.,* 2017
Cornus mass L.	HK; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Cornus sanguinea L.	HK; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Coronilla scorpioides (L.) W. D. J. Koch	Barina *et al.,* 2017

Name of species	Publication
Coronilla valentina L.	Barina *et al.,* 2017
Coronopus didymus (L.) Sm.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Crataegus monogyna Jacq.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Crataegus oxyacantha L.	Xhulaj & Mullaj, 2002
Crepis foetida L.	HK; Baldacci, 1896; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Cressa eretica L.	Baldacci, 1896
Cressa cretica L.	HK; Barina *et al.,* 2017
Crithmum maritimum L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Cruciata laevipes Opiz	HK; Topi *et al.,* 2013; Barina *et al.,* 2017
Crupina crupinastrum (Moris) Vis.	Barina *et al.,* 2017
Crypsis aculeata (L.) Aiton	CORINE biotopes 1991; Barina *et al.,* 2017
Crypsis alopecuroides (Piller & Mitterp.) Schrad.	Barina *et al.,* 2017
Cupressus sempervirens L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Cuscuta campestris Yunck.	Barina *et al.,* 2017
Cuscuta europea L.	Xhulaj & Mullaj, 2002
Cydonia oblonga Mill.	Xhulaj & Mullaj, 2002
Cynanchum acutum L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Cynodon dactylon Pers.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Cynoglossum creticum Mill.	Pampanini, 1915; Barina *et al.,* 2017
Cynosurus echinatus L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Cyperus capitatus Vand.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Cyperus flavescens L.	Barina *et al.,* 2017
Cyperus fuscus L.	CORINE biotopes 1991; Barina *et al.,* 2017
Cyperus longus L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Cyperus michelianus (L.) Link	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Cyperus pannonicus Jacq.	Baldacci, 1896; Xhulaj & Mullaj, 2002
Cyperus rotundus L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Dactylis glomerata L.	Buzo, 2000; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Dasypyrum villosum (L.) P. Candargy	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Datura stramonium L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Daucus carota L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Daucus guttatus Sibth. & Sm.	Topi *et al.,* 2013
Delphinium peregrinum L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Desmazeria marina (L.) Drude.	Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a
Desmazeria rigida (L.) Tutin	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a
Dianthus armeria L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020

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Dianthus caryophyllus L.	MIE, 2019a
Digitalis lanata Ehrh.	Barina *et al.,* 2017
Digitaria sanguinalis (L.) Scop.	Barina *et al.,* 2017
Dipsacus fullonum L.	Barina *et al.,* 2017
Dittrichia graveolens (L.) Greuter	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Dittrichia viscosa (L.) Greuter	Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Dorycnium hirsutum (L.) Ser.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Dorycnium pentaphyllum Scop.	HK; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Dyopteris villarii (Bellardi) Woyn. ex Schinz & Thell. agg.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ecballium elaterium (l.) A. Richard.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Echinochloa crus-galli (L.) P. Beauv.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Echinophora spinosa L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Echium italicum L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Echium plantagineum L.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Eleocharis ovata (Roth) Roem. & Schult.	Mahmutaj *et al.,* 2020
Eleocharis palustris (L.) Roem. & Schult.	MPWTT, 2007; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Elymus elongatus (Host) Runemark	Barina *et al.,* 2017; MIE, 2019a;
Elymus farctus P.B.	CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Elymus pycnanthus (Godr.) Melderis	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; MIE, 2019a
Eragrostis minor Host	Barina *et al.,* 2017
Eragrostis pilosa (L.) P. Beauv.	Barina *et al.,* 2017
Erianthus strictus Baldwin	Buzo, 2000
Erica manipuliflora Salisb.	HK; CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Erigeron bonariensis L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Erodium cicutarium (L.) L'Hér.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Erodium malacoides L.	Topi *et al.,* 2013
Erodium moschatum (L.) L'Hér.	Barina *et al.,* 2017

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Erophila verna (L.) Chevall.	HK; Mahmutaj *et al.,* 2020
Eryngium campestre L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Eryngium creticum Lam.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Eryngium maritimum L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Euonymus europaeus L.	Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Euphorbia exigua L.	Barina *et al.,* 2017
Euphorbia helioscopia L.	HK; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Euphorbia maculata L.	Barina *et al.,* 2017
Euphorbia paralias L.	HK; Pampanini, 1915; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Euphorbia peplis L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Euphorbia peplus L.	Barina *et al.,* 2017
Euphorbia pinea L.	HK; Barina *et al.,* 2017
Euphorbia platyphyllos L.	Topi *et al.,* 2013; Barina *et al.,* 2017
Euphorbia pubescens Vahl	Barina *et al.,* 2017
Euphorbia serrulata Thuill.	Barina *et al.,* 2017
Euphorbia terracina L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Evax pygmaea (L.) Brot.	Barina *et al.,* 2017
Ficus carica L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Foeniculum vulgare Mill.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Frangula alnus Mill.	Topi *et al.,* 2013; Barina *et al.,* 2017
Frankenia pulverulenta L.	MPWTT, 2007; Topi *et al.,* 2013
Fraxinus angustifolia Vahl	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Fraxsinus ornus L.	Topi *et al.,* 2013
Fumana arabica (L.) Spach	Barina *et al.,* 2017
Fumana procumbens (Dunal) Gren. & Godr.	Barina *et al.,* 2017
Fumaria capreolata L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Fumaria kralikii Jord.	Barina *et al.,* 2017
Fumaria pettri Reichenb.	HK; Mahmutaj *et al.,* 2020
Galactites tomentosa Moench	Barina *et al.,* 2017
Galatella albanica Degen	Mahmutaj *et al.,* 2020
Galega officinalis L.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Galium palustre L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Gaudinia fragilis (L.) P. Beauv.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Geranium columbinum L.	Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Geranium dissectum L.	Barina *et al.,* 2017
Geranium molle L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Geum urbanum L.	Barina *et al.,* 2017
Gladiolus palustris Gaudin	HK; Barina *et al.,* 2017
Glycyrrhiza glabra L.	Barina *et al.,* 2017
Gratiola officinalis L.	Xhulaj & Mullaj, 2002; MIE, 2019a; Mahmutaj *et al.,* 2020
Hainardia cylindrica (Willd.) Greuter	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020

Name of species	Publication
Halimione portulacoides (L.) Aellen	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Halocnemum strobilaceum (Pall.) M. Bieb.	HK; Baldacci, 1896; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Halopeplis amplexicaulis (Vahl) Ces. & al.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Hedera helix L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Hedypnois cretica (L.) Dum. Cours.	HK; Barina *et al.,* 2017
Helianthemum nummulariumc (L.) Mill.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Heliotropium curassavicum L.	Topi *et al.,* 2013
Heliotropium europaeum L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Heliotropium supinum L.	HK; Baldacci, 1896; Barina *et al.,* 2017
Herniaria hirsuta L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Hippocrepis emerus (L.) Lassen	Barina *et al.,* 2017
Hippocrepis emerus (L.) Lassen subsp. *emerus*	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Hirschfeldia incana (L.) Lagr.-Foss.	Barina *et al.,* 2017
Holcus lanatus L.	Xhulaj & Mullaj, 2002
Hordeum bulbosum L.	Barina *et al.,* 2017
Hordeum hystrix Roth	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Hordeum marinum Huds.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Hordeum murinum L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Humulus lupulus L.	Xhulaj & Mullaj, 2002
Hydrocotile vulgaris L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a
Hymenocarpos circinnatus (L.) Savi	Barina *et al.,* 2017
Hyparrhenia hirta (L.) Stapf	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Hypericum perforatum L.	Pampanini, 1915; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Hypochaeris radicata L.	Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Imperata cylindrica (L.) Raeusch.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Inula crithmoides L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Iris germanica L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Iris pseudacorus L.	HK
Iris sintenisii Janka	HK; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Isolepis cernua (Vahl.) Roem. & Schult.	Barina *et al.,* 2017
Juncus acutus L.	CORINE biotopes 1991; Buzo, 2000; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020

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Juncus articulatus L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Juncus bufonius L.	HK; Topi *et al.,* 2013; Barina *et al.,* 2017
Juncus compressus Jacq.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Juncus effusus L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Juncus inflexus L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Juncus littoralis C. A. Mey.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Juncus maritimus Lam.	CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Juncus minutulus (Albert & Jahand.) Prain	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Juncus subulatus Forssk.	HK; Baldacci, 1896; Barina *et al.,* 2017
Kickxia commutata (Bernh. ex Rchb.) Fritsch	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Kickxia elatine (L.) Dumort.	Barina *et al.,* 2017
Knautia orientalis L.	Barina *et al.,* 2017
Kochia prostrata (L.) Schrader	Mahmutaj *et al.,* 2020
Koeleria macrantha (Ledeb.) Schult.	Barina *et al.,* 2017
Lactuca serriola L.	Barina *et al.,* 2017
Lagurus ovatus L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Lamium amplexicaule L.	HK; Barina *et al.,* 2017
Lamium purpureum L.	HK; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Lathyrus annuus L.	Barina *et al.,* 2017
Lathyrus aphaca L.	Barina *et al.,* 2017
Lathyrus niger (L.) Bernh.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Lathyrus nissolia L.	HK
Laurus nobilis L.	Xhulaj & Mullaj, 2002; MIE, 2019a; Mahmutaj *et al.,* 2020
Legousia speculum-veneris (L.) Chaix	MPWTT, 2007
Lemna gibba L.	Mahmutaj *et al.,* 2020
Lemna minor L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Lemna minuta Kunth	MIE, 2019a
Leontodon tuberosus L.	HK; Barina *et al.,* 2017
Lepidium ruderale L.	Topi *et al.,* 2013
Leucanthemum vulgare Lam.	Barina *et al.,* 2017
Leucojum aestivum L.	Barina *et al.,* 2017
Ligustrum vulgare L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Limonium oleifolium Mill.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020

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Linum hologynum Rchb.	Barina *et al.,* 2017
Linum pubescens Banks & Sol.	HK; Barina *et al.,* 2017
Linum strictum L.	Barina *et al.,* 2017
Linum tryginum L.	Mahmutaj *et al.,* 2020
Linum usitatissimum L.	Xhulaj & Mullaj, 2002
Lippia nodiflora (L.) Michx.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Logfia gallica (L.) Coss. & Germ.	Barina *et al.,* 2017
Lolium multiflorum Lam.	Xhulaj & Mullaj, 2002
Lolium perenne L.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Lonicera etrusca Santi	Barina *et al.,* 2017
Lophochloa hispida (Savi) Jonsell	Barina *et al.,* 2017
Lophochloa pubescens (Lam.) H. Scholz	Barina *et al.,* 2017
Lophocloa cristata (L.) Hyl.	HK
Lotus corniculatus L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Lotus cytisoides L.	Barina *et al.,* 2017
Lotus edulis L.	Barina *et al.,* 2017
Lotus ornithopodioides L.	Barina *et al.,* 2017
Lotus tenuis Waldst. & Kit. ex Willd.	Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Luzula forsteri (Sm.) DC.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Lychnis coronaria (L.) Desr.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Lychnis flos-cuculi L.	Topi *et al.,* 2013
Lycopus europaeus L.	Barina *et al.,* 2017
Lysimachia atropurpurea L.	Barina *et al.,* 2017
Lysimachia dubia Aiton	Barina *et al.,* 2017
Lythrum hyssopifolia L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Lythrum salicaria L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a
Malus sylvestris Miller	HK
Malva sylvestris L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Maresia nana (DC.) Batt.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Marrubium vulgare L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Marsilea quadrifolia L.	Buzo, 2000; Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a
Matricaria camomila L.	MIE, 2019a
Matthiola sinuata (L.) R. Br.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Matthiola tricuspidata (L.) W. T. Aiton	CORINE biotopes 1991; Topi *et al.,* 2013; Barina *et al.,* 2017
Medicago littoralis Rohde ex Loisel.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Medicago lupulina L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020

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Medicago minima (L.) L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Medicago polymorpha L.	Barina *et al.,* 2017
Melica ciliata L.	Barina *et al.,* 2017
Melilotus alba Medik.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Melilotus elegans Salzm. ex Ser.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Melilotus indica (L.) All.	HK; Barina *et al.,* 2017
Melilotus messanensis (L.) All.	Barina *et al.,* 2017
Melilotus neapolitanus Ten	Mahmutaj *et al.,* 2020
Melilotus officinalis L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Melilotus sulcatus Desf.	HK; Barina *et al.,* 2017
Melissa officinalis L.	Xhulaj & Mullaj, 2002; MPWTT, 2007
Mentha aquatica L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Mentha piperita L.	Xhulaj & Mullaj, 2002
Mentha pulegium L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Mercurialis annua L.	Pampanini, 1915; Barina *et al.,* 2017
Micromeria cristata (Hampe) Griseb.	Mahmutaj *et al.,* 2020
Micromeria graeca (L.) Benth. ex Rchb.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Morus alba L.	Xhulaj & Mullaj, 2002
Myosotis arvensis (L.) Hill	Barina *et al.,* 2017
Myosotis nemorosa Besser	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Myriophyllum spicatum L.	Buzo, 2000
Myrtus communis L.	HK; CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Najas marina L.	Xhulaj & Mullaj, 2002
Narcissus poeticus L	Buzo, 2000; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a
Nasturtium officinale R. Br.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Nigella damascena L.	Pampanini, 1915; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Notobasis syriaca (L.) Cass.	Barina *et al.,* 2017
Nuphar lutea (L). Sibth. & Sm.	Buzo, 2000; Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a
Nymphaea alba L.	Buzo, 2000; Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a
Nymphoides peltata O. Kuntze.	Buzo, 2000; Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a

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Olea europaea L. subsp. europaea	MIE, 2019a
Olea europea L.	HK; Xhulaj & Mullaj, 2002; MPWTT, 2007; Mahmutaj *et al.,* 2020
Onobrychis caput-galli (L.) Lam.	Barina *et al.,* 2017
Ononis pusilla L.	Barina *et al.,* 2017
Ononis reclinata L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ononis spinosa L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ononis variegata L.	HK; Baldacci, 1896; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Onopordum acanthium L.	Barina *et al.,* 2017
Onopordum illyricum L.	Barina *et al.,* 2017
Onosma echioides L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ophrys apifera Huds.	HK; Barina *et al.,* 2017
Ophrys bertolonii Moretti	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ophrys bombyliflora Link	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ophrys ferrum-equinum Desf.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ophrys fusca Link	HK; Barina *et al.,* 2017
Ophrys lutea (Gouan) Cav.	Barina *et al.,* 2017
Ophrys scolopax Cav.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ophrys speculum Link	Barina *et al.,* 2017
Ophrys sphegodes Mill.	HK; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ophrys umbilicata Desf.	Barina *et al.,* 2017
Opopanax hispidus (Friv.) Griseb.	Barina *et al.,* 2017
Orchis x paparisti Goelz & Reinhard	Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a
Origanum vulgare L.	Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a
Orlaya grandiflora (L.) Hoffm.	Xhulaj & Mullaj, 2002
Ornithogalum sibthorpii Greuter	Barina *et al.,* 2017
Ornithogalum sphaerocarpum A. Kern.	Barina *et al.,* 2017
Orobanche lavandulacea Rchb.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Orobanche ramosa L.	Barina *et al.,* 2017
Otanthus maritimus (L.) Hoffmanns. & Link	CORINE biotopes 1991; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Oxalis pes-caprae L.	Barina *et al.,* 2017
Oxybasis glauca (L.) S. Fuentes & al.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Paliurus spina-christi Mill.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Pallenis spinosa (L.) Cass.	Barina *et al.,* 2017
Pancratium maritimum L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Papaver apulum Ten.	Barina *et al.,* 2017; MIE, 2019a

Name of species	Publication
Papaver rhoeas L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Parapholis incurva (L.) C. E. Hubb.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Parentucellia viscosa (L.) Caruel	Pampanini, 1915; Barina *et al.,* 2017
Parietaria officinalis L.	Pampanini, 1915; Xhulaj & Mullaj, 2002; MPWTT, 2007
Paspalum distichum L.	CORINE biotopes 1991; Barina *et al.,* 2017
Periploca graeca L.	HK; Baldacci, 1896; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Persicaria lapathifolia (L.) Delarbre	Baldacci, 1896
Persicaria hydropiper (L.) Delabre	MIE, 2019a
Petrorhagia dubia (Raf.) G. López & Romo	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Petrorhagia prolifera (L.) P. W. Ball & Heywood	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Petrorhagia saxifraga (L.) Link	Barina *et al.,* 2017
Petrosimonia oppositifolia (Pallas) Litvinov	Baldacci, 1896; Buzo, 2000; Xhulaj & Mullaj, 2002
Peucedanum arenarium Waldst.	Buzo, 2000
Phacelurus digitatus (Sibth. & Sm.) Griseb.	Barina *et al.,* 2017
Phagnalon graecum Boiss. & Heldr.	Barina *et al.,* 2017
Phagnalon saxatile (L.) Cass.	Barina *et al.,* 2017
Phalaris aquatica L.	Barina *et al.,* 2017
Phalaris brachystachys Link	Barina *et al.,* 2017
Phalaroides arundinacea (L.) Rauschert	Xhulaj & Mullaj, 2002
Phillyrea angustifolia L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; MIE, 2019a; Mahmutaj *et al.,* 2020
Phillyrea latifolia L.	Topi *et al.,* 2013; Barina *et al.,* 2017
Phleum pratense L.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Phlomis fruticosa L.	Barina *et al.,* 2017
Pholiurus panonicus (Host) Trin.	Buzo, 2000
Phragmites australis (Cav.) Steud.	CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; MoE, 2009; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Physalis angulata L.	Barina *et al.,* 2017
Physospermum cornubiense (L.) DC.	Barina *et al.,* 2017
Picris echioides L.	Barina *et al.,* 2017
Picris hieracioides L.	Barina *et al.,* 2017

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Piptatherum miliaceum (L.) Cosson	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Pistacia lentiscus L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a
Pisum sativum L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Plantago afra L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Plantago arenaria Waldst. & Kit.	Barina *et al.,* 2017
Plantago bellardii All.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Plantago coronopus L.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Plantago crassifolia Forssk.	Baldacci, 1896; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; Mahmutaj *et al.,* 2020
Plantago lagopus L.	Barina *et al.,* 2017
Plantago lanceolata L.	MPWTT, 2007; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Plantago major L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Plantago maritima L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Plantago psyllium L.	Topi *et al.,* 2013
Platanus orientalis L.	Buzo, 2000; MPWTT, 2007; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Plumbago europaea L.	HK
Poa annua L.	Barina *et al.,* 2017
Poa bulbosa L.	HK; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Poa pratensis L.	Xhulaj & Mullaj, 2002
Poa trivialis L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Polycarpon tetraphyllum (L.) L.	Barina *et al.,* 2017
Polygala nicaeensis Risso ex W. D. J. Koch	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Polygonum arenaria Waldst. & Kit.	MPWTT, 2007
Polygonum aviculare L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Polygonum lapathifolium L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; MIE, 2019a
Polygonum maritimum L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Polypogon monspeliensis (L.) Desf.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Populus × canescens (Aiton) Sm.	Mahmutaj *et al.,* 2020
Populus alba L.	HK; CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Populus nigra L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a
Portulaca oleracea L.	Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Posidonia oceanica (L.) Delile	Xhulaj & Mullaj, 2002
Potamogeton crispus L.	Xhulaj & Mullaj, 2002
Potamogeton natans L.	Xhulaj & Mullaj, 2002
Potamogeton nodosus Poiret	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Potentilla micrantha DC.	MPWTT, 2007
Potentilla reptans L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017

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Prasium majus L.	Barina *et al.,* 2017
Prunella vulgaris L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a
Prunus spinosa L.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Pseudorlaya pumila (L.) Grande	Topi *et al.,* 2013
Psoralea bituminosa L.	HK; Barina *et al.,* 2017
Pteridium aquilinum (L.) Kuhn	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ptilostemon afer (Jacq.) Greuter	Barina *et al.,* 2017
Puccinellia festuciformis (Host) Parl.	MPWTT, 2007; Mahmutaj *et al.,* 2020
Pulicaria dysenterica (L.) Bernh.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Pulicaria odora (L.) Rchb.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Pulicaria sicula (L.) Moris	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Pulicaria vulgaris Gaertn.	Barina *et al.,* 2017
Punica granatum L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Putoria calabrica (L. f.) DC.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Pyracantha coccinea M. Roem.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Pyrus communis L.	HK
Quercus robur L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Imeri *et al.,* 2018; MIE, 2019a
Radiola linoides Roth	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Ranunculus arvensis L.	MPWTT, 2007
Ranunculus ficaria L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Ranunculus peltatus subsp. baudoti	Mahmutaj *et al.,* 2020
Ranunculus sardous Crantz	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ranunculus trichophyllus Chaix	HK; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Ranunculus velutinus Ten.	Buzo, 2000; Xhulaj & Mullaj, 2002
Rapistrum rugosum (L.) All.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Reichardia picroides (L.) Roth	HK; Topi *et al.,* 2013; Barina *et al.,* 2017
Reseda lutea L.	Barina *et al.,* 2017
Rhamnus alaternus L.	HK; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Robinia pseudacacia L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Romulea bulbocodium (L.) Sebast. & Mauri	HK; Topi *et al.,* 2013; Barina *et al.,* 2017
Rosa canina L.	Xhulaj & Mullaj, 2002; MIE, 2019a
Rosa gallica L.	Barina *et al.,* 2017
Rosa sempervirens L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Rostraria cristata (L.) Tzvelev	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Rubia peregrina L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Rubus sanctus Schreb.	Barina *et al.,* 2017
Rubus ulmifolius Schott	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020

Name of species	Publication
Rumex conglomeratus Murray	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Rumex pulcher L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Rumex sanguineus L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Ruppia cirrhosa (Petagna) Grande	CORINE biotopes 1991; MPWTT, 2007; MoE, 2009; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Ruppia maritima L.	MoE, 2009; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Ruscus aculeatus L.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Sagina apetala Ard.	Barina *et al.,* 2017
Sagina maritima Don	MPWTT, 2007
Sagina procumbens L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Salicornia europaea L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Salix alba L.	HK; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; MIE, 2019a; Mahmutaj *et al.,* 2020
Salix amplexicaulis Bory	MIE, 2019a
Salix purpurea L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; MIE, 2019a; Mahmutaj *et al.,* 2020
Salsola kali L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Salsola soda L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; MoE, 2009; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a
Salvia verbenaca L.	Barina *et al.,* 2017
Salvia viridis L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Sambucus ebulus L.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Sambucus nigra L.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Samolus valerandi L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Sanguisorba minor Scop.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Saponaria officinalis L.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Scandix australis L.	MPWTT, 2007
Scandix pecten-veneris L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Schoenus nigricans L.	HK; CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; Mahmutaj *et al.,* 2020
Schoenus oleraceus L.	HK
Scilla autumnalis L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Scirpoides holoschoenus (L.) Soják	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; Mahmutaj *et al.,* 2020
Scirpus cernuus Vahl	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Scirpus lacustris L.	HK; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Scolymus hispanicus L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Scorpiurus muricatus L.	Barina *et al.,* 2017
Scorzoner cana (C.A. Meyer) O. Hoffm. in Engles & Prantl	HK
Scorzonera laciniata L.	Barina *et al.,* 2017
Scrophularia peregrina L.	Barina *et al.,* 2017

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Scutellaria rubicunda Hornem.	Barina *et al.,* 2017
Securigera securidaca (L.) Degen & Dörfl	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Selaginella denticulata (L.) Spr ing.	Barina *et al.,* 2017
Senecio erraticus Bertol.	Barina *et al.,* 2017
Senecio vernalis Waldst. & Kit.	Buzo, 2000
Senecio vulgaris L.	Xhulaj & Mullaj, 2002
Serapias lingua L.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Serapias parviflora Parl.	HK; Barina *et al.,* 2017
Serapias vomeracea (Burm. f.) Briq.	HK; Pampanini, 1915; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Setaria pumila (Poir.) Schult.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Setaria verticillata (L.) P. Beauv.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Sherardia arvensis L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Sideritis romana L.	HK;
Silene alba Miller	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Silene cephallenia Heldr.	Barina *et al.,* 2017
Silene colorata Poir.	Topi *et al.,* 2013; Barina *et al.,* 2017
Silene conica L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Silene gallica L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Silene vulgaris (Moench) Garcke	Barina *et al.,* 2017
Silybum marianum (L.) Gaertn.	Barina *et al.,* 2017
Sinapis arvensis L.	Barina *et al.,* 2017
Sisymbrium officinale (L.) Scop.	Xhulaj & Mullaj, 2002
Sisyrinchium angustifolium Mill.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Sium latifolium L.	MIE, 2019a; Mahmutaj *et al.,* 2020
Sixalix atropurpurea (L.) Greuter & Burdet	Mahmutaj *et al.,* 2020
Smilax aspera L.	HK; CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Solanum nigrum L.	Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Sonchus maritimus L.	Topi *et al.,* 2013
Sonchus oleraceus L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Sorghum halepense (L.) Pers.	Imeri *et al.,* 2018; Mahmutaj *et al.,* 2020
Sparganium erectum L.	Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; MIE, 2019a; Mahmutaj *et al.,* 2020
Spartina versicolor Fabre	Mahmutaj *et al.,* 2020
Spartium junceum L	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020

Name of species	Publication
Spergula arvensis L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Spergularia marina L.	MPWTT, 2007; Topi *et al.,* 2013
Spergularia rubra (L.) J. Presl & C. Presl	Barina *et al.,* 2017
Sphenopus divaricatus (Gouan) Rchb.	Barina *et al.,* 2017
Spiranthes spiralis Koch.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a
Spirodela polyrhiza (L.) Schleid.	MIE, 2019a
Sporobolus pungens (Schreb.) Kunth	Buzo, 2000; Topi *et al.,* 2013; Imeri *et al.,* 2018; Mahmutaj *et al.,* 2020
Stachys maritima L.	Xhulaj & Mullaj, 2002; Imeri *et al.,* 2018; MIE, 2019a
Stellaria media (L.) Cirillo	Xhulaj & Mullaj, 2002
Suaeda maritima (L.) Dumort.	Xhulaj & Mullaj, 2002; MoE, 2009; Topi *et al.,* 2013; MIE, 2019a; Mahmutaj *et al.,* 2020
Suaeda splendens (Pourr.) Gren. & Godr.	MPWTT, 2007; MoE, 2009; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a
Suaeda vera J.F.Gmel.	HK; Baldacci, 1896; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013
Tamarix dalmatica B. R. Baum	HK; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Imeri *et al.,* 2018; Mahmutaj *et al.,* 2020
Tamarix hampeana Boiss. & Heldr.	HK; CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Tamarix parviflora DC.	MPWTT, 2007; MIE, 2019a; Mahmutaj *et al.,* 2020
Tamus communis L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Taraxacum officinale Web.	HK; Xhulaj & Mullaj, 2002
Teucrium chamaedrys L.	Pampanini, 1915; Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Teucrium flavum L.	Barina *et al.,* 2017
Teucrium polium L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Teucrium scordium L.	Barina *et al.,* 2017
Theligonum cynocrambe L.	Barina *et al.,* 2017
Thlaspi perfoliatum L.	HK; Barina *et al.,* 2017
Thymelaea hirsuta (L.) Endl.	Barina *et al.,* 2017
Thymus capitatus (L.) Hoffmanns. & Link	HK; Barina *et al.,* 2017
Thymus longicaulis C. Presl.	Xhulaj & Mullaj, 2002
Thymus vulgaris L.	MPWTT, 2007
Tordylium apulum L.	Barina *et al.,* 2017
Torilis nodosa (L.) Gaertn.	Barina *et al.,* 2017
Tragopogon pratensis L.	Barina *et al.,* 2017
Tragus racemosus (L.) All.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Tribulus terrestris L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Trifolium angustifolium L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Trifolium campestre Schreb.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Trifolium fragiferum L.	Topi *et al.,* 2013
Trifolium lappaceum L.	MPWTT, 2007; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Trifolium nigrescens Viv.	HK

Name of species	Publication
Trifolium patens Schreber	Topi *et al.,* 2013
Trifolium physodes Steven ex M. Bieb.	Pampanini, 1915; Barina *et al.,* 2017
Trifolium pratense L.	HK; Xhulaj & Mullaj, 2002
Trifolium repens L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Trifolium resupinatum L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017
Trifolium scabrum L.	MPWTT, 2007; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Trifolium setiferum Boiss.	Baldacci, 1896
Trifolium striatum L.	Barina *et al.,* 2017
Trifolium subterraneum L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Trifolium tenuifolium Ten.	Baldacci, 1896
Trifolium vesiculosum Savi	Barina *et al.,* 2017
Triglochin bulbosa L.	Topi *et al.,* 2013; Barina *et al.,* 2017
Triglochin maritima L.	Topi *et al.,* 2013
Triglochin palustris L.	Xhulaj & Mullaj, 2002; Mahmutaj *et al.,* 2020
Trigonella corniculata (L.) L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Trigonella monspeliaca L.	Barina *et al.,* 2017
Tripidium ravennae (L.) H. Scholz	HK; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Triplex calotheca (Rafn) Fr.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013
Tussilago farfara L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Typha angustifolia L.	Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Typha latifolia L.	CORINE biotopes 1991; MPWTT, 2007; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020
Typha laxmannii Lepech.	Barina *et al.,* 2017
Ulmus campestris L.	Xhulaj & Mullaj, 2002
Ulmus glabra Huds.	MIE, 2019a
Ulmus laevis Pall.	CORINE biotopes 1991
Ulmus minor Mill.	HK; Buzo, 2000; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Umbilicus rupestris (Salisb.) Dandy	Barina *et al.,* 2017
Urtica dioica L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; MIE, 2019a; Mahmutaj *et al.,* 2020
Valantia muralis L.	Barina *et al.,* 2017
Valerianella coronata (L.) DC.	Barina *et al.,* 2017
Valerianella dentata (L.) Pollich	Barina *et al.,* 2017
Valerianella eriocarpa Desv.	Barina *et al.,* 2017
Verbascum blattaria L.	Barina *et al.,* 2017
Verbascum phlomoides L.	Xhulaj & Mullaj, 2002
Verbascum sinuatum L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017
Verbascum thapsus L.	Xhulaj & Mullaj, 2002
Verbena officinalis L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Veronica anagallis-aquatica L.	Xhulaj & Mullaj, 2002; MPWTT, 2007; Barina *et al.,* 2017
Veronica beccabunga L.	Xhulaj & Mullaj, 2002
Veronica chamaedrys L.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017

Name of species	Publication
Veronica persica Poir.	Xhulaj & Mullaj, 2002
Vicia bithynica (L.) L.	Barina *et al.,* 2017
Vicia cracca L.	Topi *et al.,* 2013; Barina *et al.,* 2017
Vicia grandiflora Scop.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Vicia hirsuta (L.) S.F.Gray.	Xhulaj & Mullaj, 2002
Vicia lutea L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Vicia parviflora Cav.	Buzo, 2000; Barina *et al.,* 2017
Vicia sativa L.	Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Vicia villosa Roth	Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Vinca major L.	Topi *et al.,* 2013
Vitex agnus-castus L.	HK; CORINE biotopes 1991; Buzo, 2000; Xhulaj & Mullaj, 2002; MPWTT, 2007; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Vitis sylvestris Gmel.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Vulpia ciliata Dumort.	Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Mahmutaj *et al.,* 2020
Vulpia fasciculata (Forssk.) Samp.	HK; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Xanthium strumarium L.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; Topi *et al.,* 2013; Barina *et al.,* 2017; MIE, 2019a; Mahmutaj *et al.,* 2020
Xanthium strumarium subsp. *italicum*	Imeri *et al.,* 2018; Mahmutaj *et al.,* 2020
Xathium spinosum L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Zannichellia palustris L.	Xhulaj & Mullaj, 2002; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Zannichellia pedunculata Rchb.	MoE, 2009; MIE, 2019a; Mahmutaj *et al.,* 2020
Zostera marina L.	Buzo, 2000; Barina *et al.,* 2017; Mahmutaj *et al.,* 2020
Zostera noltei Hornem.	CORINE biotopes 1991; Xhulaj & Mullaj, 2002; MPWTT, 2007; MoE, 2009; Barina *et al.,* 2017; Imeri *et al.,* 2018; MIE, 2019a; Mahmutaj *et al.,* 2020

Aquatic invertebrates from coastal and wetland habitats of the Vjosa Delta

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Coastal wetlands and the Vjosa Delta

Coastal wetlands, such as the Vjosa Delta, are transitional ecosystems between the sea and the continent, under the great and periodic influence of the tides, and eventual floods of the rivers. They both cause the salinity gradient and other aquatic parameters to vary greatly within the wetland area and from season to season. Due to these variations, wetland ecosystems are characterized by a high number of habitats and species. Such ecosystems are known to be among the most productive on the Planet.

Their habitats provide highly productive feeding, sheltering and nursery grounds for numerous commercially and recreationally important species. They also serve as filters for removing sediments and toxins from the water. Wetlands also buffer the mainland by mitigating and absorbing storm surges eneregy, thereby reducing erosion of the coastline, etc.

The aquatic habitats of the Vjosa Delta cover an important surface, which consists of 40% of the whole area (VKM/DCM 694/2022). They include the permanent marshes represented by the lagoons of Narta and Kallenga, the marshes of Limopuo, the salt marshes of Akerni and the Dead River (Zhuke). The Vjosa River from Mifoli to the river mouth separates the delta area between the Vlora district and Fieri district. There are also other shallow wetlands with brackish water, river traces of the Vjosa bed, etc. Delta area is also crossed by many artificial aquatic bodies, such as drainage and irrigation channels, salt evaporation ponds and temporary ponds with fresh or brackish water (Tab. 1).

Considering the characteristics mentioned above, the Vjosa Delta is distinguished by a high diversity of habitats and species. 18 habitats that are listed as Natura 2000 sites are present in the Vjosa Delta, of which 6 require special protection (AKZM/NAPA, 2022b).

Table 1.
Average values (from 2-6 parallel measurements of the physical-chemical parameters measured on site during April 24th-28th, 2023, with the multiparametric probe AQUAREAD (courtesy from A. Zhori and colleagues, AMBU).

Station / Parameter	pH	*DO (%)*	*O_2 (mg/L)*	*S (‰)*
Vjose (Mifol)	8.6	106.78	10.53	0.18
Vjose (Dellinje)	8.5	119.28	11.62	0.11
Vjose (Estuary, Poro, Fieri)	8.16	105.05	10.5	1.01
Small pond (Poro, Fieri)	9.13	114.5	10.22	4.78
Big pond (Poro, Fieri)	9.65	114.32	10.35	6.22
Dead River (Darzeze, Fieri)	8.3	115.13	10.18	10.11
Dead River (Zhuke, Vlora)	8.56	132.4	11.26	8.86
Dead River Estuary (Kallenge)	8.79	124.47	10.33	22.99
Temporary pond 1 (Narta Dam, East)	8.48	108.25	10.35	1.08
Temporary pond 2 (Narta Dam, East)	8.31	192.07	17.62	6.58
Narta Lagoon (Dam, middle)	8.86	114.63	9.83	24.33
Drainage Chanel (Dam, middle)	9.14	110.95	10.38	5.91
Pond (Soda Dump, south)	8.31	101.77	9.25	1.54
Soda Dump (Shën Thanas)	9.29	117.47	10.06	27.35

Coastal wetlands, as important habitats for aquatic invertebrates

The diversity of wetland habitats, their high primary productivity, the presence of developed vegetation with underwater meadows, mainly *Ruppia* and *Zostera*, emergent vegetation, mainly reed (*Phragmites*) and cattail (*Typha*), as well as sediments rich in decomposing organic matter, create suitable conditions for these habitats to be populated by important communities of aquatic invertebrates, with high density and abundance.

Invertebrates are the first secondary consumers that populate wetland habitats, represented by species from various taxonomic groups, including bacteria, protozoans, nematods, flatworms, annelids (polychaetes, oligochaetes, hirudineans), molluscs (mainly gastropods and bivalves), crustaceans, insects' larvae, fishes, amphibians, reptiles, and birds. Also mammals, such as the Euroasian otter (*Lutra lutra*) use these habitats as foraging grounds, mainly for fish, as well as macroinvertebrates.

Some species are strictly related to the water, others are partly aquatic and partly terrestrial during their stages of life cycle. Some of them are macroscopic and can be easily seen by open eye, others are microscopic. Some species float or swim in the water column; some live on or in sediments; others live as epibionts on the bodies of plants, macroalgae, or other animals; some species fixate on hard substrates (rocks, stones); and others can drill and are housed within hard substrates. Some species cause the phenomenon of *fouling*, being fixed on artificial structures placed by man in the water, such as on the bottoms of ships, structures of ports, piers, industrial and touristic constructions, etc. Also, in the water column of lagoons, marshes, ponds and canals, together with phytoplankton, invertebrate zooplankton organisms develop, a large part of which are microscopic. These can be bacteria, protozoans, rotifers, molluscs, annelids, crustaceans, etc.

With their high diversity, density and abundance, aquatic invertebrates play a very important role in food webs in wetland habitats, in the cycle of materials, energy flow, productivity and overall function of these ecosystems. Several species of invertebrates are used by humans for food, mainly from groups of gastropods, bivalves, crustaceans, both through fishing of wild natural populations and cultivation through aquaculture. Also, many groups of invertebrates make up the main food base of many fish species, which are the object of fishing and the fish market.

Hence, aquatic invertebrates also represent a great socio-economic value of wetland ecosystems, especially in coastal lagoons and river mouths, as is the case of the Narta Lagoon and the Vjosa Delta. Also, invertebrates have practical importance for humans, because some species are good indicators for the environmental condition of aquatic ecosystems, therefore they are used as indicators in the biomonitoring, as well as in the assessment of environmental impacts on these ecosystems.

For all the above-mentioned reasons, the great importance and necessity of sustainable conservation and management not only of the aquatic invertebrate community, but also of the ecosystem of the Vjosa Delta as a whole, is evident.

Biological zonation in transitional coastal environments and the connection with the Vjosa Delta

In their report "*The paralic domain: geological, biological and economic expressions of confinement*" Guelorget & Perthuisot (1983) emphasize that the biological populations of lagoons vary depending on the degree of their communication with the sea, a term known by them as "*confinement*". This zoning method of French authors for the transitional coastal environments has been adapted into Albanian by Miho (2011), due to the importance it has for Albanian coastal wetlands (Fig. 1), especially to fishing and aquaculture activity.

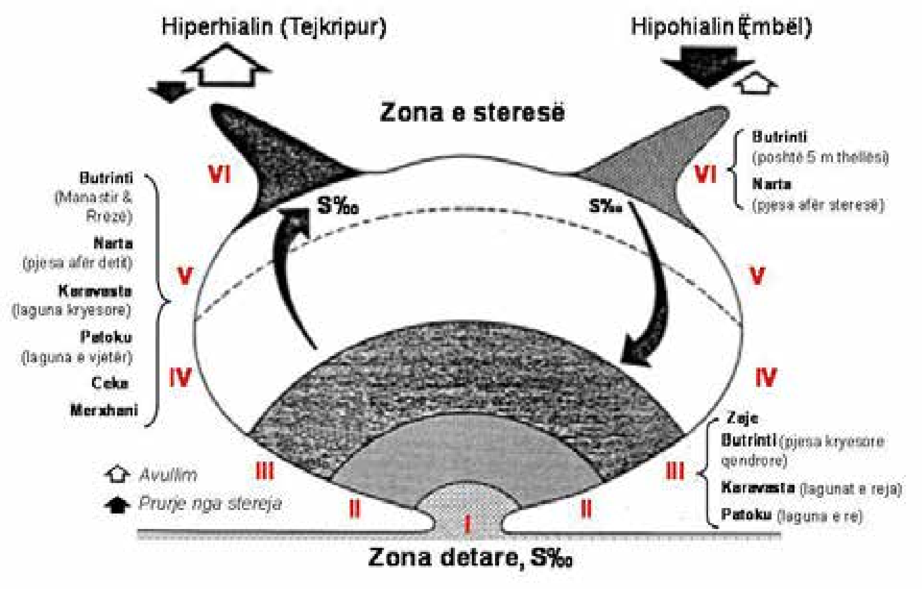

Figure 1.
Diagram showing the biological zoning (I- VI) for a Mediterranean lagoon; estimates of biological zoning for some of the Albanian lagoons according to Guelorget & Lefebvre (1993) are also reflected (updated according to Guelorget *et al*., 1983).

Based on their experience, and from the data collected during two visits to Albania, in April and August 1993, Guelorget & Lefebvre (1993; 1994) have also made a preliminary zoning of several coastal lagoons (Butrinti, Narta, Karavasta and Patoku). Therefore, we thought to bring here a summary, considering the importance of aquatic invertebrates for biological zoning, and as useful indicators for the characterization of aquatic habitats of the Vjosa Delta.

In a doctoral thesis on mollusks of five Albanian coastal lagoons, those of Vilun, Kune, Patok, Karavasta and Narta (Beqiraj 2004), considerations on their biological zonation have been presented, too, using mollusks as indicators, referred to the theory of biological zonation of Mediterranean lagoons after Guelorget & Pethuisot (1992). In major part of the lagoons' surfaces, zonation presented by Beqiraj (2004) and the one presented by Guelorget & Lefebvre (1993; 1994) match each other for the three lagoons that were common between the two studies, those of Patok, Karavasta and Narta.

Guelorget & Pethuisot (1983; 1984; 1992) classify Mediterranean lagoon areas into 6 biological zones (I-VI) (Fig. 1). Biological zonation, after these authors, is based on the biological composition of each zone, mainly in the composition of zoobenthos (Guelorget & Perthuisot, 1983; 1984; 1992; Guelorget *et al*., 2000; Dutrieux & Guelorget, 1988). The paralic environments are often populated by species found only in these environments, from blue-green algae to monocots, such as *Ruppia spiralis*, from protozoa to tunicates, to mollusks *Hydrobia acuta, Pirenella conica, Cerastoderma glaucum*, etc.

Zone I lies immediately close to the sea, with good water exchange with it, while zone VI lies far from the sea, with very limited water exchange, either entirely fresh water or much saltier than seawater when there is no freshwater input in that lagoon area.

In **zone II** marine species decrease, and replace by species of a lagoon character; in the soft bottoms of zone II one can find the mollusks *Mactra corallina, Mactra glauca, Tellina tenuis, Donax semistriatus, Donax trunculus, Acanthocardia echinata, Dosinia exoleta*; the polychaetes *Auduinia tentaculata, Megelona papillicornis, Owenia fusiformis, Phyllodoce mucosa, Pectinaria koreni*; the crustacean *Portumnus latipes; echinoderms Asterina gibbosa, Holoturia polii, Paracentroturus lividus*; in areas that are rich in organic matter, the amphioxus Branchiostoma lanceolatum is also present.

Hydroides elegans, Serpula vermicularis, Bowerbankia imbricata, Bugula stolonifera, Anomia ephippium, Modiolous barbatus, Botryllis schlosseri are more often encountered in the hard bottoms of zone II.

The depth is often higher in **zones I and II**, compared to other lagoon areas, the water is well oxygenated and poor in organic matter. These areas are suitable for intensive breeding that require clean water and good oxygenation. These areas do not require special trophic conditions. They are recommended for fish farming, or for water supply to feed breeding ponds. Sparidae species (sea breams) and sea bass, as well as other marine species can breed. Zone II is also suitable for shellfish cultivation.

Zone III has lower hydrodynamics. Organic matter increases in both sediments and water, but the conditions for life remain good. In the soft bottoms, the benthic macrofauna includes *Venerupis decussata, Venerupis aurea, Scrobicularia plana, Corbula giba, Loripes lacteus, Gastrana fragilis, Akera bullata, Nephthys hombergii, Armandia cirrosa, Glycera convoluta, Upogebia littoralis*. Zone III is very good for mollusk reproduction. Nutrient conditions are very good, and there is a good interdependence between zooplankton and phytoplankton.

Zone IV with soft bottoms is distinguished by the complete absence of marine species, and the presence only of lagoonary species, such as *Abra ovata, Cerastoderma glaucum, Hydrobia acuta, Nereis diversicolor, Gammarus insensibilis, Gammarus aequicaudata, Corophium insidiosum; macroflora is dominated by Ruppia spiralis*.

Zone V is mainly dominated by detritivorous crustaceans, such as *Sphaeroma hookeri, S. rugicauda, Corophium insidiosum, Idotea balthica*, by polychaete *Nereis diversicolor* and *Chironomidae larvae*; close to less salty waters, freshwater species appear, such as tricoptera, oligochaetes and odonates; while close to hypersaline waters, the crustacean *Artemia salina* appears. When macrovegetation is present, it is represented by *Potamogeton pectinatus*, as well as algae charophytes (Characeae).

The hard bottoms of **zones IV and V** are dominated by the cirripede *Balanus amphitrite* (also associated with *B. eburneus*), by *Brachydontes marioni* and by the polychaete *Mercieriella enigmatica*; flora consists only of chlorophytes *Ulva* spp. (*U. intestinalis, U. lactuca*), sometimes associated with *Gracilaria verrucosa*.

Zones IV and V stand out for their high content of organic matter. Sometimes these are unsalted. They may contain a large biomass of phytoplankton, where dinoflagellates and *Nannochloris* are present, too, which are often toxic algae. In addition, the proliferation of algae risks causing the lack of oxygen and dystrophic crises, especially during the hot season.

Therefore, **zones IV and V** are good environments for extensive breeding; they are suitable for growing fish species that feed on detritus, such as mullets; shrimps (*Peneidae*), too, can grow successfully in such an environment.

Zone VI is transitional to either an evaporitic zone of high salinity or a freshwater zone. The transition to a freshwater zone is accompanied by the survival of some lagoonal species, such as *Sphaeroma hookeri, Microdeutopus gryllotalpa, Gammarus insensibilis*, and by the appearance of freshwater species.

Zones that tend to change towards evaporative salinity (hyperhaline areas), are characterized by the macrofauna species loss, except for herbivores that temporarily approach to feed on the algal layers. Here the growth of layers with cyanobacteria can be distinguished, which prevent any form of aquaculture except for the direct use of phytoplankton and zooplankton.

Even in hard bottoms in *zone VI*, the macrofauna disappears, leaving space for cyanobacterial patches. In the hypersaline part, the phytoplankton is mainly populated by the chlorophyte *Dunaliella salina* or *D. viridis*, the first with a pink color in the hypersaline areas and the other with a greenish color, in the not very salty evaporating areas.

In the hard bottoms, mainly filter feeder species of macrofauna develop, such as *Mytilus galloprovincialis, Ostrea edulis, Avicula hirundo, Ciona intestinalis, Styella plicata, Phalusia mamillata, Bugula neritina, Membranipora membranacea, Balanus eburneus*. Various species of the genus *Ulva* are among the most common algae.

Narta Lagoon belongs mainly to zones V and VI, as discussed by Guelorget & Lefebvre (1994), Xhulaj & Miho (2008) and Miho (2011) (Fig. 1). After considerations of Beqiraj (2004), based on mollusks as indicators of biological zonation, major part of Narta Lagoon belongs to zones IV and V, the part of the lagoon that is close to the sea belongs to zone III, and only some peripherial parts, mainly in the north of the lagoon, belong to zone VI.

Zones IV and V that are predominant in the Narta Lagoon are suitable for extensive fishing (mainly for mullets and shrimps), according to descriptions about biological zonation of Mediterranean lagoons after Guelorget & Perthuisot (1984).

The zones V and VI in Narta Lagoon are characterized by relatively scarce exchange of water and limited communication with the sea.

Current knowledge on the aquatic invertebrates of the Vjosa Delta

Existing data on aquatic invertebrates of the Vjosa Delta are found in scientific papers, PhD and diploma works, technical reports of projects and different assessments, which are referred to Basset *et al*. (2006; 2008), Beqiraj (2001; 2004; 2014), Beqiraj *et al*. (2002; 2007; 2011), Beqiraj & Zenetos (2021), Boissin *et al*. (2020), Dhora & Salvini-Plawen (1997), Dhora (2002), Miho *et al*. (2013), Milori *et al*. (2021), Misja (2006), Peja *et al*. (1996), Ponti *et al*. (2006; 2008), Vaso & Gjiknuri 1993, Vaso (1994), etc.

Detailed data on mollusks of the Narta Lagoon have been presented in the PhD thesis of Beqiraj (2004), which has been focused on mollusks of five coastal lagoons of Albania. In that study, 32 mollusks species have been reported for the Narta Lagoon, of which 22 are gastropods and 10 are bivalves.

The Management Plan of Vjosa-Narta Landscape Protected Area (*Anonymous*, 2005) brings valuable data on the state of the habitats and biodiversity of this area, which is only a part of the Vjosa Delta area.

In that study, at least 390 species of invertebrates are mentioned to be known, including molluscs (32), Butterflies and Beetles (287), Crustaceans (61) and Echinoderms (6). Of these, 6 species of molluscs, 57 species of insects (Lepidoptera & Coleoptera), 9 crustaceans and 6 echinoderms were protected at the national level.

The study reports that the Vjosa-Narta area shelters a high number of vertebrate species, too, that belong to threatened categories either nationally or internationally.

Miho *et al*. (2013) in their Ecoguide to Discover the Transitional Waters of Albania mention data about aquatic invertabrates (i.e. mollusks) of Narta Lagoon and its coastal areas (Tab. 2 & Fig. 2). They cite Beqiraj (2001; 2004; 2006), Beqiraj & Kashta (2007; 2010; 2012), Beqiraj & Kasemi (2006), Beqiraj *et al*. (2002; 2007; 2008).

After them, 32 mollusk species have been reported for Narta Lagoon. The most widespread were gastropods *Hydrobia acuta, Ventrosia ventrosa, Pusillina mariginata, Pirenella conica, Cyclope neritea*, and *bivalves Cerastoderma glaucum, Scrobicularia cottardi*.

They also report that other 60 mollusk species have been found in coastal habitats of Vjosa – Narta area; 27 were gastropods (snails), 29 were bivalves (mussels) and 4 were cephalopods (octopus, squids and cuttlefishes); about 42 species were from marine waters, 12 from freshwaters and 6 from terrestrial habitats.

Figure 2.
Gastropod mollusks from Narta Lagoon: 1 & 1', *Alvania lineata*; 2, *Hydrobia acuta*; 3, *Pusillina lineolata*; 4, *P. radiata*; 5, *Ventrosia ventrosa*. (photos: S. Beqiraj; in Miho *et al*., 2013)

Figure 3.
Sampling benthic invertebrates and meiofauna in May and September 2023 in the Narta Lagoon.

After them, the intensive harvest of bivalves has occurred during the 15 recent years for *Tellina, Donax* and *Solen* from coastal habitats, and *Tapes decussatus* from the lagoon. This probably might have impacted the composition and structure of mollusks' populations, as well as other benthic species.

Shumka (2021) in the checklist of rotifer species from Albania, reports two species from the Narta Lagoon: *Colurella adriatica* and *Trichocerca pusilla*.

During the Scientific Week in April 2023, many individuals of *Daphnia magna* (Crustacea, Branchiopoda) were found in a brackish water pond in the Poro area, Vlora. Arapi & Sadikaj *in this volume* report that the coastal area of the Delta is characterized by quite powerful marine dynamics, especially from the waves, but also from water masses from the presence of the river delta. Therefore, mariculture (cultivation of sea fish and mussels) has never been practiced in this area. According to them, at the beginning of the 1970s efforts were made for mussel cultivation (*Mytilus galloprovincialis*) in the bed of the Old (Dead) River (Spaho & Flloko, 1994).

On the eastern shores of the Narta Lagoon, next to the Gorrica pumping station, there are traces of a former aquaculture infrastructure (about 200 ha), flooded pens and other abandoned fishing facilities. Up to the 1990s, that was used for the cultivation of Cyprinidae fish. After the 1990s, attempts were made to adapt it for the cultivation of sea shrimp (*Marsupenaeus japonicus*) in a semi-intensive way (Flloko, 2002; Arapi & Sadikaj, 2010), but without success.

Considerations on the aquatic invertebrates of the Vjosa Delta

Here in the following, there is an overview of aquatic invertebrates (Mollusca, Crustacea, Nematoda) known to date for the Vjosa Delta based on existing data. We will present and discuss also new data on benthic invertebrates (Mollusca and Crustacea) for the Narta area collected by authors of this publication in May and September 2023, as well as data on nematods collected in different habitats of the Delta in recent years (Fig. 3).

The data on molluscs and crustaceans of the Delta are reported in table 2, with the scientific name, the threat according to IUCN, Red Lists in Albania (URDHËR/ORDER 1280/2013), in the Mediterranean, in Europe, on a global scale, the involvement of several species in the annexes of international protection organizations, such as the Bern Convention, the Barcelona Convention, the Habitats Directive, the AMBI Ecological Group, the FAO-ASFIS Society Important Species Group, also including species that are reported by us for the first time (Beqiraj *et al*., here). The findings for nematodes are still at the study phase; they are determined to genus and are given separately in table 3.

126 species are reported here, with 93 molluscs (48 gastropods, 39 bivalves, 6 cephalopods), 31 crustaceans, 2 rotifers. Among them there are marine, lagoons, brackish and freshwater species.

In the Red List of the Albanian Fauna (URDHËR/ORDER 1280/2013) there are listed 60 invertebrate species that have been recorded in the Vjosa Delta, too, of which 35 species of mollusks (21 gastropods, 12 bivalves, 2 cephalopods) and 25 species of crustaceans. The most threatened invertebrates at the national scale are: gastropod molluscs *Tonna galea* (EN A1b), *Aporrhais pespelecani* (EN B2a), *Tritia mutabilis* (VU); bivalve *molluscs Ruditapes decussatus* (VU), *Mytilaster minimus* (CR), *Pecten jacobaeus* (VU), *Polititapes aureus* (VU).

22 invertebrate species are threatened on an international scale after the IUCN Red List (version 2022-2), of which 13 species are gastropods, 2 species are bivales, 4 species are cephalopods, and 3 species are crustaceans. **21 of these species are threatend at the Global level, 10 at the European level and 5 at the Mediterranean level**. 4 species are protected by the Bern Convention (Convention for the Conservation of European Wildlife and Natural Habitats, 1979), Barcelona Convention (Convention for the Protection of the Mediterranean Sea from Pollution, 1976) and by the European Habitats Directive (Council Directive 92/43/EEC).

Hence, the crustacean *Scyllarides latus* is part of Appendix III of both the Berne and the Barcelona conventions, and of the Appendix V of the European Habitats Directive; *Scyllarus arctus* is part of Appendix III of both the Berne and the Barcelona conventions; the gastropod mollusk *Tonna galea* is listed in the Appendix II of both the Berne and the Barcelona conventions; while the bivalve *Unio crassus* is included in the Appendices II and IV of the European Habitats Directive.

For some species, it is reported that their populations have decreased for the period 2000-2022. Some of these species are part of the database of the AMBI Ecological Group, as species very sensitive to disturbances (AZTI's Marine Biotic Index; https://ambi.azti.es/), where the gastropod *Aporrhais pespelecani*, and bivalves *Dosinia exoleta, Polititapes aureus, Mytilaster minimus, Ruditapes decussatus* have been included

Some of the species have been included in the FAO-ASFIS database, as species of importance to society, and are used for statistical purposes in fisheries (https://data.apps.fao.org/catalog/dataset/cwp-asfis). The following species have been included there: the gastropods *Galeoda echinophora, Aporrhais pespelecani, Tonna galea*, and the bivalves *Dosinia exoleta, Polititapes aureus, Abra alba, Scrobicularia cottardi, Scrobicularia plana, Solecurtus strigilatus, Ruditapes decussatus*.

Two alien and invasive species of marine invertebrates are also found in the Vjosa Delta, such as the bivalve *Ruditapes philipinarum* (Manila clam / Japanese carpet shell) originating from the Western Pacific, and the blue crab *Callinectes sapidus* originating from the Western Atlantic.

Introduction of the bivalve *Ruditapes philipinarum* in the Narta Lagoon, for more than 25 years already, has caused a big decline of the population of the Mediterrranean bivalve *Ruditapes decussatus*. Also, the quick increase of the blue crab *Callinectes sapidus* in the lagoon, especially since 2008, besides the effect through the competition on the population of the Mediterranean crab *Carcinus aestuarii*, it has also affected through predation the population of the bivalves, as well as fish in the lagoon, so becoming a concern for local fishermen.

Our findings on nematodes in different Delta habitats are reported in table 3. Their diversity is astonishing, in 18 genera, 12 families, 9 orders and 2 classes. The knowledge on this group of meiofauna is a new experience and much remains to be done. Our opinion is that the habitats of the Vjosa Delta offer a great diversity of species. Photos under the microscope for some nematodes that are found during our research in the Delta are presented in figures 5 and 6.

Besides the data on nematodes, the data on other groups belong to the Vjosa-Narta area, mainly the Narta Lagoon and the nearby coastal area.

Although their enormous importance, the data on aquatic invertebrates in Albania continues to be limited, despite the efforts made for years by Albanian researchers and in collaboration with international experts. Also, the existing data on the Vjosa Delta are scarce, sporadic, and focused mainly in Vlora part (southern part of the delta), while the data from the Fieri part (northern part of the delta) are even scarcer.

Tabele 2.
Checklist of the most common species of aquatic invertebrates (Mollusca, Crustacea, Rotifera, etc.), reported for the Vjosa-Narta area. Further explanations are given in the text. L, lagoon; S, sea; F, freshwater; T, terrestrial. AL, Albania; EU, Europe; Med, Mediterranean. Mentioned IUCN Categories: EN, Endangered; VU, Vulnerable; DD, Data Defficient; LC, Least Concern; NE, Not evaluated.

Scientific name	Habitat	Threatened after IUCN				Other facts
		AL	Global	EU	Med	
Alvania lineata	L	DD				
Aplysia punctata	L, S					
Aporrhais pespelecani	S	VU				AMBI; FAO-ASFIS
Bithynia tentaculata	F		LC	LC	LC	
Bittium reticulatum	L,S					
Bolinus brandaris	S	LC				
Bulla striata	L, S	LC				
Caucasotachea vindobonensis	T					
Cerithium vulgatum	L, S	LC				
Ecrobia ventrosa	L, F		LC			
Eobania vermiculata	T					
Galba truncatula	F			LC	LC	
Galeodea echinophora	S	LC				FAO-ASFIS
Haminoea hydatis	L	LC				
Haminoea navicula	L	LC				
Helix lucorum	T					
Hexaplex trunculus	S	LC				
Hydrobia acuta	L		LC	LC		
Lymnaea stagnalis	F		LC		LC	
Monacha cartusiana	T					
Naticarius hebraeus	S					
Naticarius stercusmuscarum	S	LC				
Neverita josephinia	S	LC				
Physella acuta	L, F		LC	LC		
Pirenella conica	L		LC			
Planorbarius corneus	F		LC	LC	LC	
Planorbis planorbis	F		LC	LC	LC	
Pomatias elegans	T					

Scientific name	Habitat	Threatened after IUCN				Other facts
		AL	Global	EU	Med	
Pusillina inconspicua	L	LC				
Pusillina lineolata	L	LC				
Pusillina marginata	L	LRcd				
Pusillina radiata	L	LRcd				
Radix auricularia	F		LC	LC		
Rissoa membranacea	L	LC				
Rissoa ventricosa	L	LC				
Stagnicola corvus	F		LC	LC		
Steromphala adriatica	L					
Theba pisana	T					
Theodoxus fluviatilis	F		LC			
Tonna galea	S	EN	NE	NE	NE	FAO-ASFIS, Berne Convention Ap.II, Barcelona Convention, Ap.II
Tricolia pullus	L,S					
Tritia incrassata	S					
Tritia mutabilis	L, S	VU				
Tritia neritea	L, S					
Tritia reticulata	L, S	LC				
Turbonilla lactea	L					
Turritella turbona	S	LC				
Viviparus contectus	F		LC			
Abra alba	L,S					FAO-ASFIS
Acanthocardia echinata	S					
Anodonta cygnea	F		LC	NT		
Anomia ephipium	L,S					
Bosemprella incarnata	S					
Callista chione	S					
Cerastoderma edule	S					
Cerastoderma glaucum	L, S					
Chamelea gallina	S					
Donax semistriatus	S					
Donax trunculus	S					

Scientific name	Habitat	Threatened after IUCN				Other facts
		AL	Global	EU	Med	
Dosinia exoleta	S	LC				AMBI FAO-ASFIS
Dosinia lupinus	L	LC				
Ensis minor	S	LC				
Flexopecten glaber	S					
Glossus humanus	S	LC				
Glycymeris bimaculata	S					
Glycymeris glycymeris	S	LC				
Glycymeris nummaria	S					
Laevicardium oblongum	S	LC				
Macomangulus tenuis	S					
Macomopsis cumana	L	LC				
Mactra corallina	S					
Moerella pulchella	S					
Mytilaster minimus	L,S	CR				AMBI
Mytilus galloprovincialis	L,S					
Pecten jacobaeus	S	VU				
Peronaea planata	S					
Pharus legumen	S					
Polititapes aureus	L, S	VU				AMBI FAO-ASFIS
Ruditapes decussatus	L, S	VU A1a				AMBI FAO-ASFIS
Ruditapes philippinarum	S					Alien species, FAO-ASFIS
Scrobicularia cottardi	L					
Scrobicularia plana	L, S					FAO-ASFIS
Solecurtus strigillatus	S	LC				FAO-ASFIS
Solen marginatus	L, S	LRcd				
Talochlamys multistriata	S					
Unio crassus	F		EN	VU	DD	EU Habitat Directive Ap.II & Ap.IV
Venus casina	S					
Eledone moschata	S		LC			

Scientific name	Habitat	Threatened after IUCN				Other facts
		AL	Global	EU	Med	
Loligo vulgaris	S		DD			
Octopus vulgaris	S					
Sepia officinalis	S		LC			
Sepietta oweniana	S	LC	DD			
Todarodes sagittatus	S	LC				
Achaeus gracilis	S	NE				
Alpheus dentipes	S	DD				
Alpheus glaber	S	LC				
Brachynotus sexdentatus	S	DD				
Calappa granulata	S	LC				
Callinectes sapidus	L, S					Alien species
Carcinus aestuarii	L, S					
Carcinus maenas	L, S					
Crangon crangon	L, S	LC				
Dardanus arrosor	S	LC				
Derilambrus angulifrons	S	DD				
Ethusa mascarone	S	LC				
Eualus cranchii	S	DD				
Galathea intermedia	S	LC				
Gilvossius tyrrhenus	S	LC				
Hippolyte leptocerus	S	LC				
Homola barbata	S	LC				
Liocarcinus maculatus	S	LC				
Liocarcinus navigator	S	LC				
Paguristes eremita	S	LC				
Palaemon elegans	L; S					
Palaemon antennarius	B	LC	LC			
Palaemon serratus	S	LC				
Palaemon varians	L					
Penaeus kerathurus	L; S					
Philocheras fasciatus	S	LC				
Pilumnus hirtellus	S	LC				
Pinnotheres pisum	S	LC				
Plesionika heterocarpus	S	LC				

Scientific name	Habitat	Threatened after IUCN				Other facts
		AL	Global	EU	Med	
Scyllarus arctus	S	LC	LC			Berne Convention Ap.III, Barcelona Convention Ap.III, EU Habitat Directive Ap.V
Scyllarides latus	S	LC	DD			Berne Convention Ap.III, Barcelona Convention Ap.III
Daphnia magna	L,F					
Colurella adriatica	L					
Trichocerca pusilla	L					
Total number of species	**126**	**59**	**22**	**11**	**7**	

Table 3.
Preliminary data on the Phylum Nematoda in the Vjosa Delta habitats.

Class	Order	Family	Genera
Chromadorea	Chromadorida	Chromadoridae	*Chromadorina*
			Prochromadora
	Monhysterida	Monhysteridae	*Monhystera*
		Xyalidae	*Daptonema*
			Theristrus
		Linhomoeidae	*Terscellingia*
	Rhabditida	Cephalobidae	*Acrobeles*
	Araeolaimida	Axonolaimidae	*Odontophora*
	Plectida	Plectidae	*Plectus*
Enoplea	Mononchida	Mononchidae	*Mononchus*
	Dorylaimida	Dorylaimidae	*Dorylaimus*
			Paractinolaimus
	Triplonchida	Tobrilidae	*Tobrilus*
			Brevitobrilus
	Enoplida	Oncholaimidae	*Oncholaimus*
			Metaparancholaimus
		Anoplostomatidae	*Anoplostoma*
		Thoracostomopsidae	*Enoplolaimus*

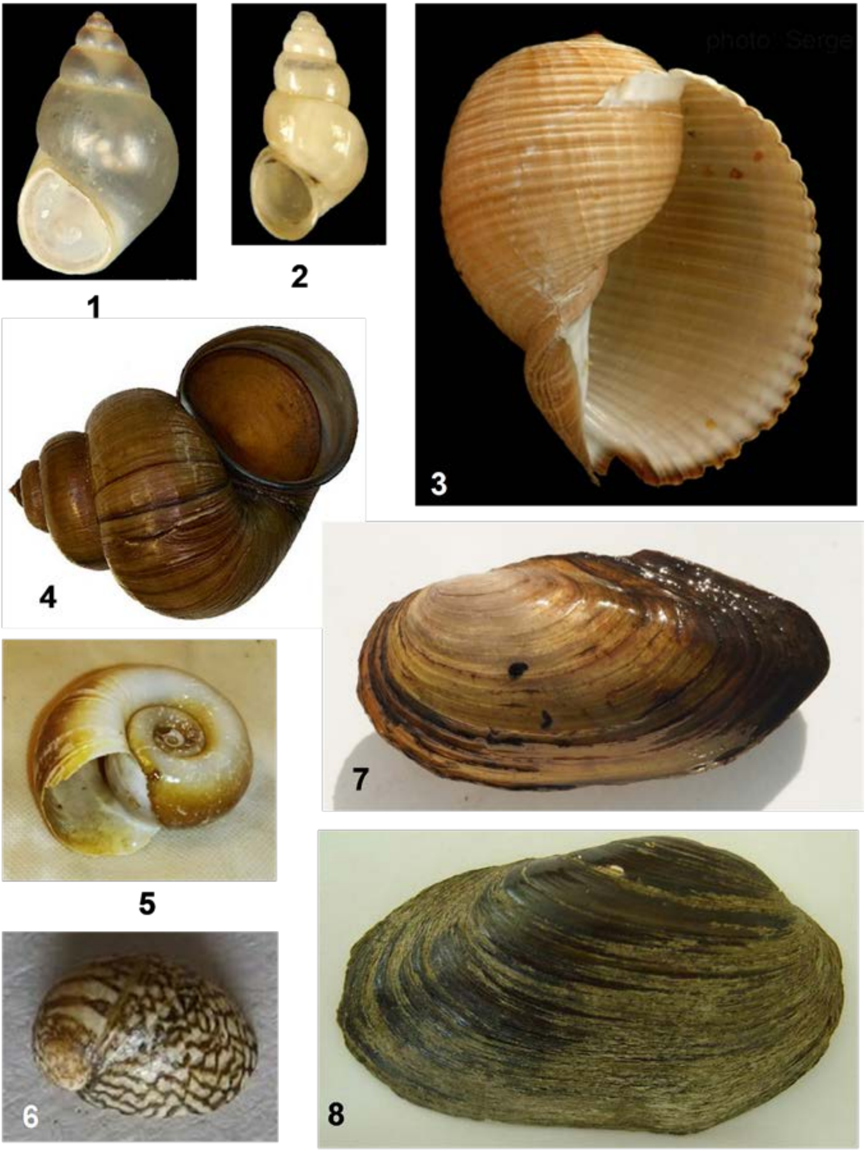

Figure 4.
Threatened mollusks from the Vjosa Delta. Gastropoda: 1, *Bithynia tentaculata*; 2, *Hydrobia acuta*; 3, *Tonna galea*; 4, *Viviparus contectus*; 5, *Planorbarius corneus*; 6, *Theodoxus fluviatilis*; Bivalvia: 7, *Anodonta cygnea*; 8; *Unio crassus*.

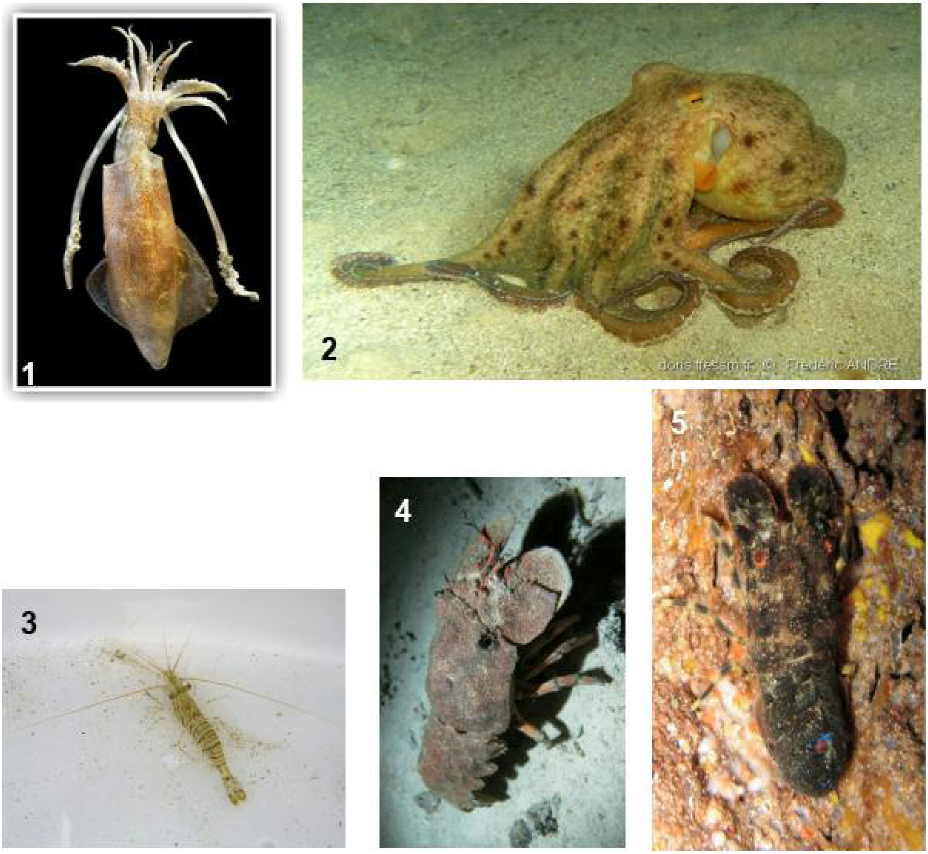

Figure 4.
Threatened cephalopods and crustaceans from the Vjosa Delta. Cephalopoda: 1, *Loligo vulgaris*; 2, *Eledone moschata*; Crustacea: 3, *Palaemon antennarius*; 4, *Scyllarides latus*; 5, *Scyllarus arctus*.

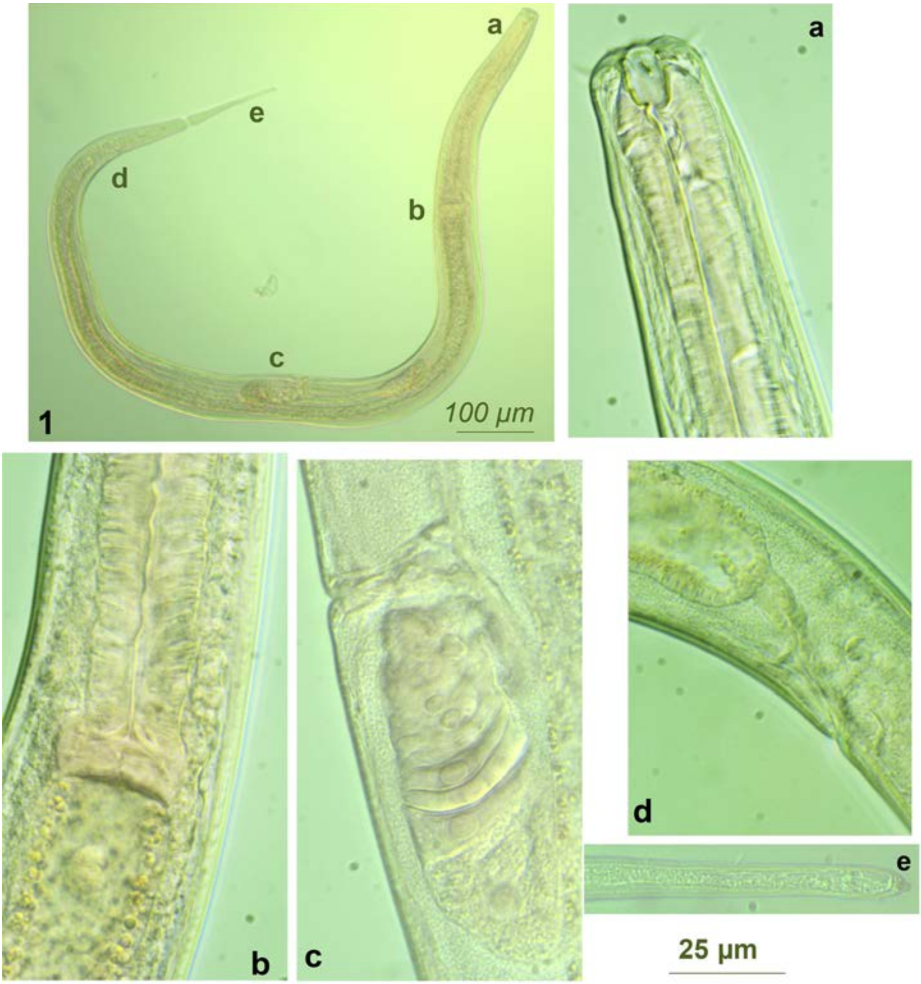

Figure 5.
Anatomy of a nematode (*Tobrilus sp. female*): **a**, head region; **b**, end of esophagus, beginning of intestine; **c**, ovary and vagina; **d**, rectum and anus; **e**, tail.

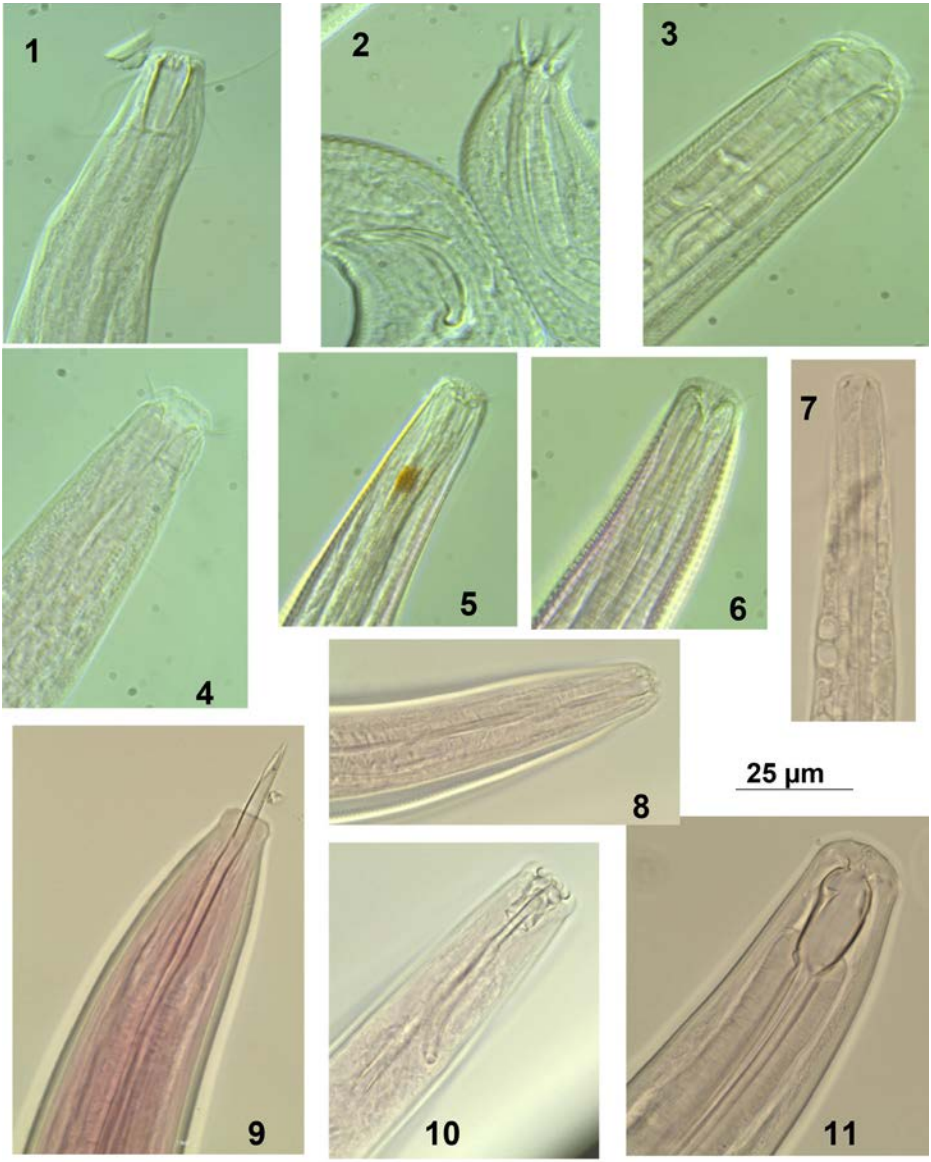

Figure 6.
Head region in nematode individuals of different genera from the Vjosa Delta: **1**, *Odontophora;* **2**, *Acrobeles;* **3**, *Theristus;* **4**, *Daptonema;* **5**, *Chromadorina;* **6**, *Prochromadora;* **7**, *Monhystera;* **8**, *Plectus;* **9**, *Dorylaimus;* **10**, *Paractinolaimus;* **11**, *Monochus.*

Major threats to aquatic invertebrates in Vjosa Delta, and recommendations for their conservation

Referring to biology and ecology of most of the reported species in the Vjosa Delta, as well as the past and current environmental impacts in this area, threats to aquatic invertebrates are related to the following activities and/or phenomena: deterioration in water quality; climate change; organic pollution; biodegradable pollution; increasing eutrophication; water acidification; land reclamation; habitat loss and degradations; alteration of water courses; changes of flow regime; alteration of salinity balance of coastal lagoons; increasing infilling of coastal habitats; over-frequent dredging; fisheries, over fishing, bycatch; agriculture activities; over-harvesting; HPPs and dam construction; aquaculture activities; collection for aquarium trade; shipping activites; drilling activities; oil spills; impacts from invasive species; inappropriate changes in land use; development of coastal areas; sedimentation of eustarine and coastal areas; inappropriate water management and conservation; inapproriate schemes of water use; excessive flooding; dredging of rivers; increasing bacterial and/or viral infestaions. These threats can act either separately or in synergy with each other, directly or indirectly, often with irreversible consequences for invertebrates' populations and for many ecosystem services.

Considering the importance and values of the macroinvertebrates' community in the Vjosa Delta, as well as environmental threats in this area, as already described above, **it is necessary to quickly undertake measures and actions for the conservation of wetland habitats and aquatic invertebrates in the Vjosa Delta.**

For research institutions we recomend: regular species inventory and monitoring; habitat monitoring; population structure; size and trend; distribution; threats; life history and ecology; impact from fisheries, harvesting and other use.

Proposals for preparation and adequate implementation of strategies, management plans, action plans, laws, regulations and decisions for conservation and protection of the Vjosa Delta in general and aquatic communities in particular, have been done for many years and persistently to **policy-making and management institutions**. Considering the current developments in this area, our common appeal for conservation of aquatic invertebrates, as well as the whole ecosystem is: **Proclamation of the Pishe Poro – Narta area as a National Park, and its inclusion in the existing National Park of the Vjosa River.**

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Overview on the insects (Class Insecta) of the Vjosa Delta

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Breafly on the Vjosa/Aoos River and Its Delta

Europe's last wild river, the Vjosa River stretches for a length of about 275 kilometers, widening in some areas over 2 km. The impressive scenery that characterizes the River along its whole length and the fact that almost all its tributaries are free flowing and untouched make this River truly exceptional, now recognized as a natural heritage asset of the entire continent old European (Schiemer *et al*., 2020; Acta ZooBot Austria, 2018).

The Vjosa River from its source in the Pindos Mountains, east of Ioannina at the foot of Mavrovouni in Greece, flows through southern Albania to the Adriatic Sea; the **magnificent Delta** lies here that begins at the Mifoli Bridge, and extends to the coastal area from Narta Lagoon in the southern part to Darzeza e Re in the northern part, where it seems to join the Semani Delta spread over an area of about 240 km² (Schwarz, *in this Volume*).

Coastal wetlands and the Vjosa Delta, mutual connections with the insect world

Coastal wetlands like it is the Vjosa Delta belong to the most productive ecosystems on earth. They are **transitional ecosystems** between the open sea and the mainland, under the strong effects the tides, twice-daily ebb and flow, where the gradient of salinity is quite crucial to their diversity of habitats and diversity species. Their habitats provide highly productive nursery grounds for numerous commercially and recreationally important species, and serve as filters to remove sediments and toxins from the water. Marshes also buffer the mainland by slowing and absorbing storm surges, thereby reducing erosion of the coastline (https://www.dnr.sc.gov/marine/pub/seascience/dynamic.html).

The aquatic habitats are inhabited by a variety of algae and serve as **primary producers** of food. But also rooted plants, i.e. **reed** that can tolerate brackish water, often grow up along the riverbanks of estuaries and on other wetlands, occasionally inundated by the sea, and also from the rivers. The soft marsh substrate is formed each fall and bacteria decompose it into a rich soup known as detritus that along with algae serves as the basis of the productive marsh food web.

Invertebrates are the first **secondary consumers** that flourish in these habitats, represented by various species of insects, crustaceans, mollusks, worms, etc. Some of them are strictly related with the water, others have a double behavior living partly in water and partly terrestrial in their life, and others are only terrestrial; some of them are macroscopic the can be easily seen, others are microscopic; some species floats in the water column, some live attached to vegetation or other substrates; diversity of species varies after the changing the water salinity; etc.

All these features together make the approach to delta species difficult, either taxonomically and ecologically. On the other side all the mentioned groups of **invertebrates are important to the normal function of the food webs in coastal wetlands**. But not only, **they are important to the man life itself**.

And among the all invertebrates in these transitional ecosystems, **the role of insects in ecosystem and to the man is enormous and variegate**. Let's bring some examples: The majority of **pollination** is done by insects, vital for the flowering plants, for the life itself, but also for the man survival; and bees collect nectar and pollen to produce **honey** for food; other insects produce other useful substances such as wax, lacquer and silk; etc.

Other insects are **parasitic** (e.g. lice, bed bugs), **transmit diseases** (mosquitoes, flies), **damage structures** (termites), or **destroy agricultural goods** (locusts, weevils); there are fresh news in the media (June-September 2023) about the invasion by locusts in the Semani area, up to Tirana, with consequences for the vegetation, but not only...; species of mosquitoes are known to spread diseases; i.e. malaria has caused more deaths in humans than any other animal in Albania until the beginning of the last century; **insectivorous insects**, or insects that feed on other insects, are beneficial to humans, in agriculture; etc.

From the above, the Vjosa Delta is also characterized by a variety of habitats and interesting biodiversity that deserve the attention of researchers and policymakers. In the Vjosa Delta, the presence of about 18 habitats listed as Natura 2000 is listed, among which 6 require special protection (AKZM/NAPA, 2022b).

What is reported to date the about the insects of the Vjosa Delta?

We will summarize what is reported for the insects (Class Insecta) of the Vjosa Delta area, including our findings for butterflies (Order Lepidoptera) collected in the area during spring-autumn 2022.

In the Vjosa-Narta Protected Landscape Management Plan (*Anonymous*, 2005), **287 species of insects (butterflies and coleoptera) are reported**, but without a checklist of species. Experts confirm that **57 species are protected at the national level, 28 species at the European level and 1 species is globally threatened (*Lycaena ottomanus-VU*)**. The most common butterflies include Swallow-tail, Cleopatra, Hairstreaks and Blues. In addition some large and small Orthopterans, Longhorn Beetles and Ant-lions occurred in abundance in the drier habitats of Vjosa-Narta area.

Data in *Anonymous* (2005) were based in site diagnosis as well as in existing publications (they cite at the end: Luquet & Misja, 1989; 1989; Misja, 1984; 1990; 1992; 1997; 1999; 2001). They stress that for certain groups, especially mollusks, crustaceans, insects and echinoderms, further scientific surveys is needed. The same data for the Vjosa-Narta area are also brought from the material hosted by the MIE (2019).

Miho *et al*. (2013) in their Ecoguide to Discover the Transitional Waters of Albania mention that more than **150 species of winged insects (Pterygota)** were reported in different aquatic and terrestrial habitats of Vjosa-Narta zone, belonging to Lepidoptera (63 species), Coleoptera (43), Odonata (8) and Orthoptera (7). They cite at the end as sources: Misja, 2006; Peja *et al*., 1996; REC, 1997; Xhulaj M, 2001; Pano *et al*., 2007; Mima *et al*., 2003; NEA/AKM, 1999.

After them, some of coleopters may endanger agricultural cultures or natural vegetation, like *Anomala vitis, Anisoplia agricola, A. austriaca, Tropinota (Epicometis) hirta, Oxytherea funesta* and *Cetonia aurata*, and the *lepidopters, Cossus cossus, Odonestis pruni, Papilio machaon and Zeuzera pyrina*. They stress that the biological equilibrium is disturbed some times by the massive blooms of some species with multi annual dynamics, like night butterflies, like *Thaumetopoea pityocampa* (the pine processionary), *Hyphantria cunea* and *Malacosoma neustria*. The same information is mentioned by Topi *et al*. (2013) in their preliminary Report for Key Biodiversity Area of Narta Lagoon.

During the spring-autumn 2022, Lepidoptera representatives were collected by us in the Vjosa-Narta area. Collection, processing and determination was after Misja (2005), Paparisto & Misja (2005), Higgins & Riley (1983), Culin (2018), Cuvelier *et al*. (2018) and Butterflies of Albania on the UT website (Cuvelier & Paparisto, 2023) were used for species identification.

View on the insects of the Vjosa Delta

22 species of butterflies (Order Lepidoptera) were found by us in different habitats of the Vjosa-Narta (Tab. 1). In the hosting on the Butterflies of Albania by Cuvelier & Paparisto (2023), 29 species are reported for the Vjosa-Narta (without specifying the habitat), out of 216 species reported for Albania.

With the species mentioned by Miho *et al*. (2013), **the total number of butterfly species for the Delta reported here amounts to 44 species**. We have grouped all in table 1. They belong to 9 families, where Nymphalidae and Lycaenidae are the most abundant. Let's mention again the globally threatened species *Lycaena ottomanus* (VU). Photos of butterflies present in the Vjosa Delta are reported in figure 1.

Paparisto *et al*. (2021) report **10 species of dragonflies (Odonata) for the Vjosa-Narta area** (Tab. 2). There is a mix of vegetation (pine forest) and reed-covered swamps (mainly *Phragmites*); these are suitable habitats for feeding, reproduction and protection of dragonflies as well.

Table 1.
Checklist of butterfly species present in the Vjosa Delta based on our findings during the spring-autumn 2022 and historical data (Cuvelier & Paparisto, 2023).

Species	English name	Source
Papilionidae		
Iphiclides podalirius	Scarce swallowtail	Peqini *et al.*, 2023; Cuvelier & Paparisto, 2023
Papilio machaon	Swallowtail	Peqini *et al.*, 2023; Cuvelier & Paparisto, 2023; *Anonymous*, 2005
Zerynthia polyxena	*Southern Festoon*	Cuvelier & Paparisto, 2023
Hesperiidae		
Carcharodus alceae	Mallow Skipper	Peqini *et al.*, 2023; Cuvelier & Paparisto, 2023
Erynnis tages	*Dingy Skipper*	Cuvelier & Paparisto, 2023
Gegenes pumilio	Pigmy Skipper	Peqini *et al.*, 2023; Cuvelier & Paparisto, 2023
Muschampia alta	*Sage Skipper*	Cuvelier & Paparisto, 2023
Pyrgus malvae	*Grizzled Skipper*	Cuvelier & Paparisto, 2023
Pieridae		
Colias croceus	Clouded Yellow	Peqini *et al.*, 2023; Cuvelier & Paparisto, 2023
Gonepteryx cleopatra	Cleopatra	*Anonymous*, 2005
Pieris rapae	Small White	Peqini *et al.*, 2023;
Pontia edusa	Eastern Bath White	Peqini *et al.*, 2023;
Lycaenidae		
Aricia agestis	Brown Argus	Peqini *et al.*, 2023; Cuvelier & Paparisto, 2023
Cyaniris semiargus	*Mazarine Blue*	Cuvelier & Paparisto, 2023
Lampides boeticus	Pea blue	Peqini *et al.*, 2023;
Lycaena ottomanus	*Grecian Copper*	Cuvelier & Paparisto, 2023
Lycaena tityrus	*Sooty Copper*	Cuvelier & Paparisto, 2023
Plebejus argyrognomon	*Reverdin's Blue*	Cuvelier & Paparisto, 2023
Polyommatus escheri	*Escer's Blue*	Cuvelier & Paparisto, 2023
Polyommatus icarus	*Common Blue*	Peqini *et al.*, 2023; Cuvelier & Paparisto, 2023
Polyommatus thersites	Chapman's Blue	Cuvelier & Paparisto, 2023
Pseudophilotes vicrama	Eastern Baton Blue	Cuvelier & Paparisto, 2023
Nymphalidae		
Boloria graeca	Balkan Fritillary	Cuvelier & Paparisto, 2023

Species	English name	Source
Charaxes jasius	Two-tailed pasha	Peqini *et al.,* 2023;
Coenonympha rhodopensis	Eastern Large Heath	Cuvelier & Paparisto, 2023
Cyaniris semiargus	*Mazarine Blue*	Cuvelier & Paparisto, 2023
Danaus chrysippus	Plain Tiger	Peqini *et al.,* 2023; Cuvelier & Paparisto, 2023
Hipparchia semele	Grayling	Peqini et al., 23;
Lasiommata maera	Large Wall Brown	Cuvelier & Paparisto, 2023
Lasiommata megera	Wall Brown	Peqini et al., 2023; Cuvelier & Paparisto, 2023
Limenitis reducta	Southern White Admiral	Peqini *et al*., 2023; Cuvelier & Paparisto, 2023
Maniola jurtina	Meadow Brown	Peqini *et al.,* 2023; Cuvelier & Paparisto, 2023
Melitaea trivia	Lesser Spotted Fritillary	Peqini *et al.,* 2023;
Minois dryas	Dryad	Peqini *et al.,* 2023; Cuvelier & Paparisto, 2023
Nymphalis antiopa	Camberwell Beauty	Peqini *et al.,* 2023;
Polygonia egea	Southern Comma	Peqini *et al.,* 2023; Cuvelier & Paparisto, 2023
Vanessa atalanta	Red Admiral	Peqini *et al.,* 2023;
Vanessa cardui	Painted Lady	Peqini *et al.,* 2023; Cuvelier & Paparisto, 2023
Cossidae		
Cossus cossus	Goat moth	Miho *et al.,* 2013
Zeuzera pyrina	Leopard moth	Miho *et al.,* 2013
Erebidae		
Hyphantria cunea	Fall webworm	Miho *et al.,* 2013
Lasiocampidae		
Odonestis pruni	Plum lappet moth	Miho *et al.,* 2013
Malacosoma neustria	Lackey moth	Miho *et al.,* 2013
Notodontidae		
Thaumetopoea pityocampa	Pine processionary	Miho *et al.,* 2013

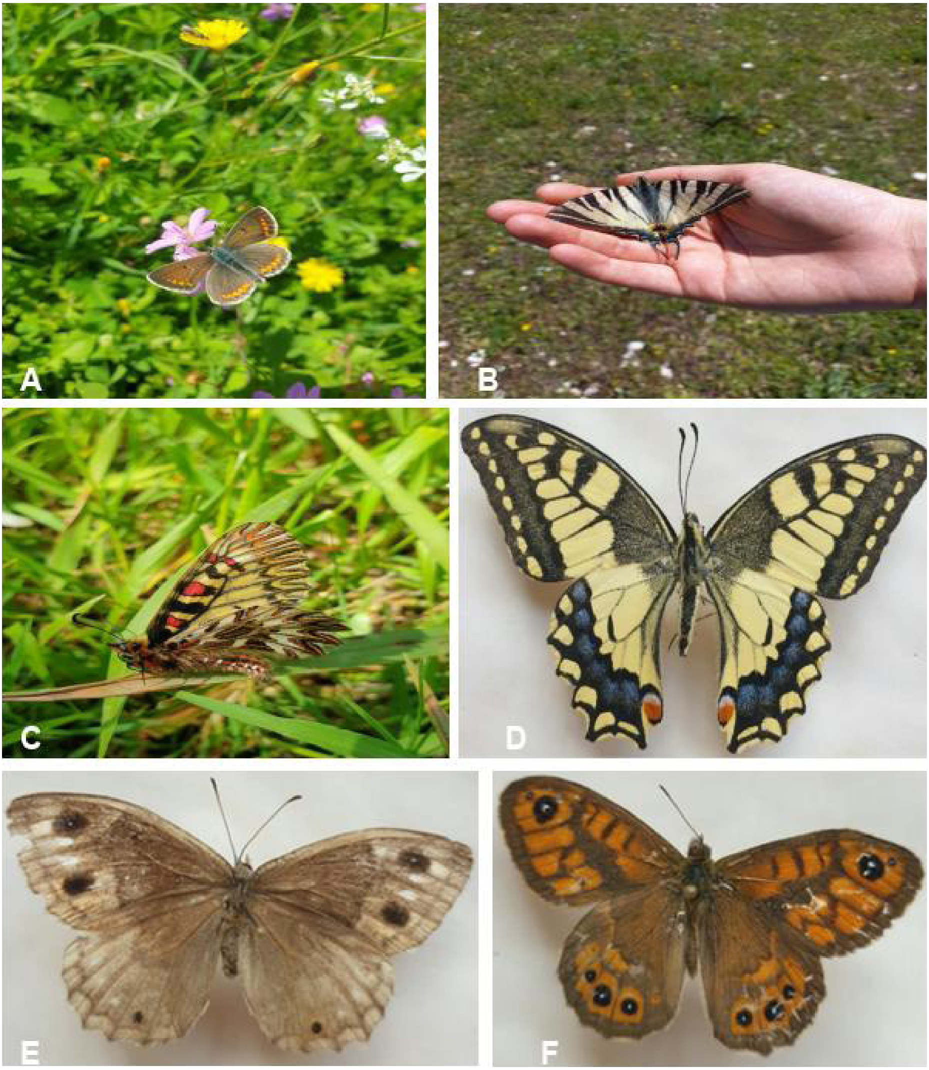

Figure 1.
Butterflies from the Vjosa Delta:
A, *Aricia agestis;* **B**, *Iphiclides podalirius;* **C**, *Zerynthia polyxena;* **D**, *Papilio machaon;* **E**, *Hipparchia statilinus* **F**, *Lasiommata megera.*

Table 2.
Checklist of species of dragonflies (Odonata) from the Vjosa-Narta area. (Paparisto *et al*., 2021)

Species	Place
Aeshna affinis	Nartë, Zvërnec
Calopteryx xanthostoma	Pylli i Sodës
Lestes barbarus	Nartë, Zvërnec
Libellula fulva	Nartë, Zvërnec
Orthetrum cancellatum	Nartë
Orthetrum coerulescens	Zërnec, Nartë
Platycnemis pennipes	Novoselë
Sympetrum fonscolombii	Nartë, Zvërnec, Novoselë
Sympetrum striolatum	Nartë; Zvërnec
Sympetrum vulgatum	Nartë

Byk *et al*. (2019) report data on the coleoptera (Coleoptera: Scarabaeoidea) of Albania, with the material collected during the visit in May-June 2016. They report 128 species for the whole Albanian territory; 12 species were found in Akerni, Vlora, and two species in Darzeza, Fieri (Tab.3).

The same group of Polish experts (Plewa *et al*., 2018) report data on the occurrence of longhorn beetles (Coleoptera: Cerambycidae) for the same period; from 51 species found for the whole of Albania, 4 species are reported for Akerni, Vlora. With the reporting by Miho *et al*. (2013) there are 23 species in total of coleoptera that are reported by name for this area. All are reported in table 3, as an additional contribution to the biodiversity of the Delta.

Rogozi *et al*. (2021) in their bioecological and taxonomic study on mosquitoes (Diptera: Culicidae) in Albania, 2010-2012, report the presence of three species for the Vjosa-Narta area (Tab. 3): *Culex pipiens, Anopheles plumbeus* and *A. maculipennis. C. pipiens* is the most widespread, both in the adult and the larval stage.

Rogozi *et al*. (2021) point out that the biting activity of the *Culex* species (mainly *C. pipiens*) have several peaks throughout the night; whereas *Anopheles* mosquitoes bite shortly after dark (between 9:00 and 10:00 p.m.), with a few more peaks at night and one or two more peaks in the early morning hours. *Anopheles* mosquitoes are in most cases encountered in pig sheds and stables, while their larvae prefer calm and clean waters.

Table 3.
Checklist of coleopteran species (Coleoptera: Scarabaeoidea & Cerambycidae) reported for the Vjosa Delta area by Byk *et al*. (2019) and Plewa *et al*. (2018), during the period May-June 2016); and the mosquito species (Diptera: Culicidae) (Rogozi *et al*., 2021)

Species	Place	Source
Coleoptera: Scarabaeoidea		
Anisoplia agricola	Vjose-Narte	Miho *et al*., 2013
Anisoplia austriaca	Vjose-Narte	Miho *et al*., 2013
Anomala matzenauer	Darzeze	Byk *et al*., 2019
Anomala vitis	Vjose-Narte	Miho *et al*., 2013
Aphodius fimetarius	Akerni	Byk *et al*., 2019
Aphodius foetidus	Akerni	Byk *et al*., 2019
Cetonia aurata	Vjose-Narte	Miho et al., 2013
Chaetopteroplia segetum	Akerni	Byk *et al*., 2019
Euniticellus fulvus	Akerni	Byk *et al*., 2019
Onthophagus furcatus	Akerni	Byk *et al*., 2019
Onthophagus opacicollis	Akerni	Byk *et al*., 2019
Onthophagus ruficapillus	Akerni	Byk *et al*., 2019
Onthophagus taurus	Akerni	Byk *et al*., 2019
Oxythyrea funesta	Akerni	Byk *et al*., 2019
Penctodo biden punctatus	Darezeze	Byk *et al*., 2019
Psammodiud pierottii	Akerni	Byk *et al*., 2019
Scarabeus sacer	Akerni	Byk *et al*., 2019
Tropinota (Epicometis) hirta	Vjose-Narte	Miho *et al*., 2013
Trox scaber	Akerni	Byk *et al*., 2019
Coleoptera: Cerambycidae		
Clytus (s. Str.) rahmni rahmni	Akerni	Plewa *et al., 2018*
Stenopterus rufus genicolatus	Akerni	Plewa *et al., 2018*
Stenopterus flavicornis	Akerni	Plewa *et al., 2018*
Lamia textor	Akerni	Plewa *et al., 2018*
Diptera: Culicidae		
Anopheles maculipennis	Panaja	Rogozi et al., 2021
Anopheles plumbeus	Panaja	Rogozi et al., 2021
Culex pipiens	Panaja	Rogozi *et al*., 2021

Final considerations

Concluding, appart their enormous importance the knowledge on insects in Albania continues to be quite scarce beside the efforts made in years by Albanian researchers and in collaboration with experts from abroad. **The existing data about the insects on the Vjosa Delta are quite scarce too, sporadic and mainly in Vlora part.**

The presence of **44 species of butterflies (Order Lepidoptera), 10 species of dragonflies (Odonata), 23 species of coleoptera (12 species of Coleoptera: Scarabaeoidea and 4 species of Coleoptera: Cerambycidae) and 3 species of mosquitoes (Diptera: Culicidae) is reported by name here, or a total of 84 species of insects, for the Vjosa-Narta area.**

But from what has been mentioned above (*Anonymous*, 2005; MIE, 2019; etc.) for butterflies, beetles and ragonfiles (Lepidoptera & Coleoptera & Odonata), and also for other groups of insects, although the data are somewhat unclear, the number of species and threatened species should be much higher.

Therefore the need for a more complete and integrate study in time and space of all invertebrate groups would be neccessary. It would help to know better the ecosystem function, the appropriate preventive or restoration measures, the appropriate use in all its services. Only in this way it can be prevented in time the adverse phenomena that may follow the balance disturbances between invertebrates and other groups of the food chain.

Worth stressing that the **transitional ecosystems as the Vjosa Delta is are contiously under the pressure of the human activity**. It causes the reduction and fragmentation of habitats, water pollution, etc. All together, these can enhace the biodiversity loss and decrease of the ecosystem services. Understanding the related causes and their consequences helps to find the right paths for mitigation and sustainable use (Newton *et al*., 2023). For this reason, either their knowledge and proper use is prioritized by national legislation and international conventions.

Vjosa River and its three tributaries (Drino, Bença and Shushica) was declared a National Park (II category 2 of protected areas) by the Albanian government on March, 2023. Therefore, the first national park of the last wild river in Europe was established. **The Vjosa Delta has been undervalued** and left outside the Vjosa NP area. About 160 km² are Protected Landscape (Category V) (VKM/DCM 694/2022), an undeserved protection category, not in line with the ecosystem values and services that this area offers. Moreover, this category does not protect it from the ever-increasing human pressure.

The diversity of habitats, the high species richness, and the endangered species should **bring to the attention of decision-makers the importance of protecting the Vjosa Delta and its incorporation within the territory of the National Park**. This transitional ecosystem represent a natural and heritage resource for present and future generations.

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The fish of Vjosa Delta – A richness of dynamics and simplicity

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Summary

The combined effects of human and natural factors are continuously changing the landscape of river deltas and coastal ecosystems including wetlands. The major hypotheses of this review lie in the fact: How did events in the geological past and in human history affect the fish community in River Vjosa Delta? It aims further to assess the fish richness, diversity and associated threats.

On a long historical context, threats such as large-scale changes to the upstream water regime associated with majority of rivers (e.g., construction of the large reservoir) were simply affecting species migration and contributed to declines despite good intentions. These included also iconic species as sturgeons that were reported as present within Vjosa. Further on, large-scale gravel extraction (still evidently present in along River Shushica) leads to increased erosion of the coastal area, but also affect the upstream flooding regime; it influence directly the fish presence and abundance.

The lower part of Vjosa is home of at least 34 fish species inhabiting the river and delta system; 29 are native, including eight species endemic to the Balkans. With 12 species, Cyprinidae are by far the most specious family, followed by Mugilidae (five). Salmonidae and Acipenseridae are represented by 2 species each. The remaining ten families are represented by a single species. At least four species (*Pseudorasbora parva, Oncorhynchus mykiss, Carassius sp., Gambusia holbrooki*) were introduced into the Vjosa basin. The lower river reach is populated by other species as: European eel (*Anguilla anguilla*), species of Family Mugilidae (*Mugil cephalus, Liza ramada, Liza salienes* and *Chelon labrosus*), Seabream (*Sparus aurata*), Seabass (*Dincentrarchus*

labrax), Flatfish (*Platichthys flesus, Common sole* (*Solea* spp.), etc.; while other species include saltwater species; numerically prevalent are two species *Atherina boyeri* and *Aphanius fasciatus* showing presence and significance.

The question of stressors affecting fish species within lower river flow and its delta is not easily definable, but it could be considered as a complex and interactive. It can count upstream water intervention (damming, river mining), various type of pollution, land use change, housing, development projects, alien species and climate changes.

Introduction

Following the Palearctic Habitat Classification (Devillers & Devillers-Terschuren, 1996), there are two bio geographical regions in Albania: Mediterranean and Alpine. The major part of the country belongs to the Mediterranean type, which include all the Southern part and the Northwest. Meanwhile the Alpine type covers the North-eastern part. Hence, Albania is well known as a country with one of the most diverse freshwater ichthyofaunas in Europe, with more than 101 fish species (Shumka *et al*., 2023). Further on, the ichthyofauna is distinguished by a large number of endemics, including 10 Balkan endemic species that only exist in the waters of Albania and one of the neighbor countries.

Vjosa basin as a part of the Balkan Peninsula provides a unique opportunity to test biogeographical theories, as it is characterized by a young geology with distinctive geographical barriers and highly fragmented hydrographic networks (Bãnãrescu, 2004; Oikonomou *et al*., 2014). The recent reports related River Vjosa affirms the high fish diversity and conservation needs (Shumka *et al*., 2018a; 2023n; Meulenbroek *et al*., 2018; 2020; Hammerschmied, 2019).

The European Water Framework Directive (WFD, 2000) presents requirements and assessments for controlling water quality and classifying water bodies (Ecological Status). The fundamental goal of the WFD is to achieve good ecological status which is reflected by indicators that include biological quality elements (BQE) that are especially sensitive to nutrient loads (Lyche-Solheim *et al*., 2013; Dudley *et al*., 2013). Fishes are listed among the BQEs, as a sensitive components to changes in water state and nutrient concentrations, so thus for country under European integration steps need to integrate into monitoring practices as a good indicator for assessing trophic status of aquatic ecosystems. Beside the WFD requirements and within new EU revisions, it is worth that these countries (including Albania) to strength the need of incorporating the fish among biological components for monitoring of water quality and assessing trophic state in water bodies

Due to various human activities, freshwater environments and river systems in particular are among the most endangered ecosystems in the Mediterranean region. The introduction and proliferation of alien species has one of the most detrimental effects on these ecosystems. However, overfishing, habitat destruction, pollution, hydrological and climate change frequently have a combined, synergistic effect on the effects of alien and invasive fish species on the native fauna (Dudgeon *et al*., 2006; Buj *et al*., 2023). A serious threat to the local ichthyofauna is listed as being posed by alien species (non-indigenous, non-native) in Albania's Biodiversity Strategy and Action Plan (MoE, 2015).

The native ichthyofauna of Vjosa reflects the rich geological past and geographic position of the basin, given the large number of Near Endemic species (Species almost entirely found within Vjosa territory and most of them are found in two lake systems shared with neighboring countries i.e., Albania and Greece) and Endemics Balkans (Species restricted to the southern Balkans, specifically, to the Southeast Adriatic). There are species in the genera *Oxynoemacheilus, Cobitis* and *Pelasgus*.

The alien fish that have been introduced here from a number of continents, originating from various biogeographic areas has also reached Vjosa basin. These species have a broader range of ecological tolerances and occupy a spectrum of ecological niches (*Pseudorasbora parva, Gambusia holbrooki, Carassius gibelio*, etc.).

Following the fact that not all alien species present an equal threat to the native ichthyofauna, nor is their influence equally present and strong in difference habitat types (ecological conditions), here we consider the interrelationship and competitions among native Mediterranean Killifish (*Aphanus fasciatus*) and introduced Mosquito fish (*Gambussia holbrooki*).

Certain species, following introduction, can have a small population size and may not necessarily have a negative impact on the native fauna (Buj *et al*., 2023). Following this, on the other hand, there are species that rapidly develop large populations, and they have an exceptionally large impact on the local ecosystems and native species, as they quickly and easily spread into new areas and new waters, making them invasive species.

Introduced, alien fish species can have a direct impact on the native fauna, as well as an indirect effect on the ecosystem or competition for resources.

The successful adaptation and expansion of non-native species is frequently aided by water pollution, habitat destruction, and modifications in the composition of native fish groups. The effects of these impacts include altered fish community composition, decreased abundance of native fish species, particularly those that are uncommon, endemic, and threatened species, or even their total extinction.

Following our analysis it is clear Vjosa Delta ecosystem offers people numerous services, including biodiversity conservation, water purification, flood prevention, healthy fisheries, and landscape and culture. Increased fishing pressure and the use of non-friendly gears (which increases fishing pressure but also has destructive impacts) were by far the factors of most concern for the fishers. A typical fishing method with "Bilançiera" a non-selective one their incredibly high number directly influence to both reduced rate of recruitments and migration density. It is clear that, fishers observe and identify this factor, which they can directly observe each day while fishing.

Further to that the land-use changes, lack of waste water treatment facilities along the Vjosa stretch, solid waste pollution, increased sedimentation rates and turbidity, intensive fishing within Adriatic coast and Mediterranean, etc., are likely to be the main factors impacting aquatic ecosystems and ultimately causing the apparent reductions in fish yields (Shumka *et al*., 2023b). Changes in land-use and hydrological variation affect large areas over lengthy periods, so they are not amenable to accurate observation or recall by casual observers who work in restricted locales.

The discrepancies between fishermen's perceptions and, in some cases, their own actual data and the true underlying environmental causes of changes highlight the need for more representative long-term monitoring data on key ecosystem attributes and the calibration of any interviews against actual monitoring data.

The transitional habitats and fish of the lower River and Delta of Vjosa - The contrast between Rare/Endemic and Introduced fish species

Aphanius fasciatus vs. Gambusia holbrooki – local records of potential alien invasive pressures on Mediterranean Killifish

Beside the fact the relationship among these two species is not intensively studied, few literature data confirms the aggressive impacts of Gambusia holbrooki on the genus *Aphanius fasciatus* and other related small-sized native fishes in other regions of Mediterranean (Pyke 2005; Kalogianni *et al*., 2014; Valdesalici *et al*., 2015). *A. fasciatus* spawns in the benthic submerged vegetation, with a spawning period from March to September, depending on the geographic position of the population (Kottelat & Freyhof, 2007). Populations in Italy spawn from March to June, in Greece from April to July and in Corsica from April to September (Leonardos & Sinis, 1998; Marčić *et al*., 2015; Shumka *et al*., 2023b). Spawning takes place on the bottom and in submerged vegetation. The species is short-lived and maturity is reached within less than a year. Reproductive strategies of *Aphanius* show the typical adaptations to the unstable and unpredictable environment of transitional waters, such as batch spawning and early sexual maturation (Leonardos & Sinis, 1998). Our observational evidence shows that they reproduce in spring and/or early summer at Vjosa delta complex (Shumka *et al*., 2023b).

The Mediterranean Killifish (Aphanius fasciatus) is a native fish of inland waters on Albania and other Mediterranean countries. It is known to be found in several localities on the coastal areas of Albania, both Adriatic and Ionian (Shumka *et al*., 2023a). This small fish (usually 4 to 6 cm in total length) feeds mainly on zooplankton, often devouring large numbers of eggs, larva and aquatic life-forms of mosquitoes and midges (Zogaris *et al*., 2017.

The Mediterranean Killifish is a protected species and a Mediterranean basin endemic; it is listed in Annex II of the Habitats Directive and the Bern Convention. Although assessed as "Least Concern" in the IUCN Red List, it is considered as "Endangered" within Albanian territories, including area of lower flow of Vjosa.

A. fasciatus is not a migratory fish, but in normal conditions it spreads beyond its resident areas. Our survey on the lower flow of Vjosa, Lagoon of Narta and lowland Drainage channels has shown that at the Wetlands complex, *Aphanius's* distributional pattern expands and contracts depending on meteorological conditions and seasonal drought effects on the local populations.

Hence, ones we focus of Vjosa "dead" section (historical river bed) the fish survive the long dry periods of the summer time, and after rains are appeared (mostly during winter season) fish become very rate. Following Zogaris *et al*. (2017) by late spring they are breeding and locally abundant at certain areas, but especially so in saline-brackish and saline waters where there is no competition with alien mosquito fish (*Gambusia holbrooki*). The fish that have survived in refugia will be the population sources for future expansion events.

Following the patterns within communication channels (around Akernia area), *Gambusia appears* to have an expansion phase during the summer months. Following the season it is expanding only in fresh and brackish waters; but at some sites populations may rise to enormous abundances. We trust that the population's source for Mosquito fish in the wider aquatic network in the Vjosa lowland flow is poorly known. The observations shows that sub-populations exist in different grade channels (drainage and irrigation ones, permanent and intermittent as well) and they may be source populations for colonization after winter or drought summer periods of the year.

The recent developments and interventions at the lower part of Vjosa might accelerate the fact that *A. fasciatus* is negatively influenced primarily by completion with *Gambusia*, not primarily by the salinity changes.

The intervention on the different water structures (channels) might lead to the fact that Killifish no longer be able to penetrate into the long-lasting aquatic refugium of the area and similar threat was highlighted by Zogaris for the Zakaki Marsh in Cyprus (Zogaris, 2017). It is due to active displacement by the summer abundant mosquito fish.

In case lower part of the Vjosa – Narta complex, Aphanius thrive in slightly brackish and saline inland marsh and lagoon ecosystem and it seems can survive quite well also in freshwaters, although there are data that they prefer to reproduce in brackish conditions. Following the complex of communicating channels, lagoon, etc., they show higher abundance in small brackish pools in salt marshes and disperse among pools during winter-spring flooding events, but generally they are not considered good dispersers. *Aphanius* forms dense concentrations when waters shrink in spring and summer, while they can survive in very crowded conditions and in very warm waters.

Position of the lower River Vjosa and its Delta on the Ichthyology Map of Albania and Europe

Albanian watersheds are defined as distinct river basins or isolated sub-basins, usually defined naturally by watershed boundaries. In Albania, there are several large, temporally independent river and lake systems. From north to south, they are arranged as follows: Drini (Ohrid-Drin-Skadar system including the Buna River), Mati, Ishmi, Erzeni, Shkumbini, Semani (consisting of two major tributaries - Devoll and Osumi), Vjosa (Aoos in Greece) river systems, several short rivers flowing from the Çika Mountains to the southernmost part of the Adriatic Sea and to the northernmost part of the Ionian Sea, the area around the Butrint lagoon (rivers Bistrica and Pavllo) and Lake Prespa (Shumka *et al*., 2023a).

Most of the above lakes and rivers belong to the catchment area of the Adriatic Sea and the southernmost areas to the slope of the Ionian Sea. Only a very small area in the northernmost part of Albania, in the Albanian Alps, is part of the Danube River basin. The area covered by this study corresponds to Vjosa basin and as stated above it lies at the Adriatic Basin. The river basins delineated via fish number and species differences (Shumka *et al*., 2023a) are presented in figure 1.

The differences in geological settings and structures, physico-chemical characters of water in the different drainage basins enables different conditions for the development of fish communities, within Adriatic watercourses. That has also enabled speciation processes. Worth to mention that the waters belonging to different basins have been under the influence of different conditions and events.

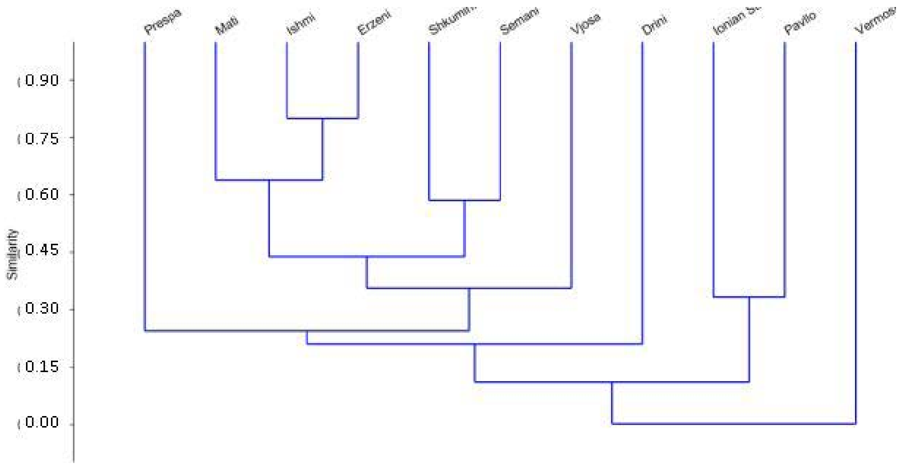

Figure 1.
Relative placement of 11 Albanian basins according their fish population using Multi Dimensional Scaling (MDS).

Diversity of habitats of the lower River Vjosa and its Delta System as a basis for development of fish communities

Following Schiemer (2000) the fluvial geomorphic processes provide the habitat diversity and the specific habitat conditions for characteristic species assemblages and result in high levels of habitat diversity. Within this context the local species richness and differences between habitats and consequently, overall species richness of a river section is changing. In Vjosa case this issue has been elaborated in details by Meulenbroek *et al*. (2018).

Hence, within river stretches were identified following habitats: the main channel of the river (litoral zones), shallow runs, downstream connected and disconnected side-arms, erosion pools within the active channel without- and with aquatic macrophytes, and water bodies within the floodplain fed by hillside streams with clear water and macrophytes. Such braided reaches with moderate floodplain development represent highly unstable lotic to semi-lotic alluvial channels and the dominating coarse material of bed and banks is transported and deposited by fluvial action. Very diverse and heterogeneous current and substrate patterns dominate the aquatic environment. The range of different morphological types within braided systems is very broad.

Table 1 gives the species of fish present in the Vjosë River, the corresponding categories (native or alien) and the threatness (Albania, IUCN and Berne Convention).

Table 1.
Fish species present in River Vjosa. Acronyms: RL, Red List; N, native; A, alien; VU, Vulnerable; EN, Endangered; LR, Lower Risk; LC, Least Concern; CR, Critically Endangered; NT, Near Threatened; II, listed in Annex II (strictly protected fauna species); III, listed in Annex III (protected fauna species).

Species	Categories	Albanian RL	IUCN	Bern Convention	References
Acipenser naccarii Bonaparte, 1836	N	EN	CR	II	Poljakov *et al.,* 1958; Rakaj, 1995
Acipenser sturio Linnaeus, 1758	N	EN	CR	II	Poljakov *et al.,* 1958; Rakaj, 1995
Alburnoides aff. prespensis	N				Poljakov *et al.,* 1958; Rakaj, 1995; Stlerandova *et al*., 2016; Shumka *et al.,* 2023
Alburnus scoranza Bonaparte, 1845	N		LC		Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al.,* 2010; Barbieri *et al.,* 2015
Alosa fallax (La Cepède, 1803)	N				Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al.*, 2023
Anguilla anguilla (Linnaeus, 1758)	N		CR		Shumka *et al.,* 2010; Moulenbroeck *et al.,* 2020
Atherina boyeri Risso, 1810	N		LC		Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al.* 2023
Aphanius fasciatus (Valenciennes, 1821)	N	EN		II	Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al.,* 2010
Barbus prespensis Karaman, 1924	N	LR	LC		Crivelli, 1996; Kottelat & Freyhoff, 2007; Markova *et al.,* 2010; Shumka *et al..* 2010;
Carassius gibelio (Bloch, 1782)	A				Poljakov *et al.,* 1958; Rakaj, 1995;
Chelon aurata (Risso, 1810)	N				Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al.,* 2010
Chelon labrosus (Risso, 1810)			LC		Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al.,* 2023
Chelon ramada (Risso, 1827)	N				Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al.,* 2023
Chelon saliens (Risso, 1810)	N				Rakaj, 1995; Kottelat & Freyhoff, 2007

Species	**Categories**	**Albanian RL**	**IUCN**	**Bern Convention**	**References**
Chondrostoma vardarensis Karaman, 1924	N	LR	NT	III	Crivelli, 1996; Kottelat & Freyhoff, 2007; Shumka *et al.,* 2010; Gieger *et al.,* 2014
Cobitis ohridana Karaman, 1928	N	LR	LC		Crivelli, 1996; Kottelat & Freyhoff, 2007; Shumka *et al.,* 2010; Sanda *et al.,* 2010
Ctenopharyngodon idella (Valenciennes, 1844)	A		LC		Shumka et al. 2023
Dicentrarchus labrax (Linnaeus, 1758)	N		LC		Rakaj, 1995; Shumka *et al*., 2010
Gambusia holbrooki Girard, 1859	A		LC		Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al*., 2008; 2010
Gobio skadarensis Karaman, 1936	N	LR	EN		Crivelli, 1996; Kottelat & Freyhoff, 2007; Shumka *et al.,* 2010; Sanda *et al.,* 2010
Gobius sp.	N				Shumka (non-published data)
Luciobarbus albanicus (Steindachner, 1870)	N		LC		Poljakov *et al.,* 1958; Rakaj, 1995; Crivelli, 1996;
Mugil cephalus Linnaeus, 1758	N		LC		Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007
Oncorhynchus mykiss (Walbaum, 1792)	A				Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al*., 2010
Oxynoemacheilus pindus (Economidis, 2005)	N		VU		Kottelat&Freyhoff, 2007; Shumka et al. 2010
Pachychilon pictum (Heckel et Kner, 1858)	N		LC	III	Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al*., 2010
Pelasgus thesproticus (Stephanidis, 1939)	N		NT		Poljakov *et al.,* 1958; Rakaj, 1995; Kottelat & Freyhoff, 2007;
Petromyzon marinus Linnaeus, 1758	N	VU	LC	III	Poljakov *et al.,* 1958; Rakaj, 1995;
Platichthys flessus (Linnaeus, 1758)	N	VU	LC		Rakaj, 1995; Shumka *et al*., 2010
Pseudorasbora parva (Temm&Schlegel, 1846)	A				Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al*., 2008; 2010
Salmo farioides Karaman, 1938	N				Rakaj, 1995; Kottelat & Freyhoff, 2007; Shumka *et al*. 2008; Snoj *et al*. 2009
Squalius platyceps Zup., Mar, Nas& Bog, 2010	N				Kottelat&Freyhoff, 2007; Shumka *et al*. 2023
Solea sp.	N				Shumka unpublished data
Syngnathus abaster Risso, 1827	N				Shumka *et al*. 2023

The clear spatial distribution patterns for the species (Meulenbroek *et al*., 2018), confirmed that sites within the main channel were dominated by Barbus prespensis, *Chondrostoma vardarense* and *Gobio skadarensis*. *Anguilla anguilla* and *Squalius platyceps* were also commonly found. High numbers of *Oxynoemacheilus pindus* were caught in the shallow runs within the Main channel accompanied mainly by *Gobio skadarensis* and *Barbus prespensis*.

The downstream connected side-arms still reflected species found in the running waters, though the most abundant species were *Alburnus scoranza* and *Squalius platyceps*. *Pachychilon pictum* and *Alburnoides bipunctatus* additionally characterize this habitat type.

The disconnected river side-arms and small erosion pools were mostly inhabited by *Alburnus scoranza, Squalius platyceps*, *Cobitis ohridana* and *Pseudorasbora parva* and some individuals of the non-native *Gambusia holbrooki*. In the larger erosion pools within the active channel with a generally high cover of macrophytes and clear water situations and in the waterbodies within the floodplain fed by hillside streams *Pelasgus thesproticus, Alburnoides and Gambusia holbrooki* were dominant, while *Pachychilon pictum, Alburnus scoranza, Squalius platyceps, Cobitis ohridana* and *Pseudorasbora parva* are also represented.

How did events in the geological past and in human history affect the fish community in the lower River Vjosa and its Delta System?

Besides that there are numerous advanced methods at disposal to determine the age of an area, and to decipher the geological events that shaped it, in case of Vjosa the data on these contexts are limited. The high biodiversity of Balkan Rivers is a consequence of the region's geologic and palaeoclimatic history, as well as the geophysical variety of inland water bodies (Griffiths *et al*., 2004). Hence, during the Pleistocene, glaciers were restricted to mountain summits. The lowland areas provided refugia for the continental freshwater fauna and flora (Skoulikidis *et al*., 2009).

The River Vjosa and its tributaries (two its main arms: Drino and Shushica) can be categorized as gravel-dominated, laterally active, anabranch rivers with large sediment yields, where the supply of bed loads is greater than the channel's actual transit capacity. This is evident, especially in the middle section of the river, where large gravel plains that can reach 2,000 meters in width are present and are traversed by numerous lateral and parallel rovers, oxbows, and side channels. The quick desertion of the main river channel during catastrophic flood events and the creation of new, parallel river channels in old floodplains are two further characteristics of laterally active, anabranch gravel bars.

From an ichthyogeographical perspective there are two major divisions that are known in the Balkans: the Ponto-Caspian and the Western Balkan. These divisions are biogeographically distinct because mountain boundaries form old barriers to fish dispersal. The Western Balkan rivers are dominated by relatively depauperate but endemic-rich assemblages that have experienced long periods of isolation (Skoulikidis *et al*., 2009).

The Adriatic and Ionian subdivisions were considered to comprise a single ichthyogeographic region (the Southern Adriatic–Ionian Division) (Economidis & Banasescu, 1991). Further on Bianco (1986) discussed the issue that the Adriatic and Ionian drainages host different fish faunas and proposed their separation. The Adriatic subdivision, delineated to the north by the Drini and to the south by the Aoos, is rich in endemic fishes (for faunistic descriptions see Crivelli *et al*., 1997; Shumka *et al*., 2023).

The Ichtyophauna of the lower River Vjosa and its Delta

The very recent research and literature data focused to the freshwater of Albania and River Vjosa have confirmed that the current fish fauna consists of 34 species from 10 orders and 14 families. Among them 29 species are native to the River Vjosa basin: with 12 species, Cyprinidae are by far the most specious family, followed by Mugilidae (five). Salmonidae and Acipenseridae are represented by 2 species each. The remaining ten families are represented by a single species.

The lower river reach is populated by other species as: European eel (Anguilla anguilla), species of Family Mugilidae (*Mugil cephalus, Chelon ramada, Chelon salienes and Chelon labrosus*), Seabream (*Sparus aurata*), Seabass (*Dincentrarchus labrax*), Flatfish (*Platichthys flesus*, Common sole (*Solea* spp.) etc.; while the resident species associated with saline water are numerically prevalent with the two species *Atherina boyeri* and *Aphanius fasciatus* showing presence and significance.

At least five species (*Pseudorasbora parva*, *Oncorhynchus mykiss, Carassius gibelio, Chtenopharyngodon idella* and *Gambusia holbrooki*) were introduced into the Vjosa basin. They are all introduced over the past 100 years as a consequence of human activity or unintentional one.

According to the Albanian Red List (MoE, 2013), three species are endangered (*Acipenser naccarii, Acipenser sturio, and Asphanius fasciatus*) and two vulnerable (*Petromyzon marinus and Platychthis flesus*). IUCN considers three species to be critically endangered (*Acipenser naccarii*, *Acipenser sturio* and Anguilla anguilla) and additionally *Gobio skadarensis* is categorized as endangered.

The Bern convention lists three species in Annex II (strictly protected fauna species) (*Acipenser naccarii, Acipenser sturio* and *Asphanius fasciatus*) and two as in Annex III (*Alburnoides* aff. prespensis, *Chondrostoma vardarense*, *Pachychlion pictum* and *Petromyzon marinus*) (Shumka *et al*., 2018; 2023a). There is a severe lack of knowledge concerning these systems compared to other systems in Europe, resulting in limited available data information about these species and their population status. This means that more species than previously thought could be severely threatened.

Following Hammerschmidt (2019) the majority of fish species in the Vjosa belong to the lithophilic spawning guild (15 species, 47 percent) followed by pelagophilic (nine species, 28 percent) and phytophilic (five species, 16 percent).

Two species are categorized as being both lithophilic and phytophilic. Based on feeding guilds many species show indifferent feeding strategies and thus a clear categorization is difficult. Most fish species present show insectivorous (eight species, 25 percent) or insectivorous and herbivorous (11 species, 34 percent) feeding behavior, followed by omnivorous feeding behavior (six species, 19 percent). Only two species (*Alosa fallax* and *Petromyzon marinus*) are exclusively piscivorous in their adult life stage.

To reach their spawning habitats or feeding grounds during different life stages some fish exhibitmigratory behavior. While some speciesmay only travel to the next small creek or tributary to spawn (*Salmo trutta*), other species travel 5000 kilometers in order to reach their spawning habitats (*Anguilla anguilla*) (Kottelat & Freyhof, 2007). Concerning the native fish fauna of the Vjosa, migratory behavior was described for: *Acipenser naccarii, Acipenser sturio, Anguilla Anguilla, Alosa fallax, Atherina boyeri, Barbus prespensis, Chelon aurata, Chelon labrosus, Chelon ramada, Chelon saliens, Chondrostoma vardarense, Dicentrarchus labrax, Luciobarbus albanicus, Petromyzon marinus, Plathichthys flesus, Salmo farioides* and *Squalius platyceps* (Bianco, 1998; Kottelat & Freyhof, 2007; Smith, 1990; Thomson, 1990; Zupancic *et al*., 2010). These species are categorized by their average distance covered during migration in three groups, namely:

- **Sea-run species**: Showing a migration from saltwater to freshwater (*Acipenser naccarii, Acipenser sturio, Alosa fallax, Anguilla Anguilla, Chelon aurata, Chelon labrosus, Chelon saliens, Dicentrarchus labrax, Chelon ramada, Petromyzon marinus, Platichthys flesus*).

- **Long migratory species**: Covering average annual migration distances of 20 kilometers or more (*Barbus prespensis, Chondrostoma vardarense, Luciobarbus albanicus, Salmo trutta, Onchorryhnchus mykiss*).

- **Short migratory species**: Covering average annual migration distances less than 20 kilometers (*Alburnoides prespensis, Alburnus scoranza, Carassius gibelio, Cobitis ohridana, Gambusia holbrooki, Gobio skadarensis, Oxynoemacheilus pindus, Pachychlion pictum, Pseudorasbora parva, Squalius platyceps, Pelasgus thesproticus, Atherina boyeri, Aphanius fasciatus*).

Figure 2 shows photos of important fish species present in the Vjosa Delta and in the lower reaches of the River. Figure 3 shows photos of the fresh water fish species present in the Vjosa River.

Figure 2.
Important fish species in the Delta of Vjosa system and in the lower reaches of the River: **a**, Eel (*Anguilla anguilla*); **b**, Gilthead seabream (*Sparus aurata*); **c**, Sand smelt (*Atherina boyeri*); **d**, Thin lip grey mullet (*Chelon ramada*); **e**, Goby species (*Gobius sp.*); **f**, Common sole (*Soleavu lvulgaris*); **g**, Flathead grey mullet (*Mugil cephalus*); **h**, European sea bass (*Dicentrarchus labrax*); **i**, Cruastacean: Karamote prawn (*Melicertus kerathurus*).

Figure 3.
Freshwater fish species present in River Vjosa:
a, *G. skadarensis*; **b**, *O. pindus*; **c**, *A.cf.prespensis*; **d**, *C. ohridana*; **e**, *P. pictum*; **f**, *B. prespensis*; **g**, *A. anguilla*, **h**, *S. faroides*.

Non-native fish species and threats to native Ichtyophauna

As stated above, there are five fish species that have been introduced into the Vjosa basin intentionally or accidentally. All alien species are not native at all to Albania: *Pseudorasbora parva, Oncorhynchus mykiss, Carassius gibelio, Chtenopharyngodon idella* and *Gambusia holbrooki*.

Poljakov *et al*. (1958) provided information on the presence of only two introduced species, *Gambusia holbrooki* and *Cyprinus carpio*. Further on Rakaj (1995) reported for Albania the presence of altogether a total of 20 non-native fish species. The ten-fold increase in the number of exotic species was due to the importing of species for aquaculture, especially East Asian cyprinids and several salmonids.

With the exception of *L. gibbosus*, all remaining species found recently were included in Rakaj (1995), though two of the species mentioned by him and not found now are apparently incorrectly identified specimens of other introduced species: *Carassius carassius* (Linnaeus, 1758) and *Gambusia affinis* (Baird & Girard, 1853). Furthermore, Misgurnus fossilis (Linnaeus, 1758) and *Sabanejewia balcanica* (Karaman 1922), included in Rakaj (1995), are of uncertain status. Šanda *et al*. (2008) speculated that the record of *S. balcanica* in Rakaj (1995) could be due to misidentification of non-typical C. ohridana specimens. The same could apply to *M. fossilis*. On the other hand, *M. fossilis* is well differentiated morphologically from *C. ohridana* (different number of barbels around mouth). Because many East Asian cyprinids were introduced to Albania, the presence of unintentionally transported East Asian *Misgurnus*, instead of *M. fossilis*, is also possible.

Several introduced species have become established in Albania, while the occurrence of *O. mykiss* probably results from escape from hatcheries and that of H. molitrix from past introductions with no recorded successful reproduction.

According to many local fishermen that were contacted, there are no recent records of most of the East Asian cyprinids *Hypophthalmichtys* nobilis (Richardson, 1845), *Ctenopharyngodon* idella (Valenciennes, 1844), *Megalobrama terminalis* (Richardson, 1846), *Parabramis pekinensis* (Basilewsky, 1855), nor of a few other species (*Thymallus thymallus* (Linnaeus, 1758), *Ameirus melas* (Rafinesque, 1820), *Coregonus sp*. reported in Rakaj (1995). Introductions of the above mentioned taxa were most probably unsuccessful. Three alien fish species and annelid, present in the Vjosa River, are shown in figure 4.

Finally, introduced species represent a serious threat in some areas. Although non-native species were, in the present study, not found to be frequent in most areas in Albania, they are quite common in all four large lakes, where established populations of several invasive species, namely *C. carpio, C. auratus* and *P. parva* exist, the last mentioned of which seems to be very abundant in all these lakes. In Prepsa lakes two other introduced species as *Tinca tinca* and *Lepomis gibbosus*, have become established; while around Lake Ohrid the rearing and accidental release of *Oncorhynchus mykiss* continues virtually unchecked.

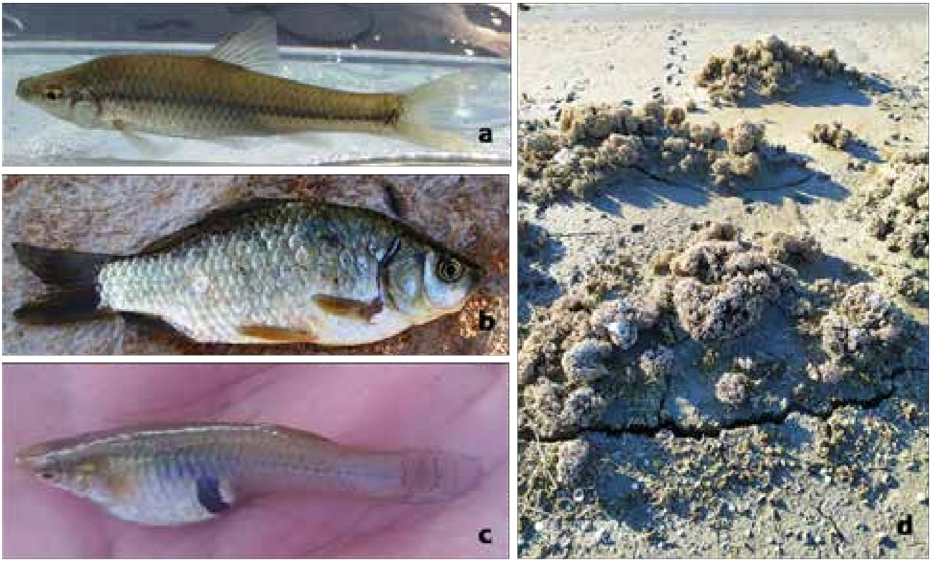

Figure 4.
Three alien fish species and an annelid present in the Vjosa River: **a**, *P. parva*; **b**, *C. gibelio*; **c**, *G. holbrooki*; **d**, *Annelida-Serpulidae: F. enigmaticus*.

How Vjosa National Park can contribute to fish species recovery and survival?

The natural special character and unique landscape, biological diversity and other associated values of the River Vjosa has led to protection of this area at different levels - it is protected under the national legislation as a national park; it is included within its lower part in the candidate list of Emerald (ASCI sites) and potential Natura 2000 network; IBA (Important Bird Area), etc.

Nevertheless, the harmful effects of anthropogenic activity have not spared this area, like many others, despite the different levels of protection and great natural resources. The fragile aquatic ecosystems of the River Vjosa and particularly its lower section including delta are affected negatively in many different ways, but perhaps nowhere is this more apparent than in the native fish population.

Following Sovnic (2021) the concept of protecting the wild river and its tributaries is based on strict protection of the entire narrow riverbed of the rivers, while allowing existing traditional land use activities (such as agriculture and grazing) to continue if managed for subsistence use and not on an industrial scale, with the possibility of developing the entire Vjosa River Valley as an excellent area for green, cultural and recreational tourism. This is in line with fish conservation objectives, since preservation of the habitat heterogeneity is a precondition for species survival and their life cycle development (Shumka *et al*, 2018b).

Conclusions

Vjosa River as a typical dynamic systems create a distinct longitudinal sequence of steep gradient headwaters, braided and meandering channel types and deltaic areas. This enables existence of rich fish diversity and large migration corridor. Potential hydro-morphological alterations (embanking, straightening, reservoir building) will directly influence on state and evolution of delta and have reduced the recharge of groundwater aquifers.

Given to the fact that nowadays, the aquatic and riparian fauna and particularly fish species in many river basins in Albania are at risk, the conservation approaches are of vital importance. Lowland section and deltaic system of Vjosa is at greatest risk due to changes in agricultural practices, current development large sale of infrastructure, tourism and large-scale modifications in headwaters. To that fact the environmental decision-making processes are very complex and require specific attention for biodiversity conservation and integrated river basin management. Following this, the WFD demands a reduction of human impacts to establish a ‘good’ water status, however, at present the Directive is only being implemented in EU country, but Albania as a candidate one has to consider the conservation and monitoring aspects.

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Fishing and aquaculture and in the Vjosa Delta, state and threats

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Briefly on lagoon habitats of the Vjosa Delta

The Vjosa River has formed a wide and very active Delta in the Adriatic Sea; from Mifoli Bridge it expands to the coastal area of Vlora, from Narta Lagoon in its southern part, to Hoxhara Channel in the northern part (Fieri), where its border is almost merged with the Delta of the Semani River. The northern part is part of the Fieri Municipality, while the southern one of the Vlora Municipality.

The coastline in this area is very dynamic. Semani and Vjosa flow here, the two main rivers of the southern part of Albania. The whole area is distinguished by its sandy coast, by the presence of beaches, dunes covered with pine forests and lagoons with variable water surfaces.

The Vjosa Delta is diverse in terms of the physical conditions of the biotopes, the nature of the biocenoses and the intensity of fishing. We can point out the ecosystems of Pishe-Poro, lagoons of Narta, Limopuo, Kallenga, the Akerni godulla and Kume Pond (Dellinje) and the Salt or Dead River, Zhuke and Darzeze (Fig. 1 & 2). The Vjosa River from Mifoli to Estuary separates this area of Vlora, with the Fieri area on the northern side of the Delta. The area is crossed also by an active network of drainage canals and pumping stations, of Vlora, Akernia and Darzeza. For more details on the description of the entire Delta area please refer to figure 2 in the introductory chapter (Miho *et al*., in this volume); moreover, description of aquatic habitats are given by Miho *et al*., *in this volume*; *on Non Vascular Plants*.

Figure 1.
Left, view of Narta Lagoon, April 2023; *right*, view of the Dead River in Darzeze, May, 2022.

According to VKM/DCM 694/2022, within the protected area there are: 119.6 ha of water surface, 2,540.1 ha of swamps and 3,471.8 ha of water area; hence, **6,131.5 ha in total, or 38% of the whole protected area, are aquatic habitats**, with salt, brackish or freshwater; moreover, these habitats are important for fish, fisheries and aquaculture.

The Narta Lagoon is the main water body in the entire Delta area (Pano *et al*., 2005) (Fig. 1, *left*; Fig. 2); it covers an area of 2,900 ha, average depth of 1.2 m (minimum 1.08 m and maximum up to 2.08 m); it communicates with the sea through two artificial tide channels: the southern one is 200 m long, 6-48 m wide and 0.2-1.8 m deep; the northern channel (Big Dajlani) is 800 m long, 11-60 m wide and 0.3-0.5 m deep (flow of 2.2-4.3 m^3/s) (MEI, 2019). The south wind lowers the level of the lagoon by 20-25 cm, while the north wind increases the level by 15-20 cm.

Figure 2.
Views of the Narta Lagoon, including the dunes and the pine forest on the belt that separates the lagoon from the Adriatic Sea. (Lauria *et al*., 2020)

The characteristic of the lagoon is the water supply from the sea during the tide period and the discharge of water during the low tide. The lagoon waters are slightly alkaline (pH 8.4-8.8). The dissolved oxygen fluctuates between 5-10 mg/l. When the amount of fresh water entering the lagoon is small (especially during the summer season) and when the communication channels are blocked by alluvium, an area of about 1000 ha dries up while another part of about 800 ha has a depth of no more than 10 cm. The extreme reduction of the depth is quite harmful for the biocenosis of the lagoon.

Kallenga is also a shallow lagoon of 450 ha, which is artificially connected to the sea through a channel that was opened only recently (MIE, 2019). It must be said that since our last visit in April 2023 this channel was completely blocked. Kallenga is also used for fishing with nets, while recently a fishing walley was built at the mouth of the canal.

Fish diversity in Delta area

The presence of River Vjosa and its wide Delta, as well as, the lagoon of Narta, make the zone important for the fish diversity, for fishing and aquaculture. The fish diversity in the Delta area seems to be different according to reports made by different authors and in different periods. We are bringing here the complete data that each provides for a more complete view on the situation.

Miho *et al*. (2013), in their publication about transitional waters of Albania evidence that about 39 fish species were recorded for the zone. *Alburnus albidus, Cobitis taenia* and *Chelon ramada* were mentioned for the plain part.

Sea migratory fishes visit the river for feeding or reproduction; the most common species belong to Acipenseridae, i.e. *Acipenser sturio, A. naccarii*; other migratory species reported are *Lampetra fluviatilis, Alosa fallax nilotica, Anguilla anguilla* and *Platichthys flesus* (Miho *et al*., 2013).

Miho *et al*. (2013) mention also that the sea or littoral sea waters of Vjosa zone are visited by fish species, like *Aphanius dispar, A. fasciatus, A. iberus, Argyrosomus regius, Arnoglossus laterna, Atherina hepsetus, Boops boops, Dicentrarchus labrax, Diplodus annularis, D. sargus, D. vulgaris, Poecilia reticulata, Lepidorhombus whiffiagonis, Lichia amia, Chelon ramada, Mugil cephalus, Pagrus pagrus, Sciaena umbra, Scophthalmus rhombus, Seriola dumerili, Sparus aurata, Scorpaena porcus, Trachinotus ovatus, Trachinus draco and Umbrina cirrosa.*

Other fish species mentioned for Narta by Miho *et al*. (2013) are: *Chelon ramada, C. labrosus, Solea solea* and *Raja clavata*; harvested invertebrates are *Carcinus maenas* and *Sepia officinalis*. The endangered species, flathead grey mullet (*Mugil cephalus*) was drastically declined in the last years, because of over fishing and the scarce exchange with the sea. Other endangered fishes are the seabreams, like sand steenbras (*Lithognathus mormyrus*), two-banded seabream (*Diplodus vulgaris*), white seabream (*D. sargus*), annular seabream (*D. annularis*) and Saddled seabream (*Oblada melanurus*). Moreover, the sparidae (*Lebistes sp*. and *Aphanius sp*.) were not considered common as before, concentrated only in the western part.

In the posting about the Vjosa-Narta Protected Landscape from the Ministry of Infrastructure and Energy (MIE, 2919), it confirmed that the Delta area is an important wetland area for several types of fish; at least 102 species of fish frequent the water bodies of the Vjosa-Narta area (sea, brackish water and fresh waters). The most important are: eel (*Anguilla anguilla*), bream (*Sparus aurata*), sea bass (*Dicentrarchus labrax*), mullet (*Mugil cephalus*) and sand smelt (*Atherina spp*.).

Shumka *et al*., in this volume report the most recent data on the fishes of the Delta area. According to them the lower part of Vjosa is home of at least 34 fish species inhabiting the river and Delta system; 29 are native, including eight species endemic to the Balkans. With 12 species, Cyprinidae are by far the most specious family, followed by Mugilidae (five). Salmonidae and Acipenseridae are represented by 2 species each. The remaining ten families are represented by a single species. At least four species (*Pseudorasbora parva, Oncorhynchus mykiss, Carassius sp., Gambusia holbrooki*) were introduced into the Vjosa basin. The lower river reach is populated by other species as: European eel (*Anguilla anguilla*), species of family Mugilidae (*Mugil cephalus, Chelon ramada, C. saliens* and *C. labrosus*), seabream (*Sparus aurata*), seabass (*Dicentrarchus labrax*), slatfish (*Platichthys flesus)*, common sole (*Solea spp*.), etc.; while other species include saltwater species; numerically prevalent are two species *Atherina boyeri* and *Aphanius fasciatus* showing presence and significance. The stressors affecting fish species within lower river flow and its delta is not easily clear, but it could be considered complex and interactive.

Fishing as an important ecosystem service

Fish are part of food chain dynamics, nutrient cycling, and ecosystem resilience. Use of Narta for fishing is known since early times, mainly from the surrounding villages, Narta and Zverneci.

Peja *et al*. (1996) give an overview of characteristics of Albanian lagoons and their fisheries. We are reporting their fishing data here to enable comparison with today's situation. In that period the fishery emploied 60 fishermen, as part of a State cooperative; since 1991 they are organised as a private cooperative. Fishing takes place both within the lagoon and at fixed-trap stations on the canal connecting the lagoon to the sea (dajlan). The annual production varied from 200 to 340 t per year (Tab. 1). Crabs, Carcinus aestuarii, accounted for between 35 and 50% of the total production. Excluding crabs, the yield of the lagoon varied from 36 to 63 kg/ha/year.

The Mugilidae in table 1 are mainly *Mugil cephalus* and *Chelon saliens*; the Sparidae were *Dentex dentex, Sparus aurata* and *Boops boops*; other species were *Gobius bucchichi, Lichia amia, Aphanius fasciatus, Arnoglossus laterna, Umbrina cirrosa* and *Raja spp*. Eels, sea bass and gilt-head bream in that period were exported to Italy and the rest were sold on the local market.

Table 1.
Fish and crab annual catches (t per year) of the fishery at Narta lagoon from 1986 to 1990. (Peja *et al*., 1996)

Taxa	1986	1987	1987	1989	1990
Mugilidae	-	14.8	26.6	14.8	-
Dicentrarchus labrax	-	3.0	4.7	6.8	-
Anguilla anguilla	-	35.4	24.7	20.4	-
Sparidae	-	2.7	6.3	4.5	-
Atherina hepsetus	-	126.1	99.1	55.1	-
Others	-	1.1	0.6	3.0	-
Carcinus aestuarii	-	102.9	177.7	95.1	-
Total	**206.5**	**286.0**	**339.7**	**199.7**	**209.4**

Also, in the MIE material (2019) dealing with the description of the Vjosa-Narta protected area, it is reported that during the period 1975-1990 the annual fish catches were about 55 kg/ha (i.e. 1590 kv/year) with a maximum of 70 kg/ha ha (2023 kv/year) in the years 1980-87. About 30% of the annual production consisted of crabs (*Carcinus aestuarii*).

Miho *et al*. (2013) stress that the most important fish species, not only in the socio-economical aspect, but also as an indicator of the ecosystem, is the European eel (*Anguilla anguilla*), known as facultative catadromous fish. Mullets, flathead grey mullet (*Mugil cephalus*), thin lip mullet (*Chelon ramada*) and leaping mullet (*Chelon saliens*) have economic importance. The presence of gilt-head seabream (*Sparus aurata*) indicates the abundance of mollusks. European seabass (*Dicentrarchus labrax*) and spotted seabass (*D. punctatus*) are voracious species, hunting other fishes in the lagoon, such as mullets, sand smelt, etc. Mediterranean sand smelt (*Atherina hepsetus*) and big-scale sand smelt (*A. boyeri*) represented about 30% of fish production; they grow in weed areas and migrate toward sea only in winter when temperature is lower than 5-6˚C.

According to the MIE data (2019), the fishermen number and catches have decreased respectively. The number of legal fishermen has decreased to 50 people, while the catch in 2003 was 46 kg/ha or 1,340 kv/year. The main types of fish are flounder (four different types), eel, sea bass, flounder and flounder. The structure of the fish is dominated by the flounder, which has a low value in the market. **The most valuable species, such as sea bass and cod, account for only 25% of the catch. These quantities are 2-4 times lower than in other coastal lagoons of Albania.**

Even today we think the main groups of marine species that make up the principal catch of coastal fishermen are: Fish, Cephalopods and Crustaceans.

Figure 3.
Fishes catched with nylon unit (njice) by coastal fishermen. (Bardhi, 2016)

The largest fish catch belong to Sparidae, gilthead, banded and caddled seabreams, Pandora, picarel and rarely salema porgy, as well as dentex; from Mugilidae are the flathead, the thinlip and the golden grey mullets (Fig. 3). Other species are the seabass, the red and the striped red mullets, the greater weever, the sole, the shi drum, the barracuda, the bogue, the conger, the eel, the leerfish and some others. Small-spotted catshark, thronback and electric ray are catched from sharks (Rakaj, 1995; Dulcic *et al*., 2005; UNEP-MAP-RAC/SPA, 2014; Bardhi, 2016).

Cephalopods in coastal occupations include cuttlefish and octopus. Of the Peneidae crabs (shrimps), the caramote prawn (*Penaeus kerathurus*) is most often fished. In recent years, an increasing amount of the blue crab (*Callinectes sapidus*), an alien species, has been fished (Hila, 2021).

Peja *et al*. (1996) report that among the invertebrates, *Cerastoderma edule, Cerithium vulgatum, Palaemon elegans, Palaemon varians* and *Carcinus aestuarii* were particularly abundant in Narta.

Figure 4.
Fishermen fishing on the coast and estuaries using the stavnik (*on the left*), the jigs (*in the center*) and the balancers (*on the right*) as fishing tools. (Ndoj & Kamberi, 2018)

There are no specified data on coastal catch according to fishing areas; hence, it is difficult to judge the contribution of fishermen from the Delta area. According to MIE (2019), 50-100 people may be employed in fishing in the Delta. According to the data from the fishermen, the daily catch on the coast varies from less than 1 kg to 25 kg per fishing unit (2 fishermen hunting using a boat and a complex of fishing gears). Obviously, the number of active fishing days during a year depends on various spontaneous (eg weather, life cycles of fishing target species, etc.) and human factors.

Figure 5.
Catch activities using different fishing gears in the Narta lagoon; *top left*, a 1956 postcard showing Narta fishermen pulling eels from fishing trap nets; *upper right*, fishermen catching with gillnets; *lower left*, a fisherman setting the fyke nets system; *lower right*, fishing walley (two photos on the right from Lauria *et al*., 2020).

Water spaces for professional fishing in the area of the Vlora, include the lagoons of Narta Kallenga and Limopua (Lauria *et al*., 2020), the old bed of Vjosa or the Salt River, the lagoons of and the coastal belt. The fishermen who practice catching activity, in indicated areas **are members of the OMP (Fishery Management Organization) 'Narta Lagoon'-Vlora**; they have a fishing license and permit, and respect the hunting season and other legal fishing standards. **Professional fishing is of an artisanal form** as long as small boats equipped with outboard motor or without motor (about 30 of them) are used for fishing, as well as fishing gears such as fishing walley (dajlan), fishing trap nets (vallkonjte), set gillnets (njicat), beach seine (tratat e plazhit) dhe long hook lines line (Fig. 5). About 30 subjects with a total of about 60 fishermen are licensed (MBZhR, 2019).

From direct observations in the coastal area of Fier part, the number of natives who engage in part-time fishing with nets, typical of artisanal fishing, seems to be higher compared to the number of professional fishermen who engage full time (Fig. 5). At the hunting season peak, the number of the former exceeds the number of the latter several times. In fact, it seems that the entities licensed to exercise fishing activity for this area are very few. In 2021, only 17 subjects (mainly in coastal fishing) (2.3%) were licensed for whole of Lushnja and Fieri out of 752 subjects in total for Albania.

Fishing equipments and fishing gears

Fishers of the area use small 'sanall' type boats for navigation, made mostly of wood; there are also cases of using boats made of plastic material, fiberglass and metal, as well as rafts (Fig. 6). Navigation is done using oars (paddles) or by activating outboard motors.

Figure 6.
"Sanall" type boats used by coastal fishermen during fishing. C, A dinghy with an outboard motor in the coastal area of Seman (Darzeza beach).

Coastal fishermen applying special forms of artisanal fishing; the catch gears are corridor and fence nets (Fig. 7A), nets, beach trawls or shingle trawls, perzevolles and hooks, which are thrown in the form of 'long lines', as fishing tools. At least in the last 5-6 years, the use of stavniks, as stationary hunting tools, has not been observed (Kallogjeri, 1975; Spaho, 2012).

Figure 7.
Nylon monofilament unit; B & C, Two boats made of plastic material, equipped with outboard motors, used by coastal fishermen for throwing fishing gear. (Bardhi, 2016)

Aquaculture and development opportunities

The Delta coastal area is characterized by quite powerful marine dynamics; in particular, from waves, but also displacements of water masses caused by the presence of two river deltas. This is the main reason that mariculture (cultivation of sea fish and mussels) has never been practiced in this area.

Experiments for the cultivation of the Mediterranean mussel (*Mytilus galloprovincialis*) were carried out since the beginning of the 1970s. It is worth mentioning it, perhaps as an opportunity for the mussel growth. The tests were carried out right inside the bed of the Old (Dead) River, adapting a 'long lines' type plant equipped with metal barrels (with the quality of floaters) and steel cavos (with the quality of suspenders). The system worked due to the fact that the 'river' was supplied with sea water during the tidal phase and received fresh water from rains or streams coming from irrigated agricultural lands. Although successful, these experiments were not followed up in market large-scale cultivation; the installation of a commercial plant would require interventions towards the systeming of cultivation basin, snd to keep open the mouth connecting the 'river' to the sea (Spaho & Flloko, 1994).

On the eastern shores of the Narta Lagoon (Fig. 8), on the side of the Gorrica Pumping Station, there are traces of a former aquaculture infrastructure (about 200 ha), submersed ponds and other abandoned fishing facilities. Before the 1990s, it was used for the fish cultivation of the Cyprinidae family. After the 1990s, attempts were made to adapt it for the cultivation of Kuruma prawn (*Marsupenaeus japonicus*) in a semi-intensive way (Flloko, 2002; Arapi & Sadikaj, 2010), but without success.

Fishing activity in Delta

Artisanal fishing with fishing walley (dajlan) is currently carried out by two groups. In the two fishing walleys, nine fishermen are employed with three fishing boats each. **The catch activity takes place from April 11th to February 9th of the following year.**

Figure 8.
Abandoned aquaculture ponds in eastern lagoon shores of Narta.

The fishing structure after OMP, Narta, according to the fishing forms and fish species is given in table 2, according to the data published by the Ministry of Agriculture and Rural Development, for the year 2019 (MBZhR, 2019). The main species of grey mullets are (flathead, thicklip, the leaping, the thinlip), eel, sea bass, gilthead sea bream, and the big-scale sand smelt. The catch structure is dominated by the grey mullet, with a low value in the market. High-value species such as sea bass and sea bream make up only 25% of the catch.

Table 2.
Fish catch in % of OMP Narta, according to forms of hunting (*above*) and according to fish species (*below*). (MBZhR, 2019)

Catching methods	**%**
Fishing walley	60
Set gillnet, trammel net and beach seine	30
Fyke net system	10
Fish species	**%**
Gray mullets (4 species)	40
Gilthead sea bream and European sea bass	25
European eel	25
Big-scale sand smelt	10

Bakiu *et al*. (2022) make a preliminary view of the basic socio-economic framework of Albanian lagoon fisheries. It was based on on-the-spot interviews conducted with fishers operating in Narta Lagoon (15 fishers) from and Kune-Vaini lagoons (28 fishers), from April to mid May 2019. After them, **the fisheries in Narta were family-based**, younger vessels, smaller in size, with less powerful engines, and less persons involved in comparison with Kune-Vaini lagoons. The lagoon fisheries were in decline, ageing fishers (males older than 50), and encountering problems with illegal fishery and invasive species. Most of the fishers were aware about the existing protected areas, but not conscious about the establishing new Marine Protected Areas (MPAs). An aggravating factor that threatened the viability of the lagoon fisheries and coastal ecosystems was high incidental catches of the Blue crab, *Callinectes sapidus*.

Factors limiting fish catch

In general, fish catch in the Delta area can be considered ‘scarce‘. Factors limiting the fish catch are anthropogenic and natural. Among the anthropogenic factors as the most important, we can mention **irrational fishing in shallow waters by fishing vessels that use bottom trawls as catching gears.** This fishing form destroys the fish stocks that migrate from the sea towards the lagoon and on the other hand harms the herds of reproducers that migrate from the lagoon to the spawning grounds in the coastal area. In addition, we can mention as **elements of illegal fishing**: unlicensed fishing, the use of prohibited catch forms and the use of fishing gears out of the standards defined in the relevant legislation (Law 64/2012). We think that these and others act sporadically throughout the area of the coastal Delta (*see* also Bakiu *et al*., 2022).

Among the factors that cause the reduction of fish stocks in the Narta Lagoon, we mention the **eutrophication of this basin**. Unstable communication with the sea, the intake of water from the saltpans, the insufficiency of fresh water supply, the discharge of sewage, the introduction of organic industrial pollutants, etc., are a concern for the lagoon (MEI, 2019; Miho *et al*., *in this volume*; *Non Vascular Plants*).

It can be concluded that the state of the Delta area has changed a lot in the last 100 years, compared to the former natural state. This is due to reclamation, urbanization and all other activities within the basin that we mentioned above. **The construction of the airport within the area, further urbanization will undoubtedly cause the further reduction of natural values, the integrity of habitats, their fragmentation and biodiversity loss. It as a whole cannot but have negative consequences for the diversity of fish, molluscs, shrimps, etc., with economic value, and for the fishing sector in general.**

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Amphibians and reptiles of the Vjosa Delta, the current status and potential threats

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Briefly on the herpetofauna (amphibians and reptiles)

Herpetofauna includes two groups of tetrapod vertebrates:

Amphibians are ectothermic animals characterised by permeable skin, eggs without shells, and complex life cycles often but not always including an aquatic larval stage. They have a high diversity of reproductive modes. Currently are causing a debate involving the scientific community and other stakeholders due to the global decline of their populations.

Currently there are a total of 8,680 amphibian species (Frost, 2023) worldwide, comprising: frogs (7,644), salamanders (815) and caecilians (221 species).

-**Reptiles** are vertebrates of class Reptilia, mostly oviparous ectotherms, with a shelled egg, internal fertilization, scaly skin covering partially or entirely their body, and that breath through their lungs.

The most recent official report of December 2022 indicates 11,940 reptile species worldwide, comprising: lizards (7,310 species), snakes (4,038 species), turtles (363 species), amphisbaenians (201), crocodiles (27) and tuataras (1 species) (Uetz *et al*., 2023).

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Fossil evidence shows that amphibians are the earliest land vertebrates. They have been living in our planet since 365 million years ago (Carroll, 2009). For more than 100 million years, amphibians remained the dominant land vertebrates. About 350 million years ago some of them evolved into reptiles. The earliest reptiles evolved from a sauropsida ancestor by about 315 million years ago (Carroll, 1964). Dinosaurs evolved around 225 million years ago and dominated animal life on land until 65 million years ago, when they all went extinct (Langer *et al*., 2010). Other reptiles survived and evolved into the classes of reptiles that exist today .

Importance of amphibians and reptiles

Amphibians and reptiles are vertebrates that are found throughout global ecosystems and are important to the well-being of these ecosystems.

Amphibians are good indicators of significant environmental changes. Amphibians, unlike humans, breathe at least partly through their skin, which is constantly exposed to everything in their environment. Consequently, their bodies are much more sensitive to environmental factors, such as habitat destruction and water quality. The worldwide occurrences of amphibian declines and deformities could be an important, warning that some of our ecosystems are seriously out of balance.

Amphibians affect the nutrient cycle, because by consuming decomposers they return several important minerals in soil. At the same time, their dual life standard between land and water helps in the circulation of energy and nutrients between these two habitats, influencing their sustainability.

Some species feed on algae helping to **prevent the eutrophication of ponds and lakes**. Some other species feed on insects, like mosquitos, thereby **reducing the spread of infectious diseases in humans** (Rubbo *et al*., 2011). Amphibians are a food source for many species of fish, reptiles, and birds. Studies even show an immediate decline in the health and diversity of the populations of their predators after the decline of amphibians present in that habitat (e.g. Zipkin *et al*., 2020). Some amphibians produce chemicals through their skin that have been successfully used in medicine to fight drug-resistant bacteria, the HIV virus, or heart problems (Song *et al*., 2010).

Reptiles have significant economic value for food and ecological services such **as insect control**. Thus, lizards enable the preservation of crops and gardens by eating insects. Snakes help **keep rodent populations under control**, which often, because of declining of snake populations from hunting, become so large and cause disease outbreaks or economic impact to agriculture.

Sea turtles help **keep invertebrate populations in balance**, including jellyfish that often becomes a problem for recreational areas. Some reptiles also feed on carrion, thereby ensuring the cleaning of the ecosystem. A healthy ecosystem is important to the fishery and the fishing community.

Reptiles are also widely used in science and medicine. In some cases, they have also been used in the pharmaceutical industry to produce painkillers (Mackessy, 2010). Reptiles are among the most widely used groups of animals in traditional folk medicine, too (Alves & Santana, 2008).

In some cases, such as that of sea turtles, **reptiles are used in ecotourism**, generating income from the presence of thousands of tourists interested in seeing phenomena such as the hatching of eggs and the crawling of hatchling toward the sea (Jacobson & Figueroa Lopez, 1994).

Why are populations of amphibians and reptiles declining?

Global assessments reveal that, among tetrapods, 40.7% of amphibians, and 21.1% of reptiles are threatened (Cox *et al*., 2022).

As of 2015 nearly a third of described amphibian species that have been assessed by the IUCN are classified as threatened; therefore their conservation is important (Catenazzi *et al*., 2016).

According to Bishop *et al*. (2012) **amphibians are threatened by 6 factors classified into two groups. The first group includes factors present for more than a century such as habitat change (destruction and fragmentation), alien invasive species and over-exploitation/exploitation, while the second group includes more recent factors such as emerging infectious diseases, pesticides and environmental toxins and global climate change (including UV radiation).** The degree to which each of these environmental factors threatens the species exposed to it is defined by Chanson *et al*., (2008) as presented in figure 1.

According to Cox *et al*. (2022), **reptiles are threatened by the same main factors that threaten other tetrapods such as: agriculture, logging, urban development and invasive species. The threat from climate change is not clear yet.** They found out that forest-dwelling reptiles, where these threats are higher, risk exctinction more than species in dry habitats. Across all IUCN geopolitical regions, Europe presents the highest average probability of impact for any of these threats (Farooq *et al*., 2023). The same source presents **urbanization as the main problem in coastal areas in Europe.**

Disa zvarranikë, përfshirë shumicën e llojeve të breshkave, kërkojnë veprim të menjëhershëm për të parandaluar zhdukjen; nga përpjekjet për të mbrojtur tetrapodët e tjerë, si ruajtja e habitatit dhe kontrolli i tregtisë dhe i specieve pushtuese, ndoshta mund të përfitojnë edhe shumë zvarranikë.

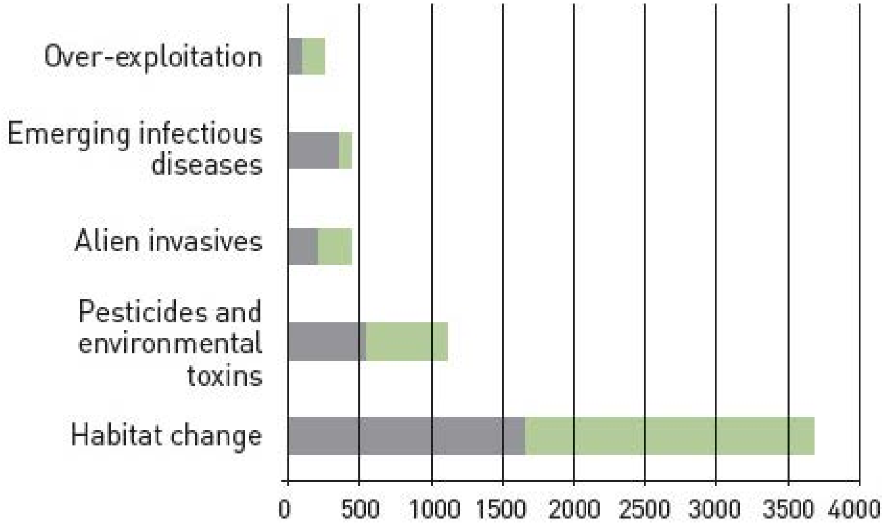

Figura 1.
Total (Grey+Green) and threatened (Grey) numbers of amphibian species that are affected by five of the six major environmental risks. N.B. Data were not available for determining how many amphibian species are threatened by Global climate change (including UV radiation). (from Chanson *et al*., 2008)

Among **reptiles**, freshwater turtles, although not very abundant or diverse, are highly threatened (e.g. when used as food). Most other reptiles (e.g., snakes) have low abundance and often specialised habitat requirements. Furthermore, several species of reptiles are listed in CITES appendices regulating trade of wildlife (https://cites.org/). Threatened species listed in international agreements are important to guide conservation management and decisions (Catenazzi *et al*., 2016)

Të dhëna mbi herpetofaunën e Deltës së Vjosës

Albania is a rich country with a high diversity of habitats and species. High number of Herpetofauna species are found in Vjosa Delta, too. **Of 16 species of amphibians known today in Albania, 9 of them (or about 56%) are found in the area of Vjosa – Narta; of 43 species of reptiles known in Albania, 23 of them (or about 50%) are also found in the area in question.** For these data, we are based on studies conducted over the years by local and foreign authors (Haxhiu, 1994; 1998; Schneider & Haxhiu, 1994; Bruno, 1989; Jablonski, 2011; Mizsei *et al*., 2017; Sacdanaku, 2017; Szabolcs *et al*., 2017; Sacdanaku *et al*., 2020; Piroli, 2021), as well as in recent studies carried out within the Vjosa river conservation campaign (Frank *et al*., 2018).

The cheklist of amphibian and reptile species known for the Vjosa Delta area is reported in table 1, with the threat status according to the IUCN, the Albanian Red List of Fauna (RL, 2013) and the European Habitats Directive (EUHD, 92/43).

Table 1.
The species checklist of amphibians and reptiles present in the area of the Vjosa Delta, their English and Albanian name, their threat status according to the IUCN, the Red List of the Albanian Fauna (RL, 2013) and the European Habitats Directive (EUHD, 92/43).

Scientific name	English name	IUCN	RL (2013)	EUHD 92/43
Amphibians				
Triturus macedonicus	*Macedonian crested newt*	VU	LC	II, IV
Lissotriton vulgaris	*European newt*	LC	LC	-
Salamandra salamandra	*The fire salamander*	LC	LC	-
Bufo bufo	*European toad*	LC	NT	-
Buftes viridis	*European green toad*	LC	NT	IV
Pelophylax kurtmuelleri	*Balkan frog*	LC	VU	-
Pelophylax shqipericus	*Albanian water frog*	VU	NE	-
Hyla arborea	*European tree frog*	LC	LC	IV
Rana dalmatina	*Agile frog*	LC	LC	IV

Scientific name	English name	IUCN	RL (2013)	EUHD 92/43
Reptiles				
Caretta caretta	*Loggerhead sea turtle*	VU	EN	II, IV
Testudo hermanni	*Hermann's tortoise*	NT	NT	II, IV
Emys orbicularis	*European pond turtle*	NT	NT	II, IV
Mauremys rivulata	*Western Caspian Turtle*	LC	VU	II, IV
Hemidactylus turcicus	*Mediterranean house gecko*	LC	LC	-
Lacerta viridis	*European green lizard*	LC	LC	IV
Lacerta trilineata	*Balkan green lizard*	LC	LC	IV
Podarcis muralis	*Common wall lizard*	LC	NE	IV
Podarcis tauricus	*Balkan wall lizard*	LC	NT	IV
Anguis fragilis/graeca	*The slow wor/Greek slow worm*	LC	NE	-
Pseudopus apodus	*European glass lizard*	LC	NT	-
Xerotyphlops vermicularis	*European blind snake*	CR	LC	-
Malpolon insignitus	*Eastern Montpellier snake*	LC	LC	-
Platyceps najadum	*Dahl's whip snake*	LC	LC	IV
Hierophis gemonensis	*Balkan whip snake*	LC	CR	-
Dolichophis caspius	*Caspian whipsnake*	LC	LC	IV
Zamenis longissimus	*Aesculapian snake*	LC	EN	IV
Elaphe quatuorlineata	*Four-lined snake*	NT	CR	IV
Zamenis situla	*European ratsnake*	LC	CR	II, IV
Natrix natrix	*Grass snake*	LC	NE	-
Natrix tessellata	*Dice snake*	LC	NE	IV
Telescopus fallax	*European cat snake*	LC	LC	IV
Vipera ammodytes	*Horned Viper*	LC	NT	IV

In the figure 2, the distribution of these species is reported, according to a study carried out within the project: 'Paving the way towards a sustainable Natura 2000 network in Albania: The case of Nartë-Pishë-Poro complex site' (October 2019 – March 2021), implemented by PPNEA (2021).

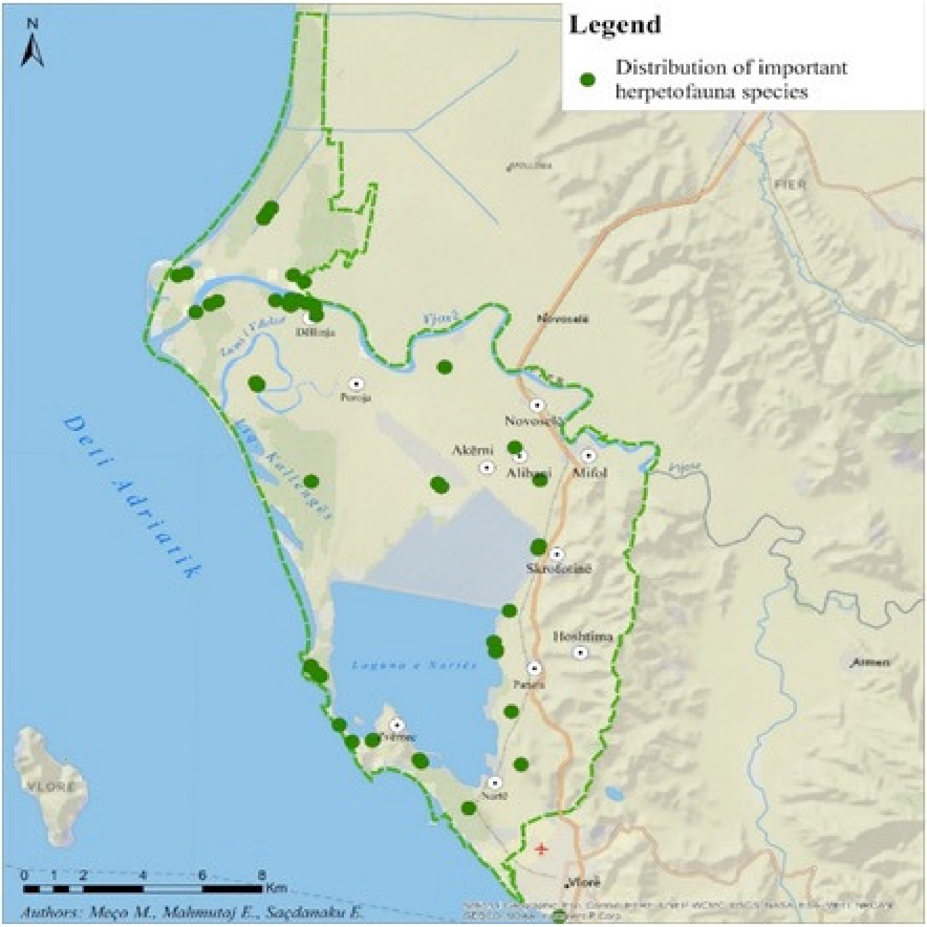

Figure 2.
Distribution of the number of observations of amphibian and reptile species in the Vjosa delta area.

Species that require special attention

Albanian frog, *Pelophylax shqipericus*: Among the amphibians, the Albanian frog, *Pelophylax shqipericus* (Hotz *et al*., 1987), which belongs to the group of green frogs (Family Ranidae), is of particular importance. It is considered an **endemic Balkan species with natural distribution in Albania and Montenegro**. In Albania it is found from Lake Shkodra in the north, along the Adriatic coastline, to Vlora (Orikumi) area in the south (Speybroeck *et al*., 2016). Scarce data exists regarding its origin and ecology. This species was reported for the first time in Italy, from where it is thought to have entered (introduced) through the international trade of frogs (Domeneghetti *et al*., 2013).

In the Vjosa Delta, *P. shqipericus* has been found in many habitats, such as freshwater channels, ponds, marshes with rich vegetation; these are present everywhere in the area, starting from the northern part of the Vjosa estuary (Pishe Poro, Fieri) to the wetlands and canals around the Narta lagoon, Zverneci and Soda Forest in the south (Fig. 3).

Figure 3.
Pelophylax shqipericus and its habitat (© E. Saçdanaku).

***P. shqipericus* is classified as an endangered species with a status VU according to the IUCN Red List** (Uzzel & Isailovic, 2009). Its population is of limited extent, from Lake Shkodra to Orikumi, and is declining due to the degradation of the habitats where it is found (Speybroeck *et al*., 2016). *Pelophylax shqipericus* is also a species protected by the Berne Convention, Annex III (Convention on the Conservation of Wild Life and Habitats in Europe, 1979).

Figure 4.
Hyla arborea (***above***) and *Triturus macedonicus* (***below***) photographed in the area (© E. Saçdanaku).

The Macedonian crested newt (*Triturus macedonicus*), the European green toad (*Bufotes viridis*), the European tree frog (*Hyla arborea*) and the Agile frog (*Rana dalmatina*): These other four species of amphibians, present in the area (Fig. 4), are also considered of high conservation interest, as they are part of the annexes (II, IV) of the European Habitats Directive (Habitat Directive, 43/1992). *T. macedonicus* has recently been assessed on the IUCN Red List of Threatened Species in 2022 as a threatened species with *VU* status, according to criterion B2ab(iii,v).

Loggerhead sea turtle (*Caretta caretta*), European pond turtle (*Emys orbicularis*), Western Caspian turtle (*Mauremys rivulata*), Hermann's tortoise (*Testudo hermanni*): On the other hand, the presence of reptiles is very important for the area in question. Worth noting the presence of turtle, *C. caretta*, terrapins *E. orbicularis* and *M. rivulata* and the tortoise *T. hermanni* (Order Testudines) All four of these species are part of both annexes (II, IV) of the European Habitats Directive. Also, 12 other species of lizards and snakes are part of Annex IV of this Directive (Tab. 1).

Hence, **about 70% of the herpetofauna species found in the Vjosa delta area (16 out of 23 species present in the area) are considered species of high conservation interest.** Figures 5 & 6 shows some photos of other species of reptiles of conservation interest photo-graphed from the Vjosa delta area.

Figure 5.
Photos of tortoise and terrapin species of conservation interest encountered in the area: a & b, *Emys orbicularis; c, Testudo hermanni; d, Mauremys rivulata; e, Podarcis tauricus; f, Podarcis muralis* (© E. Saçdanaku).

Figura 6.
Photos of lizard species of conservation interest encountered in the area: *a, Podarcis tauricus; b, Podarcis muralis* (© E. Saçdanaku).

Threats to the amphibians and reptiles of the Vjosa Delta

As - mentioned above, today there is **a significant decline in the populations of amphibians and reptiles all over the world: often this is related to the loss and degradation of the habitat, uncontrolled and illegal trade, the introduction of invasive species, pollution, various parasitic diseases, climate change, etc.**

Amphibians are considered one of the most globally threatened groups (Gibbons *et al*., 2000; Alroy, 2015). Threfore, the study of herpetofauna is of particular importance; collecting as much data gives the possibility of better knowledge of the populations and the state of the habitats where these species are found.

The loss or degradation of the habitat is regarded as one of the main factors in the decline of amphibian or reptile populations. This is due to the human impact. Efforts towards a **highly developed agriculture** causes the loss of the habitat or its degradation. It is caused by the **large reclamation of the marshlands for agriculture, tourist infrastuctures or other uses**. Albania faced such interventions since years 1960s, especially in Western Lowland, including Vjosa Delta area, where is still happening.

The Vjosa Delta is considered an interurban area where development agricultural activities are practiced. Among the main activities with negative impact on certain species (especially amphibians and especially *Pelophylax shqipericus*) we mention:

- the bed practices related with the management of the irrigation system of canals (**their periodic cleaning**);
- the **drainage and draining process in order to dry the swamps for new agricultural lands**;
- **urbanization, industrialization and intensification of agriculture**.
- **unsustainable** harvest is another threatening factor, especially for **the population of the Albanian frog (*P. shqipericus*)**.

The agritourism development around the area favors malicious initiatives for many species (concretely also for the frog); illegal actions for indiscriminate collection for trading purposes, within the country in various restaurants, but also for export abroad, constitute a direct threat.

Miho *et al*. (2013), reported that two amphibian species, *Rana balcanica* (now *Pelophylax kurtmuelleri*) and *R. lessonae* (now *Pelophylax shqipericus*), represented in that period economical interest for the zone, as in other wetland zones of Albania; a collecting center in Novosela, the biggest in Albania, practiced since 30 years harvesting, elaboration end export of green frogs; it was reported that about 23,000 tones of frogs were harvested.

From the media, it seems that this activity continues successfully. According to MBZhR (2017), since 1994 the 'Vival' factory in Novosela deals with the collection and processing of frogs and fish products; it is said that in 2017 it is a modern establishment with about 60 employees and an annual turnover of about 2 million Euros. The average amount of harvested production is about 2,700 kv/year MIE (2019). From field observations, contacting fishermen and local residents, frogs are caught with fishing hooks, nylon stockings and frog skin and sold at this Center in Novosela.

It really deals with the harvest of a rare, threatened, endemic Balkan species, and within the habitats of a protected area. Not seams that this activity is accompanied by management plans that take care on species protection. It is against Albanian and international acts on protection of biodiversity, especially threatened species, and in protected areas. We recommend paying special attention to this activity.

From our observations around the Vjosa delta, it is observed **the jeopardy of the Western caspian turtle (*Mauremys rivulata*), categorized as vulnerable in the Albanian territory (RL, 2013)**. It is due too the tourism development and the habitat change as a result of the reclaming of marshes; these causes threaten the populations of this species even in other countries of our region (van Dijk *et al*., 2004).

European ratsnake (*Zamenis situla*), Four-lined snake (*Elaphe quatuorlineata*) and Balkan whip snake (*Hierophis gemonensis*) categorized as critically endangered in the Albanian territory (RL, 2013), could be affected as well to extinction by any possible development of the delta area in terms of tourism or intensification of agriculture. Both these factors, together with prosecution from humans, fires and pollution are also reported by IUCN assessments as threats for each species for our region (Böhme *et al*., 2009, Crnobrnja Isailovic *et al*., 2009; Lymberakis & Ajtic R, 2009).

Aesculapian snake (*Zamenis longissimus*) which according to the Red List (2013) holds the endangered category, is also very sensitive and threatened by habitat fragmentation resulting from agricultural development, human prosecution, or by clearing the heaps of grass and other vegetation where their nests are found (Agasyan *et al*., 2017) activities which, from our observations, threaten its presence in the Vjosa delta as well.

The loggerhead turtle (*Caretta caretta*) is of special importance for the Vjosa Delta. This turtle has been reported to be nesting in Albania since 2018 (Piroli & Haxhiu, 2018; 2020a; Piroli, 2021); **the presence of nesting in the Vjosa Delta area has been noted by the coastal community since 2010** (Piroli & Haxhiu, 2020a).

It is known that the loggerhead turtle almost every year uses the coastal area on both sides of the Vjosa Estuary (Pishe – Poro, Fieri and Vlora) as habitats for reproduction (Rae *et al*., 2021; Piroli, 2021; Piroli & Haxhiu, 2023). The coastline with its naturally preserved and not disturbed dunes present in this area (Narta, Zverneci, Pishe Poro, New Darzeza, Semani) is considered as suitable for their nesting (Piroli & Haxhiu, 2020a; Piroli, 2021); it is also due to the low or no presence of human activity observed in the area (Fig. 6).

Worth mentioning the efforts done during the last 4-5 years by the Regional Administration of Vlora Protected Areas, RAPA, Fieri and LIFEMEDTURTLES project from Herpetofauna Albanian Society, in monitoring the coastal area every year, from June to September, and reporting the presence of nests.

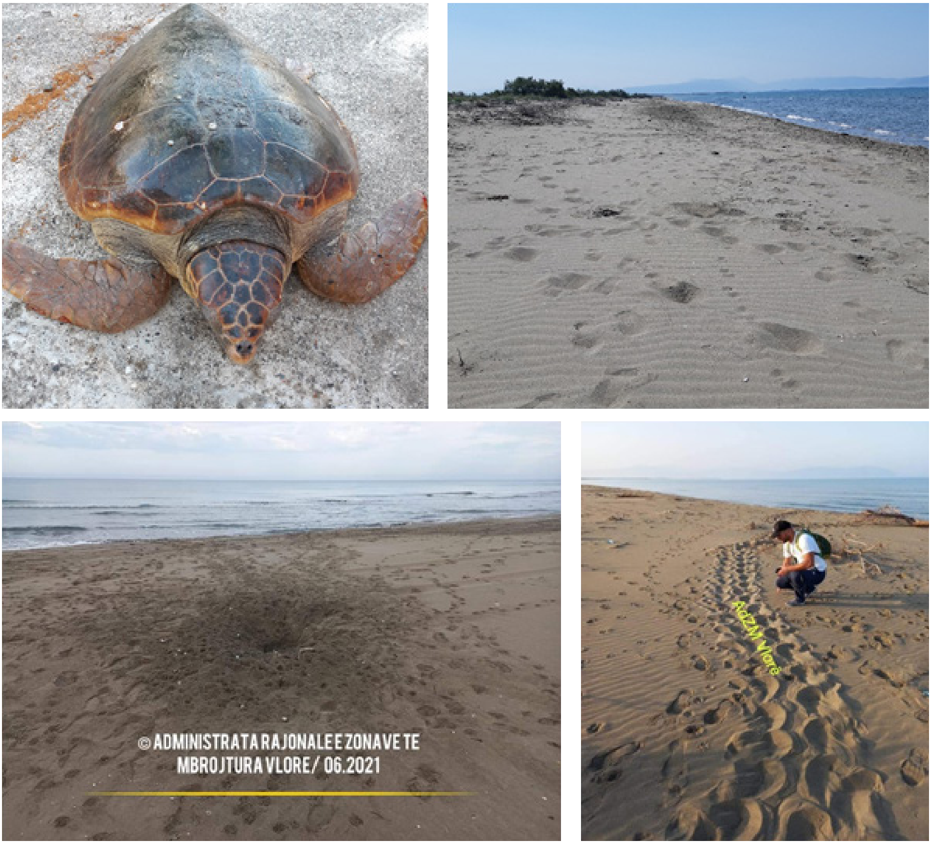

Figure 7.
The sea turtle *Caretta caretta* and its nesting habitat in the Vjosa delta area.

This giant reptile (with more than 450 kg), spends most of its life in the shallow waters along the continental shelves and transitional habitats, such as those of the Vjosa Delta. Along the Albanian coast, an increased presence near deltas and river mouths is reported, probable link with the ecological characteristics of these areas and especially the communities of invertebrates is sugessted (Piroli, 2021).

Loggerhead turtles have a low reproductive rate. The turtles from the Mediterranean population reach their sexual maturity at an overage age of 25 years (range 21-34 years) and has an average lifespan of 47–67 years. Females visit quite briefly undisturbed ashore habitats to lay eggs (hiding them in the sand of undisturbed beaches) (Fig. 4), at intervals of 2 to 4 years. They lay 1 to several nests per season, approximately 12 to 14 days apart, and then head back to foraging areas again (Miller, 1985; Limpus & Miller, 1993). Through their global range they lay an average of 100 to 126 eggs per nest, but 50-106 eggs have been reported for the nest from the Albanian coastline (Piroli & Haxhiu, 2023). Eggs incubate for about 60 days (Sea Turtle Conservancy, 2023).

Due to these very special features in its survival **the loggerhead sea turtle is considered a vulnerable species by the IUCN (Tab. 1) and prohibited by CITES, Appendix I.**

Globally this species is threatened by bycatch in fishing gear, coastal development and human consumption of eggs, meat or other products (Wallace *et al*., 2011, Casale & Tucker, 2017). Meanwhile, for the Mediterranean sub-population of the loggerhead turtle, unintentional capture in fishing gear and habitat destroy from coastal development are reported to be the main threats (Casale & Margaritoulis, 2010; Casale, 2015), which also apply to the Albanian coast (Piroli & Haxhiu, 2020b; Piroli, 2021) and from our observations in the area they also apply for the Vjosa Delta area.

The continuity of the existence of this species is directly linked to its conservation (Casale & Tucker, 2017), therefore it is crucial to intervene with conservation measures and, when possible, preventive measures against these threats. **Extending the protected area beyond the river's banks to include the Vjosa delta itself would minimize the risks posed to turtles by fishing gear or the beaches destruction by urban development.**

Nesting and hatching success of sea turtle eggs are affected by environmental characteristics such as abiotic, biotic and anthropogenic conditions. Changes in such conditions will also dictate the change of the animal itself, as a response that would enable ist survival. Species, in rdert o survive, usually exhibit changes such as shifts in their geographic distribution, phenological and/or physiological changes (Hickling *et al*., 2006; Ford *et al*., 2016; Lenoir *et al*., 2020). However, in the case of sea turtles, reptiles that have been living on earth for more than 100 million years and that from a long time ago have acquired anatomo-physiological stability, as an adaptation to these changes, to ensure the continuity of the species itself, the mechanisms of change remain those linked with behavior. Thus, the use of phenological mechanisms such as the earlier start of the reproduction period, or mechanisms in geographical shifts in distribution such as the selection of the most suitable nesting areas, has been observed (Mazaris *et al.*, 2008; Almpanidou, 2018; Monsinjon *et al.*, 2019) .

Since the nesting of the loggerhead turtle in Albania is a recent finding, but with a present increasing trend, it is suggested it may be a response to changes in environmental conditions, such as temperature; in the future there will be an even greater increase in nesting and the importance of Albanian coastline for nesting of this specie (Piroli & Haxhiu, 2020a); increase in nesting has been suggested for other areas of Mediterranean (Witt *et al*., 2010), too. Hence, **the area of the Delta of Vjosa, which already has the nesting of the loggerhead turtle almost every year, will gain even greater importance in the coming years and an increased need for the conservation of the area will emerge.**

Sea turtles nest on beaches with specific conditions, thus changes in the environment such as increased artificial lighting or changes in the topography of beaches, caused by urban development, directly affect the reproduction of this species. Hence, **an urban development of the Vjosa delta area and modification of the current topography would directly affect the nesting of these species**. The female turtles that nest in this area will in most cases avoid laying their eggs in the delta area, while the newly hatched hatchlings will be disoriented by the artificial lights of the buildings, causing them to move on the opposite side and never reach the sea.

We again stress that **sea turtles have a significant contribution to the marine ecosystem**; they maintain balances between living populations, maintain the health of underwater meadows and coral reefs. These turtles are the living representatives of a group of reptiles that have been swimming in the seas for over 100 million years, having a contribution to the circulation of materials from the marine environment to the coastal one. They are also of cultural, spiritual and economic importance to a number of coastal communities. **As a living heritage of nature, their presence should be appreciated and protected at all costs by our country, so taking protective measures in the Vjosa Delta area is strongly recommended.**

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Due to these herpetofauna values of and other values, the Vjosa Delta has been protected for years by both parts, Vlora and Fieri (MIE, 2019a; AKZM/NAPA, 2022). Recently, a good part of it (16,124.61 ha) was re-proclaimed a Protected Landscape (Category V) (VKM 694/2022).

On the other hand, the above mentioned concerns, especially regarding the development of the tourist infrastructure, are increasing and may increase even more in the future (MIE, 2019b,c). This requires decision-making and investment entities to pay more attention in conservation issues and sustainable use, applying national and international criteria for the protection of rare and threatened species and habitats.

We applaud that the Albanian government declared National Park (Category II according to the IUCN) the Vjosa River and its tributaries Drino, Bença and Shushica (VKM/DCM 155/2023), in March 2023, distinguished as the last wild river in Europe. **However, based on our observations, its Delta area from Darzeza (Fieri) to Narta (Vlore), is as wild and rich in habitats and threatened species which could be threatened from human activity and especially those linked with unstudied development. Therefore, always attention is required in development plans, to ensure the balance between business and environment and the ecosystem integrity.**

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Birds of the Vjosa Delta, status and threats

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What do we understand with "the Vjosa Delta"?

The cross-border ecosystem Vjosa/Aoos River, between Albania and Greece, is among the biggest in the Western Balkans. The river corridor of Vjosa and its tributaries constitute a living natural hydro-morphodynamic model, free-flowing (wild), untouched by human influence. Hence, this unique ecosystem in Europe, is very rich in threatened habitats and particularly aquatic biodiversity of European importance (Acta ZooBot Austria, 2018; Schiemer *et al*., 2020; Sovinc, 2021 etc.).

Due to its free flowing character and natural dynamism, Vjosa River has formed a wide and quite active Delta in the Adriatic Sea (Fig. 1), which extends in an area of about 240 km² (Schwarz, in this volume), including the Narta Lagoon, the Vjosa estuary and the areas around it, freshwater wetlands, swamps, reed beds, woodlands, islands and sandy beaches, up to Darzeze/Poro, Fieri. About 160 km² of the whole area has the status of Protected Landscape (IUCN Category V) (VKM 694/2022); the rest is mainly agricultural zone.

Durmishi *et al*. (2018) mention that the Delta area has undergone major changes in the last 500 years. The estuary is displaced from the Vlora Gulf (where the Narta Lagoon was created) to the foot of Frakulla crests (Fieri), less than 1 km southwest of the ancient city of Apollonia.

Despite the human interventions, the Vjosa Delta area represents one of the most preserved transitional ecosystems in Albania. Schwarz, in this volume, reports that the deltas of Vjosa, Semani, and Shkumbini form relatively intact adjoining deltas ('triple delta'), among all Mediterranean deltas based on hydromorphology and land use obstructions in their catchment. It makes the Vjosa Delta unique and important for the ecosystem services it offers to humans and nature.

Figure 1.
Satellite view of the Vjosa Delta (Schwarz, *in this volume*).

Briefly on birds and connections with transitional wetlands

Briefly on Birds: Birds (*Class Aves*) are a group of warm-blooded vertebrates, with wings and feathers, toothless beaked jaws (Field *et al*., 2020). According to the International Ornithological Committee, there are about 11,000 species of birds in the world classified into 2,384 Genera, 253 Families, and 44 Orders (Puiu, 2023).

Waterbirds: This group is distinct among other birds; there many data for them from different monitoring schemes, such as International Census of Waterfowl (IWC) etc.

For the IWC purpose, Wetlands International considers as waterbirds all the species of the following families: Gaviidae (Loons), Podicipedidae (Grebes), Pelecanidae (Pelicans) dhe Phalacrocoracidae (Cormorants), Ardeidae (Herons), Ciconiidae (Storks), Threskiornithidae (Glossy Ibises and Spoonbills), Phoenicopteridae (Flamingos), Anatidae (Ducks, Geese and Swans), Gruidae (Cranes), Rallidae (Water Rails, Moorhens and Coots), Haematopodidae (Oystercatchers), Recurvirostridae (Stilts and Avocets), Burhinidae (Stone Curlews), Charadriidae (Plovers), Scolopacidae (Shanks, Sandpipers, Snipes dhe Phalarops), Laridae (Gulls and Terns).

Seabirds: Some species known as **seabirds** or **marine birds** are adapted to life within the marine environment. Many species are currently threatened by human activities such oil spills, nets, and climate change and severe weather.

Birds of prey: Some bird species, known as **birds of prey, predatory birds**, or **raptors** actively hunt and feed on other vertebrates (mainly mammals, reptiles and other smaller birds) and invertebrates as well. Although predatory birds primarily hunt live prey, many species (eagles, vultures etc.) are scavengers that scavenge and eat carrion (Perrins & Middleton, 1984).

Other birds: This group is composed by birds that are not part of orders mentioned above such as Passerines, Doves, Swifts, Cuckoos, Woodpeckers etc.

Migratory birds: Twice a year, many bird species migrate vast distances across the globe, from breeding grounds in arctic towards those in the south hre they spent the winter and vice-versa (Fig. 2). More than 2 billion birds including passerines, ducks, raptors etc. migrate from their breeding grounds in Europe, and in central and western Asia towards wintering areas in tropical Africa. (Ogwang, 2023)

As they migrate southwards the Mediterranean sea, birds from their breeding grounds must cross the ecological barriers, such as European mountains (Urals and Alps), seas and deserts. They then make use of the narrow straits and land bridges to connect from Europe into Africa. The migrating birds connect the continents biomes twice each year (Ogwang, 2023).

Migratory routes of birds: Birds use three major routes of migration towards Africa (Ogwang 2023) (Fig. 2).

- **The Western flight route** is through Italy and Spain across the Straits of Gibraltar, over the Atlas Mountains and the western Sahara into west and central Africa.
- **The Central route** from western and central Europe through Greece and Albania, to the Mediterranean Sea, across the Sahara into central and southern Africa.
- **The third route** from eastern Europe and Asia through the middle east down in to east Africa and into southern Africa.

Figure 2.
World bird migration routes (Ogwang, 2023).

The importance of birds to ecosystems and humans, and their threats worldwide today

Birds as other animal groups play a very crucial role, related with the **control and balance of environment** (Mathialagan, 2023; Leffer, 2021; etc.). They are nature's scavengers and get rid of pest that harms us (i.e. harmful insects). They help in pollination and the growth of new plants. Birds are nature sanitary, distributors of seeds and plants, transformers of ecosystems. On the other hand, birds are an important part of our cultural and historical heritage and inspirators of human science. Everything above, demonstrates the importance of bird preservation for ensuring the future of our life in this Planet.

The decline of bird populations: Human activities have caused population decline or extinction of many bird species. **Many bird populations are declining worldwide, with circa 49% of about 11,000 bird species assessed in decline in 2022. Of these, 1,409 bird species are assessed as Globally Threatened (BLI, 2022).**

According to BLI (2022), the threats that concern the highest number of globally threatened bird species are the development and intensification of agriculture, forest logging, invasive species and other problematic species and hunting while climate change is a significant threat that will increase in significance in the future.

The most commonly cited human threat to birds is **habitat loss** (Norris & Pain, 2002). Other threats include **overhunting, accidental mortality** due to collisions with buildings or vehicles, long-line fishing bycatch (Brothers, 1991), pollution (including oil spills and pesticide use) (Wurster *et al*., 1965), competition and predation from nonnative invasive species (Blackburn *et al*., 2004), and climate change.

Threats during migration: Migration carries high costs for migratory birds whose threat has increased from the loss and degradation of habitats, particularly for those habitats used for resting and wintering; illegal hunting or capturing; pollution and poisoning; collision with buildings or flying vehicles (airplanes, helicopters, balloons etc.), energy infrastructure including energy transmission lines, wind turbines etc.

These threats influence birds through a set of mechanisms where the ost important is the **change and degradation of habitats**. Therefore, governments and conservation groups make efforts to protect birds, either by passing laws that preserve and restore bird habitats and rehabilitate bird populations.

Importance of transitional wetlands for birds and their conservation

Wetlands and especially transitional coastal wetlands as it is Vjosa Delta are important bird habitats, and birds use them for breeding, nesting, and rearing of chicks, foraging, resting, shelter dhe social interaction (Stewart, 2016). Migratory birds seek wetlands along their migration route to rest and feed (Kusler, 2004). According to BLI (2023), the **Vjosa-Narta area is a crucial stopover site for migrating birds between Europe and Africa and is one of the most important wetlands in the entire Adriatic flyway.**

Therefore, **the proper understanding and use, conservation and protection of wetlands, including Vjosë-Narta, is a priority of the international conventions** and all international organizations concerned with the protection of such coastal areas as the Ramsar Convention, the Bern Convention, the Barcelona Convention, Bonn Convention etc.

The protection of natural wetland habitats is at the same time a request of the EU Strategy for haltin the loss of biodiversity including Birds Directive (79/409/EEC), Habitats Directive (92/43/EEC), Water Framework Directive (WFD, 2000) etc.

The preservation of wetlands should be a priority of the **Albanian legislation as well despite the changes of the recent years includin the legal frame for strategic investments, the reduction of the surface of the wetland protected areas, and the recent changes of the Law 81/2017 for Protected Areas (Ligji 21/2024), etc.**

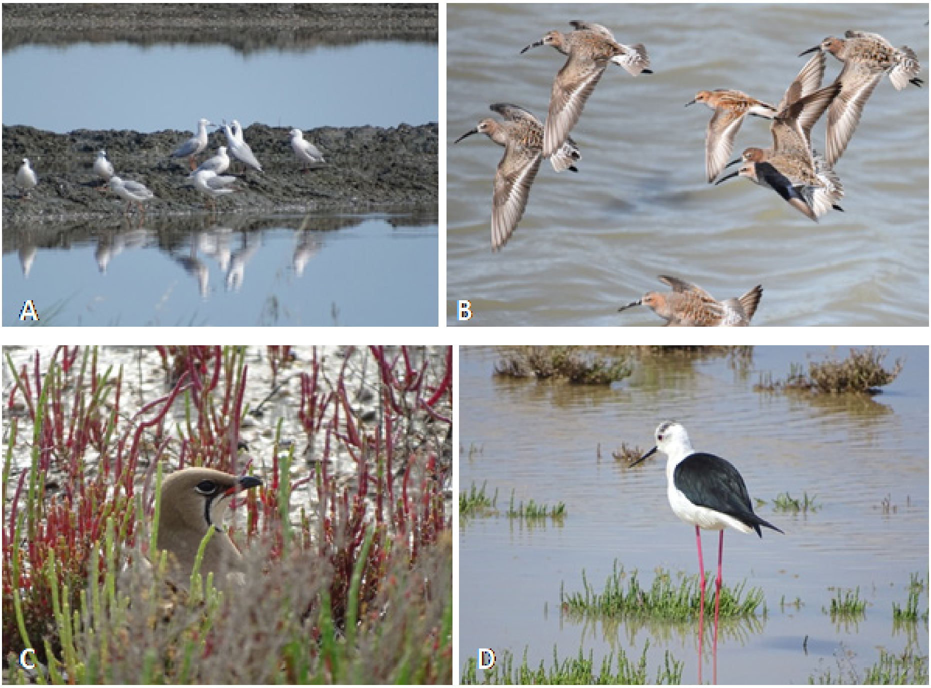

Figure 3.
Birds from Narta: **A**, Slender-billed Gull (*Chroicocephalus genei*); **B**, Curlew Sandpiper (*Calidris ferruginea*); **C**, Collared Pratincole (*Glareola pratincola*); **D**, Black-winged Stilt (*Himantopus himantopus*) (Photos: T. Bino).

Figure 4.
Birds from Narta: **A**, Pied Avocet (*Recurvirostra avosetta*); **B**, Greater Flamingo (*Phoenicopterus roseus*); **C**, Dalmatian Pelican (*Pelecanus crispus*) (Photos: T. Bino).

The existing data on the birds of the Vjosa Delta

Despite the importance of the transitional ecosystem of the Vjosa Delta, publications about the delta and particularly about birds of the delta, are quite scarce except for Hagemeijer (1994), Tempelman & Defos du Rau in Zekhuis & Tempelman (1998), (1998), Bino in Mima *et al*. (2003), Mladenov *et al*. (2018), etc.

Neverthelesss, data for birds, including those brought for this publication are not missing; but they are present in reports (eg. Kayser *et al*., 1995; 1997; Bino *et al*., 1996; Xhulaj, 2001; Bino & Jorgo, 2002; Xhulaj & Mullaj, 2010; Topi *et al*., 2013; 2020; Bino & Carugatti, 2016; Bino, 2017; 2018; 2019; Bino & Xeka, 2020; Mahmutaj *et al*., 2020; Topi *et al*., 2020; PPNEA/EuroNatur, 2021; AKZM, 2022b; Bino *et al*., 2023; etc.); in assessments for drafting management plans (eg. Bino in *Anonymous*, 2005; MHW, 2003), the development plans of the area (eg. PDZRK, 2019) or different environmental impact assessments studies.

Besides the above, abundant promotional information about birds and illustrated with photos, is available in social media (BLI, 2023a; AOS, 2023; PPNEA, 2018; Topi, 2019; etc.), as well as for tourism purposes (Albatrip 2022; Kalinichenko 2023; IntoAlbania 2023; etc.).

Analytical data on biodiversity and birds in particular is provided in the Management Plan of the Vjosa-Narta Protected Landscape, drafted by the Ministry of Environment (Bino in *Anonymous*, 2005), and in the reports of Bino *et al*. (2023a&b); information is given on bird species, their conservation status at global and national level, inclusion in Annex I of Birds Directive. Mladenov *et al*. (2018) also report data for the assessments carried out during two field trips undertaken in Narta in April and May 2016. They report abour 135 species during their sruveys in the Vjosa-Narta area in April and May 2016.

Miho *et al*. (2013), in the Ecoguide to discover the transitional waters of Albania (Chapter 12) provides, among others, general data on birds and some illustrations with photos.

The Management Plan of Vjose-Narta (*Anonymous*, 2005) confirms that the wetland complex is important for the wintering and breeding of 192 species, especially for waterbirds; 44 species are mentioned and discussed as the most important, reported here in Appendix 1.

Studies for birds in Vjosa delta from the authors, the Albanian Ornithological Society (AOS) and Center for Protection and Preservation of Nature and Environment in Albania (PPNEA) extend from 1993, for a period of almost 30 years (Fig. 5). Besides the above, in this review here are included data form other reports: eg. from the assessment of habitats as potential for Natura 2000 sites in Vjosa river and its tributaries (Bino *et al*., 2023); the eventual impact assessment in bird species due to the size reduction of the Landscape PA Pishe Poro - Narta (Bino *et al*., 2023b); *online* sources; sporadic interviews with local hunters, etc.

Among the two parts of Vjosa Delta, the southern part of Vjosa (Vlora) is also the area with most of data about birds. Meanwhile, there is limited information about the northern part of the delta of Fieri.

Figure 5.
Birdwatching in Vjosë-Narta (Photo: K. Bashmili).

Birds of the Vjosa Delta

In the transitional area of the Vjosa Delta there are 18 habitats, listed in Natura 2000, 6 habitats are in priority (AKZM/NAPA, 2022b; Meço *et al*., *in this volume*). Despite human impacts, many of them are still in good natural condition, with high ecological integrity.

About 40% of the Pishe Poro - Narta protected area (VKM/DCM 694/2022) are aquatic habitats, with salty, brackish or fresh water. The Narta Lagoon itself and the Salina of Skrofotina (41.5 km²) compose one of the most largest and most important wetland ecosystems, not only in the Albanian coast, but in the entire Eastern Adriatic.

From the reported data in this Volume, it seems that until today about 2,310 species are known (1,350 plants, 70 fungi and 890 animals) mainly for the Vlora part of the Delta (Miho *et al*., *in this volume*). About 198 species are threatened in Albania and represent about 47% of threatened animal species for the entire Albanian territory. These are by no means small values for such a space, compared to other similar areas in the country. Radford *et al*. (2011) list the area Pishe Poro - Vjosa (Vlora) among the Important Plant Areas (IPA A35).

The checklist of bird species reported for the Vjosa Delta according to different sources (*Anonymous*, 2005; Mladenov *et al*., 2018; etc.) and our findings in years (1993-2023) is given in **the Appendix 1**. For each of the species, data are given regarding: Presence & Breeding; Habitats; Conservation status (IUCN & Albanian Red List); presence in the Annex I of EU Birdd Directive (EBD), Bern Convention on the Conservation of European Wildlife and Bonn Convention on the Consevation of Migratory Species of Wild Animals.

The data analysis of Appendix 1, shows that **248 species of birds have been encountered so far in the Delta area.** These are about 70% of the 360 species registered up today in Albania. All species of the deta are reported during 1993-2023; they belong to 22 orders, where the order Passeriformes (Passerines) is the richest with 92 species), followed by Charadriiformes (Waders, Gulls and Terns) with 53 species (Fig. 6). Bird photos from the Vjosa-Narta area are reported in figures 3-4, 8-10.

From the data, it is clear that the Delta complex is one of the most important bird areas of Albania. This is also confirmed by many reports or publications with which we have been advised, cited above.

The Vjosa - Narta is listed as an Important Bird and Biodiversity Area (IBA) by BirdLife International (BLI 2023b), with criteria A1, A4i, A4iii, B1i (2000), but classified as IBA in Danger. We will discuss the threats against the area even in this review.

109 species or 44% of all species are always present (resident) in the Delta area (Tab. 1); 44 species (18%) show only during winter, and 160 species (65%) use the habitats of the area for breeding. Here we count the majority of residents as well as birds that visit Albania only for breeding. Meanwhile, 30 species (12%) use the area as a temporary stopover site during their migration route.

Out of 248 species, only 5 species are considered accidental, and 13 others as Rare. The White-headed Duck *Oxyura leucephala* was observed only once in 1993 (Hagemeijer, 1994), and it can be considered as extinct from the Vjosa Delta. Hence, about 220 bird species are regularly observed in the area.

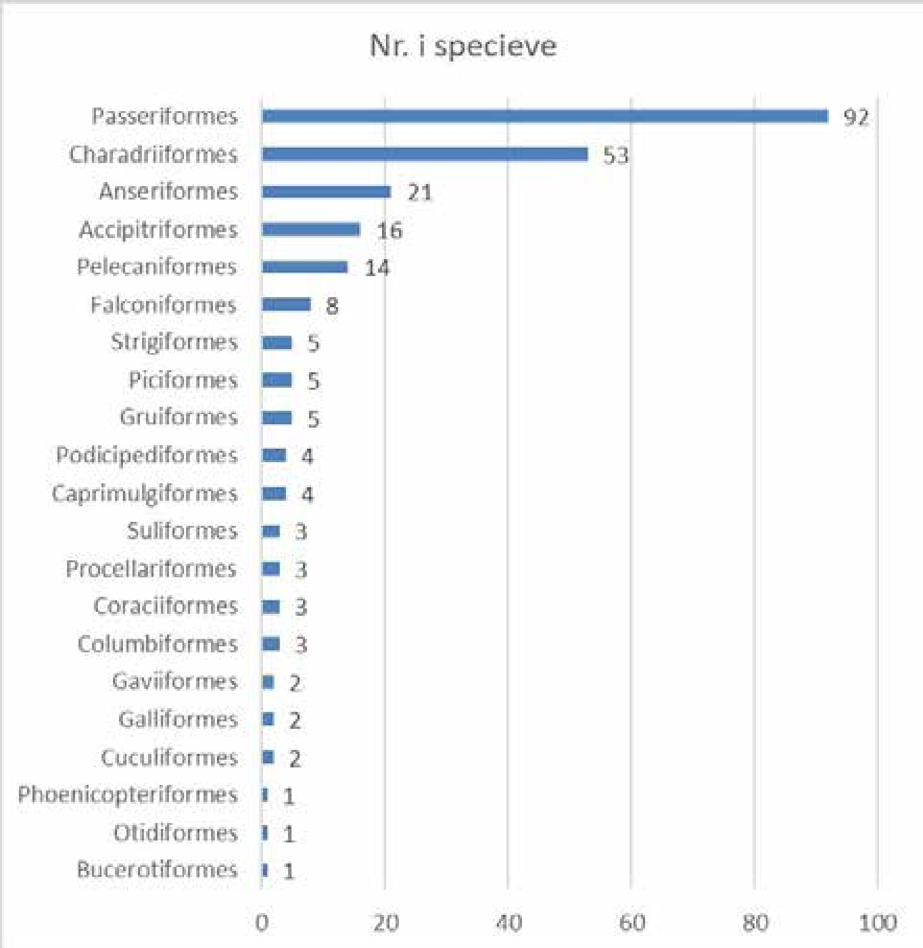

Figure 6.
Distribution of bird species present in the Vjosa Delta according to orders.

Table 1.
Distribution of bird species present in the Vjosa Delta according to presence and frequency.

Presence & Frequency (Acronym)	Species (%)
Resident (Re)	109 (44%)
Wintering (Wi)	44 (18%)
Breeding (Br)	160 (65%)
Migrating (Mi)	30 (12%)
Rare (Ra)	13 (5%)
Accidental (Ac)	5 (2%)
Total species (To)	**248**

Birds are present in all habitats of the Delta, as shown in table 2 and mentioned by Mladenov *et al*. (2018). The majority, composed of 108 species, frequent wetland areas, lagoons (Narta, Kallenga), the salina and other marshes; 63 species frequent the pine forests over the dunes of Zverneci, Akerni and Poro. Many species visit the other areas, such as settlements, grasslands and shrubs or areas with orchards, olive groves, rocky areas, agricultural lands, banks of rivers and channels etc. Despite the obove numbers, some species could use simultaneously a variety of habitats such as forests, grasslands, agricultural lands, open areas etc.

A high number of bird species present in Vjosa Delta have a threatened conservation status at global level and in Albania. **From 248 species, 21 of them are threatened at global level. The White-headed Duck (*O. leucocephala*), although thought to be extinct, it is classified as Endangered (EN). In addition, 6 species of Globally Vulnerable status have been observed so far in the Delta** (Tab. 3).

Meanwhile, **the Delta shelters as well 58 species at different threat level in Albania** (Fig. 7). 10 of those species are Critically Endangered (CR), 14 species are Endangered (EN), 20 species are Vulnerable (VU), 11 species in Lesser Risk (LR) and 3 species are Data Deficient (DD). Photos of regionally important bird species from the Vjosa Delta are reported in figures 8 & 9, while globally threatened species are given in figure 10.

Table 2.
Distribution of bird species present in the Vjosa Delta according to habitats.

Habitat (Acronym)	Species
Wetlands (lagoon, salina, swamps) (We)	108
Forest (Fo)	63
Urban areas (Ur)	42
Scrubs (Sc)	40
Grasslands (Gr)	19
Reed (Re)	8
Rocks (Ro)	13
River (Ri)	16
Arable land (Ar)	15
Salicornia (Sa)	5
Open areas (Oa)	24
Plain (Pl)	4
River banks (Ba)	3

Table 3.
Globally Threatened species present in the Vjosa Delta.

Scientific name	English name	Status
Oxyura. leucocephala	White-headed Duck	EN
Aythya ferina	Common Pochard	VU
Clanga clanga	Greater Spotted Eagle	VU
Falco vespertinus	Red-footed Falcon	VU
Melanitta fusca	Velvet Scoter	VU
Puffinus yelkouan	Mediterranean Shearwater	VU
Streptopelia turtur	Turtle Dove	VU

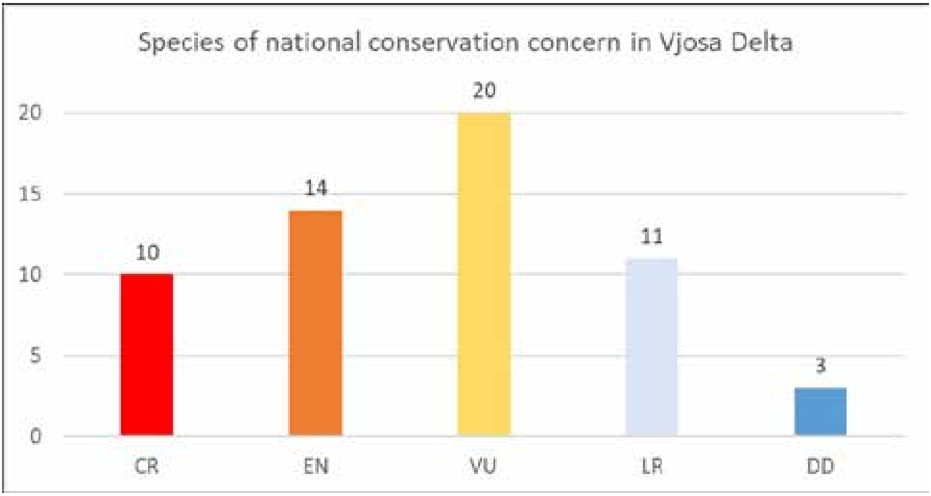

Figura 7.
Bird species of national conservation concern from the Vjosa Delta. **IUCN** categories: CR, Critically Endangered; EN, Endangered; VU, Vulnerable; LR, Lower Risk; DD, Data Defficient.

82 species are part of Annex I of the Birds Directive (EBD) (Tab. 4). According to the Birds Directive, species of Annex 1 are the subject of special conservation measures concerning their habitat in order to ensure their survival and reproduction in their area of distribution. Meanwhile, 11 species belong to the Appendix I of the Bonn Convention (CMS) and 130 species are part of Appendix II of the Bern Convention. Appendix I of Bon Convention includes Endangered Migratory Species while the Appendix II of the Bern Conventon includes Strictly Protected Species.

Photos of species present in the Birds Directive (Annex I), which require special conservation are shown in figure 10.

Figure 8.
Regional important bird species from the Vjosa Delta: **A**, Greater Flamingo (*Phoenicopterus roseus*) >2% of the regional population (Photo: G. Hyseni); **B**, Dalmatian Pelican (*Pelecanus crispus*) 1.3-1.4% of the regional population (Photo: T. Bino); **C**, Grey Plover (*Pluvialis squatarola*) >1% threshold of the European population.

Figure 9.
Globally Vulnerable species from the Vjosa Delta: **A**, Common Pochard (*A. ferina*) – regular wintering waterbird; **B**, Greater Spotted Eagle (*C. clanga*) – rare wintering bird of prey; **C**, Velvet Scoter (*M. fusca*) – rare to regular wintering waterbird; **D**, Turtle Dove (*S. turtur*) – regular breeding bird; **E**, Yelkouan Shearwater (*P. yelkouan*) – resident bird; **F**, Red-footed Falcon (*F. vespertinus*) – regular migratory bird.

Waterbirds in the Vjosa Delta

Apart from the high number of species threatened globally and locally, the aquatic habitats of the Delta shelter a large number of individuals of waterbirds. The multiyear average 1995-2023 of the waterbirds observed during International Waterbird Census shows that **the Delta serves as a wintering habitat for ca. 20,300 waterbirds** (Tab. 5) (Kayser *et al*., 1995; 1997; Bino *et al*., 1996; Bino & Smart, 2005; Bino & Carugatti, 2016; Bino, 2017; 2018; 2019; etc., Bego F. for the period 2016-2023 in Pishe-Poro-Semani and PPNEA for 2016-2023 in Vjosa-Narta); it fulfills one of the criteria of the Ramsar Convention for Wetlands of International Importance. **Within the Vjosa Delta itself, its southern part, the Vjosa-Nartë area, is the most important area for wintering watebirds.**

The wetland habitats of the complex shelter about 12% of wintering waterbirds in Albania. Comparing the long-term data of Vjosa-Narta with other wetlands of interest for waterbirds in Albania, shows that Vjosa-Narta ranks 5th in Albania for the total number of waterbirds. However, from the point of view of diversity (*see* the Shannon-Wiener index in table 6), the Vjosa-Narta exosistem is among the richest in Albania, ranking 3rd.

Figure 10.
Birds Directive species (Annex I) from the Vjosa Delta that need special conservation: **A**, Dalmatian Pelican (*P. crispus*) (Photo: T. Bino); **B**, European Roller (*C. garrulus*) (Photo: J. Margjeka), **C**, Calandra Lark (*Melanocorypha calandra*) (Photo: J. Margjeka).

Table 4.
Number of species from the Vjosa Delta that are present in the annexes of EU directives and international conventions.

Directives & Convents	Species
European Birds Directive (EBD)	82
Appendix II Strictly Protected Fauna Species Bern Convention for the Conservation of European Wildlife and Natural Habitats (Be)	130
Appendix I Endangered Migratory Species Bonn Convention on Migratory Species (**CMS**)	11

Table 5.
The number of wintering birds present in the habitats of the Vjosa Delta.

Sites	No. wintering of waterbirds (IWC data 1995-2023)
Pishe-Poro-Semani	989
Vjose-Narte	19,314
Total	20,303*
One of the criteria for consideration as Ramsar site; IWC, International Waterbird Census.	

Table 6.
Relative importance of Vjosë-Narta compared with other wetlands in Albania (period 1995-2023. N, Average number of waterbirds; H‘, Shannon-Wiener Diversity Index.

Sites	N	Species	H’	Period
Divjake-Karavasta	36,505	81	2.71	1995-2023
Shkodra	27,478	51	1.30	1995-2023
Prespa (AL)	21,404	39	1.02	1996-2023
Ohrid (AL)	20,650	39	0.92	1995-2023
Vjosa-Narta	**19,314**	**63**	**2.62**	**1995-2023**
Thana	8,957	51	2.27	2002-2023
Kune-Vaini	8,054	69	2.30	1995-2023
Butrinti	6,370	62	2.66	1995-2023
Lalzi	4,161	54	2.39	1995-2023
Patoku	2,885	55	2.50	1995-2023
Bune-Velipoja	2,682	67	2.16	1995-2023
Orikumi	2,644	43	1.74	1995-2023

Meanwhile, Vjosë-Narta is the main wintering place in Albania for 4 species of waterfowl, including the Golden Plover (*P. appricaria*), the Kentish Plover (*C. alexandrinus*), the Goldeneye (*Bucephala clangula*) and the Cattle Egret (*Bubulcus ibis*).

Despite the importance of Vjose-Narta for winterin waterbirds, the numbers registered in the frame of the Interantional Waterbird Census 1996-2023 show that in the long-term there is a decrease in the number of wintering waterbirds (Fig. 11).

The negative slope (-1138) of the linear regression model implies a decreasing trend in the number of water birds over time. It’s important to note that R2 is relatively low (0.2289), suggesting that the linear model might not be a perfect fit for the data. It could mean that other factors, not included in the model, might influence the number of waterbirds. Nevertheless, this does not contradict the fact there there is a negative tendency in the number of waterbirds during 1995-2023.

The highest figures of waterbirds have been registered in January 1997 and January 2001 with respectively 81,223 and 79,321 waterbirds. Meanwhile the lowest figure has been registered in January 2014 with only 7,390 waterbirds. During the last years, there is a kind of stability in bird numbers. Nevertheless, the registered figures are below the long-term average of circa 19,300 waterbirds.

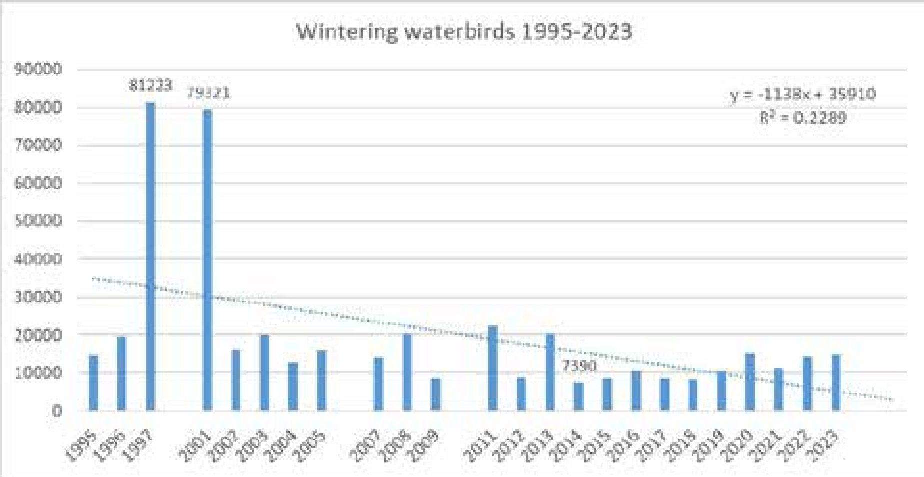

Figure 11.
Wintering waterbirds in Vjose-Narta 1993-2022 (IWC data, AOS and PPNEA); IWC, International Waterbird Census.

The community of wintering waterbirds (Fig. 12) is dominated by dabbling ducks (Anatini and Tadornini) and the group of Coots (*Fulica atra*). Another dominant group is that of Waders (part of Charadriiformes) followed by Gulls and Terns (*Laridae*), Flamingos (*Phoenicopterus roseus*) and Cormorants (part of *Phalacrocoracidae*).

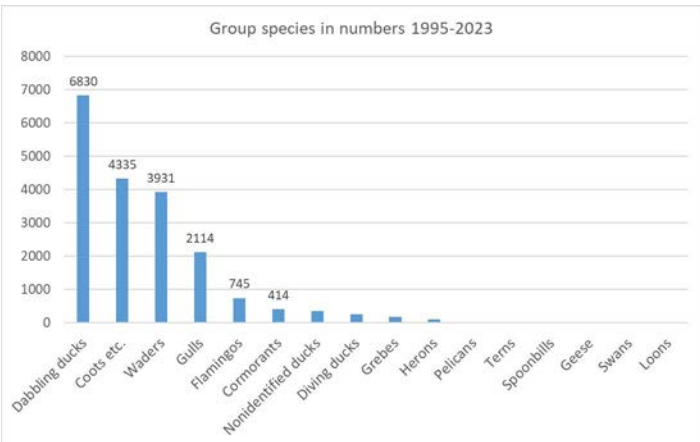

Figure 12.
Average number of main groups of waterbirds during IWC 1995-2023 in Vjosa-Narta; IWC, International Waterbird Census.

From the point of view of the distribution of wintering waterbirds on different surfaces of the Vjosë-Nartë wetland complex, it seems that **the most important areas for wintering are the open lagoon waters such as the Narta Lagoon, Limopuo, and Kallenga. These areas shelter about 70% of birds** (Fig. 13). The second most important sub-area is the Salina of Skrofotina with about 24% of wintering birds during the period 1995-2023. It is interesting that the Akerni area, where Vlora International Airport is being built today, is used by about 5% of waterbirds on average.

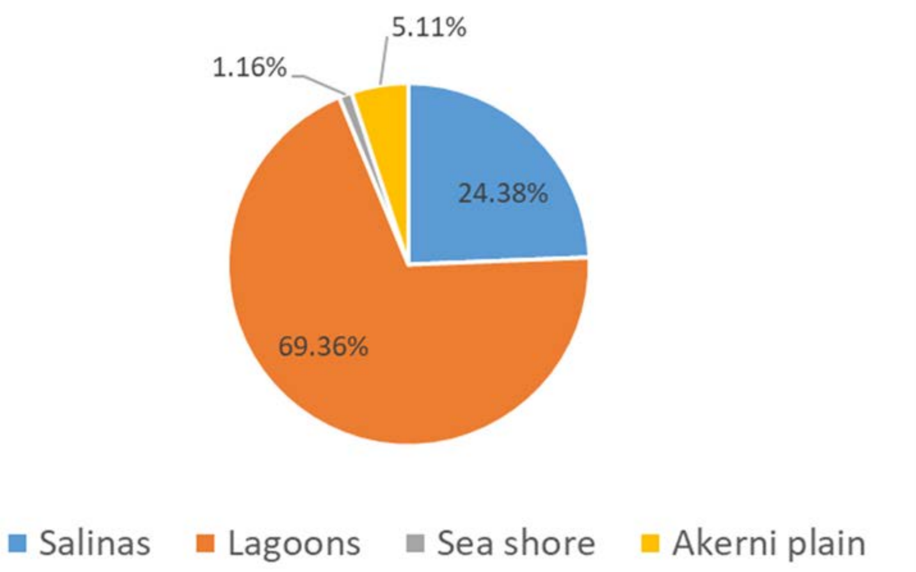

Figure 13.
Distribution of wintering waterbirds (in %) in different areas of Vjosa-Narta (1995-2023).

The Akerni area, although seemingly abandoned agricultural land, is constantly used by some waterbirds, such as Golden Plover (*P. appricaria*), Northern Lapwing (*Vanellus vanellus*), Euroasian Curlew (*Numenius arquata*) etc. However, Akerni is regularly flooded, partially or completely, during the winter and creates host habitats for other waterfowl such as non-diving ducks, herons, other waders, etc

On average, Akerni shelters around 1000 waterfowl every year. But in different years, this sub-zone accommodates high numbers such as about 5,480 waterfowl in 2001, 4,020 in 2005, 2,150 birds in 2008, etc. (Fig. 14).

Based on the data published in (Mladenov *et al*., 2016; etc.) and reports (Topi *et al*. 2020; etc.), **Vjosë-Narta area is one of the most important areas in Albania for the breeding of numerous waterbirds,** such as Kentish Plover (*Charadrius alexandrinus*), Black-winged Stilt (*Himantopus himantopus*), Pied Avocet (*Recurvirostra avosetta*) etc. The Great White Pelican (*Pelecanus onocrotalus*) has been observed in Narta Saline (Topi, 2019).

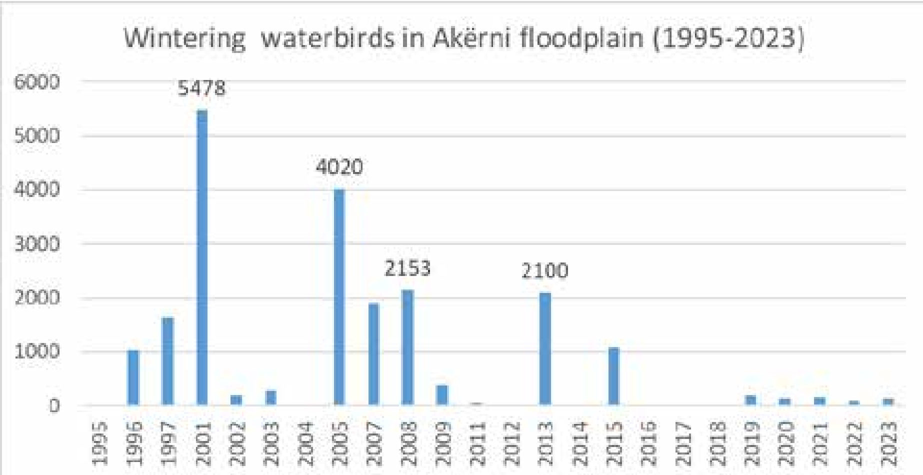

Figure 14.
Wintering waterbirds in Akerni floodplain (1995-2023).

Besides them, in early July 2023, the authors recorded in the Salina of Skrofotina a colony of the Gull-billed Tern (*Gelochelidon nylotica*) composed of 152 breeding pairs with chicks and eggs and distributed in several sandy islands. This is the largest colony of the Gull-billed Tern in Albania and represents a significant growth of the colony compared with 5-7 breeding pairs registered by AOS in June 2020.

Furthermore, the observation of AOS in July 2023, confirmed also the breeding of 5-8 pairs of the Slender-billed Gull (*Chroicocephalos genei*), as well as the first case of breeding in Albania of the Mediterranean Gull (Larus melanocephalus) with 5-8 breeding pairs (Fig. 15)

Figure 13.
Above, mixed colony of Gull-billed Tern (*Gelochelidon nilotica*), Mediterranean Gull (*Larus melanocephalus*) and Slender-billed Gull (*Chroicocephalus genei*) in 2023 in the Salinas of Skrofotina (Photo: T. Bino); **below**, adult of Slender-billed Gull feeding its chick in Narta (Photo: E. Xeka).

Bino *et al*. (2023b), in their report on the breeding birds along the Vjosa NP, conclude that the lower part of the Vjosa to Mifoli is the most important. We think that this is also for the riverside part from Mifoli to Vjosa Mouth. Unfortunately, these river streteches are among the most threatened, from the presence of feral animals and the poor management of their waste, the river mining, the artificial stony river banks, etc. Particularly harmful has been the the river bank reinforcement in recent years, from Selenica to Poro.

After them, comparative analysis of habitat changes during 2018-2023 clearly shows that bank reinforcement has caused the loss of steep of the river banks and their immediate replacement by river bars covered by riparian vegetation. It has led to large scale destruction of potential nesting grounds for thousands of Sand Martin (*Riparia riparia*), European Bee-eater (*Merops apiaster*) and Common Kingfisher (*Alcedo atthis*).

Bino *et al*. (2023b) suggest that **management practices need to be undertaken for the riverbanks of the lower part of Vjosa, including the River part within the Vjosa Delta.** The measures should ensure the conservation of their nesting habitats, avoid and mitigate the threats mentioned above.

Threats on birds of the Vjosa Delta

Anonymous (2005) in the Management Plan of the Vjosa Narta area mention as the eventual threats for the birds : the presence of the industrial park and the TPP; harbour activity; increaseing traffic; overgrazing; pollution from industry, from hydrocarbons, from sewage and from agriculture. Experts at that time emphasized the potentials for **the development of ecotourism in the Zverneci area**.

The area has inherited high pollution from former activities in the vicinity such as Soda-PVC factories, and after the new brewery. Wastewater partly of the Vlora city and the municipality of Center flows untreated directly into the Narta lagoon, causing organic and inorganic pollution and serious health concerns.

Deforestation in the Vjosa watershed is also an eventual threat; it can enhance sedimentation and shoreline changes, tide channel closures, etc. Moreover, the eventual construction of HPPs in Vjosa may cause erosion and changes to the coastline. As such, the coastline is vulnerable to erosion and some habitats are at risk of extinction.

Based on the model of the designation of the Natura 2000 sites, it seems that there are many factors with a negative impact on the fauna and especially the birds of the Vjosa Delta (Tab. 7). Among them, we highlight: (i) the construction and possible operation of the Vlora Airport; (ii) the urbanization of natural areas; and (iii) the modification of the natural ecosystem.

The construction of Vlora Airport is causing loss of semi-natural habitats as well as other impacts including air pollution, significant increase in noise, light pollution, human disturbance inside and around the construction site etc.

The footprint of the Vlora International Airport with an area of 340 ha lies in the Akerni Lowland. This lowland occupies an area of about 1,600 ha within the Landscape Protected Pishe Poro-Narta, or more than 30% of the protected area.

Table 7.
Cheklist of potential threats in the Vjosa Delta area according to Bino *et al*. (2023). H, High.

Code	Description	Impact on fauna
D	Transportation and service corridors	H
D04	airports, flyways	H
D04.01	**Airport**	H
D04.02	aerodrome, heliport	H
D04.03	flyways	H
E	Urbanisation, residential and commercial development	H
E01	**Urbanised areas, human habitation**	H
E01.01	**continuous urbanization**	H
E01.02	discontinuous urbanization	H
E01.03	dispersed habitation	H
E01.04	other patterns of habitation	H
J	**Natural system modifications**	H
J02	Human induced changes in hydraulic conditions	H
J02.03	canalisation and water deviation	H
J02.05	general modification of hydrographic functioning	H
J02.06	water abstractions from surface waters	H

Despite its extensive use, Akerni Plain is recognized as a semi-natural habitat due to the presence of natural vegetation in abandoned agricultural areas as well as frequent floods that lead to the formation of temporary wetlands. Situated in the center of the Protected Area and in the corridor that connects the wetlands of Vjosë-Narta with those of Divjaka-Karavasta National Park, Akerni is used by at least 170 species of wild birds (Bino & Bego, 2023).

Temporary wetlands, created during the winter as a result of rainfall and flooding, form suitable habitats for over 60 species of waterbirds. Bird species using this area for nesting, feeding or resting during the summer belong to the families Alaudidae (Larks and some species of Pipits), Emberizidae (Buntings), Motacillidae (Wagtails), Burhinidae (Stone Curlew), Sturnidae (Starlings), Passeridae (Sparrows), Corvidae (Crows and Magpies), Accipitridae (Sparrowhawks), Falconidae (Falcons), Cisticolidae (Zitting Cistiola, Upupidae (Common Hoopoe), Phasianidae (Common Quail), etc.

The construction of the airport has resulted in covering of natural vegetation with soil and gravel and consequently the immediate disappearance of the haline vegetation and the habitat itself consisting of carpet communities with different dominant species of *Arthrocnemum* sp. and their associated species, such as *Limonium vulgare*, *Puccinellia festuciformis, Elymus farctus, Inula crithmoides, Aster tripolium*, etc. The immediate habitat loss has an impact to all the species abovementioned.

However, the most significant impact is expected during the operation of the airport, which will be accompanied by a wider impact in the delta area, especially in the perturbation of all birds species that use the migration corridor Divjaka-Karavasta-Vjosa-Narta, as well as the nesting birds in the salinas, in the Vjosa-Narta complex, but also to those that nest in Divjaka-Karavasta, such as the Dalmatian Pelican (*Pelecanus crispus*), other waterbirds and various birds of prey.

The impact will appear in the form of continuous and loud noises, the continuous disturbance of habitats due to the permanent presence of humans, accidents of fauna due to road traffic, and particularly the accidents of many birds during the airplanes landing and take-off of. Furthermore, the effects of the airport will be added to the current impacts in the area but also to those expected in the near future, especially the urbanization of the coastline.

Annex 1

Checklist of the bird species reported for the Delta of Vjosa according to different sources (in the last column) and our findings in years. Further explanations are given in the text or related tables. **Presence & Breedining (Acronym)**: Re, Resident; Wi, Wintering; Br, Breeding; Mi, Migratory; Ra, Rare; Ac, Accidental; Ex, Extinct; Bp, Bird of prey. **Habitats**: Wetlands (lagoons, salinas, marshes); Fo, Forest; Ur, Urban Areas; Sc, Shrubs; Gr, Grasslands; Rs, Reeds; Ro, Rocks; Ri, River; Ar, Arable lands; Sa, Salicornia; Oa, Open areas; Pl, Fields; Ba, River banks. **Threatened according to IUCN**: EU, Europe; Gl, Global; Al, Albania. **IUCN categories**: CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; NE, Not evaluated; DD, Data Defficient. **Directives and Conventions** (Annexes I, II, etc.): Be, Bern & Ra, Ramsar (+); Em, Emerald Network; EBD, Birds Directive; CMS, Bonn Convention; AEWA, African-Eurasian Migratory Waterbird Agreement (+), SITES, (*) & Bc, Barcelona (I/II).

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Accipiter gentilis	Northern Goshawk	Re, Br, Fo, Oa	LC	VU				Kayser *et al*. 1995, Bino *et al. 2023a*
Accipiter nisus	Eurasian Sparrowhawk	Re, Br, Fo, Oa	LC	EN				Kayser *et al*. 1995; Bino *et al*. 1996; *2023a;* Mladenov *et al*. 2018
Acrocephalus arundinaceus	Great Reed Warbler	Br, Rs	LC	LC				Mladenov *et al*. 2018; Bino *et al. 2023a*
Acrocephalus melanopogon	Moustached Warbler	Wi, Mi, Rs	LC	EN		I		Bino *et al. 2023a*
Acrocephalus schoenoabaenus	Sedge Warbler	Br, Rs	LC	EN				Bino *et al. 2023a*
Acrocephalus scirpaceus	Reed Warbler	Br, Rs	LC	LR				Bino *et al. 2023a*
Actitis hypoleucos	Common Sandpiper	Re, Br, We, Ri	LC	LC	II			Kayser *et al*. 1995; Bino *et al*. 1996; 2023a&b; *Anonymous* 2005; Mladenov *et al*. 2018
Aegithalos caudatus	Long-tailed Tit	Re, B, Fo	LC	LC				Mladenov *et al.* 2018; Bino *et al*. 2023a
Alauda arvensis	Eurasian Skylark	Re, Br, Gr, Ag	LC	LC				Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Bino *et al. 2023a*

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Alcedo atthis	Common Kingfisher	Re, Br, We, Ri, Ba	LC	LC	II	I		Hagemeijer 1994; Kayser *et al.* 1995; 1997; Bino *et al.* 1996; *2023a&b*
Anas acuta	Northern Pintail	Wi, We	LC	LC		IIA; IIIB		Hagemeijer 1994; Kayser *et al.* 1995; Bino *et al.* 1996; 2023a; *Anonymous* 2005
Anas crecca	Eurasian Teal	Re, We	LC	LC		IIA; IIIB		Hagemeijer 1994; Kayser *et al.* 1995; Bino *et al.* 1996; 2023a*; Anonymous* 2005.
Anas platyrhynchos	Mallard	Re, Br, We	LC	LC		IIA; IIIB		Hagemeijer 1994, Kayser *et al.* 1995, Bino et al. 1996, *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al. 2023a*
Anser albifrons	White-fronted Goose	Wi, We, Ag	LC	VU		IIA; IIIB		Hagemeijer 1994; Kayser *et al.* 1995, Kayser *et al.* 1997, *Anonymous* 2005; Bino *et al. 2023a*
Anser anser	Greylag Ggoose	Wi, We, Gr,	LC	LC				Kayser *et al.* 1997; *Anonymous* 2005; Bino *et al. 2023a*
Anthus campestris	Tawny Pipit	Br , Oa, Sa, Ag, Pl	LC	LC		I		Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al. 2023a*
Anthus cervinus	Red-throated Pipit	Mi, Gr (Ra)	LC	LC				Mima *et al.* 2003; Topi *et al.* 2013; Bino *et al. 2023a*
Anthus pratensis	Meadow Pipit	Wi , Oa, Sa, Ag, Pl	NT	LC				Hagemeijer 1994; Kayser *et al.* 1995; 1997; Mladenov *et al.* 2018; Bino *et al. 2023a*
Anthus spinoletta	Water Pipit	Re , Br , Oa, Sa, Ag, Pl, Gr	LC	LC				Hagemeijer 1994; Kayser *et al.* 1997, Bino *et al. 2023a*
Anthus trivialis	Tree Pipit	Br, Fo	LC	LC				Mladenov *et al. 2018*
Apus apus	Common Swift	Br, Ur	LC	LR				Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al. 2023*
Apus pallidus	Pallid Swift	Br, Ur	LC	LR	II			Bino *et al. 2023a*
Aquila fasciata	Bonelli's Eagle	Re, Br, Mo, Oa, Sc, We (for juv.)	LC	EN		I		Bino *et al. 2023a*

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Ardea alba	Great White Egret	Re, NBr, We	LC	EN	II	I		Bino *et al.* 1996; Mladenov *et al.* 2018; Bino *et al. 2023a*
Ardea cinerea	Grey Heron	Re, Br, We, Ri	LC	VU				Hagemeijer 1994; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al. 2023a*
Ardea purpurea	Purple Heron	NBr, We	LC	EN	II	I		Zekhuis & Tempelman 1998
Ardeola ralloides	Squaco Heron	Br, We, Ri	LC	VU	II	I		Bino *et al. 2023a*
Arenaria interpres	Ruddy Turnstone	Mi, Wi, We	LC	LC	II			Zekhuis & Tempelman 1998; Bino 2017; Bino *et al. 2023a*
Asio otus	Long-eared Owl	Br, Fo	LC	LR	II			Bino *et al. 2023a*
Athene noctua	Little Owl	Re, Br, Ur	LC	LC	II			Kayser *et al.* 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al. 2023a*
Aythya ferina	Common Pochard	Wi, We	VU	LC		IIA; IIIB		Hagemeijer 1994; *Anonymous* 2005
Aythya fuligula	Tufted Duck	Wi, We	LC	LC		IIA; IIIB		Hagemeijer 1994; Kayser *et al.* 1995
Aythya nyroca	Ferruginous Duck	Re, Br, We	NT	CR		I	I*	Bino *et al. 2023a*
Bubulcus ibis	Cattle Egret	Re, Br, We	LC	LC	II			Bino *et al. 2023a*
Bucephala clangula	Common Goldeneye	Wi, We	LC	LC		IIB		Hagemeijer 1994; Kayser *et al.* 1995; *Anonymous* 2005; Bino *et al. 2023a*
Burhinus oedicnemus	Eurasian Thick-knee	Re, Br, We, Ri	LC		II	I		Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al. 2023a&b*
Buteo buteo	Common Buzzard	Re, Br, Fo, Oa	LC	VU				Kayser *et al.* 1995; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al. 2023a*
Calandrella brachydactyla	Short-toed Lark	Br, Gr, Ri	LC	LC	II	I		Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al. 2023a*
Calidris alba	Sanderling	Wi, We	LC	LC	II			Mladenov *et al. 2018*; Bino *et al.* 2023a

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Calidris alpina	Dunlin	Wi, We	LC	LC	II	I		Hagemeijer 1994; Kayser *et al*. 1995; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Calidris canutus	Red Knot	Mi, Wi, We (Ra)	NT	LC		IIB		Mladenov *et al.* 2018; Bino *et al*. 2023a
Calidris falcinellus	Broad-billed Sandpiper	Mi, We (Ra)	LC	LC	II			AOS 2016; Mladenov *et al.* 2018; Bino *et al.* 2023a
Calidris ferruginea	Curlew Sandpiper	Mi, We	NT	LC	II			Zekhuis & Tempelman 1998; Bino *et al.* 2023a
Calidris minuta	Little Stint	Wi, We	LC	LC	II			Hagemeijer 1994; Kayser *et al*. 1995; Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al*. 2023a
Calidris pugnax	Ruff	Mi, We	LC	LC		I		Hagemeijer 1994, Mladenov *et al.* 2018; Bino *et al.* 2023a
Calidris temminckii	Temminck's Stint	Mi, We (Ra)	LC	LC	II			Hagemeijer 1994; Bino *et al.* 2023a
Calonectris diomedea	Cory's Shearwater	Re, ??, Ma	LC	EN		I		Hagemeijer 1994; Mladenov *et al.* 2018; Bino *et al*. 2023a
Caprimulgus europaeus	European Nightjar	Br, Fo, Gr, Sc	LC	LR	II	I		Mladenov *et al.* 2018; Bino *et al.* 2023a
Carduelis carduelis	European Goldfinch	Re , Br , Fo,Sc, Ur	LC	LC	II			Hagemeijer 1994; Kayser *et al*. 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al*. 2023a
Cecropis daurica	Red-rumped Swallow	Br, Ur	LC	LC	II			Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Cettia cetti	Cetti's Warbler	Re, Br, Sc, We	LC	LC				Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Charadrius alexandrinus	Kentish Plover	Re, Br, We	LC	LC	II	I		Hagemeijer 1994; Kayser *et al.* 1995; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Charadrius dubius	Little Ringed Plover	Br, We, Ri	LC	LC	II			Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a&b

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Charadrius hiaticula	Ringed Plover	Mi, We	LC	LC	II			Hagemeijer 1994; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023
Chlidonias hybrida	Whiskered Tern	Br, We	LC	LC	II	I		Zekhuis & Tempelman 1998; Bino *et al.* 2023a
Chlidonias leucopterus	White-winged Tern	Mi, We	LC	LC	II			Bino *et al.* 2023a
Chlidonias niger	Black Tern	Mi, We	LC	LC	II	I		Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Chloris chloris	Euroepan Greenfinch	Re , Br , Fo, Sc, Ur	LC	LC	II			Kayser *et al.* 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Chroicocephalus genei	Slender-billed Gull	Re, Br, We	LC	VU	II	I		Hagemeijer 1994; Kayser *et al.* 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Chroicocephalus ridibundus	Black-headed Gull	Re, We	LC	LC		IIB		Hagemeijer 1994; Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Ciconia ciconia	White Stork	Br, We	LC	CR	II	I		Bino *et al.* 2023a
Ciconia nigra	Black Stork	Br, We, Ri	LC	DD	II	I		Bino *et al.* 2023a&b
Circaetus gallicus	Short-toed Eagle	Br, Fo	LC	VU		I		Mladenov *et al. 2018*; Bino *et al.* 2023a
Circus aeruginosus	Marsh Harrier	Re, Br, Rs	LC	VU		I		Hagemeijer 1994; Kayser *et al.* 1995; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Circus cyaneus	Hen Harrier	Wi, Oa, Ag, Sa	LC	EN		I		Kayser *et al.* 1995; Bino *et al.* 1996; 2023a; Mladenov *et al.* 2018
Circus macrourus	Pallid harrier	Mi , Ag, Gr, Sc, Oa	NT	CR		I		Mladenov *et al. 2018*; Bino *et al.* 2023a
Circus pygargus	Montagu's Harrier	Br, Pl	LC	EN		I		Mladenov *et al. 2018*; Bino *et al.* 2023a
Cisticola juncidis	Zitting Cisticola	Re, Br, Sc, Ri	LC	LC				Zekhuis & Tempelman 1998, Mladenov *et al.* 2018; Bino *et al.* 2023a

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Clamator glandarius	Great Spotted Cuckoo	Br, Fo (Ra)	LC	LC	II			Bino *et al.* 2023a
Clanga clanga	Greater Spotted Eagle	Wi, We	VU	CR		I	I*	Hagemeijer 1994, Kayser *et al.* 1995, Bino *et al.* 2023a
Clanga pomarina	Lesser Spotted Eagle	Mi, Fo, We	LC	CR		I		Bino *et al.* 2023a
Columba livia	Rock dove	Re, Br, Ag, Fo, Ur	LC			IIA		Bino *et al.* 2023a
Coracias garrulus	European Roller	Br, Ca, Oa	LC	CR	II	I	I*	Bino *et al.* 2023a&b
Corvus corax	Common Raven	Re, Br, Ro, Oa	LC	LC				Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023
Corvus cornix	Hooded Crow	Re, Br, Ur	LC	LC		IIB		Hagemeijer 1994; Kayser *et al.* 1997; Zekhuis & Tempelman 1998; Bino *et al.* 2023a
Corvus frugilegus	Rook	Re, Br, Ur, Gr	LC	LC		IIB		Bino *et al.* 2023a
Corvus monedula	Eurasian Jackdaw	Re, Br, Ur	LC	LC		IIB		Kayser *et al.* 1995; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino et al. 2023a
Coturnix coturnix	Common Quail	Re, Br, Gr	LC	LC		IIB		Mladenov *et al. 2018*; Bino *et al.* 2023a
Crex crex	Corncrake	Mi, Ar	LC	VU	II	I		Bino *et al.* 2023a
Cuculus canorus	Common Cuckoo	Br, Fo	LC	LC				Bino *et al.* 2023a
Curruca cantillans	Subalpine Warbler	Br, Sc	LC	LC	II			Mladenov *et al. 2018*; Bino *et al.* 2023a
Curruca communis	Common Whitethroat	Br, Sc	LC	LC	II			Mladenov *et al. 2018*; Bino *et al.* 2023a
Curruca crassirostris	Eastern Orphean warbler	Br, Sc	LC	LC	II			Mladenov *et al. 2018*
Curruca conspicillata	Sectacled Warbler	Re, Br, Sc (Ra)	LC	LC	II			Kayser *et al.* 1995
Curruca curruca	Lesser Whitethroat	Br, Sc	LC	LC	II			Mladenov *et al. 2018*; Bino et al. 2023a
Curruca melanocephala	Sardinian Warbler	Re, Br, Sc	LC	LC	II			Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Curruca ruppeli	Rüppell's warbler	Br, Sc (Ra)	LC	LC	II	I		Mladenov *et al. 2018*
Cyanistes caeruleus	Blue Tit	Re, Br, Fo, Ur	LC	LC	II			Bino *et al.* 2023a
Cygnus olor	Mute Swan	Re, Br, We	LC	LC		IIB		*Anonymous* 2005; Bino *et al.* 2023a
Delichon urbicum	House Martin	Br, Ur	LC	LC				Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Dendrocopos major	Great Spotted Woodpecker	Re, Br, Fo, Ur	LC	LC	II			Bino *et al.* 2023a
Dendrocopos syriacus	Syrian Woodpecker	Re, Br, Fo, Ur	LC	LR	II	I		Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Dryobates minor	Lesser Spotted Woodpecker	Re, Br, Fo, Ur	LC	LR	II			Bino *et al.* 2023a
Egretta garzetta	Little Egret	Re, Br, We, Ri	LC	VU	II	I		Zekhuis & Tempelman 1998; Mladenov *et al. 2018*; Bino *et al.* 2023a
Emberiza calandra	Corn Bunting	Re, Br, Ar, Oa, Sc	LC	LC				Kayser *et al*. 1997; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al*. 2023a
Emberiza cirlus	Cirl Bunting	Re, Br, Sc	LC	LC	II			Kayser *et al.* 1995; 1997: Mladenov *et al.* 2018; Bino *et al.* 2023a
Emberiza citrinella	Yellowhammer	Re, Br, Fo		LC	II			Kayser *et al*. 1997
Emberiza melanocephala	Black-headed Bunting	Br, Sc, Oa	LC	LC	II			Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Emberiza schoeniclus	Reed Bunting	Re, Br, Rs	LC	LC	II			Kayser *et al.* 1997; 1997; Bino *et al.* 2023a
Erithacus rubecula	European Robin	Re, Br, Fo, Sc	LC	LC	II			Hagemeijer 1994; Kayser *et al.* 1995; 1997; Mladenov *et al.* 2018; Bino *et al.* 2023a
Falco biarmicus	Lanner Falcon	Re, Br, Ro	LC	CR	II	I		Bino *et al.* 2023a
Falco columbarius	Merlin	Re, Br, Ro	LC	VU	II	I		Kayser *et al.* 1995, Bino *et al.* 1996; 2023a
Falco eleonorae	Eleonora's Falcon	Br, Ro	LC	CR	II	I		Bino *et al.* 2023a

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			Gl	Al	Bern	EBD	CMS	
Falco naumanni	Lesser Kestrel	Mi, NBr, Ur	LC	VU	II	I	I*	*Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Falco peregrinus	Peregrine Falcon	Re, Br, Ro, Ur	LC	VU	II	I		Hagemeijer 1994; Kayser *et al.* 1995, 1997; Bino *et al.* 1996; 2023; *Anonymous* 2005
Falco subbuteo	Eurasian Hobby	Br, Fo, Ri	LC	VU	II			Hagemeijer 1994; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino et al. 2023a
Falco tinnunculus	Common Kestrel	Re, Br, Ro, Ur	LC	VU	II			Hagemeijer 1994; Kayser *et al.* 1995; Bino *et al.* 1996; 2023a; Mladenov *et al.* 2018
Falco vespertinus	Red-footed Falcon	Mi, Fo	VU	LC	II	I	I*	Zekhuis & Tempelman 1998; Bino *et al.* 2023a
Ficedula albicollis	Collared Flycatcher	Br, Fo, Sc	LC	LC		I		Bino *et al.* 2023a
Ficedula hypoleuca	Pied Flycatcher	Br, Fo, Sc	LC	LC				Bino *et al.* 2023a
Fringilla coelebs	Common Chaffinch	Re, Br, Fo	LC	LC				Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Fringilla montifringilla	Brambling	Wi, Gr	LC	LC				Kayser *et al.* 1995; 1997; Bino *et al.* 2023a
Fulica atra	Eurasian Coot	Re, Br, We	LC	LC		IIA, IIIB		Hagemeijer 1994; Kayser *et al.* 1995; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Galerida cristata	Crested Lark	Re, Br, Gr, Ur	LC	LC				Zekhuis & Tempelman 1998, Mladenov *et al.* 2018; Bino *et al.* 2023a
Gallinago gallinago	Common Snipe	Wi, We	LC	LC		IIA, IIIB		Bino *et al.* 1996; 2023a
Gallinula chloropus	Common Moorhen	Re, Br, We, Rs	LC	LC		IIA		*Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Garrulus glandarius	Eurasian Jay	Re, Br, Fo, Ur	LC	LC		IIB		Mladenov *et al.* 2018; Bino *et al.* 2023a
Gavia arctica	Black-throated Diver	Wi, Ma, We	LC	LC	II	I		Bino *et al.* 2023a

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Gavia stellata	Red-throated Diver	Wi, Ma, We	LC	LC	II	I		Bino *et al.* 2023a
Gelochelidon nilotica	Gull-billed Tern	Br, We	LC	LC	II	I		Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Glareola nordmanni	Black-winged Pratincole	Mi, We, Oa (Ac)	NT	LC	II			Rubinic 2005 (*pers. comm*); Bino *et al.* 2023a
Glareola pratincola	Collared Pratincole	Br, We, Oa	LC	VU	II	I		Zekhuis & Tempelman 1998; *Anonymous*, 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Grus grus	Common Crane	Mi, We, Oa, Ar	LC	LC	II	I		Bino *et al.* 2023a
Haematopus ostralegus	Eurasian Oystercatcher	Re, Br, We	NT	VU		IIB		Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Haliaeetus albicilla	White-tailed eagle	Re, ??, We	LC	CR		I	I*	Hagemeijer 1994*; Anonymous* 2005
Hieraaetus penatus	Booted Eagle	Br, Ro	LC	EN		I		Bino *et al.* 2023a
Himantopus himantopus	Black-winged Stilt	Br, We	LC	EN		I		Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov *et al. 2018*; Bino *et al.* 2023a
Hippolais icterina	Icterin Warbler	Br, Fo	LC	LC				Bino *et al.* 2023a
Hippolais olivetorum	Olive-tree Warbler	Br, Fo, Sc	LC	DD		I		Mladenov *et al.* 2018; Bino *et al.* 2023a
Hirundo rustica	Barn Swallow	Br, Ur, Ar	LC	LC				Mladenov *et al.* 2018; Bino *et al.* 2023a
Hydrobates pelagicus	Storm-petrel	Re, ??, Ma	LC	EN	II	I		Bino *et al.* 2023a
Hydrocoleus minutus	Little Gull	Wi, We	LC	LC	II	I		Mladenov *et al.* 2018; Bino *et al.* 2023a
Hydroprogne caspia	Caspian Tern	Wi, We	LC	LC	II	I		Hagemeijer 1994; Mladenov *et al.* 2018; Bino *et al.* 2023a
Iduna pallida	Olivaceous Warbler	Br, Sc	LC	LC				Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Ixobrychus minutus	Little Bittern	Br, We	LC	LC	II	I		Mladenov *et al. 2018*; Bino *et al.* 2023a

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN		Bern	EBD	CMS	Source
			Gl	Al				
Jynx torquilla	Wryneck	Br, Fo, Sc	LC	LR	II			Mladenov *et al. 2018*; Bino *et al.* 2023
Lanius collurio	Red-backed Shrike	Br, Sc	LC	LC	II	I		Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023
Lanius senator	Woodchat Shrike	Br, Sc	NT	LC	II			Zekhuis & Tempelman 1998, Mladenov *et al.* 2018; Bino *et al.* 2023a
Larus audouinii	Audouin's Gull	Wi, We	LC	LC	II	I	I*	Hagemeijer 1994, Kayser *et al.* 1995 *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Larus canus	Common Gull	Wi, We	LC	LC		IIB		Hagemeijer 1994, Bino *et al.* 2023a
Larus fuscus	Lesser Black-backed Gull	Wi, We	LC	LC		IIB		Hagemeijer 1994, Bino *et al.* 2023a
Larus melanocephalus	Mediterranean Gull	Mi, ??, We	LC	LC	II	I		Hagemeijer 1994; Kayser *et al.* 1995; Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Larus michahellis	Yellow-legged Gull	Re, Br, We	LC	EN		IIB		Hagemeijer 1994; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Leiopicus medius	Middle Spotted Woodpecker	Re, Br, Fo, Ur	LC	LR	II	I		Bino *et al.* 2023a
Limosa lapponica	Red-tailed Godwit	Mi, We	LC	LC		IIIB		Bino *et al.* 2023a
Limosa limosa	Black-tailed Godwit	Wi, We	NT	LC		IIB		Mladenov *et al. 2018*; Bino et *al.* 2023
Linaria cannabina	Common Linnet	Re, Br, Sc, Oa	LC	LC	II			Hagemeijer 1994; Kayser et al. 1995; 1997; Bino *et al.* 2023a
Locustella luscinoides	Savi's Warbler	Mi, Rs	LC	DD				Bino *et al.* 2023a
Lullula arborea	Wood Lark	Re, Br, Gr, Ur	LC	LC		I		Kayser *et al.* 1997; Bino *et al.* 2023a
Luscinia megarhynchos	Common Nightingale	Br, Fo, Sc, We, Ri	LC	LC	II			Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Lymnocryptes minimus	Jack Snipe	Wi, We	LC	LR		IIA; IIIB		Bino *et al.* 2023a

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Mareca penelope	Eurasian Wigeon	Wi, We	LC	LC		IIA; IIIB		Hagemeijer 1994, Kayser *et al.* 1995, Bino *et al.* 1996; 2023; *Anonymous* 2005
Mareca strepera	Gadwall	Wi, We	LC	LC		IIA		Kayser *et al.* 1995, Bino *et al.* 1996; 2023a; *Anonymous* 2005
Melanitta fusca	Velvet Scoter	Wi, Ma, We	VU	LC		IIB		Bino 2017
Melanocorypha calandra	Calandra Lark	Re, Br, Gr	LC	LC	II	I		Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Mergellus albellus	Smew	Wi, We	LC	LC	II	I		Bino *et al.* 1996; *Anonymous*, 2005a
Mergus serrator	Red-breasted merganser	Wi, We	LC	LC		IIB		Kayser *et al.* 1995; *Anonymous* 2005; Bino *et al.* 2023a
Merops apiaster	European Bee-eater	Br, Ba	LC	EN	II			Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a&b
Microcarbo pygmaeus	Pygmy Cormorant	Re, Br, We	LC	CR	II	I		Bino *et al.* 2023a
Milvus migrans	Red Kite	Mi, Ro, Oa, Fo	LC	EN		I		Xeka (*pers. comm.* 2023)
Motacilla alba	Pied Wagtail	Re , Br , Ri, Ur, Oa, Gr	LC	LC	II			Hagemeijer 1994; Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Motacilla cinerea	Grey Wagtail	Re, Br, Ri, Ur	LC	LC	II			Hagemeijer 1994, Kayser *et al.* 1995; 1997; Bino *et al.* 2023a
Motacilla flava	Yellow Wagtail	Br, Sa	LC	LC	II			Zekhuis & Tempelman 1998, Mladenov *et al.* 2018; Bino *et al.* 2023a
Morus bassanus	Northern Gannet	Wi, Ma (Ra)		LC				Hagemeijer 1994
Muscicapa striata	Spotted Flycatcher	Re , Br , Fo, Sc, Ur	LC	LC	II			Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Netta rufina	Red-crested Pochard	Wi, We		LR				Kayser *et al.* 1995

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			Gl	Al	Bern	EBD	CMS	
Numenius arquata	European Curlew	Re, Nbr, We	NT	LC		IIB		Hagemeijer 1994; Kayser *et al.* 1995; 1997; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Numenius phaeopus	Whimbrel	Mi, We	LC	LC		IIB		Mladenov *et al. 2018*; Bino *et al.* 2023a
Nycticorax nycticorax	Night Heron	Br, We, Fo	LC	VU	II	I		Mladenov *et al. 2018*; Bino et al. 2023a
Oenanthe melanoleuca	Black-eared Wheatear	Br, Gr, Oa	LC	LC	II			Mladenov *et al. 2018*; Bino *et al.* 2023a
Oenanthe oenanthe	Wheatear	Br, Gr, Oa	LC	LC	II			Mladenov *et al. 2018*; Bino *et al.* 2023a
Oriolus oriolus	Golden Oriole	Br, Fo, Ur	LC	LC	II			Zekhuis & Tempelman 1998; Mladenov et al. 2018; Bino *et al.* 2023a
Otus scops	Scops Owl	Re, Br, Ur, Fo	LC	LC	II			Mladenov *et al. 2018*; Bino *et al.* 2023a
Oxyura leucocephala	White-headed duck	Wi, We (Ex)	EN	CR	II	I	I*	Hagemeijer 1994, Bino *et al.* 2023a
Pandion haliaetus	Osprey	Mi, We	LC	VU		I		Mladenov *et al. 2018*; Bino *et al.* 2023a
Parus major	Great Tit	Re, Br, Fo, Ur, Gr, Sc	LC	LC	II			Kayser *et al.* 1995; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Passer domesticus	House Sparrow	Re, Br, Ur	LC	LC				Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Passer hispaniolensis	Spanish Sparrow	Re, Br, Ur	LC	LC				Kayser *et al.* 1995; Zekhuis & Tempelman 1998;, Mladenov *et al.* 2018; Bino *et al.* 2023a
Passer montanus	Eurasian Tree Sparrow	Re, Br, Fo, Ur	LC	LC				Kayser *et al.* 1997; Mladenov *et al.* 2018; Bino *et al.* 2023a
Pastor roseus	Rose-coloured Starling	Mi, Ro (Ra)	LC	LC	II			Bino *et al.* 2023a
Pelecanus crispus	Dalmatian Pelican	Re, Br, We	NT	CR	II	I	I*	Hagemeijer 1994; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Pelecanus onocrotalus	Great white pelican	NBr, We	LC	LC	II	I	I*	Topi, 2019

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			Gl	Al	Bern	EBD	CMS	
Pernis apivorus	Eurasian Honey Buzzard	Br, Fo	LC	EN		I		Bino *et al.* 2023a
Petronia petronia	Rock Sparrow	Re, Br, Ro	LC	DD	II			Bino *et al.* 2023a
Phalacrocorax carbo	Great Cormorant	Re, Br, We	LC	LC				Kayser *et al.* 1995; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Phalaropus lobatus	Red-necked Phalarope	Mi, We (Vg)	LC	LC	II	I		Bino *et al.* 2023a
Phoenicopterus roseus	Greater Flamingo	Re, Br, We	LC	LC	II	I		Kayser et al. 1995, *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Phoenicurus ochruros	Black Redstart	Re, Br, Ur, Oa	LC	LC	II			Kayser *et al.* 1997; Bino *et al.* 2023a
Phoenicurus phoenicurus	Common Redstart	Br, Ro	LC	LC	II			Mladenov *et al. 2018*; Bino *et al.* 2023a
Phylloscopus collybita	Common Chiffchaff	Re, Br, Fo, Sc, Ur	LC	LC				Hagemeijer 1994; Kayser *et al.* 1995; Mladenov *et al.* 2018; Bino *et al.* 2023a
Phylloscopus orientalis	Eastern Bonelli's Warbler	Br, Fo	LC	LC				Bino *et al.* 2023a
Phylloscopus sibilatrix	Wood Warbler	Mi, Fo	LC	LC				Bino *et al.* 2023a
Phylloscopus trochilus	Willow Warbler	Mi, Fo	LC	LC				Bino et al. 2023a
Pica pica	Eurasian Magpie	Re , Br , Fo, Sc Ur	LC	LC		IIB		Kayser *et al.* 1995; Mladenov *et al.* 2018; Bino *et al.* 2023a
Platalea leucorodia	Eurasian Spoonbill	Re, NBr, We	LC	EN	II	I		Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Plegadis falcinellus	Glossy Ibis	Br, We	LC	EN	II	I		Mladenov *et al.* 2018; Bino *et al.* 2023a
Pluvialis apricaria	Goden Plover	Wi, We	LC	LC		I		Bino *et al.* 1996; *Anonymous* 2005a
Pluvialis squatarola	Grey Plover	Wi, We	LC	LC		IIB		Hagemeijer 1994; Kayser *et al.* 1995; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Podiceps cristatus	Great Crested Grebe	Re, Br, We	LC	LC				Hagemeijer 1994; Kayser *et al.* 1995, *Anonymous* 2005, Bino *et al.* 2023a

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			Gl	Al	Bern	EBD	CMS	
Podiceps grisegena	Red-necked grebe	Wi, We	LC	LC	II			Hagemeijer 1994
Podiceps nigricollis	Black-necked Grebe	Wi, We	LC	LC				Hagemeijer 1994; Kayser *et al.* 1995; Mladenov *et al.* 2018; Bino *et al.* 2023a
Prunella modularis	Dunnock	Re, Br, Fo, Sc	LC	LC	II			Bino *et al.* 2023a
Ptyonoprogne rupestris	European Crag Martin	Re, Br, Ro	LC	LC				Bino *et al.* 2023a
Puffinus yelkouan	Mediterranean Shearwater	Re, ??, Ma	VU	EN	II	I		Bino *et al.* 2023a
Rallus aquaticus	Water Rail	Re, Br, We	LC	LC		IIB		Kayser *et al.* 1995; Mladenov *et al.* 2018; Bino *et al.* 2023a
Recurvirostra avosetta	Pied Avocet	Re, Br, We	LC	EN	II	I		Hagemeijer 1994; Kayser *et al.* 1995; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Regulus regulus	Goldcrest	Re, Br, Fo		LC	II			Kayser *et al.* 1995
Regulus ignicapilla	Common D191Firecrest	Re, Br, Fo, Ur	LC	LC	II			Bino *et al.* 2023a
Remiz pendulinus	Penduline Tit	Re, Br, Fo, Sc	LC	VU				Zekhuis & Tempelman 1998, Bino *et al.* 2023
Riparia riparia	Sand Martin	Br, Ba, Ri	LC	LC				Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; *Bino et al.* 2023a&b
Saxicola rubetra	Whinchat	Br, Ar, Gr, Sc	LC	LC	II			Mladenov *et al. 2018*; Bino *et al.* 2023a
Saxicola torquatus	Common Stonechat	Re, Br, Sc	LC	LC	II			Hagemeijer 1994; Kayser *et al.* 1995;1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; MIE, 2019; Bino *et al.* 2023a
Scolopax rusticola	Woodcock	Wi, Fo, Oa	LC	LC		IIA, IIIB		Bino *et al.* 2023a
Serinus serinus	European Serin	Re, Br, Fo, Ur	LC	LC	II			Hagemeijer 1994; Kayser *et al.* 1995; 1997; Bino *et al.* 2023a
Spatula clypeata	Northern Shoveler	Wi, We	LC	LC		IIA, IIIB		Hagemeijer 1994; Kayser *et al.* 1995; Bino *et al.* 1996; 2023; *Anonymous* 2005

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			Gl	Al	Bern	EBD	CMS	
Spatula querquedula	Garganey	NBr, We	LC	LC		IIA		Zekhuis & Tempelman 1998; Bino et al., 2023a.
Spinus spinus	Eurasian Siskin	Re, Br, Fo		LC	II			Kayser *et al.* 1995; 1997
Sterna hirundo	Common Tern	Br, We	LC	EN	II	I		Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov et al. 2018; Bino *et al.* 2023a&b
Sternula albifrons	Little Tern	Br, We	LC	LC	II	I		Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a&b
Streptopelia decaocto	Collared Dove	Re, Br, Ur	LC	LC		IIB		Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino et al. 2023a
Streptopelia turtur	Turtle Dove	Br, Fo	VU	LC		IIB		Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Strix aluco	Tawny Owl	Re, Br, Fo	LC	LR	II			Kayser *et al.* 1997; Bino *et al.* 2023a
Sturnus vulgaris	Common Starling	Re, Br, Fo, Oa, Ur	LC	LC		IIB		Hagemeijer 1994; Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Sylvia atricapilla	Eurasian Blackcap	Re , Br , Fo, Sc, Ur	LC	LC	II			Kayser *et al.* 1995; Mladenov *et al.* 2018; Bino *et al.* 2023a
Sylvia borin	Garden Warbler	Re, Br, Sc	LC	LC	II			Bino *et al.* 2023a
Tachybaptus ruficollis	Little Grebe	Br, We	LC	LC	II			Kayser *et al.* 1997; Mladenov *et al.* 2018; Bino *et al.* 2023a
Tachymarptis melba	Alpine Swift	Br, Ro, Ur	LC	LC	II			Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Tadorna ferruginea	Ruddy Shelduck	Wi, We (Vg)	LC	LC	II	I		Bino *et al.* 2023a
Tadorna tadorna	Common Shellduck	Re, Br	LC	LC	II			Hagemayer *et al.* 1993; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Tetrax tetrax	Little Bustard	Wi, Ar (Ra)	NT	CR	II	I	I*	Bino *et al.* 2023a
Thalasseus sandvicensis	Sanwich Tern	Wi, We	LC	VU	II	I		Hagemeijer 1994; Kayser *et al.* 1995; Mladenov *et al.* 2018; Bino *et al.* 2023a

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN					Source
			Gl	Al	Bern	EBD	CMS	
Tringa erythropus	Spotted Redshank	Wi, We	LC	LC		IIB		Hagemeijer 1994; Kayser *et al.* 1997; Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Tringa glareola	Wood Sandpiper	Mi, We	LC	LC	II	I		Bino *et al.* 2023a
Tringa nebularia	Common Greenshank	Wi, We	LC	LC		IIB		Hagemeijer 1994; Kayser *et al.* 1997; Zekhuis & Tempelman 1998, *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Tringa ochropus	Green Sandpiper	Re, Nbr, We, Ri	LC	LC	II			Hagemeijer 1994; Kayser *et al.* 1995; 1997; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Tringa stagnatilis	Marsh Sandpiper	Mi, We	LC	LC	II			Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Tringa totanus	Common Redshank	Re, Br, We	LC	LC		IIB		Hagemeijer 1994; Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; *Anonymous* 2005; Mladenov *et al.* 2018; Bino *et al.* 2023a
Troglodytes troglodytes	Northern Wren	Re, Br, Fo, Sc	LC	LC	II			Kayser *et al.* 1997; Bino *et al.* 2023a
Turdus iliacus	Redwing	Wi, Fo	NT	LC				Kayser *et al.* 1995,
Turdus merula	Black Bird	Re , Br , Fo, Sc, Ur	LC	LC		IIB		Mladenov *et al. 2018*; Bino *et al.* 2023a
Turdus philomelos	Song Thrush	Re, Br, Fo	LC	LC		IIB		Kayser et al. 1995, Kayser *et al.* 1997, Mladenov *et al.* 2018; Bino *et al.* 2023a
Turdus pilaris	Fieldfare	Re, Br, Fo	LC	LC				Kayser *et al.* 1997
Turdus viscivorus	Mistle Thrush	Re, Br, Fo	LC	LC		IIB		Kayser *et al.* 1995: Bino *et al.* 2023
Tyto alba	Barn Owl	Re, Br, Ur	LC	VU	II			Mladenov *et al. 2018*; Bino *et al.* 2023a

Scientific name	English name	Presence, Breeding, Habitat	Conservation status according to IUCN		Bern	EBD	CMS	Source
			Gl	Al				
Upupa epops	Common Hoopoe	Br, Fo, Gr, Sc	LC	VU	II			Zekhuis & Tempelman 1998; Mladenov *et al.* 2018; Bino *et al.* 2023a
Vanellus vanellus	Northern Lapwing	Re, Br, We	NT	LC		IIB		Hagemeijer 1994; Kayser *et al.* 1995; 1997; Zekhuis & Tempelman 1998; *Anonymous* 2005; Bino *et al.* 2023a
Xenus cinereus	Terek Sandpiper	Mi, We (Vg)	LC	LC		I		AOS 2020, Bino *et al.* 2023a
Zapornia pusilla	Baillon's Crake	Br, We	LC	DD	II	I		Bino *et al.* 2023a
Gjithsej / Total:		**248**	*	**				

**Gl: 1 species EN, 6 species VU, 14 species NT;*
***AL: 13 species CR, 22 species EN, 21 species VU, 12 species LR, 5 species DD.*

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Mammals of the Vjosa Delta- status and threats

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Why Vjosa Delta is important for Mammals?

Geographical position and the diversity of habitats created during the evolution process of Vjosa Delta are main factors that determine a rich mammalofauna in the area.

So far, some 46 species of mammals are reported in Vjosa Delta; 45 species terrestrial and one species is a marine mammal.

Bats (Order Chiroptera) are the richest group represented with 18 species, followed by rodents (Order Rodentia) with 14 species.

Delta hosts a number of large and medium-sized carnivores (8 species), of which we can distinguish the presence of otter (*Lutra lutra*) (Fig. 1), badger (*Meles meles*), jackal (*Canis aureus*), fox (*Vulpes vulpes*), stone marten (*Martes foina*), polecat (*Mustela putorius*). Although rare, Vjosa Delta is visited during winter by wolf (*Canis lupus*), giving the area a special conservation interest.

Estuarine water of Vjosa Delta are often visited by marine mammals, of which most common is the bottlenose dolphin (*Tursiops truncatus*).

23 mammal species are enlisted in the Annex II and/or Annex IV of the Habitat Directive (as priority or strictly protected species),while other 10 species are included in the Annex III of the Bern Convention as protected species.

Figure 1.
Tracks of otter (*Lutra lutra*) on sandy beaches of Vjosa Delta.

Threatened Mammals of Vjosa Delta

3 mammal species of Delta are threatened at Global, European and Mediterranean scale, making the area very sensitive from the ecological point of view (Tab. 1). 6 mammal species are threatened at national level, of which 4 are vulnerable (VU) and 2 are endangered (EN).

Main threats to Mammals of Vjosa Delta

Mammals are threatened by threats of anthopogenic origin, such as:

-Wetland reclamation and convertion into arable land;

-Illegal hunting (Fig. 4) and irresponsible fishing;

-Traffic (both terrestrial and marine) (Fig. 3).

Plans for the construction of an international airport in Akërni and those related with massive tourism development in costal areas of Pishë Poro (Fieri and Vlora) are serious new threats that are added to the existing ones.

Figure 2.
Old river bed of Vjosa (Zhuka, Vlora).

Figura 3.
Badger (*Meles meles*) roadkill on the highway Levani-Vlora.

Figure 4.
Bullet, evidence of poaching inside the study area.

Tabela 1.
List of Mammals in Vjosa Delta and their status of conservation. **IUCN categories**: CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; NE, Not evaluated; DD, Data Defficient.

Scientific name	Protection status (HD 92/43/EU; Bern Convention	IUCN Red List	Albania Red List (2013)	Bego, *et al.*, (2008; 2018)	Benda, *et al.*, (2019); Theou & Loçe (2019)
Erinaceus roumanicus	none	LC		X	
Crocidura leucodon	Bern Convention (III)	LC		X	
Crocidura suaveolens	Bern Convention (III)	LC		X	
Suncus etruscus	Bern Convention (III)	LC	DD	X	
Talpa stankovici	none	LC		X	
Rhinolophus euryale	Annex II & IV	VU	VU		X
Rhinolophus ferrumequinum	Annex II & IV	LC	LRcd		X
Rhinolophus hipposideros	Annex II & IV	NT	LRnt		X
Myotis blythii	Annex II & IV	NT			X
Myotis emarginatus	Annex II & IV	LC	DD		X
Myotis myotis	Annex II & IV	LC			X
Myotis mystacinus	Annex IV	LC			X
Pipistrellus kuhlii	Annex IV	LC			X
Pipistrellus nathusii	Annex IV	LC			X
Pipistrellus pipistrellus	Annex IV	LC			X
Hypsugo savii	Annex IV	LC			X
Pipistrellus pygmaeus	Anne IV	LC	NL		X
Nyctalus leisleri	Annex IV	LC	DD		X
Nyctalus noctula	Annex IV	LC	DD		X
Eptesicus serotinus	Annex IV	LC			X
Plecotus kolombatovici	Annex IV	LC	NL		X
Miniopterus schreibersii	Annex II & IV	VU	LRnt		X
Tadarida teniotis	Annex IV	LC	DD		X
Lepus europaeus	Bern Convention (III)	LC			
Sciurus vulgaris	Bern Convention (III)	LC	LRnt		X
Microtus rossiaemeridionalis	none	LC		X	
Microtus thomasi	none	LC		X	
Micromys minutus	none	LC		X	

Scientific name	Protection status (HD 92/43/EU; Bern Convention	IUCN Red List	Albania Red List (2013)	Bego, *et al.*, (2008; 2018)	Benda, *et al.*, (2019); Theou & Loçe (2019)
Apodemus flavicollis	none	LC		X	
Apodemus sylvaticus	none	LC		X	
Rattus norvegicus	none	LC		X	
Rattus rattus	none	LC		X	
Mus macedonicus	none	LC		X	
Mus musculus	none	LC		X	
Mus spicilegus	none	LC	DD	X	
Glis glis	Bern Convention (III)	LC	LRlc	X	
Muscardinius avellanarius	Annex IV	LC	DD	X	
Canis lupus	Annex IV	LC	VU		
Canis aureus	Annex V	LC	VU		
Vulpes vulpes	none	LC			
Mustela nivalis	Bern Convention (III)	LC			
Mustela putorius	Bern Convention (III)	LC	EN		
Martes foina	Bern Convention (III)	LC	LRnt		
Meles meles	Bern Convention (III)	LC	EN		
Lutra lutra	Annex II & IV	NT	VU		
Tursiops truncatus	Annex II & IV	LC (Global), VU (Med.)	DD		

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Traditional and innovative DNA-based methods for biodiversity and ecological assessment of aquatic ecosystem: preliminary results from Vjosa River, Albania

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Aquatic biodiversity includes all unique species, their habitats, their interaction, and ecosystem functions. Biodiversity monitoring and conservation strategies to protect and preserve aquatic life are necessary to maintain the balance of nature and resources for future generations.

To ensure the conservation of aquatic ecosystems, water resources, biodiversity and their ecosystem services, various national and international regulations have been implemented. These include the European Union Water Framework Directive (WFD, Directive 2000/60/EC) and the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC), which aim to protect aquatic ecosystems and water resources in Europe. Additionally, the United States redacted the Clean Water Act enforced by the Environmental Protection Agency (EPA) while, globally, the United Nations Convention on the Law of the Sea (UNCLOS, 1982) (Nordquist *et al.*, 2012) also plays a crucial role in regulating the protection of aquatic ecosystems.

These regulations have the primary objective of protecting aquatic ecosystems from harm and revitalizing impaired systems to reach a state of "good status", which refers to conditions that have undergone minimal alteration due to human activities. To accomplish this goal and evaluate the recovery of ecosystems following restoration or rehabilitation efforts, precise assessment is necessary and constitutes an integral component of all global environmental initiatives.

Since the year 2000, the European Union has been monitoring the condition of aquatic ecosystems through the evaluation of biological communities, as well as the analysis of physical-chemical and hydro-morphological factors. The presence and abundance of biological indicators carry the most significance in determining the ecological status of different water bodies. In order to meet the demands of the aforementioned legislation, numerous biotic metrics/indices (e.g., ecological indicators) have been developed in various countries. These metrics/indices rely on the morphological identification of different groups of aquatic indicator organisms and guilds at various organizational levels (Birk *et al*., 2012; Borja *et al*., 2013).

Depending on the type of water body, these biological elements may consist of "phytoplankton", "diatoms", "aquatic flora", "macroalgae and angiosperms", "benthic macroinvertebrates", and "fish". The abundance and classification of these Biological Quality Elements (BQEs) are used to calculate biotic metrics/indices and determine the ecological quality status of the water bodies.

Numerous methods, approximately 300 in total, have been devised to evaluate the ecological status of aquatic ecosystems, encompassing rivers, lakes, transitional waters, and marine-coastal waters. These methods have been implemented by various Countries that adhere to the WFD (Birk *et al*., 2012).

Benthic macroinvertebrates are frequently used as BQEs due to their ability to effectively indicate the health status of freshwater ecosystems, transitional water ecosystems and deltas, as well as marine-coastal waters. These organisms demonstrate sensitivity to environmental stressors such as sediment conditions and nutrient levels, anthropogenic stressors and pollution making them valuable Biological Quality Elements and ecological indicators of ecosystem health (Pinna *et al*., 2024; Birk *et al*., 2012; Macher *et al*., 2016; Elbrecht & Leese, 2017).

The traditional methods used for ecological assessment involve collecting, sorting, and morphologically identifying numerous taxonomic groups. However, these sorting and taxonomic identification processes heavily rely on human expertise, leading to potential variations in results across different laboratories (Haase *et al*., 2006). Additionally, this traditional approach is known to be time-consuming, and requiring extensive labor (Pinna *et al*., 2013) and highly skilled taxonomists capable of accurately identifying relevant invertebrate species (Pfrender *et al*., 2010). Moreover, this approach cannot be very accurate regarding rare and non-indigenous species (Zangaro *et al*., 2024; Jones, 2008).

In the last decade, new methods based on DNA barcoding and metabarcoding are gaining attention in biomonitoring (Baird *et al*., 2012). These methods can identify a single species, or whole communities of an ecosystem, using the sequencing of DNA. These molecular methods are referred to as DNA barcoding, DNA metabarcoding and environmental DNA (eDNA) metabarcoding (Taberlet *et al*., 2012; 2018). DNA barcoding consists in the identification of only one species; DNA metabarcoding uses the identification of species present in a bulk sample (Hajibabaei *et al*., 2012; Yu *et al*., 2012); and eDNA metabarcoding uses DNA extracted from environmental samples (Pawlowski *et al*., 2014; Visco *et al*., 2015; Deiner *et al*., 2016; Valentini *et al*., 2016; Specchia *et al*., 2023; Pinna *et al*., 2024). This method includes DNA extraction, PCR amplification, and DNA sequencing with next generation sequencing (NGS). After this, species are identified based on the barcode reference libraries and, then, through bioinformatic processes a biotic index is calculated to make a bio-assessment for the aquatic ecosystems (Pawlowski *et al*., 2018; Fig. 1).

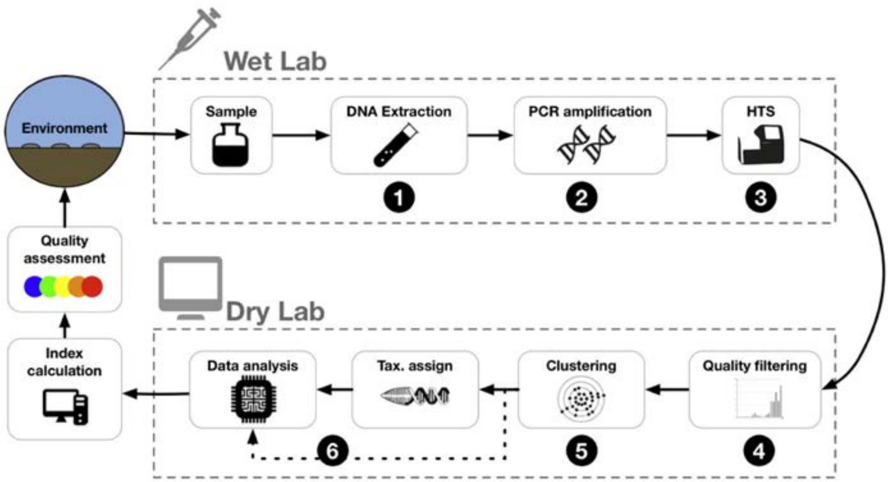

Figure 1.
DNA metabarcoding assessment steps. From Pawlowski *et al*., 2018.

The advantages of this method are that it is noninvasive, easier, faster, and can quickly lead to the identification of non-indigenous species, too (Deiner *et al*., 2017; Pawlowski *et al*., 2020; Zangaro *et al*., 2024). This method can lead to identification of a large number of taxa and overlap the limitations in the identification of species in early life stages (Hering *et al*., 2018; Sagova-Mareckova *et al*., 2021). The success of the DNA-based taxon identification depends directly on the coverage of taxa in the barcode reference libraries and the quality of available barcode records (Leite *et al*., 2020; Weigand *et al*., 2019). However, due to the lack of DNA barcodes in the reference libraries, some sequences cannot be annotated, potentially limiting their use in biomonitoring and affecting the understanding of species occurrence.

The most commonly used DNA barcode for DNA and eDNA metabarcoding is the Mitochondrial Cytochrome Oxidase subunit I (COI) gene for animal species and is also used in monitoring programs and biodiversity assessments (Andújar *et al*., 2018; Porter & Hajibabaei, 2018; Leray *et al*., 2019; Specchia *et al*., 2022; Pinna *et al*., 2024). Other barcodes are the ribosomal RNA (rRNA) gene 16S for prokaryotes, and 18S for plants and algae (Specchia *et al*., 2023). These DNA barcodes have been shown to provide high taxonomic resolution across a wide range of taxa, from invertebrates to vertebrates (Hebert *et al*., 2003; Aylagas *et al*., 2014; Elbrecht & Leese, 2015).

Actually, the reference libraries for the mitochondrial barcodes of fish are almost complete (Geiger *et al*., 2014; Leese *et al*., 2018), but for other groups, such as insects or diatoms, are still limited (Visco *et al*., 2015). So, the increased performance of this data first needs the compilation of the DNA barcodes for all the aquatic taxa in the referenced libraries. In this sense, the GAP analyses of DNA barcodes are needed. The two references libraries used for the GAP analyses are the Barcode of Life Data System (BOLD Systems) and the NCBI GenBank databases. These barcode reference libraries contain data for the main taxa that are used for the bio-assessment of aquatic ecosystems (Benson *et al*., 2013; Ratnasingham & Hebert, 2007).

During the year 2022, we realized a gap analysis for aquatic ecosystems of Albania, including the Narta Lagoon (Ismailaj *et al*., 2024) and Vjosa River. Our gap analysis considered the COI DNA barcode and was based on a species list, reported in different sources (scientific and gray literature). Based on the results of this analysis we can say that the COI DNA barcode gap in Vjosa River is most relevant for the phytoplankton taxa at 75% (Ismailaj *et al*., 2023; Fig. 2). The gap analysis of COI DNA barcodes for the species inhabiting the Vjosa River showed a high gap concerning aquatic insects (30%) and Gastropoda (20%) (Ismailaj *et al*., here; Fig. 2). The barcoding of these taxa is needed to complete the dataset of COI DNA barcodes in the reference libraries, in order to make the application of this method more efficient in the future.

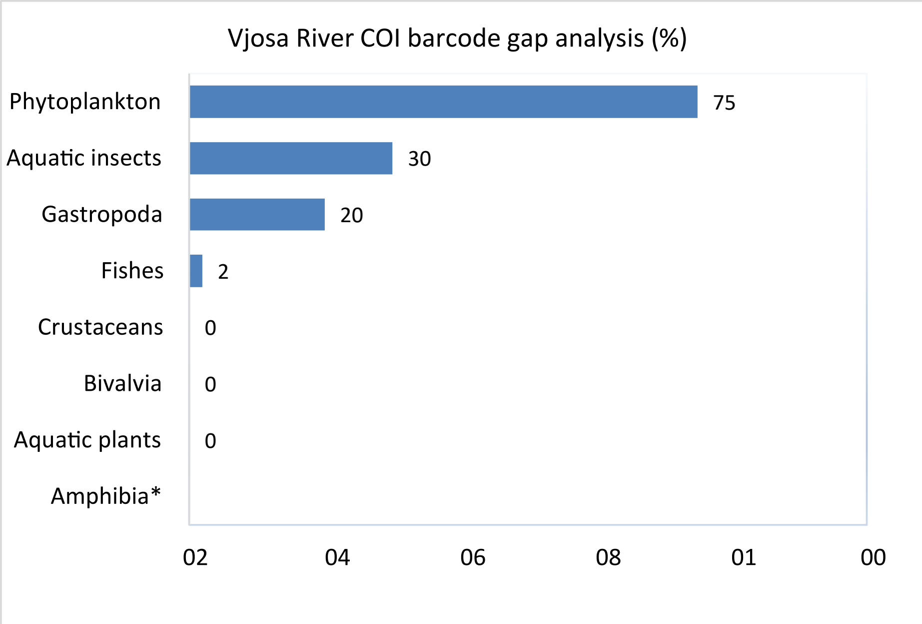

Figure 2.
Gap analysis of DNA barcodes of COI gene for species living in the Vjosa River. (*) means that species are not reported in the lists. From Ismailaj *et al*., 2023.

The taxa that are more represented in the reference libraries, so with the lower COI DNA barcode gap are bivalves, crustaceans, and fishes. Recent studies show that different countries have a variability in the barcodes gap for these species. For example, a study from China rivers that has the focus on three animal groups (fishes, mollusks, and insects), shows that the gaps in COI DNA barcodes coverage range from 40% to 70% in the BOLD or NCBI databases. The representative of these taxa groups in the database of the reference libraries is not complete (Feilong *et al*., 2022).

These new molecular methods were used also in a most relevant Albanian river, the Vjosa River (Brasseur *et al*., 2023). Here, the DNA-based methods were applied to benthic macroinvertebrates living in the Vjosa River (Brasseur *et al*., 2023). The results show that the DNA metabarcoding is a very useful method, and it has revealed the presence of benthic macroinvertebrate species never reported before. This research, made in Vjosa River during 2018, concerns the difference between the two methods, both traditional and DNA-based. It shows that with the traditional methods 32 benthic macroinvertebrate species were found from which: 21 species were observed in autumn, 17 species in spring, and only 6 species were found in both seasons (Brasseur *et al*., 2023).

On the other hand, using DNA metabarcoding in species level of MOTUs (molecular operational taxonomic units), 236 taxa were detected. In this case, 181 bentich macroinvertebrate species were present: 132 and 134 species were found in spring and autumn, respectively; 69 were found to occur in both spring and autumn, with 63 species detected only in spring, and 65 exclusively in autumn. Finally, the differences between the two methods show that DNA metabarcoding captured approximately 5.6 times more species than the traditional one (Brasseur *et al*., 2023).

Overall, DNA and eDNA metabarcoding provide versatile and powerful approach for understanding ecological indicators and responses in aquatic ecosystems. Their ability to rapidly and accurately assess macroinvertebrate communities, fish communities, microbial diversity, and ecological responses to disturbances makes them a valuable tools for ecological research and environmental monitoring.

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The significance of research and the development of a science-policy interface as a provision for proper and sustainable management of the Vjosa river system and its delta areas

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The Vjosa river-system has during the last decade received considerable international attention due to its **outstanding near-to natural condition, the largely undisturbed hydro-morphic dynamics and its high and specific biodiversity. The river has been identified as a benchmark for European environmental policy and as a unique natural laboratory for river science that could guide management efforts in rivers across Europe (Acta ZooBot Austria, 2018; Schiemer *et al*., 2020; Sovinc, 2021; etc.).**

The Albanian Government has recognized its value as natural heritage by the decision to conserve the riverine landscape of the Vjosa and its major tributaries as a Wild River National Park (VKM/DCM 155/2023). Sustainable catchment development is among the priorities of the Albanian Government with the vision to '***meet basic living needs, make users competitive and prioritize economic benefit, taking into account the sustainability of ecosystems***'. Considering current political development in Albania towards an EU-membership, management decisions have to be aligned with the EU-regulations and standards for sustainable ecosystem management, e.g. the Water Framework Directive (WFD), the Habitats Directive, the EIA Directive, etc.

Integrated water management requires a detailed research-based understanding of river-specific mechanisms, ecosystem functioning and biodiversity. Management has to address the hazards of the various pressures like unregulated disposal of solid waste and discharge of untreated sewage impact the river system. Management decisions should therefore be based on comprehensive, long-term and interdisciplinary research programs in order to **understand the key fluvial ecosystem services: clean water provisioning, flood control, maintenance of the characteristic natural biodiversity.**

At present a research project on has been initiated, focused on: ***Environmental assessment of the Vjosa riverscape as the basis for an integrated water management and sustainable catchment development (VjosSusDev, 2022-2026),*** financed by the Austrian Development Cooperation (OeAD). The project aims for a comprehensive understanding of the biodiversity and functional processes of the whole river system including its main tributaries, sustainable development of the riverine landscape and its human use. The project combines the research interests of 3 Albanian and 3 Austrian universities: it involves research teams on geomorphology, hydrochemistry, water quality assessment, microbiology, vegetation ecology, groundwater ecology, phytobenthos and zoobenthos, fish, terrestrial invertebrates and vertebrates.

The project focuses interdisciplinary approach integrating three disciplinary cross-cutting research topics:

- **Understanding and monitoring the fundamental physical regime governing the Vjosa riverscape:**

This work package is oriented towards a catchment-wide analysis of short-term and historical hydro-geomorphological processes. The physical basis created by flow and sediment regimes shape hydromorphological conditions and habitat availability and provide the framework for ecological services and its specific biodiversity.

- **Maintaining the ability of the riverine landscape to support the high and specific biodiversity of the Vjosa and its major tributaries:**

Research under this topic is aiming for a detailed understanding of the outstanding biodiversity of the river and its floodplains.

- **Ecosystem dimensions behind clean water provisioning, a key fluvial ecosystem service:**

Research is concentrating on self purification processes and water quality aspects aiming for the sustainable supply of high quality water for human use.

The project follows a transdisciplinary approach and is oriented towards proper management of the Vjosa river system.

The scientific results of the VjosSusDev-project will be presented in a form required by practitioners, and useable for the planning-, decision-, and participatory processes. Our principal aim is the cooperation with the governmental institutions responsible for assessment and monitoring programs on water quality, natural resources, ecosystem management and conservation, sustainable development, the Agency for Water Resources Management (AMBU), the National Environmental Agency of (NEA), the

National Agency for Protected Areas (NAPA) and the respective Ministry of Environment and Tourism, and the Ministry of Infrastructure and Energy. Beneficiaries will be the local community in the Vjosa watershed, with respect to the long-term provisioning of high-quality water supply, irrigation, flood protection and the sustainable economic growth e.g. by development of ecological tourism and rural tourism.

The VjosSusDev-project is carried out in close cooperation with other running activities, oriented to develop management concepts in the Vjosa area, e.g., the ESPID4Vjosa-program and the EUSIWM program, both organized via the Austrian Development Agency (ADA). A further partner ist he Vjosa National Park planning team. This integration of activities will strengthen the of development of an efficient water governance for the Vjosa river system. **A further detailed research program on the Vjosa delta is urgently required.**

Not included in the present study program is the delta area of Vjosa. It requiresa specific research program including experts on geomorphology, marine ecologists, wetland experts, ornithologists, etc. The delta area, the intersection between the river and the sea,is governed by the interaction of the sediment input of the river and the wave actions and currents of the sea. This interaction creates a complexity of habitat and wetland types of outstanding conservation significance.

The Vjosa delta is a biodiversity hotspot with a number habitat types listed in the EU-list of endangered habitats, as well as an international bird and plant area (BirdLife International, 2023; Radford, 2011; AKZM/NAPA, 2022; MIE, 2019). Besides their conservation value coastal deltas perform a wide range valuable natural functions - ecosystem services- as filters and sinks including nutrient and toxicant retention, regulating the nutrient flow into the sea, reduce eutrophication effects and are significant in reducing CO_2- emission to the atmosphere. They are significant in shoreline stabilisation, storm control and groundwater recharge. However, deltas in general are particularly sensitive and exhibit a high vulnerability to management decisions at the watershed level.

Delta areas are extremely dynamic systems: they are permanently shaped and re-shaped by the sediment input of the river and the currents of the sea. Therefore sufficiently large areas are required to allow the geomorphological processes to be continued and the delta and associated wetlands and lagoons to be maintained: **Deltas must be conserved at large scale, in order to maintain their conservation values and natural functions.** The larger the area conserved the higher will be its value. A well managed Vjosa Delta including its accompanied lagoons can become a major a tourist attraction, like the Camargue, the Rhone Delta in France or the Donana National Park at Sevilla in Spain.

The present activities and the production of this booklet indicate that the need for a detailed understanding of the Vjosa delta zone and its lagoons has been recognized. **The necessity ahead is to organize a concerted interdisciplinary research program.** This effort should find the full support by the politician responsible for planning and management of the Vjosa catchment, and full cooperation the National Park planners and the involved governmental institutions in order **to find optimized solutions for the delta area and ist accompanying lagoons in view of conservation to an attractive National Park and the development of an eco-friendly tourism.**

A final recommendation:

The Vjosa River Basin Council is, no doubt, a valuable platform in order to achieve a good interaction between management and the public. However, what is further required is a stronger interlink between scientists, practitioners and political decision makers. Therefore:

A long-term interactive platform between scientists and decision makers in the field of landscape planning and water governance should be instituted.
Management decision should be evidence-based. River Basin Management Planning and the development of sustainable management concepts require a platform were science can ‘speak to’ policy and decision makers, authorities, stakeholders, practitioners. A well-structured, long-term discussion and interaction process is prerequisite to formulate comprehensive plans and to find acceptable solutions. A long term mandate of such a panel – **a science-policy platform** - with a clear participation and decision structure and a direct engagement of decision makers in the discussion process will increase the acceptance of recommendations by experts and will help to develop sustainable solutions.

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Updated data are provided in this Special Volume (15 works in total, with 37 co-authors from Albania, Austria, Slovenia, Italy), on the natural/wetland ecosystem of the Vjosa River Delta (Landscape Protected Pishe Poro - Narta): geography, landscape, intactness, habitats, flora and vegetation (aquatic and terrestrial), invertebrates (aquatic and terrestrial), amphibians and reptiles, fish, birds and mammals, their sensitivity and threats. The aim is to help the decision-making, policy-making, investors, and other stakeholders, to protect this area as an inseparable hydrodynamic and ecological part of the National Park of the Vjosa Wild River.

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