ELECTRO-ENERGETICAL HISTORY OF THE LIKA REGION – EVELOPMENT OR DEVASTATION OF THE DINARIC KARST[1]

ELEKTROENERGETSKA POVIJEST LIČKOG KRAJA – RAZVOJ ILI DEVASTACIJA DINARSKOG KRŠA

Ivan BRLIĆ
Senior Research Associate
Institute of Social Sciences Ivo Pilar
Regional centre Gospić
ivan.brlic@pilar.hr

Ivan ŠULC
Assistant professor
University of Zagreb, Faculty of Science
Department of Geography
isulc@geog.pmf.hr

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Summary

The Dinaric karst area is one of the most geographically and geomorphologically dynamic and typical regions in Croatia, a region with a long history of exploitation and valorization of natural resources. Abundant and significant water resources have represented an important potential for new forms of electrical energy production since the end of the 19th century. Therefore, the Lika region is a clear example of long-term investment in hydropower and the use of other resources with a significant environmental footprint. Large capital investments such as the construction of the Hydropower plant system Senj and the Pumped-storage hydropower plant Velebit have gained economic and energy significance for the entire area, with a significant impact on the karst environment. Large municipal and energy investments in the area of central and southern Lika in the form of construction of hydropower and transportation infrastructure have resulted in changed livelihood opportunities for the local population and altered ecosystems along Velebit.

Key words: Hydroelectric power, local community, Dinaric karst, environment, sinking rivers
Ključne riječi: Hidroenergetska snaga, lokalna zajednica, Dinarski krš, okoliš, rijeke ponornice

1. INTRODUCTION - RESEARCH SPACE AND METHODS

The Lika region, a mountainous area in the Republic of Croatia, is mostly characterized as a part of the Dinaric Karst region. The river Lika owes its name to water, or rather, it is the land of water, a key resource for the sustenance of human life, especially for the inhabitants of Lika. At the start of the 20th century, an idea about utilizing new forms use of hydrological resources was born. This was particularly relevant as this area had always been a rural periphery, with only small steps being made toward modernization.[2] With new forms of economy, and industrial and technical advancements, conditions were

[1] This work has been fully supported by the Croatian Science Foundation under the project number UIP-2019-04-3024.
[2] ROGIĆ Ivan, *Tehnika i samostalnost – okvir za sliku treće hrvatske modernizacije*, Hrvatska sveučilišna naklada, Zagreb, 2000.

created in which the flows of Lika's sinking rivers (the Lika, sharing its name with the region, the Gacka and the Ričica) could gain a new purpose, that of becoming a source of electrical power.

This research paper is based on an in-depth analysis of numerous archival records (from State Archive in Gospic and Zagreb) and - secondary sources that are relevant for this eco-historical topic and have not been presented in the scientific press until now. Furthermore, this paper deals with the positive and negative impacts of such large capital buildouts in an environmentally sensitive and economically passive area. This should confirm the hypothesis that large energy-economic projects have had a strong impact on the economic reality of Lika region.

Building hydropower plants in the 20th century was a means of showing the level of development of the human mind and technology - by conquering nature, this was for a long time a show of how humanity can turn water into energy. Under the agenda of necessary development due to the great economic crisis, the two global powers Russia and the USA embarked on a major technological showdown with their greatest national resource and symbol, the Volga and Mississippi rivers. Before the struggle for the discovery of space, the construction of large hydropower plants on these rivers was a priority regardless of the costs and human losses. Such an approach of "taming" the water power of the world's rivers prevailed after the Second World War and in a weakened and divided Europe.[3] In Yugoslavia, the new state in this area started an accelerated energy renovation and development, and the main driving force for the megalomaniacal technological projects was the Karst Rivers. Therefore, the utilization of hydropower created via the rivers in Lika is no exception to this rule. Large energy projects in Lika changed the relationship between humans and nature in the region. This is when Lika became an area "stretched" between the politics of large new economic projects and the concept of environmental protection.[4]

The hydropower potential of Lika was often a hot topic, discussed by many scientists of various affinities and jurisdictions.[5] At the same time, quality research was done on the topic of hydrology and geology, the results of which helped explain the complex phenomenon of water in Lika.[6] An important cornerstone in better understanding the water potential of Lika were the many specialist articles and other papers that were made for the purpose of utilizing the water flows of the Lika and Gacka rivers.[7] Not even science can confidently describe the behaviour of these water flows, because these are sinking rivers. Today, the academic community is once again actively taking part in researching the hydropower potential in Lika, particularly through new projects that explore the available hydropower potential of rivers in Lika.[8] The largest number of scientific contributions speak against further exploitation of the sensitive karst region of Lika. This paper has two goals: First is to analyze the complex eco-historical and socio-economic processes that have been developing in this particular Dinaric karst region of Lika for almost 200 years; Second goal is to highlight the potential consequences of further (oversize) exploitation of the sinking rivers in the Dinaric karst.[9] In order to understand why the area of Lika, that is, the water capacities of its sinkholes, we must know that this area is highly dependent on karst hydrology.

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3 ZEISLER-VRALSTED, Dorothy, "The cultural and Hydrological Development of the Misssissippi and Volga Rivers", in: *Rivers in history*, ed. Cvhristof Mauch, Thomas Zeller, 2008, 75-77.

4 ŠUNDALIĆ Antun, "Ekocentrični pristup ruralnom prostoru", *Socijalna ekologija*, 15, no. 3 (March 2006): 207.

5 Among those who have written about the importance of Lika's rivers and lakes are the following: ROGIĆ, PEJNOVIĆ, BONACCI, PAVIČIĆ, LUČIĆ, PETRIĆ, LUKIĆ and others For instance, connected river flows of the Lika and Gacka are discussed in papers by PAVIČIĆ A. RENIĆ, A., IVIČIĆ, D. (2001) "Groundwater tracing in the karst of Lika - Croatia", in K-P Seiler and S Wohulich (ed.) New Approaches Characterizing Groundwater Flow, Balkema: 41 – 45.

6 BAHUN Stjepan, Franjo FRITZ, "Hidrogeologija Ličkog polja (Donje Pazarište – Gospić – Gornja Ploča)", *Problemi hidrogeologije i inženjerske geologije Jugoslavije*, no. 1, (Beograd, 1971): 7 – 13.

7 *HES Kosinj – studija o utjecaju na okoliš HES Kosinj*, (Zagreb: Elektroprojekt, 2016) 1 – 835; *Studija optimalnog korištenja voda slivova Like i Gacke*, book 4, (Zagreb: Geološki zavod, 1984) 1 – 40.

8 "HPS Kosinj – project summary", accessed May, 6 2023, HEP grupa - Hydropower System Senj 2.

9 ZUPAN Nadja, Andrej MIHEVC, Mitja PRELOVŠEK "Land use", in: Introduction to the Dinaric Karst,eds., 2010., 47.

2. WHY IS KARST HYDROLOGY SO IMPORTANT FOR HYDROENERGY SYSTEM IN LIKA REGION?

Lika is a typical region in the Dinaric Karst, characterised mainly by carbonate ground that has been transformed by Alpine orogenesis. Geomorphologically, the area is a mosaic of medium-sized mountains up to 1750 metres high, lower massifs, large karst plateaus and large and small karst poljes.[10] The main hydrological feature is the general absence of surface water, as most rainwater soon disappears underground and continues to flow through the canal system. When they encounter impermeable rocks, underground watercourses appear on the ground, often in the form of a karst spring, and flow on the ground as long as there are impermeable rocks and sediments (e.g. the rivers Lika, Gacka, Krbava...), often in karst poljes or in the form of gorges in carbonate rocks. In contact with permeable rock, karst rivers and streams end in swallow holes or ponors and continue to flow underground.[11]

In addition to the special geomorphological landforms of high value, karst represents a very sensitive area due to its hydrological processes. Since the direction of underground water flow is not always clear and karst waters lack the ability to self-purify, any pollution from the surface goes directly into the groundwater and spreads rapidly in different directions, potentially affecting large areas[12].

Due to the maritime annual pattern of rainfall, with often large differences in runoff between seasons, swallow holes often do not have enough capacity to absorb all the incoming water, causing flooding in the lower parts of the karst poljes and river valleys and damage to agriculture and human settlements. Local communities have lived with floods for centuries and have adapted their settlements

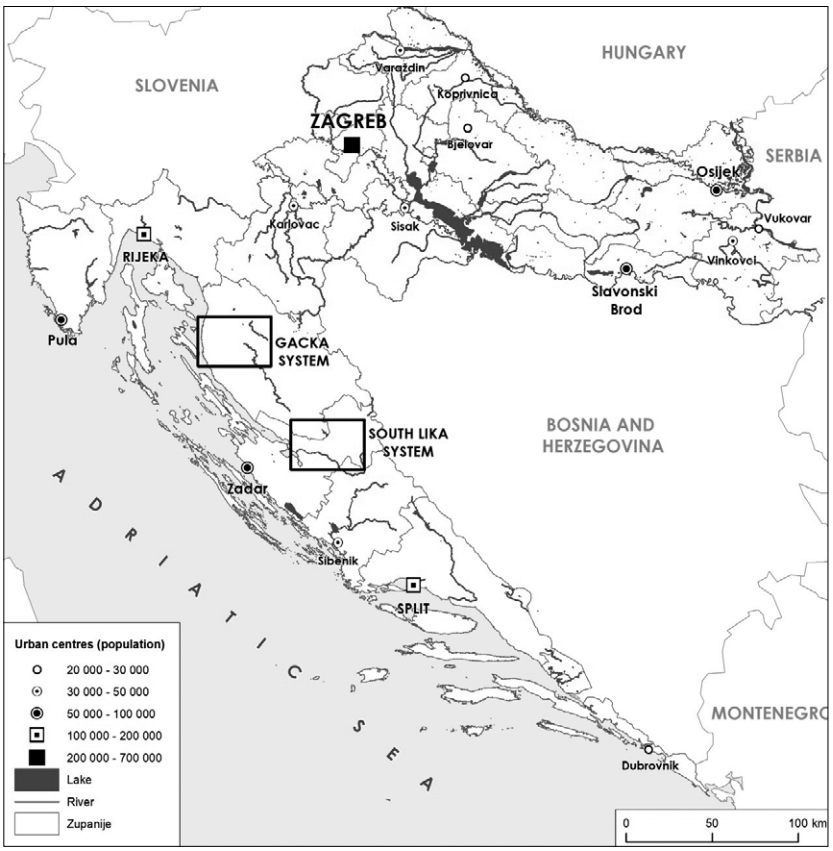

Figure 1: *Hydroenergy systems of the Lika rivers Gacka, Lika and Ričica, with a focus on Croatian territory. Source: author I. Šulc using Geographic Information System*

[10] In Lika region there are specific karst poljes that are playing important role in the hydrological balance of karst areas. "Poljes", in: in: *Encyclopedia of caves and karst* sciences, Fitzroy Dearborn, 2004., 1279.

[11] MIHEVC, A. 2010, 48.

[12] BOČIĆ, Neven, Geomorphology and hydrography of karst (lectures), University of Zagreb, Faculty of Science, Department of Geography, Zagreb.

and way of life to these natural phenomena. They have built their settlements on slightly higher ground, usually at the points where the karst poljes meet the mountains or at elevated places within the poljes, leaving large, flat, drained areas with fertile soils for agriculture and livestock elsewhere.

Although seasonal flooding is a natural phenomenon, its frequency and magnitude can be influenced by human activities, especially increased sedimentation in river beds and gulleys, increased amounts of detritus reflecting human activities (e.g. trees or branches), or even the dumping of waste into watercourses and caves. This human influence on floods became known in the mid-19th century. Therefore, local governments during the Austro-Hungarian Monarchy in the second half of the century, paid special attention to suppressing floods by cleaning watercourses and swallow holes. While cleaning cannot prevent floods, it can help reduce and shorten exceptional floods and their effects. Another advance during this period was the initiation of long-term measures based on studying the characteristics of natural floods and planning land use and space for them. [13] It must be emphasised that above-average floods can be caused by extreme amounts of rainfall that could not be predicted, and therefore some parts of Lika (e.g. Gospić, Kosinj, Švica, Gusić Polje) were often flooded.

3. THE FIRST STEPS IN HYDROPOWER UTILIZATION OF THE LIKA KARST IN THE FIELD OF ELECTRIC ENERGY GENERATION

Even in the 18th century, the military construction office of the distinguished general Gideon von Laudon built windmills on the Krbava Polje in Lika for the purpose of flour milling. In the following century, the local military leadership tried to suppress the floods through the actions of their construction office. A similar role was held by the construction committee and Inspectorate for Afforestation of Karst and Barren Regions and Flood control in Senj. The significance of this karst landscape was best presented by scientists and travel writers that passed through Lika in the 17th, 18th and 19th century. One of them was also French natural scientist and Dinaric Karst researcher Belsazar Hacquet, who described many karst features of Lika as follows: "The Dinaric Alps[14] have little soil, and even less water, as both is swallowed by large cracks in the sinkholes and caverns of the rock mass". Furthermore, Hacquet recognized the Lika region landscape as a space in which there used to be a lake; today, if the caverns that swallow the waters were to collapse, the area would once again become a sea in figurative sense.[15] The Gacka valley is different in that it is so rich in water that Otočac, the central town in the Gacka Valley, was even compared to Venice.

We can say that Haquet's observations are neither scientific nor terribly precise, but certain segments and the relationship to water and people are certainly correct, and in some future events they proved to be correct. When it comes to Kosinj, an area which 200 years after Hacquet's descriptions became a key location for the development of hydroelectric energy, Hacquet states that 60 or more years ago some of the sinks that drained the water were buried, as people took poor care of cleaning them, which caused floods in many areas during rainy seasons.

Another travel writer from the 18th century, local army functionary Dominik Vukasović, had a different attitude regarding the Kosinj Valley. He stated that the valley itself, to the detriment of locals, was flooded in early spring every year due to the river Lika, which "is a sinking river that usually" becomes sinking near the village of Lipovo Polje in that area. This is why the villagers often had to sow their crops three or four times in a year.[16]

[13] MIHEVC Andrej," Kratka razlaga poplav in mnenje o smiselnosti čiščenja plavja med poplavo na Planinskem polju", *http://zgs.zrc-sazu.si/Portals/8/hidrogeografija/Planinsko_polje_mnenje_khg.pdf* (accessed May 14, 2023.)

[14] Dinaric Alps are an expression of geologists that does not overlap with the Dinaric Karst.

[15] HOLJEVAC, Željko, "Ljudi, voda i prirodna sredina na Triplex Confiniumu: Vukasovićeva i Hacquetove ekohistorijske opservacija u Lici i Krbavi u drugoj polovici 18. stoljeća", in Triplex Confinium (1500 - 1800): ekohistorija, ed. Drago Roksandić et al. (Zagreb: Književni krug Split Zavod za hrvatsku povijest FFZG, 2003), 148 – 149.

[16] HOLJEVAC, Ž., 2003, 151.

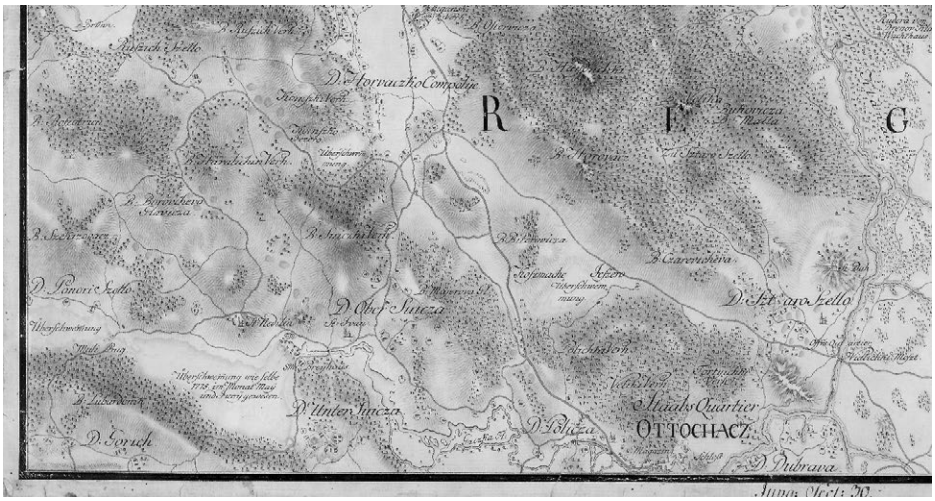

Figure 2: *Floods (Überschwemung) in the Gacka Valley in 1775. Source: Arcanum maps (mapire.eu)*

These two environmental-history descriptions representative for many rivers of Lika recognize the challenges of the Lika Dinaric karst for human economy, these challenges will thoroughly transform with the opportunity of a new system for the management of Lika's sinking rivers. However, if we go back to the eco-history processes in the karst of Lika during the 19th century, one can notice further challenges in the management of water resources. The number of mills and mechanisms that controlled the flows of water did not grow with the population. Instead, uncultivated areas, which were common at the time, became a breeding ground for contagious diseases. Floods during the 19th and 20th century became more common, which can be tied primarily to an increasing amount of precipitation in a short period of time[17], as well as insufficient anthropogenic influence in the context of natural sinks which the waters of the Lika, Gacka and Ričica flow into.

The generally rich and dynamic Lika area has also in the past proven to be a region of great oscillations and extremes: from periods of extreme summer drought to markedly flooded areas. While floods are not a rare sight in karst areas, they certainly point to the dynamic of Lika's sinking rivers. One such large flooding of the Gacka was described by Slovenian polymath J. Valvasor, who noted that the river bed of the Gacka was not maintained and kept clear until 1792, so the river regularly flooded. The areas that were flooded by the river are visible to this day along the Gacka Valley when there are larger amounts of water in the river. The largest well-documented flood to this day was in 1802, which Franz Bach described as follows: In 1802, this Otočac regiment was so flooded that the water, which the ravines in the sinkholes could no longer absorb, flowed back from Švica to Otočac.[18]

The region around the Lika and Gacka rivers has for millennia been flood-prone area. Very often, the people living around the river largely adapted to it. The flooded areas proved to be excellent agricultural soil, with a clear risk that, during seasons of snow thawing and precipitation, there may be floods, as well as a higher risk of contagious diseases. One such occasion was marked in 10-year flood in the Švica area. This area was the first to be found in the initial plans and ideas for the electrial-energy valorisation of hydropower.[19]

One of the first persons who recognized the power of electrical energy, especially hydroelectric energy, was Nikola Tesla. By building a hydroelectric power plant on the Niagara Falls, he paved the way for lighting the world[20]. After a great success in the USA in 1892, he took a short trip to Europe,

[17] ŽIVAKOVIĆ-KERŽE, Zlata i Marija BENIĆ PENAVA. "Velike vode : Poplave rijeka Drave i Save u 19. stoljeću." Ekonomska i ekohistorija 17, br. 1 (2021): 5-14. https://hrcak.srce.hr/272642 14.

[18] BACH Franz: Povijest Otočke pukovnije. O nastanku ovoga kraja, njegovima žiteljima i njihovima sudbinama Otočaner Regimentsgeschichte: vom Ursprung dieser Gegend, ihrer Bevölkerung und ihrer Schicksale (Karlstadt 1854), Zagreb, 2010.;

[19] "Kroatien. Agram. Elektrizitätprojekt", *Der Bautechniker*, February 1, 1918., 149

[20] In a book about the origin of the idea of cultivating the power of water on Niagara, it is best described by an author from 1890, who says that in the new Darwinian age, it is time to solve the problem with human intervention. Nikola Tesla was waiting.

where he visited his homeland Croatia. In line with a request of the mayor of Zagreb, Tesla held a lecture on the possibilities of bringing electrical energy to the then-capital of the Triune Kingdom of Croatia, Slavonia and Dalmatia. When asked if the hydropower potential of the Plitvice Lakes could be used to light Zagreb, Tesla noted that this would require the degradation of some of the lakes, even though he calculated that this resource could be of much use.[21] That lecture was the motivation for the greatest scientist from Lika to approach the question of utilizing the waters in Lika. After he visited his homeland, he returned to USA and made a great deal at Niagara falls. One curiosity is that at the same year Hydropower plant (further: HPP) Jaruga at Croatian river Krka was completed.

3. FIRST ORGANIZED PLANS FOR THE UTILIZATION OF LIKA'S SINKING RIVERS FOR HYDROPOWER PRIOR TO THE GREAT WAR

The beginnings of actual using the waters of the Lika, Gacka and other sinking rivers in the region for hydropower can be traced back to the early 20th century. Various proposals that dealt with the "taming" of the Lika rivers were not realized also because the government in that area often changed, i.e., political and social relations. In Lika was a rigid military administration of the Military Border (Vojna Krajina). For over 350 years, from 1522 to 1881, the Habsburgs maintained a military zone, the Militdrgrenze, Konfin, or Vojna Krajina, along the southern border of Croatia. The original purpose of this organization had been a defensive screen against Turkish incursions, but already in the middle of the 18th century an Austrian general observed that it was 'not only a rampart against the Turks, but also a restraint upon the rebellious tendencies of the Hungarian and Croatian nobility.[22] Then, after a short French episode[23], the civil era followed in the framework of the dual monarchy.

The use of the river Gacka, and the later construction of the complex hydropower system in Senj, was first thoroughly researched and planned in 1907.[24] Later, in 1912, the waters of the Lika were included in these plans. Further projects kept this plan almost in its entirety, confirming this with the first project in 1922.[25] There are several reasons as to why even then there were very clear projects for the exploitation of hydropower in Lika. The main reason is tied to the spatial strengthening of the energy potential of Croatia at the time, considering new technologies of energy production.

This process that affected Croatia, a country that was then part of the Austro- Hungarian Empire, is a logical activity that already strongly affected the United States of America. The rest of the world soon caught up and by 1900, hundreds of small hydropower plants were in operation spread across Europe, Asia, Australia and South America.

Another reason is a feeling of certainty that, once the hydroelectric power plants are built, the wild rivers in Lika would be *tamed*, thereby lowering the chances of large floods, which also reduces the possibility of material and human losses.

According to the available documentation, the idea of using the power of the river Gacka and building a hydropower plant (HPP) in Vlaška Draga (near Senj) was then included in the first studies of the use of waters in Lika to generate hydroelectrical power. They were done between 1907 and 1909 by the "Primorje Association for Hydro-Power and Electricity" from Sušak, with finances in form of French-Hungarian capital. The size of the investment is best shown by the French capital in the amount of

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21 BRLIĆ, Ivan, "Pregled povijesti zaštite prirodnog i kulturnog okoliša u Lici (1746–1942) ", in *Koga (p)održava održivi razvoj*, ed. Anita Bušljeta Tonković et al., (Zagreb: Institute of Social Sciences Ivo Pilar, 2017), 25.

22 ROTHENBERG Gunther E., " The Origins of the Austrian Military Frontier in Croatia and the Alleged Treaty of 22 December 1522 ", The Slavonic and East European Review, Jun., 1960, Vol. 38, No. 91 (Jun., 1960), pp. 493-498.

23 The French managed, after the conflict with the Austrian army, Lika region became a part of Illyrian provinces for only five years, but certain cultural and social changes began (roads, schools, afforestation etc.). The real changes began half a century later, when the process of abandoning the military system began. BERTOŠA Slaven, Svjetska povijest modernoga doba (XVI.-XIX. stoljeće) (Zagreb: Profil international, 2004.), 207.

24 "50 000 PS in Kroatien", *Die Wasserwirthshaft*, July 15, 1909.,231.

25 SZAVITS NOSSAN Stephan, "Die Wasserkräfte Jugoslawiens", Zeitschrift des Österr. Ingenieur und Architekten Vereines Heft, no. 11/12 (November/December 1924): 97.

10 000 000 crowns.[26] The studies focused only on the river Gacka with Vlaska draga, but the project was rather ambitious, so the media at the time reported about investments that would produce a power of 50,000 hp (37,284,993.58 W). In 1912, a new project was made by Austrian engineers. This project could reach a power of 120,000 hp, making use of the Gacka and the Lika rivers. A similar project was created by Theodor Schenkel, criticizing the French project for not considering the geological and karst specificities of the Gacka and Lika.[27] At that time, during high flows, around 30 m^3/s of water reached the Gacka waterfalls in Švica.[28] Considering that that is the slope of the northern arm and the arm towards Poljice was rather small, the water would spill out of the river bed and create marshes, which were the source of epidemics among the local people. A fifth of the population suffered from fever-related diseases.[29] In order to lower the water level in Otočac so it could flow out faster, the channel of the Upper Švica Lake was made deeper and wider, up until the mills built and used by the locals in Švica. After this, Karlo's Channel near Vivoze was dug out. The project was done by the famous Karl Terzaghi, father of soil mechanics, who studied the soil and its physical and mechanical properties. He spent some time in the area and studied the karst phenomena in the Gacka Valley (and other locations) from 1909 to 1910[30]. Since not even these efforts produced the desired results, the wetlands and health issues remained in the area. To change this, the northern arm toward Brlog was deepened, the sink in the Gusić Polje was cleared and deepened, and an arm of the northern branch, as well as the southern branch toward Švica, were deepened. These operations helped significantly improve the overall health of the population of Otočac, and the number of fever-related diseases fell from 20% to 9%, later on even to 1.6%. The surface of the dried-out wetlands amounted to about 22 acres.[31] Along with the Lika-Gacka-Adriatic Sea project, Austrian engineers were equally interested in the hydropower potential of southern Lika, with the flows of the Ričica and Zrmanja rivers. The aforementioned Theodor Schinkel wrote about this large project of bringing together the region's sinking rivers and streams in the area of today's Gračac Municipality in order to utilize them for the purposes of hydroelectric production. At the beginning of World War II, his project once again became relevant,[32] but 30 years passed before the new system was built.

Austria, France and again Austria worked on the hydrotechnical arrangement of swallow holes and parts of riverbeds so that flooding would be shorter and smaller in scope (area). They it turned out that all these measures are not nearly enough even local authorities encouraged local people to clean and maintain sinkholes of sediment and branches.

4. THE BEGINNING AND DEVELOPMENT OF HYDROELECTRIC POWER IN LIKA - HPP ŠVICA

The Lika region had a relatively low level of electrical power grid coverage. It was only once the railroad crossing Lika was built, almost 100 years after the English railroad, that introducing electrical energy into households had begun.[33] This was the first larger hydropower plant in Lika. HPP Švica was mentioned in the previous chapter and is considered to be the first such hydropower facility in Lika, even though there were many private initiatives before it. Considering the conditions in Lika at the time, this large hydropower plant was the result of the efforts invested by the citizens of Otočac, who managed to

[26] "Otocac - Kroatien", *Der Bautechniker*, September 17, 1909, 734.
[27] SCHENKEL Theodor, *Karstgebiete und Ihre Wasserkräfte,* (Wien und Leipzig: A. Hartleben´s Verlag, 1912), 73.
[28] SCHENKEL Theodor, *Karstgebiete und Ihre Wasserkräfte,* (Wien und Leipzig: A. Hartleben´s Verlag, 1912), 75.
[29] SZAVITS NOSSAN Stephan, "Die Wasserkräfte Jugoslawiens", *Zeitschrift des Österr. Ingenieur und Architekten Vereines Heft*, no. 11/12 (November/December 1924): 99.
[30] HGI, UNI RI, "Definiranje ekološki prihvatljivih protoka Gacke i Like, Hidrološke i hidrogeološe podloge,",. Rijeka, 2021. (viewed at 09.06.2023. https://voda.hr/sites/default/files/dokumenti/PUVP3%20-%20KPV%20-%200038.pdf 43).
[31] PERNAR Lidija, "Švica – ljepota na jedan dan", *Hrvatska vodoprivreda*, no. 193. (April 2009), 53.
[32] BAUČIĆ F., "Elektrifikacija Ričice", in *Vila Velebita*, ed. Ivan Brkić, (Zagreb: Društvo Ličana, 1943), 62 – 63.
[33] As such, Gospić, the largest town in Lika, gained access to electricity only in 1925, then Gračac and Perušić in 1929. Otočac only gained access to electricity in 1935, once the HPP Švica on the Gacka was built. *Elektrolika Gospić – 1956. – 1986.*, Gospic, 1986., 8.

make great advances through the local officials in the economic development of their region.[34]

In the Švica area, the land next to the Gacka river was expropriated, which is where the slope of the Gacka flow is the steepest, or rather, where the widely known Švica falls are. In this area, there were more than 40 watermills, and a part of the population who had their livelihoods closely tied to the water were very much against this project, even though it would partially reduce the floods that could occur following heavy rain events or a sudden thawing of snow in the mountain massifs of Velebit and Mala Kapela.

The construction of the hydropower plant started on 12 July 1935. The first hydropower plant in Lika started operating in December 1935. The construction was done by the Gabriel Kumpanec company from Zagreb. Another two-storey building was done, which housed two *Francis* (105 hp) turbines and a three-phase generator (400V, 50Hz). The utilized hydropower plant head was 10.3 meters. The electrical energy was produced with a three-phase generator and was then transported to the nearby town of Otočac via 6-kilometre-long power lines. Thanks to this investment, a street lighting network was built in Švica, along with an electric sawmill and flour mill. The town of Otočac therefore got the most modern and largest hydropower plant in Lika.[35] This plant was the beginning of the electrical power utilization of water resources from rivers in Lika. The work in HPP Švica proved to be cost-effective, while also highlighting the results that renown engineers Karl Terzaghi and Theodor Schinel long ago claimed could come out of such a project. Since 1935, we can talk about the dominant paradigm of prioritizing hydropower exploitation, regardless of environmental values, before environmental protection and tourism valorization (the same applies to the Plitvice Lakes).

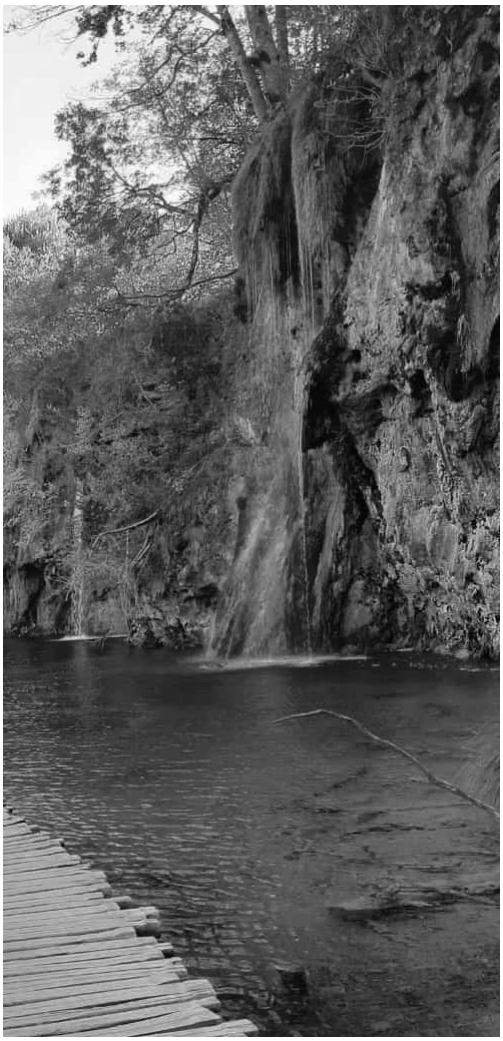

Figure 3: *The tufa system, crucial of the biodinamic system at the Plitvice lakes, warterfall at Galovac lake. Photo I. Brlic 2023*

Aside from private initiatives and small power plants, the Plitvice Lakes also had an important role in the future economic development of the Lika region.[36] The Plitvice Lakes are Croatia's oldest and biggest national park.

Due to its specific and sensitive ecosystem, in 1928 it was declared a protected area. Even though this area was protected at the time, in the karst area of the Plitvice Lakes there it came to expand tourism.[37] There was soon a need for further tourism development there, which included a large number of visitors. It was very difficult to fight these economic processes for the sake of the sensitive and attractive ecosystems themselves. On the other hand, the development of tourism in protected areas is not in itself negative (as long as it is not excessive and includes the construction of a large number of solid structures in nature) but can even contribute to conservation (because it valorizes precisely such preserved nature)

[34] "Sela prikupljaju novac za elektrifikaciju", *Ličke novine*, July 1, 1965.

[35] "Vijesti iz Like – Električna hidrocentrala općine Otočac", *Lička sloga*, March 15, 1936, 4.

[36] BRLIĆ, Ivan. "Nacionalni park Plitvička jezera – zaštita i(li) razvoj koreničkoga kraja – komunalna infrastruktura kao podloga za turistički razvoj (1949. – 1990.)." Časopis za suvremenu povijest 52, br. 2 (2020): 420. https://doi.org/10.22586/csp.v52i2.9900

[37] BRLIĆ I., 2014., 210.

Figure 4: *Photo of vacated HPP Burget in the Plitvice Lakes National Park today. Source: photo I. Brlic, 2014.*

and provide a financial basis for protection nature. There was a growing need for a safer and more stable public infrastructure, which would entail developing a power supply network. The only logical step was to build a hydropower plant, particularly due to the needs of the large Hotel Jezero that has been built by the end of 19th century. The solution was to build the HPP Burget on the lake Veliki Burget. The Burget lake, from a height of 545m, falls into a large lake below it named Kozjak. The vertical drop here was 9 meters, with a capacity that enabled the building of a power plant. The plant was finished in 1935. This is a power plant with a concrete sluice. Under it, the engine room building, with a built-in turbine, generator and other elements, was placed in a cave. The generator was a three-phased one, with the following dimensions: height 1m, length 1.2m and width 0.85m. It was mounted on a concrete base, and the nameplate stated it was produced by the AEG Union Factory. The hydropower plant provided electricity to the local area, which is confirmed by the preserved original concrete utility poles.[38]

In the following years, and in line with the socialist politics of reconstruction and industrialization, there was a growing interest for the building of new hydropower plants on the Gacka and Lika rivers muche bigger than the one in Švica. This is when the Italian concern Servis entered the fray. They wanted to build a facility in Gorski Kotar, near the town Fužine, as well as in Lika, specifically in Švica. This concern was also of the opinion that a hydropower plant should be built near Sveti Juraj on the coast, more specifically, in the Vlaška Draga inlet.[39] This is a relatively old project, which in the following decades would prove to be a challenge for the political institutions, and which would, in the end, connect the hydropower potential of not only the river Gacka, but also the sinking river Lika. Before that project, HPP Švica was very important for the area around the town of Otočac, which is why, in line with the new social and economic developments in Lika, there was an urgent need to expand HPP Švica so that it included newer, stronger turbines and a more powerful generator. Thus, the People's Committee in Otočac sent an urgent clarification to the Ministry of Public Works on February 1, 1952, and demanded the expansion of HPP Švica, as it was of vital importance for the energy modernization of the Gacka region. The local community could not gather the necessary funds, so they asked the competent ministry for a loan in the amount of 20 million dinar.[40] HPP Švica stopped operating in 1965, when HPP Senj officially started its operations as the final act of the Vlaška Draga project.

After World War II, another hydropower plant was built on the grounds of the Plitvice Lakes National Park. The board of the park got the approval of the competent municipal institution in April of 1957. They then started building a smaller HPP in the Plitvički Ljeskovac area.[41] The reasoning behind this was the ever-growing number of tourist activities and a larger need for electrical energy.

[38] PERNAR Lidija, "Švica – ljepota na jedna dan", *Hrvatska vodoprivreda*, no. 193. (April 2009), 54.
[39] "Vijesti iz Like - Talijanski koncern proučava podizanja hidrocentrale u Lici", *Lička sloga*, June 9, 1938, 8.
[40] HR-DAGS, f. 5. Narodni odbor kotara Otočac, box 38, Expansion of the power plant in Švica, k. br. 738.
[41] HR-DAGS-23, Narodni odbor općine Plitvička jezera, box 8, 1957., Building permission. Construction of hydropower plant in Plitvice Ljeskovac., ABR. 604/57.

5.THE ENERGY DEVELOPMENT AFTER WORLD WAR II: LARGE SYSTEMS OF THE HYDROPOWER PLANT (HPP) SENJ AND PUMPED-STORAGE HYDROPOWER PLANT (PSHPP) VELEBIT

The new social and political order was very clearly oriented toward a rapid and expansive industrial development, which, of course, demanded many investments in public infrastructure. In large parts of Croatia and Lika at the time, this infrastructure had been devastated by the war. In Lika, traditionally viewed as a rural periphery, such a process was truly needed, but also very demanding. The military and metal industries developed in the Lika region were crucial in strengthening the power grid in Lika and in constructing the first larger hydropower plants. The production process demanded a modern and powerful enough electrical power grid. At the same time, the Elektrolika company was founded, which will be one of the key companies in developing the power grid and in generating electricity from new production sources, such as hydropower.

The whirlwind of World War II reached Lika as well, and the overall weak power supply network there was boosted by small power plants built for the needs of the Partisan army. New small-capacity plants were built in Karlobag, Lovinac, Srb, Udbina and Vrhovine.

The first post-war connection of the Lika area to the state power grid was done in 1956 by building a 64-kilometre-long 35kV power line reaching from the HPP Slapovi on the Una river in Bosnia and Herzegovina to the electrical substation Lički Osik (35/10kV). [42] Gradually, the surrounding network and consumption was connected to this power grid.[43] This is also when the local company Elektrolika was founded. In almost 30 years, it brought electricity to 249 villages out of 252 in the area, which is almost 100%. A key role in the electrification of Lika was played by the hydropower facilities in Sklope, Senj and Obrovac.

5.1. THE LARGEST HPP PROJECT IN THE HISTORY OF LIKA: BUILDING THE HYDROPOWER SYSTEM SENJ

It was said by the official political establishment - and not only in local partisan newspapers, but also in the main and implementation projects for the construction of Lika hydropower plants, that this project would finally stop the floods, advance the development of Lika, bring an abundance of benefits, and ensure that the inhabitants of the region remain there, as opposed to emigration to other regions or countries. Before this project, the first large reservoir for the HPP Sklope, was built, there were many plans, ideas and projects for the containment of the water-level of the Lika river. In 1930s, a local suggested that at the site of the largest narrowing nearby the soon-to-be HPP Sklope, they should *build a wall, as robust as possible. This wall would stop all objects brought forth by the water, and then the objects could be taken out from the sides of the wall. Of course, there should be left a hole in the wall for the water to pass during normal water-levels, while the hole would be closed during normal levels. By stopping and removing various materials brought by the water, and by regulating the flooding river, the constant and damaging floods could be stopped to a satisfactory degree.*[44] After each bigger flood, many ideas for solutions would come up among the public, all with the aim of managing the flows of the sinking rivers in Lika. However, all these plans demanded significant funds. In the early 50s, the media supported a major UN project for Lika as part of the then-current political agenda. The project was HPP Senj. It soon became clear that the project would actually be only short-term help for the already weakened economy in Lika. The only entity that would benefit in an economic sense from this project was the state company. So, how was this major project built?

[42] BRLIĆ Ivan ‚The Plitvice Lakes National Park – Protection and/or Development of the Korenica Region – Communal Infrastructure as the Basis for the Development of Tourism (1949–1990)', Časopis za suvremenu povijest, 52(2) 2020, 427. https://doi.org/10.22586/csp.v52i2.9900

[43] *Razvoj elektrifikacije Hrvatske II dio*, ed. Boris Marković, (Zagreb: Institut za elektroprivredu, 1987), 263.

[44] ŠPOLJARIĆ Ivan, "Kako da umanjimo poplavu rijeke Like", *Lička sloga*, February 21, 1938, 2.

The first blueprints, studies and plans were done right after World War II as part of a new economic paradigm with the goal of industrializing Lika - turning farmers into workers. Lički Osik and the Plitvice Lakes were at the time the two main drivers of the development in Lika. The former was marked as the centre of military industry, while the second one latter became the *golden goose* of tourism in Lika.[45] But for both of them to function, energy independence was crucial. The size of the endeavour is demonstrated by the many construction and hydropower facilities of the system: the Sklope embankment dam on the Lika with the Kruščica upstream reservoir (128 x 10^6 cubic meters of water), the Sklope impoundment facility, the Lika-Gacka penstock, the Šumećica complex on the Gacka with its riverbed regulation system, the dams Vivoze and Šumećica, the water discharge channel toward Donja Švica and the Gornja Švica - Marasi, and Marasi - Gusić Polje penstocks with their reservoirs, the Gusić Polje - Hrmotine main penstock, with the intake and surge tank, and finally, the HPP Senj. In some stages of construction, this project was different from those first ideas and projects that were created at the beginning of the 20th century. This primarily refers to the underground drains or canals that, according to the plans of the Austro-Hungarian planners, should have been built along the entire course of Gacka-Lika all the way to the sea, that is, to the future HPP Senj plant. There is a clear intention to use the water potential of these two Lika rivers for economic profit and help the local community in supplying the population and the country.

Figure 5: *First hydropower potential utilization project on the Lika and Gacka - the precursor of the HPP Senj. Source: Theodor Schenkel, Karstgebiete und ihre wasserkräfte, Wien and Leipzig, 1912., 73.*

Despite the fact that Lika was, for centuries, considered a rural periphery and its modernization was slow, as part of the renewed economic development sustained by the new world economic agenda, a stimulating environment was finally created in Lika. As part of this, four large hydropower plants were built in the then-Yugoslavia, which were meant to produce 6.2 billion kilowatts of electrical energy.[46] A key role in providing the opportunity for a large project in Lika was played by the United Nations Economic Commission for Europe (UNECE). The project was particularly interesting as this international organization had enough political and economic power and stability to, in a way, help the development of not only Western Europe, but also Yugoslavia. Yugoslavia was a country that, on a political level, had a growing role in the West since 1948, while at the same time leaning on the ideas and processes of the socialist paradigm. The UN project was presented in a session of the Energy Division of the UNECE. The planned financial value of the project was estimated to more than $410 million.[47] Finally, the loan for the construction of the central hydropower station Senj was signed in Washington, with the final amount being $30 million.[48] As with other large projects in Lika which were carried out later on, during the presentation of this major hydropower intervention, it was pointed out that this project would help with the modernization of commercial enterprises, providing support in the development of agriculture,

[45] BRLIĆ, Ivan. "The life and decline of a planned industrial town: the case of Lički Osik." Review of Croatian History XVI, br. 1 (2020): 125-141. https://doi.org/10.22586/review.v16i1.11295, 126.

[46] " Lika će izvoziti električnu energiju", *Lička novine*, March 15, 1955, 1.

[47] "Lika će izvoziti električnu energiju", *Lička novine*, March 15, 1955, 8.

[48] "Zajam za izgradnju hidroelektrane kod Senja", *Lička novine*, March 1, 1961, 4.

wood and other industries. Interestingly, a similar enthusiasm about new methods of energy production was present with the emergence of nuclear power, as well. Some authors mentioned that same type of energy as a lifeline for Lika, its agriculture, and the development of the community.[49] When researching the local press materials published between 1953 and 1991, it is easy to notice the large amount of attention given to all kinds of topics related to hydropower distribution and development. Often the titles would point out that the karst region, due to its hydropower potential and the much needed vertical relief dissection, is excellent ground for an economic development based on utilizing the hydropower. It can also be noted that there was very little information in the media about the potential negative consequences of the development of hydropower in the karst region. Similarly, the government was the one to strongly support these projects, as according to them, they were irreplaceable for the locals. A large financial capital was available for local companies and enterprises, as well. However, the issue was that there were almost none such companies in the Lika region. The large number of poor, illiterate and spatially scattered inhabitants of this mountainous region could be of no help for the construction of the power plants.

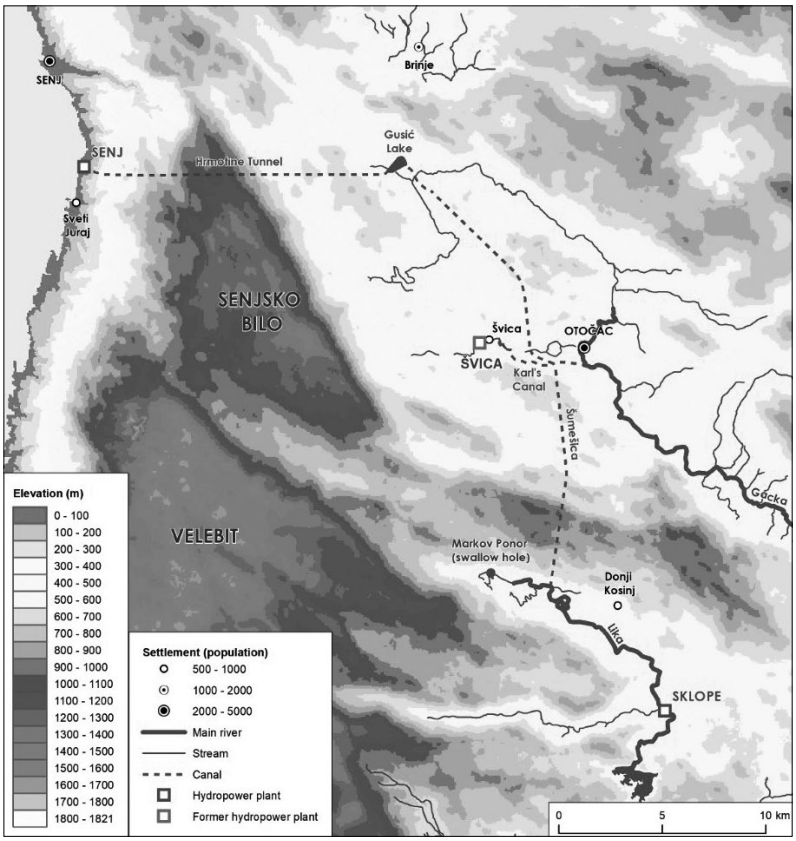

Figure 6: *Hydropower plant system Senj (Source: Digital Atlas of the Republic of Croatia, GIS Data, 2006 modified)*

The investor and bank had the most benefit, despite the fact that building a hydropower plant is characterized largely by expenses related to construction itself (buying the construction and nationalization land, moving roads and infrastructure, ensuring a functioning water supply etc.).[50]

Work on this HPP project, started in 1959 and lasted for over five years, when the HPP Senj officially started operating. The same year 1965, the area was struck by a major flood, which "sank" the general idea that the newly-built system will help regulate the waters of the flooding Lika and Gacka rivers. In order to allow the entire hydropower system to work, reach the highest efficiency and bring about additional value for the local community, work started on building the HPP Sklope, a smaller facility that was, in reality, the most important part of the project. This facility includes a special embankment dam.[51] In 1970, a 23,5MW turbine was installed, which was financed in its entirety by local manufacturers. The HPP Sklope has a 60-meter head, a flow rate of 45 m^3/s, and a power of 22 MW. Building the HPP Sklope has caused a modification of the flow of the Lika River, Croatia's largest sinking river.

[49] "Nuklearna energija – velika nada poljoprivrede", *Ličke novine*, October 1, 1953, 2.

[50] *Razvoj elektrifikacije Hrvatske*, 386., (Čakovec: Institut za elektroprivredu, 1986), 48.

[51] This type of dam is very important for teh specific karst environment and geomorphological and hydrological features. "Dams and reservoirs on karst", in: *Encyclopedia of caves and karst* sciences, Fitzroy Dearborn, 2004., 571.

Additionally, building the facility did not help "control" the river in the Kosinj Valley. There is also a problem in the Bakovac stream, which flows into the Lika river after the Sklope dam. According to the work regulations of the HPP Sklope, the Kruščica reservoir was supposed to be emptied every 10 years. This is also when it became clear that the plan to develop tourism in the area of the HPP reservoir was not strategically planned, as even today there are still only few private initiatives to bring some sort of tourist activities to the Kruščica (reservoir) lake. In Lipovo Polje, a village near the Kosinj Valley, the flow of the Lika was diverted toward the Selište penstock. At the outskirts of this village is Markov Ponor, a natural ponor zone of the Lika River. Today, many locals and experts note that the increasingly frequent floods are caused precisely due to the irregular clearing of that very ponor zone and occasional raise the piezometric karst water table. Then, most of the river flow is diverted by a tunnel through the Šumećica penstock into the large reservoir in Gusić Polje. Later on, the system is directed with a high vertical drop toward the coast, where it reaches the final facility - HPP Senj. When talking about the project of HPP Senj, it is important to point out that, thanks to this project, the development of the electrical power grid in Lika was accelerated. This is how many surrounding villages and settlements received their power grid.

5.2. BUILDING THE PUMPED-STORAGE HYDROPOWER PLANT VELEBIT

As the role of the HPP Senj was first and foremost to strengthen the energy resources of the northern Croatian Littoral, so it was the goal of the PSHPP Velebit, a facility supplied by the flow of the southern Lika, to finally solve the issue of lacking electricity in Northern Dalmatia, or the Zadar area.

For the local community, the crucial question was certainly that of revenue - or rather, what amount of money will the local community, i.e. the Gračac and Obrovac Municipalities, get every year from Elektrodalmacija[52]. How the income of the future power plant would be divided depended on basic criteria which included natural conditions (water, position, used land plots), the size of the investment and the number of employees in the future PSHPP. For this reason, investment in a reversible pump system was started to make utilization the most efficient. Further relevant criteria were related to the loss of arable land and other kinds of damages, as well as corrective criteria, which encompassed the expected level of development in the year the plant would start operating. Based on the studies and the then-relevant Electricity Law, a decision was made to split the hydropower income between the two municipalities, in such a way that the Gračac Municipality would get 71%, and the Obrovac Municipality would receive 29%.[53] It was this positive economic calculation that was the tailwind needed for the economic growth of one of the weakest regions in the country at the time.

The idea of building this plant in Obrovac originated in the 50s, or rather, it came from the idea to build a two-fold solution to the problem: the HPPs Dobarnica and Zrmanja, with a capacity of 276MW.[54] However, due to the high costs of expropriation and even higher costs of relocating railways, roads, and power lines (35 kV and 220 kV), these two projects were abandoned, and the idea of building a standard hydropower plant was replaced with that of building a pumped-storage one. This system proved to be the safest and most effective, so the entire system of the PSHPP Velebit puts significantly less ecological pressure on the water environment. The general idea behind the implementation planned in 1963 was to collect water from the rivers Ričica, Krivak, Otuča and Opsenica. They were then to be used in the gross head of around 550 meters toward the river Zrmanja, the natural border between the regions of Lika and Dalmatia. Projects aimed at building the PSHPP Obrovac had to undergo research and comply with certain conditions regarding the hydrogeological, geotechnical and other works. It should be noted that, in the reports on the hydrogeological layers, geological and groundwater energy balance, there have

[52] Elektrodalmacija, a company established in 1920 with the fundamental mission of building an electrical energy system for the distribution of electrical energy for the area of the south of Croatia(region Dalmacija).

[53] HR-DAGS-SO Gračac, box 153, Study of the basis for the distribution of the share of PSHPP Velebit income to the Municipalities of Gračac and Obrovac, k.br.3.

[54] TOMIČIĆ, Zlatko. "Ričica – II energetski sistem hidrocentrala Like", *Ličke novine*, September 1, 1953., front page.

been certain issues around the analysis itself, as it was done *ad hoc* and it was not thorough. Still, in the end, all the reports provide a conditionally positive opinion of the main project, and it was approved for construction.[55]

Machines pumped water from the lower reservoir into the upper reservoir, Štikada. This was done during night tariffs, when electricity is more accessible and cost-effective, with the goal of using the water pumped into the upper reservoir for the production of electricity during peak demand, when it is most needed in the electrical power system.[56] This large system is run by two aggregates with the capacity of 2x 155 MVA, and the yearly electricity generation capacity from the plant's catchment is around 430 GWh. Overall, this system relies on the vast hydropower resources of the sinking rivers in the Lika region, including the Ričica, Krivak, Otuča and Opsenica and finally the Štikada reservoir. The goal of this project was to generate as much electrical energy as possible, while also having a financial gain for the state company and investor, Elektrodalmacija. In that sense, the entire hydropower potential was processed through the power plant. Only in specific cases, such as when there was significant water inflow or in excess situations, water was released into natural sinks and other underground structures to prevent damage to the object.

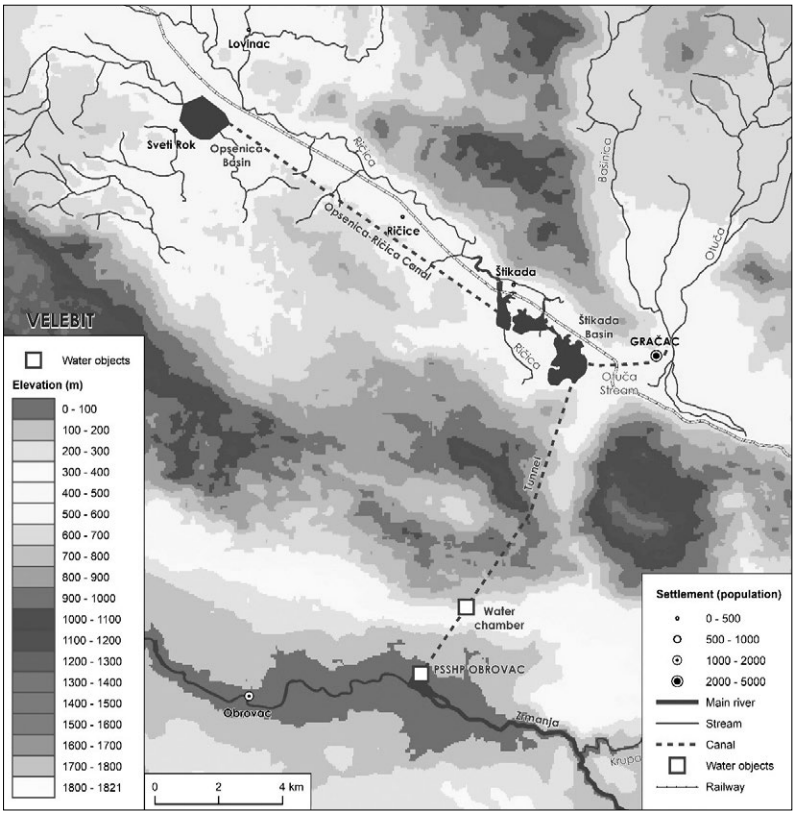

Figure 7: *Hydropower plant system Sklope (Source: Digital Atlas of the Republic of Croatia, GIS Data, 2006 modified)*

By analysing the available documentation on this project, certain base elements can be discerned that were achieved with the construction of this large system. Thanks to the project, the Gračac Municipality managed to build high-quality and modern waterworks, which reduced the uncontrolled pollution of local water flows and sources. However, these projects were also not finished according to plan in the summer of 1982, so the Municipality, and hydropower facilities suffered hefty economic losses, primarily due to a huge water reduction during summer months. Waste water was redirected to the Štikada reservoir through the new filtering system. Furthermore, the areas surrounding and waters of the Ričica, Opsenica and Krivak rivers continued to be of exceptional quality, and the new projects helped preserve these areas even further, so they would not be disturbed by roads and railways.[57]

PSHPP Velebit is to this day still one of the key energy components of the Croatian state company Hrvatska elektroprivreda, and because of its considerate and high-quality production procedure, it has been certified as an environment, quality and energy management system.

[55] HR-DAGS-SO Gračac, box 150., Constructional activities, HPP Obrovac – reports.
[56] *Razvoj elektrifikacije Hrvatske*, ed. Boris Markovčić, (Čakovec: Institut za poljoprivredu, 1987), 169.
[57] HR-DAGS-SO Gračac, box 150., Constructional activities, HPP Obrovac – reports.

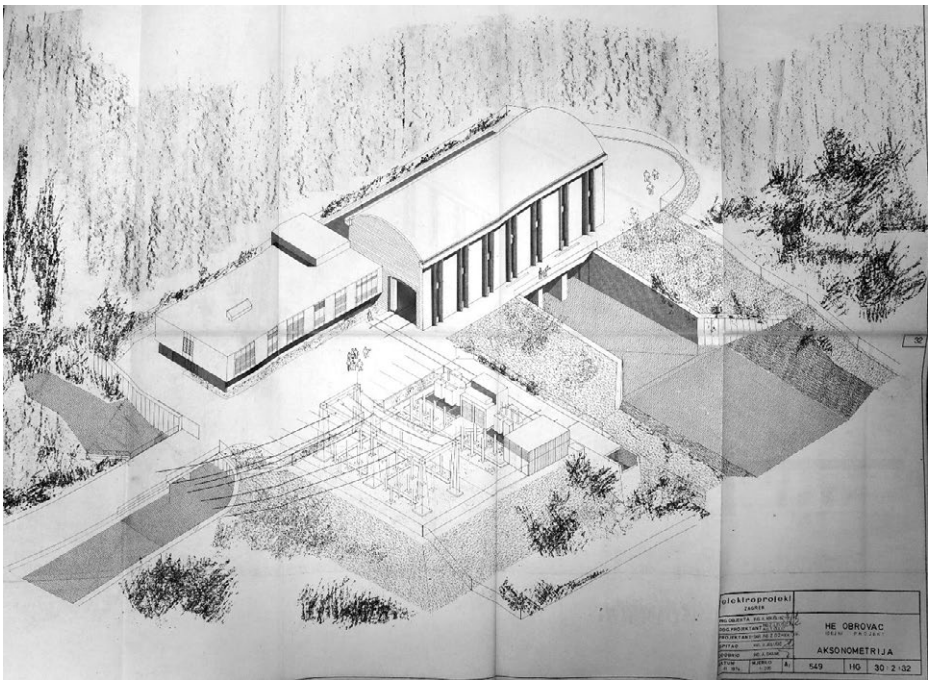

Figure 8: *Preliminary design of PSHPP Velebit (Obrovac) – substation, axonometry. Source: State Archive in Gospić, Municipality of Gračac, Constructional activities, PSHPP Velebit, 1974.*

6. THE CROATIAN HOMELAND WAR AND RECONSTRUCTION: A FIGHT FOR ENERGY AND THE PRESERVATION OF THE SYSTEM AND PEOPLE

The hydropower system in Lika was not just weakened by natural hydrological changes, but also the events of the Croatian Homeland War (1991-1995). In the autumn of 1991, Serbian rebels and power plant workers mined the intake facility of the Gusić Polje reservoir, thereby forcing the HPP Senj to stop operating for a month. Just from September 1991 to May 1992, the HPP Sklope produced 0 kWh instead of 50 million KWh of electricity. Great bravery was shown by the workers of the HPP Senj and PSHPP Velebit in this four years' war. The majority of the energy grid was destroyed and retaking the plant and resuming operations was only possible after the military Operation Storm. This is when the key 400kV power lines, Konjsko-Obrovac-Melina, Konjsko-Brinje, and 110 kV Gračac-Lički Osik, were built.[58] With the rebuilding of the power supply network and the related facilities in HPP Senj and PSHPP Velebit, the preconditions were fulfilled to enable these two systems to generate more than 500 MW of electricity each year.

7. NEW HYDROPOWER PROJECTS OR STABILITY: BETWEEN OLD METHODS AND ENVIRONMENTAL PROTECTION

In parallel with building the last major hydropower plant in Lika (Obrovac/Velebit), and particularly after the Croatian Homeland War, new ideas have started coming up regarding potential projects, the goal of which is usually to further strengthen the hydropower potentials of Lika's karst sinking rivers. For over half a century, there has been a growing need to build another major project in Lika - the new hydropower system Kosinj 2. The local media reported heavily on the project, saying that, according to the state umbrella company Hrvatska elektroprivreda, this project could help mitigate the floods still present in the karst poljes of Lika.[59] In the half a century since the Kruščica reservoir was built, there have still been many floods in the Kosinj and Gacka areas.[60] These events were a strong argument to

[58] *Hrvatska elektroprivreda u ratu i slobodi,* ed. Đurđa Sušec, (Zagreb: HEP, 2015), 139 et. 181.
[59] Ibid., 54.
[60] S.K. "Velike poplave, Spas za Liku", *Lička novine*, November 15, 1975, 4.

accelerate the realization of the new hydropower project in Lika. The project has not yet officially been started, but certain actions are being taken to start it. Many studies, which according to the Water Law (and others) had to be written "pro forma" for this project, always point to one and the same issues. These mainly concern the specific karst area where a new reservoir is supposed to be built, which will be four times the size of the current Kruščica reservoir. Therefore, a more detailed analysis is needed in the area, compared to doing the same research in a non-karst area. Similarly, when talking about the effect that building the HPP Senj has had on the people and environment, they are to this day difficult to measure. That area, particularly the Kosinj Valley and surrounding environment, is permanently devastated, depopulated, and economically weakened. Today, there are only around 600 inhabitants in the area,[61] while 100 years ago there were some 7,000 people.[62] The inhabitants of the places that were flooded after expropriation have received significant compensation for it, while the inhabitants of the Kosinj Valley received only agony and uncertainty, despite the media's announcements that building the Sklope embankment dam would *calm* the flow of the Lika and provide ample opportunity for organized irrigation of plots in Lika. Similarly, it was believed that building large hydropower plants would strengthen all economic sectors, develop many industries, such as the wood or mining industries, and would finally encourage the construction of new processing plants for agricultural raw materials. The media thought that electrification would give incredible momentum to tourism in Plitvice area.[63] For the most part, economic benefits were short-lived, the reason for which is the fact that there was continued emigration from passive areas of Lika, lack of measures mitigating the flood hazard of the Lika and Gacka. Historical circumstances were also not very friendly for these large hydropower facilities; some of the issues include numerous floods, droughts, and wartime events. But the main reason was the fact that the delicate karst area of Bakovac, Gornji Kosinj, Mlakva, Lipovo Polje, Donji Kosinj, Švica and Brlog is very permeable, which is significant for the activities of such hydropower plants. Even today, all around the Lika region, as well as Croatia and the neighbouring countries, there have been many negative effects of such projects on the people and surrounding areas.[64]

Although the economic profitability of such projects for strengthening the energy independence of the Republic of Croatia is unquestionable, a very logical question arises. Is such a large project as HE Kosinj even necessary? Especially today, when only a quarter of the pre-World War II population lives in Lika, hydropower is no longer considered such a desirable source of energy due to the degradation (submergence) of large areas and when there are other renewable energy sources (even relatively clean non-renewable sources, such as gas).

Today's political leaders are still trying to enable the construction of the new hydropower system in Kosinj. According to them, this would permanently solve the flooding issue in nearby settled areas, such as in Lipovo Polje. It would also increase the amount of water that could be used for irrigation, and the financial gain for the municipality would also rise. This would create the conditions needed to develop sports and recreational areas around the lake/reservoir. Additionally, new workplaces would be created, which would, in the end, help the emigrated population return to Lika.[65] As many before it, this project has been described as one of national importance, not considering that this system would directly influence both nature and man, not only in this one region, but in a much wider area, as well. So it is with considerable thought that we ask ourselves to what degree this project is safe for the local community after 100 years of hydropower exploitation of the Gacka and Lika rivers. This is particularly a relevant question when we consider that today in Lipovo Polje there are only about 60 inhabitants, all of very old

[61] SI-1711 Popis stanovnistva, kucanstava i stanova 2021. Prvi rezultati po naseljima (dzs.hr)

[62] *Lički kalendar za 1922. godinu*, Zagreb, 1921., 25.

[63] BABIĆ M., "Jezera na ličkim poljima", *Ličke novine*, January 15, 1955, 4.

[64] "Protests against hydropower system Kosinj", accessed June 1, 2023, https://direktno.hr/domovina/aktivisti-zelene-akcije-i-wwf-adrie-prosvjedovali-protiv-gradnje-he-kosinj-104366/] Futhermore: ARTHINGTON, A., BUNN, S., LEROY-POFF, N. & NAIMAN, R. The challenge of providing environmental flow rules to sustain river ecosystems. Ecological Applications; 16: 1311-8, 2006

[65] *HES Kosinj – studija o utjecaju na okoliš HES Kosinj*, (Zagreb: HEP) 2016, 173. – 175.
HES Kosinj – studija o utjecaju na okoliš HES Kosinj, (Zagreb: HEP) 2016, 3-4.

age. [66] Furthermore, from a microeconomic perspective, the largest part of this project will not be related to the local economic subjects, as there are almost none left in Lika at this point. The situation is similar when it comes to the possible permanent employment of the local population, as most of the labour will be done by machines. Therefore, it is difficult to talk about any population growth, or the return of emigrated locals. In other words, under the guise of development, the importance of professionals' criticism of the project is ignored. The elements of studies that dealt with the impact on the natural environment and local communities are being overlooked. The role of science, and especially environmental history, is of huge importance in the context of further exploitation of water resources in karst areas. The influence of such scientific branches is not limited just to national frameworks.[67]

8. FINAL CONSIDERATIONS: *QUO VADIS, LIKA?*

In contemporary projects and strategies, this part of Croatia's karst region represents a major basis for future environmental protection, along with new forms of sustainability which is based on new ways of developing a green economy that is key for rural areas. Despite these strategies, there is still a strong push to continue utilizing hydropower in Lika.

So we can consider Lika as a classic example of the subordination of local interests to the wider interests of electricity production at the state level with the financial capital. And where to achieve it than in sparsely populated areas rich in resources. This is first and foremost in reference to the project of constructing the hydropower systems Senj 2, i.e. Kosinj 2, which has actually officially been approved in July 2012 by the competent ministry. Following a now-usual way of thinking, the majority of the population in Lika feels[68] that this project is a fantastic opportunity for an economic, social and natural development of Lika. The project is seen as the final solution to all the problems that the inhabitants of the Kosinj Valley are facing. There is a notable discrepancy among the base ideas of what another reservoir would bring to the investor and state, as opposed to what it would bring to the local community. The new facility should be multi-purpose, because it should not only strengthen Croatia's energy independence, but also increase the safety and efficacy of flood prevention, and enable the development of sports, tourism, and recreation in the area. Furthermore, the idea was that this project would stimulate a number of other economic sectors, and the agricultural land gained in the area around the reservoir would be considerable, as well. Further considerations could include irrigation, gravel processing etc.[69] On the other hand, for the scientific community, as well as those within the general population that are more involved in the topic, it is clear that this project cannot bring about the aforementioned benefits due to a lack of human and social capital, not to mention the ecological pressure and real risks for the environment.[70]

Based on this historical research, are we now able to clearly conclude that hydropower projects in Lika were significant, even key events in the recent history of the Lika region? For the majority of people, even those who lost their homes for these projects, these facilities represented development, progress, wealth and a general improvement for the region which was usually described as economically slow, as opposed to being seen as having natural beauty and particular geographical features. One of the more important planned effects was the strengthening of human capital in the area where the hydropower facilities were built. The idea was that there would be many new workplaces, which would be filled by working-age locals, which would cause a positive change in the already weak demographic

[66] Statistics in line | Državni zavod za statistiku (dzs.hr) (viewed at December, 06, 2023),
[67] MCNEILL J.R., "Observations on the Nature and Culture of Environmental History ", History and Theory, 42, num.4, 35.
[68] *Sociološko razvojna studija: Projekt HE Kosinj –HES Senj 2*, Institut za društvena istraživanja Ivo Pilar, Zagreb, 100.
[69] ALERIĆ Slavko, Vladimir DOKMANOVIĆ, "Gradnju novih hidroelektrana najprije treba približiti javnosti", *EGE,* 1, 2013, 90 – 94.
[70] *Sociološko razvojna studija: Projekt HE Kosinj –HES Senj 2 (Sociological development study: Project HPS Kosinj – HPS Senj 2)*, Institut za društvena istraživanja Ivo Pilar, Zagreb, 102.

Figure 9: *The latest flood in Kosinj Valley in 2018. Source: Croatian Mountain Rescue Service – Station Gospic, Archive documents from 2018.*

state of the Gospić, Otočac and Obrovac areas in the Zadar County. The process of population ageing had already started in these areas.[71]

Although today a lot more attention is given to the Lika region in the context of ecology and sustainability, there are many questions as to how the already damaged karst area can be "helped".

When it comes to pointing out the problems related to utilizing hydropower potentials from karst areas, the key lies in the fact that experts from the fields of environment history and environmental sciences need to be more involved. The fact remains that strengthening the hydropower potential of Lika in return weakens the water resources of Lika's sinking rivers, the Lika and Gacka. The specific deep karst region of Lika in the central part of the Dinaric Mountains in and of itself points to the complex interactions between movements of surface and sinking waters that are part of the Gacka and Lika. This complex combination of natural and anthropogenic influences in the past 50 years poses great challenges for water resource researchers. The situation is similar, albeit a little less unclear, with the flows of the southern Lika, which power the PSHPP Velebit. At the same time, it is obvious that the anthropogenic influences on hydrological processes, primarily the hydropower systems, coincide with natural influences. It is also clear that it is exceedingly difficult (if at all possible) to differentiate between them.[72] The biggest influence will become visible in the changes of the hydrological conditions, and in the creation of a new local base level of erosion.[73] Conditions and geomorphological forms and a total loss of a percentage of bio-diversity will also become visible. All these negative results of building a major hydropower

[71] GRAOVAC Vera and Martin GLAMUZINA "Contemporary dynamics and population Structures of former Obrovac area ", *Geoadria*, 71 (2002), 83 – 96. HUSANOVIĆ-PEJNOVIĆ Dragica, "Demografski razvoj podvelebitskog primorja u uvjetima periferije", *Senjski zbornik*, no. 37, 2010, 119 – 142.

[72] BONACCI O., I. ANDRIĆ, Zajednička hidrološka analiza Like i Gacke, *Hrvatske vode*, 17 (2009) 67., 4 (1 – 12).

[73] BUTORAC Valerija Marina CVITKOVIĆ, "Geoekološka analiza u procjeni utjecaja na okoliš – primjer buduće akomulacija Kosinj u Lici", *Acta Geographica Croatica*, 45/46(2018/2019) 29.

system like the proposed one in Lika are a clear warning of how profit is attempting to overpower the sustainable development. So, than, the only right solution is to try to correct natural environment in Lika region. New approach has to fit into developmental frames should be seen as a state project in which the nature of land, rivers, economy and people is deeply transformed. It is the reorganization of the natural world and of human society and economy, a high-modernist act of improving the human condition through science, technology, and expertise. The new "priests" of a new ecological order, particularly in Lika region must be planners, experts and bureaucrats.[74] We believe that numerous economic and ecological episodes from Lika's history can testify to this.

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SAŽETAK

Dinarski krš jedno je od geografski i geomorfološki najdinamičnijih i najtipičnijih područja Hrvatske s dugom poviješću iskorištavanja i valorizacije prirodnih resursa. Izdašni i značajni vodni resursi od kraja 19. stoljeća predstavljaju važan potencijal za nove oblike proizvodnje električne energije. Stoga je Lika zoran primjer dugoročnog ulaganja u hidroenergiju i korištenje drugih resursa sa značajnim ekološkim otiskom. Velike kapitalne investicije poput izgradnje hidroelektrana Senj i Velebit dobile su gospodarsko i energetsko značenje za cijelo područje, sa značajnim utjecajem na krški okoliš. Velika komunalna i energetska ulaganja na području srednje i južne Like u vidu izgradnje hidroenergetske i prometne infrastrukture rezultirala su promijenjenim mogućnostima egzistencije lokalnog stanovništva i izmijenjenim ekosustavima uz Velebit.

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