

Climate change, water resources and tourism

Dekanić, Antonio; Karleuša, Barbara; Sušanj Čule, Ivana

Source / Izvornik: **17th International Symposium on Water Management and Hydraulic Engineering: WMHE 2022, 2022, 234 - 242**

Conference paper / Rad u zborniku

Publication status / Verzija rada: **Published version / Objavljena verzija rada (izdavačev PDF)**

Permanent link / Trajna poveznica: <https://um.nsk.hr/um:nbn:hr:157:750329>

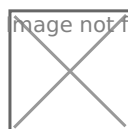
Rights / Prava: [Attribution 4.0 International](#)/[Imenovanje 4.0 međunarodna](#)

Download date / Datum preuzimanja: **2025-01-05**



Repository / Repozitorij:

[Repository of the University of Rijeka, Faculty of Civil Engineering - FCERI Repository](#)



VII Climate Change and Flood Risk Management

CLIMATE CHANGE, WATER RESOURCES AND TOURISM

ANTONIO DEKANIĆ¹, BARBARA KARLEUŠA¹, IVANA SUŠANJ ČULE¹

¹ University of Rijeka, Faculty of Tourism and Hospitality Management; Croatia
e-mail: antonio.dekanic0@gmail.com, barbara.karleusa@uniri.hr, isusanj@uniri.hr

Abstract

The impact of climate change on water resources and tourism, the possibility of adapting to climate change in a tourist destination, and mitigation of the impact of tourism activity on the climate change is analysed. Touristic activity seasonality and changes in water demands during the year is addressed. The importance of implementing the process of adaptation to climate change in a tourist destination, possible adaptation measures and opportunities to ensure sustainable management of water resources in order to ensure quality tourism activities but also the quality of life of local inhabitants in the tourist destination are presented.

Keywords: climate change, water resource, tourism, adaptation, mitigation, measures.

1. Introduction

Water resources are one of the key factors for life and development of life on Earth, and thus for humanity. Given the limited water resources, climate change and significant human activity, managing water resources in a sustainable way is an extremely important and very complex task [1]. It has been determined that climate change already has today, and will have even more pronounced and different impacts on water resources in the future. Climate change affects all life on the planet, all resources, including water resources. They also affect all human economic activities (agriculture, fisheries, energy, tourism, etc.) [2].

The need (demand) for water is globally growing due to a number of factors, including population growth, water pollution, economic progress, land use, climate change and others [3]. Drinking water is a strategic resource for socio-economic development and environmental protection, but water scarcity, deteriorating of water quality, droughts and, on the other hand, floods represent current and future challenges in water management, especially with regard to climate change. The effects of climate change are even more pronounced in regions that are already deficient in water resources and where droughts are more frequent, and therefore there is an imbalance between available water resources and water needs [4]. This problem is particularly pronounced in the Mediterranean area, which stands out as a significant tourist destination, where the seasonal (summer) increase in water demand is particularly pronounced, and on the other hand climate change affects the reduction of local and seasonal availability of water resources [5].

The aim of this paper is to analyse the impact of climate change on water resources with an emphasis on tourism and the possibility of adapting to climate change in a tourist destination, but also mitigate the impact of tourism activity on the causes of climate change. The issue of touristic activity seasonality and changes in water demands during the year are emphasized.

The paper analyses the importance of implementing the process of adaptation to climate change in a tourist destination, possible adaptation measures and opportunities to ensure sustainable management of water resources in order to ensure quality tourism activities but also ensure the quality of life of local inhabitants in the tourist destination. The emphasis in this paper is on the touristic destinations in the Mediterranean area especially in the coastal part of the Republic of Croatia.

2. Climate change impact on water resources

The Mediterranean basin, including the Adriatic Sea region, is a region that is very sensitive to climate change, but also to anthropogenic impacts [6]. Since the 1970s, the mean annual temperatures in the Mediterranean region have increased by 0.1°C per decade, and precipitation has decreased by 25 mm per decade [7]. Temperatures are expected to increase by 1.5–2.5°C, and precipitation is expected to decrease by 5% to 20% up to 2050 [8], which could lead to the decrease of freshwater resources throughout the Mediterranean basin (30–50%).

In the Adriatic region, the decrease of 15% of freshwater is expected in northern Italy and the Balkans [8]. Climate changes cause more frequent drought and flood occurrence, while the increase in water demand is expected due to

increasing urbanisation, agricultural production and tourism activities, which leads to the increase in withdrawal of water and pressures on regional water resources [9].

Water resource and supply vulnerability and risk assessments, water scarcity estimates and drought analyses due to climate change impacts are necessary for avoiding future water crises and preparing adaptation measures to mitigate the consequences of such crises [10].

To simulate the impacts of climate change on water resources in future various methodologies have been used [11]: coupling Global Circulation Models (GCMs) with hydrologic models through downscaling techniques, coupling high-resolution Regional Climate Models (RCMs) with hydrologic models and using hypothetical scenarios as inputs to hydrologic models.

The impact of climate change on the water resources in the Mediterranean has been confirmed in different studies [5]. Based on scenarios of varying future temperature and precipitation to analyse the changes in groundwater recharge and in agricultural water demand for the West Bank of the Mediterranean basin, Mizyed [12] concluded that the groundwater recharge could decrease by up to 50%.

Impact of climate change on water resources used for drinking water supply in the Adriatic region has been investigated within the DRINKADRIA project (Adriatic IPA CBC 2007–2013) [5]. As an example of the impact of climate change on water resources for analysed pilot area in northern part of Croatia (where the touristic activity is very high in summer period) for springs Sv. Ivan, Gradole and Bulaž are presented in Figure 1 [6]. The decrease in discharge of springs Sv. Ivan, Gradole and Bulaž can be observed in all historical time series and projected time series of the total lowest average monthly discharge of springs, with accompanying trends, generated using different climate models (REGCM3, ALADIN, and PROMES) for 1961–2050. The island of Corfu in Greece (also pilot area in the Project) is facing rising temperatures and declining rainfall too, especially in the summer months. Although the island of Corfu is located in the western part of the country where precipitation levels are higher than the average in Greece, climate change will negatively affect the availability of water resources [14].

3. Climate change impact and tourism

According to climate modelling results, the Mediterranean region is marked as a “hot spot” with particularly pronounced effects of climate change impact [15]. The Republic of Croatia, which for the most part belongs to that region, will certainly feel the consequences of climate change, and its vulnerability is assessed as high. The vulnerability of some economic sectors is particularly significant: tourism, agriculture, forestry, fisheries and energy, as the success of these sectors depends to a large extent on climate factors. Consequently, the extreme vulnerability of the economy to the effects of climate change can have a negative effect on overall social development. Therefore, the implementation of adaptation measures is the only way to avoid catastrophic consequences for the environment and the economy, which endangers the sustainable development of the society [16].

In the tourism sector, the main expected impacts of climate change are: reduction of tourist demand in the summer months due to high temperatures, increased UV radiation, higher frequency and intensity of extreme weather events; reduction or loss of ecosystem attractiveness and biodiversity as elements of attractiveness in tourism; reduction of water availability and occurrence of problems related to various infrastructure systems (wastewater drainage, solid waste disposal, beach infrastructure, accommodation infrastructure, etc.) and / or their reduced functionality.

Changes in climate will lead to various implications for individual tourist destinations, but they can be both positive and negative. Due to climate change (but also due to its proximity to Western and Northern European guests), the northern parts of Europe could become attractive enough for vacations during the summer months, and the Mediterranean and Croatia could remain attractive (only) for the rest of the year. The tourism sector will be forced to enrich its offer and offer higher quality products, which can have a positive effect on the competitiveness and structure of guests. Favourable climatic conditions in the coastal part of the Republic of Croatia in the off-season and pre-season can have a positive effect on reducing mass tourism in the summer months [17].

At the peak of the touristic season, some tourist destinations and islands have problems with water supply, which will continue in the future due to increased demand for water in this period [18]. The issue of water supply in the context of (oversized) development of island and coastal tourism is highlighted by a considerable number of studies in the Mediterranean area (Mallorca, Malta, Sardinia) [19].

In Croatia the problem is also highlighted on islands and in coastal areas with touristic activity. The impact of tourism on increasing demands for water supply is not only reflected by the seasonal increase of the number of tourists and seasonal workers. Namely, in addition to primary water consumption (drinking, bathing, sanitary water), tourists also encourage secondary consumption for agriculture focused on tourism, swimming pools, green areas, etc. Water consumption increases exponentially with increasing accommodation capacity [19].

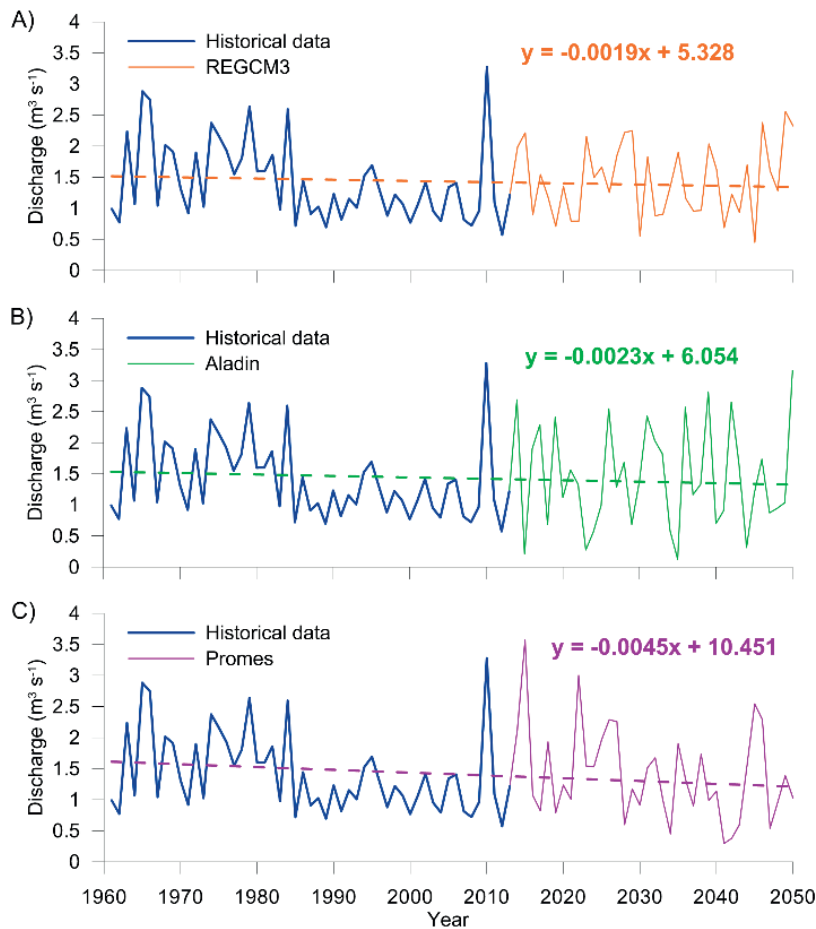


Figure 1. Historical time series and projected time series of the total lowest average monthly discharge of Sv. Ivan, Gradole and Bulaž springs generated using different climate models for 1961-2050 with accompanying trends: A) REGCM3, B) ALADIN, and C) PROMES models [6]

In DRINKADRIA project it was concluded that the decrease of available water resources in the future due to climate change impact (Figure 1) will cause stress during touristic high season period when the demands for water are the highest (even double), and the water resources availability is at the lowest [6]. This can be observed in Figure 2 where the intra-annual distribution of the long-term mean of average monthly overflow discharges and abstracted quantities on the pilot area in Croatia in Istria for springs Sv. Ivan, Gradole and Bulaž are combined together and analysed for the period 1991–2012 [5].

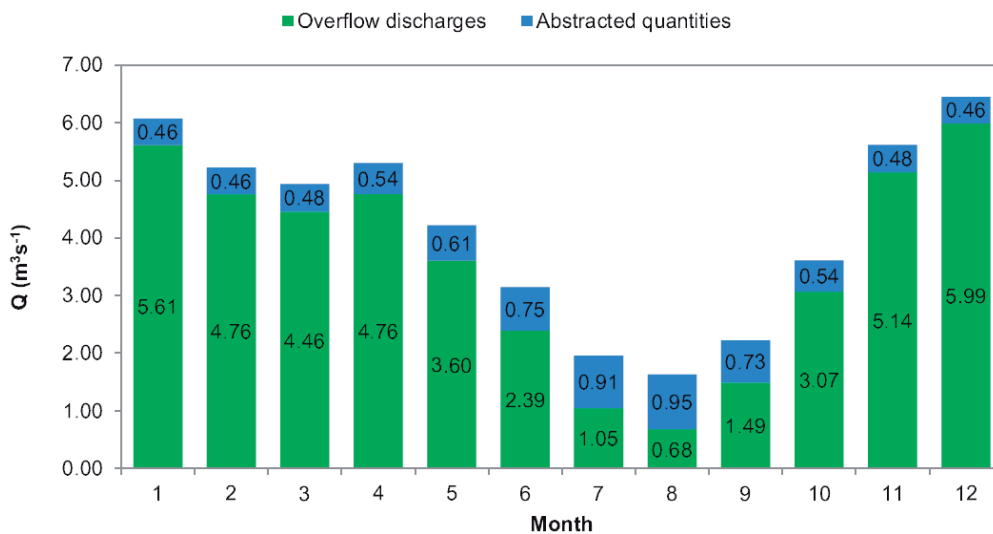


Figure 2. Intra-annual distribution of the long-term mean of average monthly overflow discharges and abstracted quantities for springs Sv. Ivan, Gradole and Bulaž combined together (1991–2012) [5]

When talking about the assumed features of tourism in the coastal part and on the islands, the starting line is usually 3S (Sun, Sea and Sand). Another often assumed basis is sustainable tourism with the fundamental theme that the island, as an eco-paradise, has untouched nature along with the local population and a way of life with low environmental impacts [20]. Tourists are looking for destinations with favourable climatic conditions, and on the other hand, tourism itself contributes to climate change. Addressing climate change is considered a prerequisite for sustainable tourism development, and sustainable water management is important for the quality of life of local inhabitants [19, 21].

4. Adaptation to climate change and mitigation measures

With increasing evidence of the impact of climate change, strategies and plans for climate change adaptation and mitigation have been developed at international, European and national levels. The Paris Agreement on Climate Change obliges the countries of the world to act in two directions: to take urgent measures to reduce greenhouse gas emissions in order to limit the increase in temperature to 1.5°C and 2°C compared to the pre-industrial period, and take measures to adapt to climate change, in order to reduce the damage from climate change (in force since 4 November 2016, confirmed by the EU on 5 October 2016, and by the Republic of Croatia on 17 March 2017, [22]).

The Intergovernmental Panel on Climate Change (IPCC) in 2019 shows that the global trend of temperature rise is +1.1°C and if the concentration of greenhouse gases continues to increase at the current rate, global warming is likely to reach 1.5°C between 2030 and 2052. The UN's 2030 Sustainable Development Goals (SDGs) set 17 global Sustainable Development Goals (SDGs), with a goal 13: taking urgent action to combat climate change and its impacts [22].

The European Commission adopted a new EU strategy for adaptation to climate change on 24 February 2021. The new strategy sets out how the EU can adapt to the inevitable impacts of climate change and become resilient to impending change by 2050. It is necessary to: make adaptation smarter by encouraging action based on reliable data and risk assessment tools, make adaptation more systematic because climate change affects all sectors, make adaptation faster because we already feel the effects of climate change, and step up action internationally because adapting is the cross-sectoral element of EU and Member State action. The Republic of Croatia is obliged to prepare a periodic report to the European Commission on measures to adapt to climate change at the national and local level [22].

The first strategic document that provides an assessment of climate change for Croatia is the Strategy for Adaptation to Climate Change in Croatia for the period until 2040 with a view to 2070 [17] and was adopted by the Croatian Parliament on April 7, 2020. The goal of the Strategy is to raise awareness of the importance and threats of climate change for society and the need to integrate the concept of climate change adaptation into existing and new policies, in order to reduce the vulnerability of the environment, economy and society caused by climate change. The Strategy identifies vulnerable sectors, including hydrology and water resources, and tourism, and prescribes the obligation to take adaptation measures. Table 1 shows the projections of climate parameters in the Republic of Croatia for the period 2041–2070 [17].

Table 1. Projections of climate parameters for the Republic of Croatia according to the RCP4.5 scenario for the period 2041–2070 (prepared by authors based on [17])

Climate parameter	Projections of future climate in Croatia according to scenario RCP4.5 for the period 2041–2070 obtained by climate modelling
Precipitation	Average annual quantity: further decreasing trend (up to 5%) except in the NW parts of Croatia
	Decrease in all seasons (up to 10% mountains and Northern Dalmatia) except winter (increase 5–10% Northern Croatia)
	The number of drought periods will increase
Surface runoff	Reduction of runoff (especially in spring)
Air temperature	Medium: increase 1.5–2.2°C (all seasons, especially in the continental part)
	Max: increase up to 2.2°C in summer (up to 2.3°C on islands)
	Min: the largest increase on the continent in winter 2.1–2.4°C; and 1.8–2°C coastal areas
Mean sea level	2081–2100 32–65 cm (estimation of average means for the Adriatic)

The main expected impacts that can lead to a high degree of vulnerability of water resources are [17]:

- reduction of water quantities in watercourses and springs;
- reduction of groundwater supplies and decline of groundwater levels;
- reduction of water levels in lakes and other dammed natural or built systems;

- rising sea levels, salinization of coastal aquifers and aquatic systems;
- increase in water temperatures accompanied by a decrease in the carrying capacity of receiving water bodies;
- increasing the frequency and intensity of floods in endangered areas;
- increasing the frequency and intensity of torrents;
- increasing the frequency and intensity of floods from rainwater in urban areas;
- increase in sea level, and thus the probability of floods at the mouths of watercourses;
- reducing the efficiency of coastal infrastructure, and
- intensification of salinization of estuaries and coastal aquifers.

The Strategy [17] provides an assessment of the impact of climate change and the vulnerability of the tourism sector on climate change and possible responses to high vulnerability, as shown in Table 2.

Table 2. Overview of the impacts and challenges of climate change adaptation in the tourism sector and possible responses to reducing high vulnerability [17]

Impacts and challenges that cause high vulnerability	Possible responses to reducing high vulnerability
<ul style="list-style-type: none"> – inadequacy of the tourist offer to projected climate change (high temperatures, increased solar radiation, frequency of extreme weather events, etc.), – changing the attractiveness of the area on the coast and in the continental part of the Republic of Croatia, – damage and / or reduced functionality of various infrastructure systems (water supply, drainage, beach infrastructure, horticulture, etc.), – deterioration of ecosystems, biodiversity and cultural heritage important to tourism due to indirect and direct effects of climate change. 	<ul style="list-style-type: none"> – adaptation of the tourism sector to changed business conditions due to the impact of climate change, – aligning tourism activities with projected climate change, – strengthening competences related to impacts and adaptation to climate change of experts directly related to the tourism sector, – inclusion of climate change adaptation measures in all segments of sustainable Croatian tourism, – the revitalisation of tourist offer across the entire territory of the Republic of Croatia and exploitation until now underutilised or untapped potential, – implementation of priority programs for the rehabilitation of cultural assets by including acceptable measures to reduce vulnerability to climate change.

Table 3 provides measures for adaptation to climate change in the tourism sector grouped into categories of very high and high importance and lists the key stakeholders.

Table 3. Climate change adaptation measures in the tourism sector: measures of very high importance (01–04), high importance (05) and key stakeholders [17]

Measure code	Name of the measure	Key stakeholders
T-01	Integrating climate change into the tourism development strategy	Ministry of Tourism, Ministry of Environmental Protection, local and regional self-government units, tourist boards, Croatian Meteorological and Hydrological Service
T-02	Raising awareness of experts involved in the tourism sector about the impact, risks and opportunities for adaptation to climate change	Ministry of Tourism, Croatian Chamber of Commerce, tourist boards, public institutions for the management of protected parts of nature
T-03	Encouraging education of students on climate change	Ministry of Science and Education, Croatian Chamber of Commerce, Croatian Chamber of Crafts
T-04	Strengthening the resilience of tourist infrastructure to various weather extremes	Ministry of Tourism, Ministry of Construction and Physical Planning, Ministry of Environmental Protection, Ministry of the Sea, Transport and Infrastructure, local and regional self-government units, Croatian Meteorological and Hydrological Service
T-05	Strengthening the resilience of local communities in the tourism sector	Ministry of Tourism, local and regional self-government units, tourist boards, Croatian Meteorological and Hydrological Service

In order to respond to the new policy goals for 2030, the existing Sustainable Energy Action Plans (SEAP) were to be upgraded to Sustainable Energy and Climate Action Plans (SECAP). The goal is to reduce CO₂ emissions by at least 40% by 2030, improve energy efficiency, reduce energy consumption and influence the adaptation to climate change. These plans serve as an effective tool for planning climate change mitigation and adaptation measures [23].

In Croatia most cities with prepared SECAP are located in the Primorje-Gorski Kotar and Istria counties (11 cities in total), and these are the cities: Kastav, Opatija and Rijeka (Primorje-Gorski Kotar County), Buje, Novigrad, Pazin, Buzet, Labin, Rovinj, Poreč and Pula (Istria County) [23].

In the field of adaptation to climate change, vulnerability and risk analysis to climate change was conducted, and in the water and tourism sector the risk is moderate or high due to high exposure due to high population density and increase in number of tourists during the touristic season.

These sectors require the timely implementation of climate change adaptation measures. Table 4 gives an example of good practice, i.e. an overview of climate change adaptation measures in the water sector and tourism sector on the example of Croatian Northern Adriatic cities: Rijeka, Kastav, Opatija (Primorje-Gorski Kotar County), Poreč and Labin (Istria County). All these cities are tourist destinations.

In Croatia in 2013, the Institute for Social Research and the Society for Shaping Sustainable Development (Institut za društvena istraživanja and Društvo za oblikovanje održivog razvoja) conducted a survey on citizens' attitudes towards climate change. Even then, 70% of citizens considered climate change a significant problem, and more than 40% of citizens thought that climate change mitigation was more important than current economic development, mostly citizens of coastal regions of the Republic of Croatia [23].

The research conducted in 2019, through the RMPPI (Renewable micro power plant initiative) project confirmed the great interest of citizens in the topic of climate change and considered climate change a significant problem [28].

Climate change is of particular importance for the long-term positioning of tourist destinations on the world market. Some destinations will gain in attractiveness, and there will be more interest in them, while others whose attractiveness will be jeopardized by climate change will have to be repositioned in order to maintain their market position [29].

Table 4. Measures of adaptation to climate change in the water and tourism sector on the example of cities in Primorje-Gorski Kotar County and Istria County (prepared by authors based on [24–27])

Cities	Climate change adaptation measures in the water sector	Climate change adaptation measures in the tourism sector
Rijeka	<ul style="list-style-type: none"> – strengthening the resilience of coastal water-communal infrastructure and coastal water resources, – preparation of project and planning documentation related to water protection infrastructure. 	<ul style="list-style-type: none"> – networking and upgrading the system of monitoring environmental indicators related to climate change.
Kastav and Opatija	<ul style="list-style-type: none"> – economic evaluation of groundwater and springs, – identifying vulnerable groups and critical assets in terms of flood risk, – reconstruction of the water supply network and installation of equipment for smart monitoring of the water supply system in order to reduce water loss in the system, – raising public awareness on the importance of water consumption and the impact of climate change, – rationalization of water consumption, – analysis of the impact of sea level rise, – strengthening the resilience of water and communal infrastructure in coastal areas, – preparation of an analysis of the possibility of recycling wastewater for reuse and rainwater collection. 	<ul style="list-style-type: none"> – increasing resistance to climate change (measuring UV radiation and temperature, availability of drinking water in public places, personal protection from UV radiation), – development and encouragement of tourism activities compatible with resistance to extreme weather conditions (supply diversification), – raising the awareness of tourism workers about the impact, risks and possibilities of adaptation to climate change, – strengthening the resilience of tourist infrastructure to various weather extremes (construction of swimming pools, indoor spa and wellness facilities, refrigerated areas, etc.), – encouraging the education of students of tourism professions on climate change.
Poreč	<ul style="list-style-type: none"> – strengthening capacities for protection against harmful effects of water, stakeholder capacity, measures for protection against harmful effects of water in the event of extreme hydrological conditions (e.g. floods), and resilience of urban areas to anthropogenic pressures caused by climate change. 	<ul style="list-style-type: none"> – development of the concept of sustainable tourism that includes adaptation to climate change, – strengthening the competencies of employees in the tourism sector, – strengthening the resilience of tourist infrastructure to various weather extremes.
Labin	<ul style="list-style-type: none"> – increasing revenues to combat water shortages, – education of the population, – regulations restricting water consumption, especially in dry summer periods, or adopting provisions that promote more rational use of water resources. 	<ul style="list-style-type: none"> – diversification of the tourist offer, – plans and programs related to climate change, – availability of early weather warning systems.

In general, most destinations are chosen by tourists because of the type of climate. In this context, identifying threats to climate change and future perspectives of change are important determinants of likely changes in preferences for travel destinations. Interest and concern about climate change have begun to spread in recent times and have become a global problem, and climate change is receiving significant attention in the field of tourism research [30].

Emphasizing the impact of tourism on the environment (which generates climate change) is a key focus of sustainable tourism development. Namely, the pronounced tourist seasonality affects the development of climate change. The process of adaptation to climate change in a tourist destination requires the interaction of sustainable tourism development and climate change [29].

The future effects of climate change will extend the touristic season. The result of predicting the future climate is greater deseasonalisation of demand, as certain seasons (spring and autumn) will offer greater comfort to tourists and visitors. Higher temperatures in the current main part of the tourist season (July and August) will reduce the number of tourists, thus increasing the number of tourists in other months of the year due to more acceptable temperatures in Mediterranean tourist destinations [18].

This future deseasonal demand in certain tourist destinations will have a positive effect on water supply systems, which have so far been overstressed in the summer months due to a big increase in tourist arrivals in July and August. Tourism is considered among the economic sectors that are least prepared for the risks and opportunities posed by climate change [21].

The development of selective forms of tourism is crucial for adapting the offer to the requirements of tourists who cannot perform normal tourist activities due to unfavourable weather conditions (unbearable heat, UV radiation or rain). The product of the “sun and sea” that is characteristic for Croatia needs to be supplemented with other forms of tourism (health, sports, culture, history, education, entertainment). It is necessary to start applying these measures of adaptation to climate change as soon as possible [31] since it is expected that the cost of investing in adaptation will reduce the cost of repairing possible damages in the future [16].

5. Conclusion

Climate change is affecting, and in the near future it will certainly affect even more intensely, the population of the Earth. This paper presented the impact of climate change with an emphasis on water resources and tourism. The impact of climate change on water resources results mostly in decreasing the available quantities of water in future. The way that tourism responds to climate change is absolutely critical to the sustainability of tourism and if that sector would withdraw from engaging in climate change problematics, it would be to its significant detriment.

For government, NGOs and decision-makers, climate change is a new strategic reality they have to face.

It is clear that there has been a dramatic increase in research in the field of sustainable tourism development and climate change. The pronounced tourist seasonality, that we currently have, negatively affects and burdens water resources and systems in tourist destinations.

Projections of climate parameters for Croatia in the future predict deseasonal touristic demand primarily due to the lower level of comfort that will prevail during the summer months due to too high temperatures. This deseasonalisation, which would redistribute tourist arrivals to the rest of the year, would have a positive impact on water resources and systems, decreasing the stress on water resources that we have now in high season.

The Mediterranean basin area has been identified as one of the most vulnerable regions of the world to climate and anthropogenic change. In this area tourist seasonality is pronounced during the summer months, which is an additional challenge for efficient water management.

High ratings tourists give to destinations with favourable climatic conditions, which are an important element when choosing a destination. Therefore, the climate as one of the most important drivers of tourism, in the future will play an even more important role in choosing a destination. Given that climate is recognized as a key driver of tourism, climate change can have a positive or negative impact on tourism, although tourism itself contributes to climate change. The overall quality of life stems from the sustainability of the tourist destination. This in turn improves the quality of life of the local population and the image and competitiveness of tourist destinations.

Timely adjustments can significantly reduce the future damage and losses caused by climate change in the tourism sector. The SECAP analysis of selected cities in the Northern Adriatic part of Croatia presents concrete and specific measures for adaptation to climate change in the water sector and in the tourism sector, that should be implemented.

The EU is fighting against climate change, so in the last financial period, until 2020, every fifth euro in the European budget was allocated for adaptation to climate change, which is 180 billion euros per year, while in the current financial

period from 2021 to 2027, every fourth euro in the European budget will be allocated for this purpose, which is more than 280 billion euros per year [2].

Another aspect that we are currently adding to our research on climate change impact on water resources and tourism are summer fires in Adriatic coastal areas since the number and fire severity have significantly increased over the past decades [32]. Fires are often consequences of human activities and unfavourable hydrological conditions during summer, have huge impact on the environment and can endanger touristic areas, while additional water resources are needed for fire control and extinguishing.

There is still a lot to be done to raise public awareness about climate change and the impact on natural resources (including water resources). Raising general public awareness about this problem will certainly accelerate further research and implementation of preventive measures. At the same time, from the scientific point of view, the impact of climate change, adaptation and mitigation measures need to be continuously investigated, quantified and included in all spheres of human activities and the environmental management.

Acknowledgements

The research for this article and the publication of this article were funded by the University of Rijeka within the projects “Implementation of Innovative Methodologies, Approaches and Tools for Sustainable River Basin management” (UNIRI-TEHNIC-18-129) and “Hydrology of Water Resources and Identification of Flood and Mudflow Risks in Karst” (UNIRI-TEHNIC-18-54).

References:

- [1] Muhar, A., Đurin B.: Utjecaj klimatskih promjena na vodne resurse u svijetu (Climate change impact on water resources), Zbornik radova Međimurskog veleučilišta u Čakovcu, 9 (1), pp. 46–54, 2018, <https://hrcak.srce.hr/202075> (accessed 14.06.2022.).
- [2] Bebić, M.: Utjecaj globalnih klimatskih promjena na vodne resurse – primjer rijeke Neretve (Climate change impact on water resources – example of river Neretva), Hrvatske vode, 29, pp. 51–56, 2021, <https://hrcak.srce.hr/256260> (accessed 14.06.2022.).
- [3] Koutroulis, A.G., Tsanis, J.K., Daliakopoulos, I.N., Jacob, D.: Impact of climate change on water resources status: a case study for Crete Island, Greece, Journal of Hydrology, 479, pp. 146–158, 2013, <https://doi.org/10.1016/j.jhydrol.2012.11.055>.
- [4] Estrela, T., Pérez-Martin, M.A., Vargas, E.: Impacts of climate change on water resources in Spain, Hydrological Sciences Journal, 57(6), pp. 1154–1167, 2012, doi: 10.1080/02626667.2012.702213
- [5] Karleuša, B., Rubinić, J., Radman, I., Volf, G., Krvavica, N.: Cross-Border Water Resources Management in Present Conditions and for Future Scenarios, International Symposium Cross-border drinking water management: proceedings, University of Rijeka Faculty of Civil Engineering, Rijeka, pp. 59–90, 2016.
- [6] Karleuša, B., Rubinić, J., Radišić, M., Krvavica, N.: [Analysis of Climate Change Impact on Water Supply in Northern Istria \(Croatia\)](#), Technical Gazette, 25 Supplement 2, pp. 366–374, 2018, doi:10.17559/TV-20170809140304.
- [7] Alcamo, J., Henrichs, T.: Critical regions: A model-based estimation of world water resources sensitive to global changes, Aquatic Science, 64(4), pp. 352–362, 2002, <https://doi.org/10.1007/PL00012591>.
- [8] Xoplaki, E., Gonzalez-Rouco, J.F., Luterbacher, J., Wanner, H.: Wet season Mediterranean precipitation variability: influence of large-scale dynamics and trends, Climate Dynamics, 23(1), pp. 63–78, 2004, <https://doi.org/10.1007/s00382-004-0422-0>.
- [9] Milano, M., Ruelland, D., Fernandez, S., Dezetter, A., Fabre, J., Servat, E.: Facing climatic and anthropogenic changes in the Mediterranean basin: What will be the medium-term impact on water stress? Comptes Rendus Geoscience, 344(9), pp. 432–440, 2012, <https://doi.org/10.1080/02626667.2013.774458>
- [10] Collet, L., Ruelland, D., Estupina, V.B., Dezetter, A., Servat, E.: Water supply sustainability and adaptation strategies under anthropogenic and climatic changes of a meso-scale Mediterranean catchment, Science of the Total Environment, 536, pp. 589–602, 2015, <https://doi.org/10.1016/j.scitotenv.2015.07.093>
- [11] Sisto, N.P., Ramirez, A.I., Aguilar-Barajas, I., Magana-Rueda, V.: Climate threats, water supply vulnerability and the risk of a water crisis in the Monterrey Metropolitan Area (Northeastern Mexico), Physics and Chemistry of the Earth, 91, pp. 2–9, 2016, <https://doi.org/10.1016/j.pce.2015.08.015>
- [12] Xu, Z.X., Chen, Y.N., Li, J.Y.: Impact of climate change on water resources in the Tarim River basin, Water Resources Management, 18(5), pp. 439–458, 2004, <https://doi.org/10.1023/B:WARM.0000049142.95583.98>.
- [13] Mizyed, N.: Impacts of climate change on water resources availability and agricultural water demand in the West Bank, Water Resources Management, 23(10), pp. 2015–2029, 2009, <https://doi.org/10.1007/s11269-008-9367-0>.

- [14] Kanakoudis, V., Tsitsifli, S., Papadopoulou, A., Čencur Curk, B., Karleuša, B.: Water resources vulnerability assessment in the Adriatic Sea region: the case of Corfu Island, *Environ Sci Pollut Res*, 24, pp. 20173–20186, 2017, <https://doi.org/10.1007/s11356-017-9732-8>.
- [15] Giorgi, F., Lionello, P.: Climate change projections for the Mediterranean region, *Global and Planetary Change*, 63, pp. 90–104, 2008, <https://doi.org/10.1016/j.gloplacha.2007.09.005>
- [16] [Ministry of Economy and Sustainable Development \(Croatia\): https://prilagodba-klimi.hr/](https://prilagodba-klimi.hr/) (accessed 14.06.2022).
- [17] Strategy for Adaptation to Climate Change in Croatia for the period until 2040 with a view to 2070, Official Gazette of the Republic of Croatia 46/20 (accessed 14.06.2022).
- [18] Perić J., Šverko Grdić Z.: Klimatske promjene i turizam (Climate change and tourism), Faculty of Tourism and Hospitality Management, Opatija, 2017.
- [19] Slavuj, L., Čanjevac, I., Opačić, V.T.: Vodoopskrba kao faktor održivog razvoja turizma otoka Krka (Water Supply as a Factor of Sustainable Tourism Development on the Island of Krk), *Hrvatski geografski glasnik (Croatian Geographical Bulletin)*, 71 (2), pp. 23–41, 2009, <https://doi.org/10.21861/hgg.2009.71.02.02>
- [20] Kelman, I.: Critiques of island sustainability in tourism, *Tourism Geographies*, 23 (3) pp. 397–414, 2021, doi: [10.1080/14616688.2019.1619825](https://doi.org/10.1080/14616688.2019.1619825)
- [21] Scott, D.: Why sustainable tourism must address climate change, *Journal of Sustainable Tourism*, 19(1), pp. 17–34, 2011, doi: [10.1080/09669582.2010.539694](https://doi.org/10.1080/09669582.2010.539694)
- [22] Ministry of Economy and Sustainable Development (Croatia): <https://mingor.gov.hr/o-ministarstvu-1065/djelokrug-uprava-za-klimatske-aktivnosti-1879/prilagodba-klimatskim-promjenama-1965/1965> (accessed 14.06.2022.)
- [23] [Society for Sustainable Development Design \(Croatia\): https://door.hr/](https://door.hr/) (accessed 14.06.2022)
- [24] Akcijski plan energetske i klimatske održivosti razvitka (SECAP) za Grad Rijeku (Sustainable Energy and Climate Action Plan (SECAP) for the city of Rijeka), 2020; <https://www.rijeka.hr/wp-content/uploads/2021/02/Akcijски-plan-odr%05%BEivog-energetskog-razvoja-i-prilagodbe-na-klimatske-promjene-za-Grad-Rijeku-SECAP.pdf> (accessed 14.06.2022)
- [25] Zajednički akcijski plan energetske i klimatske održivosti razvitka (JOINT SECAP) Grad Kastav, Grad Opatija, te općine Čavle, Matulji i Viškovo (Joint Sustainable Energy and Climate Action Plan (JOINT SECAP) for towns Kastav and Opatija, and municipalities Čavle, Matulji and Viškovo), 2021; <https://kastav.hr/wp-content/uploads/2021/10/1.-Zajednicki-akcijски-plan-energetski-i-klimatski-održivog-razvitka-JOINT-SECAP.pdf> (accessed 14.06.2022)
- [26] Strategija prilagodbe klimatskim promjenama Grada Poreča – Parenzo do 2030. godine s prvim petogodišnjim planom provedbe (Municipality of Poreč – Parenzo / Climate change adaptation Strategy (2030.) and Action plan), LIFE 2014 – 2020 – Climate Change Adaptation; http://www.porec.hr/sadrzaj/dokumenti/2019_05_29_Strategija_prilagodbe_klimatskim_promjenama_Grad_Porec_Parenzo.pdf (accessed 14.06.2022).
- [27] Strategija i plan prilagodbe klimatskim promjenama Grada Labina (Strategy and plan for climate change adaptation of the city of Labin), LIFE 2014–2020 – Climate Change Adaptation; <http://www.labin.hr/Files/202110/2.1.%20Strategija%20i%20plan%20prilagodbe%20klimatskim%20promjenama%20Grada%20Labina%20.pdf> (accessed 14.06.2022).
- [28] Renewable micro power plant initiative project, <http://ee.fesb.unist.hr/rmppi/en/project/> (accessed 14.06.2022).
- [29] Racz, A.: Međutjecaj klimatskih promjena i turističke djelatnosti – narativni pregled (Interinfluence between Climate Change and Tourism Industry – a Narrative Review), *Journal of applied health science*, 6(1), pp. 91–115, 2020, <https://doi.org/10.24141/1/6/1/10>
- [30] Farid, H., Hakimian, F., Nair, V., Nair, P.K., Ismail, N.: Trend of research on sustainable tourism and climate change in 21st century, *Worldwide Hospitality and Tourism Themes*, 8(5), pp. 516–533, 2016, <https://doi.org/10.1108/WHATT-06-2016-0032>
- [31] Šverko Grdić, Z., Krstinić Nižić, M., Mamula, M.: Povezanost klimatskih promjena i turizma: multikriterijska analiza ocjenjivanja mjera prilagodbe (Connection between the climate change and tourism: the multi-criteria analysis of assessment of adaptation measures), *Ekonomika misao i praksa*, 1, pp. 171–185, 2017.
- [32] Horvat, B.; Karleuša, B.; Delač, D.; Ožanić, N.; Volf, G.; Kisić, I.: [Spektralni indeks NBR kao temelj za procjenu utjecaja opožarenosti površine na otjecajne karakteristike sliva](#) (Spectral index NBR as a basis to estimate burnt area impact on runoff characteristics), 8. Sabor hrvatskih graditelja (8th Congress of Croatian Builders), HSGI, Zagreb, pp. 171–185, 2021.