Nordea

Climate Risk Assessment Report: Croatia

A report commissioned by Nordea Group Sustainable Finance

May 2019

Table of Contents

Authors: S. Beslik and A. Causevic

Cover photo credits: Direktno.hr

Design: H. Nygren

If you questions regarding the content of the report you are welcome to address them to:

Sasja Beslik (sasja.beslik@nordea.com)

List of abbreviations

EU	European Union
EU ETS	European Union Emissions Trading System
FDI	Foreign Direct Investment
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
NATO	North Atlantic Treaty Organization
NGOs	Non-governmental organizations
SDGs	Sustainable Development Goals
SFRY	Socialist Federal Republic of Yugoslavia
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change

Measures

cm	centimeter
km	kilometer
m	meter
mm	millimeter
MW	megawatt
pJ	picojoule
TOE	ton of oil equivalent
km2	square kilometer
m2	square meter
US$	United States dollar
°C	degrees Celsius

Introduction

Executive summary

Since the mid-1990s, climate change has caused negative economic impacts through droughts and floods, especially evident in the agricultural and electricity supply. Being the youngest member state of the European Union (EU), Croatia demonstrated a strong commitment to integrating climate change in its legal and policy frameworks by adopting and implementing relevant laws and regulations. However, more needs to be done for Croatia to become a more climate-resilient country and enhance its preparedness and capacity to respond to the impacts of climate change at local, regional and national levels.

Rationale

To highlight the available evidence that could contribute to the further development of effective strategies, policy documents and action plans with program implementation opportunities to tackle future climate change in Croatia.

Aim

To address the climate change phenomenon as a critical challenge for the socio-economic, business and political stability of Croatia. To examine the main climate risks and analyze threats and impacts of climate change on the economy of Croatia.

Results

More knowledge (i.e. data) is needed to better understand the impacts of climate change in Croatia. Climate risks in the near future will have the strongest repercussions on agriculture and electricity supply sectors. In the long run, sea-level rise could cause tourism infrastructure destruction as well as initiate severe coastal population migration.

Conclusions

To address climate vulnerability effectively, Croatia must improve coordination among the different actors, beginning with stronger climate change discussion among its ministries. Climate change needs to extend beyond the framework of environmental legislation and become an active element in aiding understanding of the causal relationships within the Croatian socio-economic context.

Country context

Socio-economic and political background

Croatia is a high-income country located in the southeast of the European continent, straddling the Balkans and Central Europe. The country is roughly divided into two sections: the coast with over 1,000 islands and islets, and the interior section with high elevation points such as the Dinaric Alps and hilly northern areas of Hrvatsko Zagorje as well as the flat plains of Slavonia in the east, part of the Pannonian Basin. The country borders Bosnia and Herzegovina to the south and the east, Hungary to the north, Serbia to the east, Montenegro to the south and Slovenia to the west. Croatia shares a maritime border with Italy. Overall, Croatia has a moderately warm and semi-rainy continental climate; the coast alongside the Adriatic Sea has a warm Mediterranean climate with hot and dry summers, while the interior has a typical continental climate with regular snowfalls in the winter months.

After Slovenia, Croatia was the second most developed republic in the former Socialist Federal Republic of Yugoslavia (SFRY). The country gained present independence in 1991 after a referendum, which was followed by the Croatian War of Independence 1991–1995, fought mainly between Croats and Croatian Serbs backed by Federal Republic of Yugoslavia (i.e. Serbia and Montenegro). After the war, until the mid-2000s the country experienced the transition period from a socialist to market-based economy that was characterized by high inflation, recession, wide-scale privatization of once state-controlled companies and a rise in unemployment, as well as the steady growth of the gross domestic product (GDP) and an increase in consumption.

The country became a member of NATO in 2009 and the EU in 2013. Today, Croatia has the highest standard of living in its region (alongside Slovenia) and an economy which is led by the services sector (i.e. different economic activities connected to mass tourism), the industrial sector (e.g. food processing and chemical industry) and agriculture (from exports of blue-water fish to the production of fine wines). Manufacturing and tourism are the biggest contributors to GDP, cumulatively accounting for over 30% of the total contribution.[1,2,3,4]

In the future, the country is expected to join the Schengen Area and adopt the euro. Currently, the most significant economic issue in the country is the brain drain trend that caused the outflow of roughly 200,000 qualified workforce individuals since the last population census in 2011. [5,6,7]

Table 1: Main socio-economic and business statistics, 2018

Country map, geographical location within Europe and the national flag	
Capital	Zagreb
Official language	Croatian
Government type	A unitary parliamentary constitutional republic
Area	56,594 km^2
Population	4.1 million
Ethnic composition	90.42% Croats, 4.36% Croatian Serbs, 5.22% others (e.g. Bosniaks, Italians, Albanians, Roma)
Life expectancy at birth	74 years (men), 80 years (women)
Currency	Croatian kuna (HRK)
GDP (current)	US$55.2 billion
Main industries	Chemicals and plastics, machine tools, fabricated metal, electronics, pig iron and rolled steel products, paper, shipbuilding, petroleum and petroleum refining, food and beverages, tourism
GDP by sector	70.1% services, 26.2% industry, 3.7% agriculture
Diaspora contribution to GDP	4.5%
Unemployment	9.4%
Major export commodities	Transportation equipment, machinery, textiles, chemicals, foodstuffs, fuels
Major import commodities	Machinery, transportation and electrical equipment, chemicals, fuels and lubricants, foodstuffs
Major export markets	Slovenia (US$1.69 billion), Italy (US$1.64 billion), Germany (US$1.55 billion), Bosnia and Herzegovina (US$1 billion), Austria (US$863 million)
Major import countries	Germany (US$3.47 billion), Italy (US$2.76 billion), Slovenia (US$2.37 billion), Austria (US$1.73 billion), Hungary (US$1.55 billion)
Average FDI inflow per year (1992–2017)	US$ 1.59 billion
Top five FDI investors (2000–2015)	25% Austria, 15% the Netherlands, 12% Germany, 9% Hungary, 6% Luxembourg
FDI inflow by sector (2000–2015)	33% financial sector, 21% manufacturing, 16% wholesale and trade, 9% real estate, 6% telecommunications, 15% other
Doing business ranking	58/190

Source: Multiple sources, 2000–2018.[8,9,10,11,12,13,14,15,16,17,18]

Role of fossil fuels in the Croatian economy

Croatia is not as heavily fossil-fuel dependent as other republics of the former SFRY, but fossil fuels still play a crucial role in the total primary energy supply. However, the role of fossil fuels as a primary energy supply has been slowly decreasing from 80% in 1990 to 70% in 2014.[19] Simultaneously, the energy intensity level of primary energy has fallen by around 20% since the year 2000.[20] Oil products account for 38%, natural gas for 25% and coal for 8% of the total primary energy supply; renewable energy encompasses 24% and other primary energy supply sources amount to 5%.[21]

In Croatia, natural gas is widely used for the production of primary energy, representing 41%, which is the second highest after the Netherlands with 88% when compared to other EU member states.[22] According to Mladen Ilickovic, Editor-journalist at Croatian Radiotelevision, domestic natural gas production will fall below 15% (from current 40%) until 2025; Ante Cikotic, former Croatian State Secretary for Energy, told Mr. Ilickovic that both domestic natural gas and oil production will significantly fall in the next decade creating a gap in domestic energy supply.[23]

Regarding energy dependence, looking at coal and its derivatives, Croatia's dependence stands at 110% and is again second highest when compared to other EU member states after the Netherlands, whose dependence stands at 111%.[24] Imported coal is used to power internal thermal energy generation facilities.

The country satisfies 21% of crude oil and 75% of natural gas demand from its domestic production, which makes it one of the leaders in the region.[25] Electricity is mainly produced by large hydro (46%), followed by thermal units powered by domestic and imported fossil fuels (39%), renewable energy (8%) and nuclear energy through a power plant co-owned with Slovenia (7%).[26,27,28] Concerning greenhouse gas (GHG) emissions, the most significant contributor is energy at 71%, followed by industry at 12%, agriculture at 11% and waste at 6%.[29]

Croatia has reduced its primary energy supply from fossil fuels and been active in attracting investors to renewable energy projects – especially wind power – but fossil fuels still play a significant role in the local economy and politics. At the time of writing, the most significant ongoing energy project was the Adria liquefied natural gas terminal on the island of Krk.[30]

In addition, the government is under constant pressure from several big oil companies to allow drilling in its Adriatic waters.[31,32] It is important to mention that after five years of campaigning by mostly non-governmental organizations (NGOs) and local communities, the government canceled construction of the 500 MW Plomin C coal thermal power plant in Istria in 2016.[33]

Perception of climate change in Croatia

A study conducted by the United Nations Development Programme (UNDP) in 2008 showed that the Croatian population is well informed about climate-related threats and has a good understanding about the measures necessary to make Croatian society more sustainable in the future. Around 72% of the interviewed individuals stated that climate change is a severe problem, while on the opposite end 2% did not care about the issue at all.[34] In a study conducted by the EU in 2014, climate change ranked as the third most crucial issue for average Croatians (16%), preceded by topics such as poverty (39%) and the economic situation (29%).[35]

Another study piloted by the EU before Croatia officially joined the Union found that just over 35% of Croatians believe they will not be affected by future changes in climate.[36] The United Nations MY World global survey results for Croatia ranked climate change as 11th on the list of 16 priorities.[37] The latest Sustainable Development Goals (SDGs) Index and Dashboard Report ranked Croatia 21st out of 156 in the SDGs implementation process, having a positive climate action performance indicator.[38]

In 2016, Croatian scientists from the Institute for Social Research, the Ivo Pilar Institute of Social Sciences and the Institute for Political Ecology in Zagreb found that Croatian citizens see climate change as an essential global trend that will affect their country in the future, but that the awareness level is below the EU average.[39]
In contrast to the results obtained by the UNDP, this

research showed a prevalent perception among interviewees that the Croatian state is not doing enough to mitigate and adapt to climate change.

Another Croatian study stated that the local population is keen to switch away from fossil fuels but due to an insufficient level of public information they lack the knowledge of how to do so in the most cost-effective manner, thus preventing them from decarbonizing their lifestyles in the long term.[40]

Before joining the EU, Croatia needed to adopt various legislative mechanisms and policy frameworks necessary to align the country with EU environmental standards. The country has therefore taken multiple steps at international, national and regional levels to change laws, sign treaties and implement conventions that support the global fight against climate change. Croatia pledged to cut 80–95% of GHG emissions by 2050 compared with a 1990 baseline.[41] Lastly, it is important to note that Croatia has signed and ratified the Paris Agreement.

Climate change within institutional and policy settings

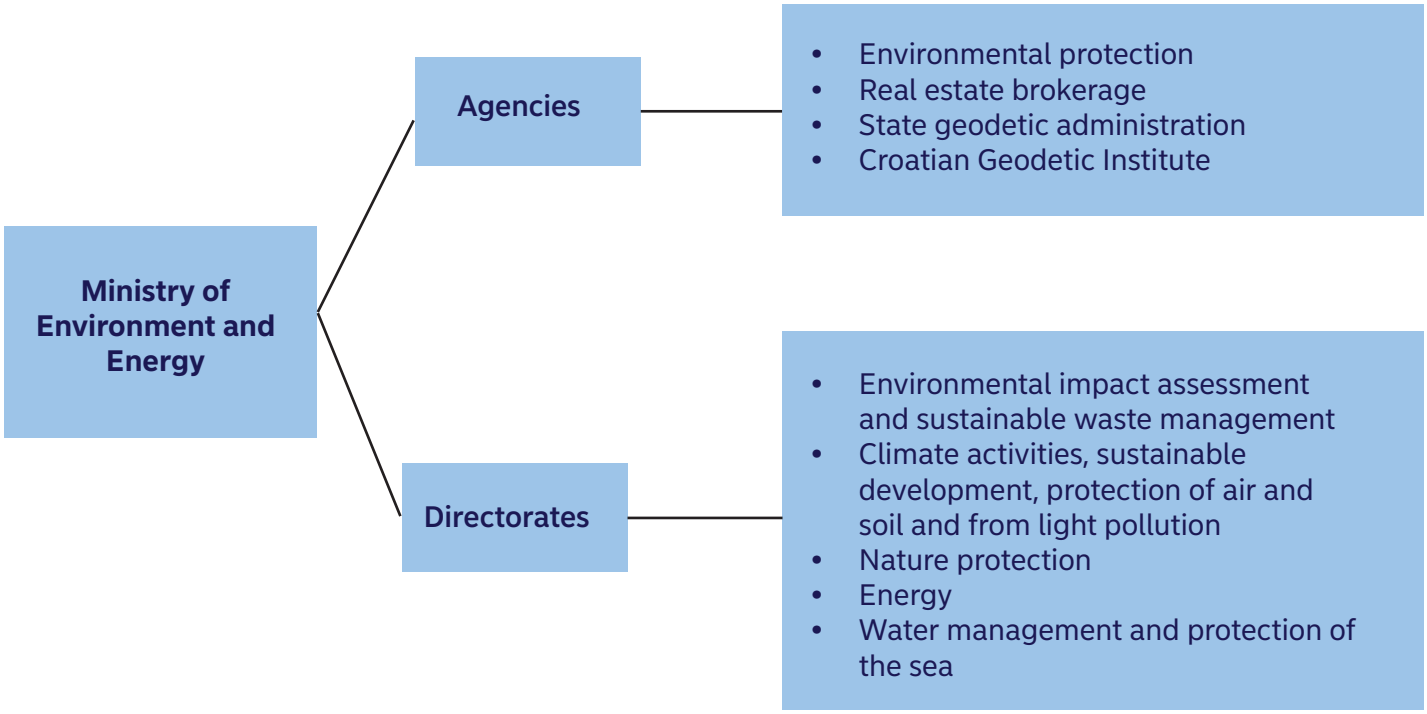
Croatia's Ministry of Environment and Energy is the central government authority in charge of administrative and expert environmental protection activities relating to climate protection. The ministry carries the responsibility for the overall national policy of environmental protection, climate change, reporting on the implementation of policies, measures and emission projections.[42] It has jurisdiction over several agencies and directorates (see Figure 1). Also, the ministry defines and monitors implementation of projects that are aimed at reducing national GHG emissions and improving the overall level of sustainability of the Croatian society.

The Croatian Agency for the Environment and Nature is in charge of organizing the preparation of the inventory of GHG emissions, data collection, development of quality assurance, a quality control plan, and selection of an authorized institution.[44] Besides the Ministry of Environment and Energy, there are other sub-national bodies responsible for active participation in climate action initiatives. For example, the North-West Croatia Regional Energy Agency joined the Paris Pledge for Action movement, an initiative for non-country stakeholders to welcome the Paris Agreement on climate change.[45]

Croatia has been a country with an active policy when it comes to international commitments. Preceding the Paris Agreement, the country fulfilled its obligations under the Kyoto Protocol. This consisted of lowering GHG emissions by 5% over the period 2008–2012 when compared with the 1990 benchmark.[46] In 2009 Croatia adopted the Sustainable Development Strategy that outlined quantified targets such as 20% renewable energy sources by 2020 and 1–2% annual decrease in energy intensity per unit of GDP.[47]

Moreover, when the country became a member of the EU in 2013 it pledged to active involvement in the 2020 Energy Strategy, which aims to reduce member states' GHG emissions by at least 20%, increase the share of renewable energy to at least 20% of consumption and achieve energy savings of 20%. According to Croatia's commitments to the Paris Agreement, the country has pledged to reduce GHG emissions by 30% when compared with the 1990 base year.[48]

Figure 1: Agencies and directorates of the Croatian Ministry of Environment and Energy



Source: Croatian Ministry of Environment and Energy.[43]

In 2017, the country initiated the EU-funded project Strengthening of the Capacity of the Ministry of Environmental and Nature Protection for Climate Change Adaptation with a goal, among other things, of delivering a draft of Strategy on Adaptation to Climate Change.[49] This was considered a critical step in the integration of the climate change topic within institutional and policy settings because the adaptation strategy will institutionalize the framework for implementing all national-level climate change adaptation measures. Being a member of the EU obliges Croatia to be included in the EU Emissions Trading System (EU ETS).[50] EU ETS encompasses a standard cap for 52 facilities from Croatia. Membership of the EU entails an active role for the Croatian government in defining targets, priorities and measures for the reduction of GHG emissions based on the five-year period and in line with the goals laid out in both the 2020 Energy Strategy and the Paris Agreement. Currently, the country is in the process of drafting a Low-carbon Development Strategy by 2030 with a view to 2050 document that is in synchronization with European strategic guidelines and the country's United Nations Framework Convention on Climate Change (UNFCCC) commitments.[51] In total the country has 11 climate laws and 4 climate policies (for more details see Tables 2 and 3).

Table 2: National climate change-related legislative portfolio, 2003–2016

Name of the law	Adoption year	Climate change relevance
Environmental Protection and Energy Efficiency Fund Act	2003	Secures funds for climate change mitigation, renewable energy and energy efficiency.
Forest law	2005	Recognizes the role of forests in mitigating the greenhouse effect and the favorable impact on the climate.
Environmental Protection Act	2007	Mentions climate change mitigation, emissions permits, emissions trading.
Law on biofuels for transportation	2009	Emphasizes commitment to GHG reduction in the transportation sector.
Air protection law	2011	Addresses climate change mitigation, adaptation and protection of the ozone layer.
Energy Act	2012	Includes an act that determines the feed-in tariffs for renewably sourced electricity.
Law on the promotion of clean and energy-efficient vehicles on roads	2013	Aims to reduce carbon dioxide emissions and improve energy efficiency.
Law on energy efficiency	2014	States strong commitment to GHG emissions reduction.
Law on renewable energy sources and highly efficient cogeneration	2015	Delivers an act that promotes efficient use of energy and reducing the impact of fossil fuels on the environment.
Law on renewable energy sources and highly effective cogeneration	2015	Setting up regulatory framework to promote the production of electricity from renewable energy sources and high-efficiency cogeneration, and to create incentives for consuming energy from renewable sources.
Law on the establishment of infrastructure for alternative fuels	2016	Lists aims for decarbonization and improvement of the environmental efficiency of the transportation sector.

Source: London School of Economics and Political Science, 2018.[52]

Table 3: Croatian climate targets

Sector	Targets
Economy-wide	• 80–95% cut in GHG emissions by 2050 compared with a 1990 baseline
Energy	• 12% average energy from renewables, 21% electricity from renewables • 80% energy from renewables by 2050 • 26 pJ energy from biomass by 2020 • 20% heating and cooling from renewables by 2020 • 35% electricity from renewable sources by 2020 • 20% renewable energy sources by 2020 • 13.65 pJ primary electricity from renewable sources by 2020 • 11.15 primary energy consumption TOE, 7% final energy consumption TOE by 2020 • 22.76 pJ energy saved by 2020 compared with an average (2001–2005) scenario • 10% cut in direct energy consumption by 2020 compared with an average (2001–2005) scenario
Transportation	• 10% transportation energy from renewables by 2020
Waste	• 35% cut in biodegradable landfill waste by 2020 against a 1997 baseline

Source: London School of Economics and Political Science, 2018.[53]

When it comes to sectors not listed in Table 3, the latest National Communication document submitted to the UNFCCC in 2018 provides more information for the future national plans of decarbonization in industry, agriculture and land use. The Industrial Strategy of the Republic of Croatia 2014–2020 states that the sector will reduce clinker factor in cement production to 35%, increase recycled glass use in glass production and reduce nitrogen dioxide emissions to 88%.[54] The strategy in agriculture will focus on the sector-wide direct reduction of methane and nitrogen compounds emissions.

The Rural Development Programme of the Republic of Croatia for the Period 2014–2020 stimulates promotion of resource efficiency and encourages the shift to low-carbon farming, resilient to climate changes in the agriculture, food and forestry sectors. This will include implementing measures such as a change in diet of cattle and pigs, improving animal feed quality, improving cattle facilities and systems of animal waste management, and improvement of mineral fertilizer application methods.[55] When it comes to land use, the Ministry of Environment and Energy has defined a specific set of projects designed to improve the calculation of emissions/sinks and establishment of a unique information system for the land use, land-use change and forestry sectors with an aim of improving the overall accuracy of the analysis to strengthen future planning of activities in this sector.[56]

Croatian Science Foundation is the only domestic agency providing finance to climate-related scientific research carried out in close cooperation with local scientific institutions. This agency, utilizing Croatian government funding, supported the Program Encouraging Research and Development in the Field of Climate Change 2015-2016.[57] The funding from this program, among others, financed research projects such as

"Climate Change and Variability in Croatia - From Global Impacts to Local Green Solutions", "Winegrowing and Climate Change in Croatia", and "Climate of the Adriatic Region in its Global Context" all hosted by University of Zagreb's Department of Geophysics Faculty of Science.

In addition to domestic and EU capacities, Croatia has over the years developed strong cooperation with the multilateral organizations focused on providing funding for climate change mitigation and adaptation efforts. The Global Environment Facility (GEF) provided US$127 million in grants for 34 projects that have attracted co-financing of US$484 million since the mid-1990s.[58] Many of the projects financed by GEF had a firm policy and institutional setting with strengthening components, and they ranged from assisting the government with developing a policy framework to enhancing the management effectiveness and sustainability of national protected areas.

Climate change in Croatia

The mean annual air temperature in the lowland area of northern Croatia is 10–12˚C and on the Adriatic coast 12–17°C. Summer temperatures can reach an average of more than 20˚C alongside the coast while during the winter average temperature can drop below 0˚C in the northern parts of the country.[60] Croatia is indeed a country that has sharp characteristics of continental, mountainous and Mediterranean climates. Central Croatia and the Adriatic coast have precipitation between 900–1,000 mm per annum, while at the same time central Adriatic and eastern Slavonia and Baranja have the lowest rates of precipitation, averaging 650 mm per annum.[61,62]

Three characteristics of the changing climate in Croatia are: 1) Overall increase in total average temperature; 2) Decrease in precipitation, although not as radical when compared with the increase of average temperature; and 3) Increase in frequency and intensity of extreme weather events (e.g. droughts, storms).[63] Over the past 50 years, analyzing the climate-relevant data and indicators in the period 1961–2010, the overall air temperature trends indicate the inclinations of average temperature increase in Croatia. The pattern for annual rainfall shows predominant non-significant trends, yet it is essential to mention that statistically significant reduction of precipitation was measured in a mountainous area of Gorski Kotar, the Istrian Peninsula and the southern coastal area.[64]

The Meteorological and Hydrological Service of Croatia conducted state-of-the-art simulations for the period 2040–2070 looking at climate change and its impact on the country based on various scenarios of average temperature increases globally. Their main conclusions of this modeling exercise were that: 1) During the winter, Northern Croatia will experience a warming of 2.5°C while the rest of the country will be warmer, between 2–2.5°C; 2) In spring the temperature will be 1.5°C warmer throughout the country; 3) Summers will have the highest increase in the temperature with 3.5°C in the Northern Adriatic, and average temperature rise in other parts of the country will vary between 3–3.5°C; 4) On average, autumns will be 2.5°C warmer; and 5) Snow cover is expected to decrease by 50% in regions such as Gorski Kotar.[65] Moreover, the country will experience a decreasing trend in precipitation, becoming drier than it is today. A decrease in rainfall will cause further problems in the future because of the decrease in supply of water and (soil) moisture, which is a big problem for the health of the local biosphere and in the long run for domestic agriculture.

Croatia's coast is around 1,777 km long.[66] Therefore, potential future rise of the sea level due to the melting of polar ice sheets will leave certain low altitude parts of the coastal territory exposed. Especially vulnerable is the Neretva river delta, which includes large areas of agricultural land producing crops such as tangerines and mandarin oranges, watermelons, figs and olives.[67] Changing climate will affect the occurrence and intensity of two crucial winds, bora and scirocco (local name: jugo). Stronger jugo winds can inflict severe coastal flooding causing infrastructure damage and act as a major disruptor of ferry transportation between numerous islands and the mainland. In general, extreme winds can disrupt road transportation as well as electricity production and supply.

Croatia is a highly flood-prone country since it is situated in the Danube basin. The flooding trend in Croatia is heavily influenced by the water flow of Sava and Drava rivers. Excluding coastal zones, it is estimated that 15% of Croatian territory is prone to flooding, making poorly planned parts of urban areas (e.g. concrete and asphalt areas and simple sewage systems) extremely exposed, as seen during the floods of 2014.[68,69]

Droughts in the Slavonia region historically affected primarily cereal production and dairy cow yields, as well as irrigation needs of the farms in the Neretva river delta and fruit growers in Dalmatia. Since large hydro is the primary source of electricity in Croatia, more prolonged droughts and the decrease in river flows will have a direct impact on this electricity production. Historically, in terms of the total losses, droughts represent a more significant threat to the country than floods.[70]

Climate change impacts and vulnerability

According to Stanford University's "Economic Impact of Climate Change on The World: Croatia" modeling calculator, the likelihood climate change will, in the future, reduce Croatia's GDP per capita by more than 10% is 48%. A reduction by more than 20% is 37% likely, and a more than 50% reduction is 7% likely.[71] The UNDP estimated that in the course of the 21st century 25% of the Croatian economy (contributing the equivalent of US$10.6 billion to GDP) will be exposed to climate change-induced hazards.[72] Existing climate variability will not only affect the economy but will have a direct impact on human development, exposing the most vulnerable socio-economic groups of society. Climate-related damages to the economy in the period 1980–2013 were roughly around US$4.2 billion but during 2014–2015, when the country was hit by massive flooding, the damages were US$3.21 billion for that period alone.[73,74] A comparison of the period 1980–2013, which includes the war years, against the period 2014–2015 shows the financial impact for each year as the intensity of climate-related hazards increases.

Agriculture and mariculture

When it comes to the agriculture sectors, climate change impacts (e.g. droughts) threaten the yields of major crops such as maize. During 2000–2007, Croatian counties claimed US$1.6 billion in crop damage caused by extreme weather conditions; when calculated on a per annum level this amounts to US$201 million of financial losses to the agricultural sector.[75] The damage from drought, frost and hail predominantly in agriculture for the period 1980–2002 was around US$174 million per year.[76] Another governmental assessment covering the 2013–2016 period estimated that climate-related damage to the agriculture sector amounted to US$436 million.[77] Severe drought conditions in the summer of 2007 led the government to provide farmers with a further US$80 million from the budget in order to help them compensate certain proportions of their losses.[78] The disturbance in the production of cereals had an immediate impact on food prices. Retail prices of milk, bread, eggs and meat all rose.

Additionally, the government declared that the country faced a deficit in corn supply. One doctoral research estimated that by mid-21st century Croatia will produce 35-40% less corn than it did in the beginning of the century.[79] Moreover, since the wine industry attracts significant FDI, the country should consider growing more climate change resilient wine grapes that would grow better in a warmer climate.[80]

At the same time, increased seawater temperature has potential to cause an increased number of invasive species and migration of the current fish stock to cooler northern waters away from the Adriatic.[81] In the period 2011–2018 Croatian fishers recorded 16 new species in their catch, most of them classified as climate migrants.[82] All the recorded species represented a threat to the native species and marine ecosystems. There is a risk that several native species, such as the populations of some edible crustaceans that are a vital food source for various fish, will slowly move away northward from the Croatian waters of the Eastern Adriatic as temperatures increase in the future.[83]

Tourism

Measuring climate change and its impact on local tourism is not as easy as looking at drought impacts on agriculture. However, some of the most popular tourist areas are the most vulnerable to sea-level changes. A great deal of infrastructure necessary for tourists to enjoy the full potential of Croatian tourism is, for example, at risk from coastal flooding if the sea level were to rise.[84] An increase in sea level by 1.8–2 m by the year 2100 would be sufficient to cause severe flooding of historical downtowns in Dubrovnik, Split, Trogir and Sibenik; all of them part of UNESCO World Heritage Sites.[85] When it comes to inland tourism, besides a loss of snow cover in Sljeme ski resort near Zagreb, Plitvice Lakes National Park may face freshwater supply crises due to decreased precipitation and surface runoff.

In general, daytime temperatures along the Adriatic coast will cause many beach tourists to avoid these destinations and switch to locations with lower temperatures. Drier summers with more extreme weather events and a rising sea level may put human and economic development gains at risk. Reduced functionality of various infrastructure systems such as lack of freshwater supply to summer resorts, or deterioration of ecosystems important for tourism and biodiversity due to increase in temperatures, can harm the sector.

For example, in 2015 wildfires caused by high temperatures prompted the municipal government of Dubrovnik-Neretva County to declare a state of emergency. These fires destroyed hundreds of hectares of land, including several small-scale vineyards, which are an essential part of a locally tourist-driven economy.[86] A more recent example was in 2017 when at the height of the tourist season wildfires reached the country's second largest city, Split. The fire destroyed several houses and around a dozen cars were burnt. The government mobilized the military to aid firefighters and police in the effort to contain the fire from spreading into densely populated areas of the city. [87] Currently, there are no measured estimates on the potential impact of climate change on the future of financial inflows from tourism in Croatia. Tourism roughly composes a quarter of the country's GDP while employing a third of the country's workforce, and any climate-induced impact in this sector will be soundly echoed across the entire economy.[88]

Electricity supply

As stated in the earlier part of this report, 46% of electricity is generated by large hydro power plants. In August 2017, the spot price on the Croatian power bourse reached a seven-month high because the country itself, as well as its primary supplier Bosnia and Herzegovina, suffered from a decrease in electricity production due to the summer drought.[89] The drought in 2003, which was the warmest year since 1862, triggered damage to the energy sector that was estimated between US$72–110 million.[90] In its Human Development Report "Croatia 2008 – A Climate for Change" the UNDP estimated that Croatian future hydropower production would probably drop, possibly up to 50%, due to reduced river discharges caused by decreases in precipitation.[91] Furthermore, Croatia as an electricity net importer might suffer from future climate-related loss of hydropower electricity productivity from its main net exporter – neighboring Bosnia and Herzegovina. Correspondingly, Croatian thermal energy generation facilities can be affected by water availability problems and temperature concerns due to a decrease in water supply and high dependence of those power plants for cooling water.[92] Extreme weather events represent a severe problem for the energy infrastructure network (e.g. grid and transformer stations) because the accidents they cause increase energy infrastructure maintenance costs.

Public health

Changing climatic conditions are a key determinant for the spread and impact of infectious diseases such as dengue fever, malaria and cholera. Malaria and dengue fever are insect-borne diseases carried by mosquitos. Also, migratory birds are able to carry avian pathogens (e.g. flu and salmonella) – increasing in frequency with global warming – that can impact both humans and livestock.[93] Research has shown that climate change can be attributed to a continuous increase in vector-borne diseases experienced in Croatia. Several research papers underline the risk of transmitting diseases via mosquitos as the causative agent vector, linking the increasing number of mosquitos with the average increased temperature across the country.[94,95,96]

It is also estimated that in August 2003 during the heat wave, mortality rate was 4% higher due to heat stroke.[97] Zaninovic and Matzarakis (2014) examined the impact of heat waves on mortality in Croatia for the period 1983–2008. They concluded that the continental part of Croatia had higher rates of death than the Adriatic coast and that mortality flows are significantly affected by the duration of the extreme weather events.[98]
Heat waves are particularly dangerous for the elderly and chronically ill people. Extreme weather events cause a higher incidence of cardiovascular risks (from heat waves), change allergic patterns (due to changing pollen counts), stimulate spread of viruses carried by insects and birds (due to increased non-native species migration and more extended warm periods), and can stimulate contamination of food (by an increase in bacteria growth).[99]

Water supply

Increase in average temperature and declining rates of annual precipitation change the sum of evaporation and plant transpiration from the Earth's land and ocean surface to the atmosphere, soil humidity, groundwater recharge and the amount of water flowing through rivers. Croatia is a country with rich and abundant water resources, and these resources are not being considered as a factor that can impede its future development.

Nevertheless, an increase in temperature and decrease in precipitation might exacerbate certain risks in the decades to come. In 2011, Croatia faced one of the most extended droughts in its history, spanning from February to November. The drought was characterized by extremely long duration in the continental region, surpassing the coastal areas, with the highest magnitudes since the beginning of the 20th century.[100] Such long droughts may stress some of the systems that depend upon freshwater. For example, local farmers can suffer from water shortages at certain critical times of the annual growing season. Another sector that might be negatively affected by drought is hydropower electricity generation, which would suffer due to reduced river discharges.

By contrast, the imbalance in the weather patterns caused by climate change can lead to extreme levels of precipitation in shorter periods, causing flood and landslides. In 2014, the Western Balkans region was affected by the worst floods in its recorded history. Although most of the flooding and damage occurred in neighboring Bosnia and Herzegovina and Serbia, Croatia was not spared. In Slavonia 38,000 people were affected, 11,000 evacuated their homes and the agricultural sector suffered US$34 million in damages.[101] The Meteorological and Hydrological Service of Croatia estimated that 4,500 housing units were flooded, of which 30% were destroyed beyond possible repair. The total impact on the economy was US$342 million.[102] The 2014 floods led to higher risk of outbreaks of waterborne diseases due to the possible contamination of water used for agricultural purposes resulting in post-flooding contamination of fruits and vegetables and a massive discharge of sewage systems into flooded water, which has a direct impact on the population in contact with that water.[103]

Sea-level rise

Global warming has raised sea levels by about 20 cm since the end of the 19th century. Looking at the future, global sea levels are expected to rise between 80–200 cm by the end of the 21st century because of large-scale melting of polar ice sheets.[104] In Croatia, the most vulnerable areas to sea-level rise are the Neretva Delta, the Krka River, Vrana Lake near Biograd and the island of Krapanj. The UNDP estimated that if the sea level rose by 50 cm then over 100 million m^2 of Croatian territory would be submerged; the figure rises to 112 million m^2 if that rise in sea level is 88 cm.[105] A study conducted by Peric and Sverko Grdic in 2015 looked at the Croatian scenario with future sea-level rise value of the submerged land, the cost of protection as a result of sea-level rise and the damages caused by the displacement of people due to the loss of land. In a scenario where the sea-level rises by 50 cm, total projected costs amount to US$8.7 billion and in the 88 cm sea-level-rise scenario those costs increase to US$11.4 billion.[106]

Furthermore, they calculated that in the case of 50 cm sea-level increase nearly 100,000 inhabitants on the coast would need to be relocated, while in the 88 cm scenario that rises to around 150,000 people.[107] According to Professor Branko Grisogono of University of Zagreb's Department of Geophysics, future frequency and intensity of meteotsunamis represents a serious threat to inhabitants and infrastructure along the country's Adriatic coast.[108]

Concluding remarks

Global warming is changing the climatic conditions in Croatia. Rising average temperatures since the mid-1990s have been recorded all across the country. Slightly declining rates of annual precipitation have followed an increase in average temperature trends. The country has already experienced various socio-economic impacts caused by climate change-triggered hazards such as drought in 2003 and floods in 2014. At time of writing, the most evident climate impacts had been recorded in the agricultural sector and the supply of electricity. Losses in both can be measured in US$ millions. One of the ways to reduce dependence on hydro power plants would be to invest more resources in the development of renewable energy infrastructure harnessing country's rich solar irradiance potential. A future rise of the average temperature in the country would not only exacerbate losses in the agricultural sector and the supply of electricity, but would seriously harm the population's health, with rising diseases linked to heat waves and an increase in illnesses carried by mosquitos, birds and other organisms.

A slow-moving yet considerable threat is sea-level rise, which could force mass relocation of the population living along the Adriatic coast and could obstruct plans for infrastructure and long-term investments in the affected areas. Higher average daytime temperatures depicted through heat waves and wildfires could have a negative impact on tourism as well as touristic infrastructure. Furthermore, warmer temperatures can lead to a variety of changes in coastal and inland ecosystems directly affecting natural beauty that inspires tourists to visit the country. The political foundation Konrad-Adenauer-Stiftung estimated that future climate change-induced impact on the Croatian economy could be US$1.15 billion since almost 25% of the local economy is based in sectors that would potentially be affected by climate change.[109]

Croatia is a small nation and one of the least developed EU member states. Nonetheless, the country demonstrated a strong commitment to reducing emissions by promoting renewable energy, encouraging energy efficiency and committing to GHG reductions from Kyoto to Paris agreements. Besides the government, there is the right amount of technological and intellectual capacity in Croatia to reduce emissions. Various businesses, NGOs and expert organizations are already engaged. Croatian universities, as well as public institutes, are active in producing both natural and social sciences research in the domain of climate change and its impact on Croatia. Also, the local population has high levels of awareness and concern about the environment and climate change, and there is strong public support to reduce GHG emissions. After all, everyone in Croatia starting from the government, across various businesses and NGOs, to the average Croatian citizen is aware that their country's natural beauty and all the benefits connected to this fact, such as tourism, will be negatively affected in the future if climate change is left unchecked.[110,111]

Becoming a member of the EU helped Croatia to strengthen its national capacities. The membership process imposed the development and integration of climate change into the country's institutional framework and policy setting. Nonetheless, there are still issues that need to be improved to better understand climate change and its significance for the country as a whole. First, many sectors such as mariculture, public health and tourism lack crucial data to estimate the potential impacts of future climate change. Many of the data needed to assess the future damages from climate change are not available. Hence, the research that this data could activate is blocked from being carried out. While doing a literature review for this report, there was a difficulty in quantifying, in monetary terms, climate change impact in the mariculture, public health and tourism sectors.

Second, even though their manifestation has been intensifying from year to year, this report was not able to obtain accurate summaries on both financial and infrastructural damage caused by summer wildfires alongside the Adriatic coast.

Third, climate change needs to acquire better prominence in governmental modeling for the future development of the economy. A stronger connection between climate and economic systems must be established.

Climate change needs to extend beyond the frames of environmental legislation and become an active element in aiding understanding of the causal relationships within the Croatian socio-economic context. The data acquired and presented in researching this report were predominately based on post-disaster stock-taking information. A journal article by Peric and Sverko Grdic (2015) was one of the few documents providing future thinking and damage estimates.

Fourth, climate change is a multi-sectoral issue, and it needs to be understood as such. The Ministry of Environment and Energy may be the primary driver of the action against climate change, but other ministries (e.g. Ministries of Agriculture, Health, Construction and Spatial Planning, Finance and Economy) need to be more actively involved in the topic. For example, at time of writing, the web pages of the Ministries of Finance and Economy, Entrepreneurship and Crafts had no climate change-related documents. Croatian scientific community needs to receive more climate change-focused funding to support their long-term social and natural sciences projects. At the moment their role is limited, as is their potential as a strong and knowledgeable domestic player that could help to better address various climate-related risks.

Finally, besides mitigation efforts that are seen in Croatia's push to reduce the energy intensity level of primary energy and decrease the overall role of fossil fuels as a primary energy supply, the country should devote more attention to adaptation. The present process of drafting a national Strategy on Adaptation to Climate Change is a good start. But more needs to be done to promote adaptation not just in legislative and policy realms, but in concrete on-the-ground projects. In the Croatian context, this can accurately be linked to addressing the adaptation to sea-level rise by protecting the critical socio-economic infrastructure.

These recommendations are not exhaustive but are based on consistent facilitators and barriers identified across information included in this document, which was desk analysis research supported by literature, available datasets and policy document reviews. They form critical starting points in leveraging the approaches to better understand Croatia's climate risk assessment by quantifying past and present climate impacts, evaluating institutional and policy settings, and identifying gaps to deliver recommendations for improvement.

Acknowledgments

The authors would like to thank the following people for valuable comments and inputs during the research process:

Branko Grisogono,
Professor, University of Zagreb, Department of Geophysics, Croatia

Matija Hlebar,
Sustainable Development Manager, Podravka, Croatia

Mladen Ilickovic,
Sustainability Editor-journalist, Croatian Radiotelevision, Croatia

Alen Soldo,
Professor, University of Split, Department of Marine Studies, Croatia

Endnotes

[1] Nordea. "Country profile Croatia." https://www.nordeatrade.com/en/explore-new-market/croatia/economical-context.
[2] World Travel and Tourism Association. "The Economic Impact of Global Travel and Tourism 2018: Croatia." https://www.wttc.org/-/media/files/reports/economic-impact-research/countries-2018/croatia2018.pdf.
[3] The Economist Intelligence Unit. "Croatia." http://country.eiu.com/Croatia.
[4] Jurun, Elza, and Snjezana Pivac. "Comparative regional GDP analysis: case study of Croatia." *Central European Journal of Operations Research* 19, no. 3 (September 2011): 319-335.
[5] European Commission. "Country Report Croatia 2018." https://ec.europa.eu/info/sites/info/files/2018-european-semester-country-report-croatia-en.pdf.
[6] Ilic, Igor. "Labor shortage compounds Croatia's struggle to catch up to western Europe." Reuters. https://www.reuters.com/article/us-croatia-workers-analysis/labor-shortage-compounds-croatias-struggle-to-catch-up-to-western-europe-idUSKBN1O41WO.
[7] Croatian Bureau of Statistics. "Statistical Yearbook of the Republic of Croatia 2018." https://www.dzs.hr/Hrv_Eng/ljetopis/2018/sljh2018.pdf.
[8] British Broadcasting Corporation. "Croatia country profile." https://www.bbc.com/news/world-europe-17212572.
[9] The Heritage Foundation. "2019 Index of Economic Freedom: Croatia." https://www.heritage.org/index/country/croatia.
[10] Croatian Bureau of Statistics. "Population by Ethnicity, by Towns/Municipalities, 2011 Census." https://www.dzs.hr/Eng/censuses/census2011/results/htm/E01_01_04/e01_01_04_RH.html.
[11] The World Bank Group. "The World Bank in Croatia." https://www.worldbank.org/en/country/croatia/overview.
[12] The World Bank Group. "Personal remittances, received (% of GDP): Croatia." https://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS?locations=HR.
[13] Central Intelligence Agency. "CIA Factbook: Croatia." https://www.cia.gov/library/publications/the-world-factbook/geos/hr.html.
[14] Croatian Bureau of Statistics. "Key Figures 2018." https://www.dzs.hr/default_e.htm.
[15] Massachusetts Institute of Technology. "Observatory of Economic Complexity: Croatia." https://atlas.media.mit.edu/en/profile/country/hrv/.
[16] The Global Economy. "Croatia: Foreign Direct Investment, billion dollars." https://www.theglobaleconomy.com/Croatia/fdi_dollars/.
[17] United Nations Conference on Trade and Development. "FDI Statistics." https://unctad.org/en/Pages/DIAE/FDI%20Statistics/FDI-Statistics.aspx.
[18] The World Bank. "Doing Business in Croatia." http://www.doingbusiness.org/en/data/exploreeconomies/croatia#.
[19] The World Bank Group. "Fossil fuel energy consumption (% of total): Croatia." https://data.worldbank.org/indicator/EG.USE.COMM.FO.ZS?locations=HR&name_desc=true&view=chart.
[20] Knoema. "Croatia - Energy intensity level of primary energy." https://knoema.com/atlas/Croatia/Energy-intensity.
[21] Pelkmans, Luc, Branko Vuk, Branka Jelavic, and Biljana Kulisic. "Croatia – 2018 update, Bioenergy policies and status of implementation." International Energy Agency Bioenergy. https://www.ieabioenergy.com/wp-content/uploads/2018/10/CountryReport2018_Croatia_final.pdf.
[22] Bluszcz, Anna. "European economies in terms of energy dependence." *Quality & Quantity* 51, no. 4 (2017): 1531-1548.
[23] Ilickovic, Mladen (Editor-journalist, Croatian Radiotelevision). Interview by A. Causevic. Telephone call. Stockholm, April 29, 2019.
[24] Eurostat. "Energy, transport and environment indicators 2015 edition." https://ec.europa.eu/eurostat/documents/3217494/7052812/KS-DK-15-001-EN-N.pdf/eb9dc93d-8abe-4049-a901-1c7958005f5b.
[25] Franki, Vladimir, and Alfredo Viskovic. "Energy security, policy and technology in South East Europe: Presenting and applying an energy security index to Croatia." *Energy* 90, no. 1 (October 2015): 494-507.

[26] *Ibid*.
[27] CEE Bankwatch Network. "The energy sector in Croatia." https://bankwatch.org/beyond-coal/the-energy-sector-in-croatia.
[28] Republic of Croatia Ministry of Economy, Labor and Entrepreneurship. "Energy Strategy of the Republic of Croatia 2009."https://www.mingo.hr/userdocsimages/energetika/White%20Paper%20Energy%20Staregy%20of%20the%20Republic%20of%20Croatia.pdf.
[29] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[30] Ivcic, Bernard. "Croatian Vision of Fossil Future." Green European Journal. https://www.greeneuropeanjournal.eu/croatian-vision-of-a-fossil-future/.
[31] MacDowall, Andrew. "Croatians 'sleep-walking' into destroying tourism with the Adriatic energy industry." The Guardian. https://www.theguardian.com/world/2015/mar/09/adriatic-coast-oil-gas-exploration-opposition-cherie-blair-summit.
[32] Offshore Energy Today. "Jutarnji: Five oil firms want to drill in Adriatic Sea (Croatia)." https://www.offshoreenergytoday.com/jutarnji-five-oil-firms-want-to-drill-in-adriatic-sea-croatia/.
[33] Energy Transport and Natural Resources. "We stopped the harmful coal project 'Plomin C'!." https://etnar.net/we-stopped-the-harmful-coal-project-plomin-c/.
[34] Landau, Seth, Susan Legro, and Sandra Vlasic. "Human Development Report Croatia 2008: A Climate for Change." United Nations Development Programme. http://hdr.undp.org/sites/default/files/nhdr_2008_en_croatia.pdf.
[35] European Commission. "Special Eurobarometer 409 Climate Change 2014." http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_409_en.pdf.
[36] European Commission. "Special Eurobarometer 300 Europeans' attitudes towards climate change." http://ec.europa.eu/commfrontoffice/publicopinion/archives/ebs/ebs_409_en.pdf.
[37] United Nations. "MY World: Croatia results." http://data.myworld2015.org/.
[38] SDG Index and Dashboards. "Country profile: Croatia." https://dashboards.sdgindex.org/#/HRV.
[39] Ancic, Branko, Jelena Pudak, and Mladen Domazet. "Do we see climate change in Croatia? Research of attitudes on some of the aspects of climate change in Croatian society." *Croatian Meteorological Journal* 51, no. 51 (2016): 27-45.
[40] Pletikosic, Merica. "Public perception of an approach to achieve the goals of climate change policies." Sustainable Development and Planning 7 (2015): 560-570.
[41] European Commission. "Intended Nationally Determined Contribution of the EU and its Member States." https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Croatia%20First/LV-03-06-EU%20INDC.pdf.
[42] Republic of Croatia Ministry of Environment and Energy. "Vision and mission." https://mzoip.hr/en/ministry/vision-and-mission.html.
[43] Republic of Croatia Ministry of Environment and Energy. "Organization of the Ministry." https://mzoip.hr/en/ministry/organization-of-the-ministry.html.
[44] Croatian Agency for the Environment and Nature. "About us (in Croatian)." http://www.haop.hr/hr/o-nama.
[45] Paris Pledge for Action. "Who's joined." http://www.parispledgeforaction.org/whos-joined/.
[46] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[47] Republic of Croatia Ministry of Construction and Spatial Planning. "Strategy for Sustainable Development of the Republic of Croatia 2009." http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/laws/4788.pdf.
[48] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[49] Republic of Croatia Ministry of Environment and Energy. "Draft Action Plan for the period from 2019 to

2023." http://prilagodba-klimi.hr/wp-content/uploads/docs/Draft%20CC%20Action%20Plan.pdf.
[50] European Commission. "The EU Emissions Trading System (EU ETS)." https://ec.europa.eu/clima/sites/clima/files/factsheet_ets_en.pdf.
[51] Sculac Domac, Marija. "Climate Change Policy and Low-carbon Development Strategy in Croatia." Republic of Croatia Ministry of Environment and Energy. http://www.cccp.com.hr/upload_folder/server/php/fotke/marija_sculac_domac_climate_change_policy.pdf.
[52] London School of Economics. "Grantham Research Institute on Climate Change and the Environment Country Profile: Croatia." http://www.lse.ac.uk/GranthamInstitute/country-profiles/croatia/.
[53] *Ibid*.
[54] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[55] *Ibid*.
[56] *Ibid*.
[57] Croatian Science Foundation. "The Foundation secures HRK 17 million for scientific projects in the field of climate change (in Croatian)." https://www.hrzz.hr/default.aspx?ID=2306.
[58] Global Environment Facility. "Country-At-A-Glance: Croatia." https://www.thegef.org/country/croatia.
[59] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[60] Simac, Zavisa, and Ksenija Vitale. "Climate Vulnerability Assessment: Croatia 2012." Network for Climate Change Adaptation – Croatia. http://www.seeclimateforum.org/upload/document/cva_croatia_-_english_final_print2.pdf.
[61] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[62] Croatian Meteorological and Hydrological Service. "Climate of Croatia." https://meteo.hr/klima_e.php?section=klima_hrvatska¶m=k1_4.
[63] Landau, Seth, Susan Legro, and Sandra Vlasic. "Human Development Report Croatia 2008: A Climate for Change." United Nations Development Programme. http://hdr.undp.org/sites/default/files/nhdr_2008_en_croatia.pdf.
[64] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[65] Landau, Seth, Susan Legro, and Sandra Vlasic. "Human Development Report Croatia 2008: A Climate for Change." United Nations Development Programme. http://hdr.undp.org/sites/default/files/nhdr_2008_en_croatia.pdf.
[66] The Miroslav Krleza Institute of Lexicography. "Adriatic Sea and islands." http://www.croatia.eu/article.php?lang=2&id=11.
[67] Simac, Zavisa, and Ksenija Vitale. "Climate Vulnerability Assessment: Croatia 2012." Network for Climate Change Adaptation – Croatia. http://www.seeclimateforum.org/upload/document/cva_croatia_-_english_final_print2.pdf.
[68] *Ibid*.
[69] ReliefWeb. "Floods in Serbia, Bosnia and Herzegovina, and Croatia 23 May 2014." https://reliefweb.int/report/serbia/floods-serbia-bosnia-and-herzegovina-and-croatia-23-may-2014.
[70] Grisogono, Branko (Professor, University of Zagreb). Interview by A.Causevic. Skype call. Stockholm, April 8, 2019.
[71] Stanford University. "Economic Impact of Climate Change on the World: Croatia." https://web.stanford.edu/~mburke/climate/map.php.
[72] Landau, Seth, Susan Legro, and Sandra Vlasic. "Human Development Report Croatia 2008: A Climate for Change." United Nations Development Programme. http://hdr.undp.org/sites/default/files/nhdr_2008_en_

croatia.pdf.
[73] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[74] Landau, Seth, Susan Legro, and Sandra Vlasic. "Human Development Report Croatia 2008: A Climate for Change." United Nations Development Programme. http://hdr.undp.org/sites/default/files/nhdr_2008_en_croatia.pdf.
[75] *Ibid*.
[76] *Ibid*.
[77] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[78] Legro, Susan, Darko Znaor, and Seth Landau. "Climate Change, Agriculture and Development in Croatia." Development and Transition 10, no. 7 (2008): 14-16.
[79] Grisogono, Branko (Professor, University of Zagreb). Interview by A. Causevic. Skype call. Stockholm, April 8, 2019.
[80] *Ibid*.
[81] Glamuzina, Branko, Marlena Cukteras, and Jakov Dulcic. "Present changes and predictions for fishery and mariculture in the Eastern Adriatic (Croatia) in the Light of Climate Change." *Annales Series Historia Naturalis* 22, no. 2 (20vi har ingen 12): 105-114.
[82] Morski Hrvatska. "In the last seven years in the Adriatic, 16 new species of fish have appeared (in Croatian)." http://morski.hr/2018/01/31/posljednjih-sedam-godina-u-jadranu-se-pojavilo-16-novih-vrsta-riba/.
[83] Glamuzina, Branko, Marlena Cukteras, and Jakov Dulcic. "Present changes and predictions for fishery and mariculture in the Eastern Adriatic (Croatia) in the Light of Climate Change." *Annales Series Historia Naturalis* 22, no. 2 (2012): 105-114.
[84] Simac, Zavisa, and Ksenija Vitale. "Climate Vulnerability Assessment: Croatia 2012." Network for Climate Change Adaptation – Croatia. http://www.seeclimateforum.org/upload/document/cva_croatia_-_english_final_print2.pdf.
[85] Reimann, Lena, Athanasios T. Vafeidis, Sally Brown, Jochen Hinkel, and Richard S. J. Tol. "Mediterranean UNESCO World Heritage at risk from coastal flooding and erosion due to sea-level rise." *Nature Communications* 9, no. 4161 (2018).
[86] Joseph, Darrel. "Fire destroys Grgich wines in Croatia." Decanter. https://www.decanter.com/wine-news/fire-destroys-grgich-wines-in-croatia-269297/.
[87] Ilic, Igor. "Croatian firefighters struggle to control the blaze in Split area." Reuters. https://www.reuters.com/article/us-croatia-wildfire/croatian-firefighters-struggle-to-control-blaze-in-split-area-idUSKBN1A21IB.
[88] Peleikis, Julia, Matthias Gratz, and Irena Brnada. "Adaptation to Climate Change in Croatia, Country Brief 2014." Regional Center for the Protection of the Environment. https://www4.unfccc.int/sites/NAPC/Documents%20NAP/Adaptation%20Strategies%20and%20Plans/Adaptation%20to%20Climate%20Change%20in%20Croatia.pdf.
[89] Zuvela, Maja. "West Balkans' energy bills surge as drought curbs hydropower output." Reuters. https://www.reuters.com/article/balkans-power/west-balkans-energy-bills-surge-as-drought-curbs-hydropower-output-idUSL8N1LG2BH.
[90] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[91] Landau, Seth, Susan Legro, and Sandra Vlasic. "Human Development Report Croatia 2008: A Climate for Change." United Nations Development Programme. http://hdr.undp.org/sites/default/files/nhdr_2008_en_croatia.pdf.
[92] Peleikis, Julia, Matthias Gratz, and Irena Brnada. "Adaptation to Climate Change in Croatia, Country Brief 2014." Regional Center for the Protection of the Environment. https://www4.unfccc.int/sites/NAPC/Documents%20NAP/Adaptation%20Strategies%20and%20Plans/Adaptation%20to%20Climate%20

Change%20in%20Croatia.pdf.
[93] Fuller, Trevon et al. "The ecology of emerging infectious diseases in migratory birds: an assessment of the role of climate change and priorities for future research." *EcoHealth* 9, no. 1: 80-88.
[94] Vilibic-Cavlek, Tatjana et al. "An overview of mosquitoes and emerging arboviral infections in Croatia." 36. Jahrestagung der Österreichischen Gesellschaft für Hygiene, Mikrobiologie und Präventivmedizin. https://bib.irb.hr/prikazi-rad?rad=942074.
[95] Klobucar, Ana et al. "Mosquitoes - vectors of arboviruses in Croatia." XX Symposium of Epizootiologists and Epidemiologists. https://bib.irb.hr/prikazi-rad?rad=936176.
[96] Reiter, Paul. "Climate Change and Mosquito-Borne Disease." *Environmental Health Perspectives* 109 (2001): 141-161.
[97] Republic of Croatia Ministry of Environment and Energy. "Seventh National Communication and Third Biennial Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change 2018." https://unfccc.int/sites/default/files/resource/2671905483_Croatia-NC7-BR3-2-96481035_Croatia-NC7-BR3-2-7.%20NC%20i%203.%20BR_resubmission_IX_2018_0.pdf.
[98] Zaninovic, Ksenija, and Andreas Matzarakis. "Impact of heat waves on mortality in Croatia." International Journal of Biometeorology 58, no. 6 (August 2014): 1135-1145.
[99] Peleikis, Julia, Matthias Gratz, and Irena Brnada. "Adaptation to Climate Change in Croatia, Country Brief 2014." Regional Center for the Protection of the Environment. https://www4.unfccc.int/sites/NAPC/Documents%20NAP/Adaptation%20Strategies%20and%20Plans/Adaptation%20to%20Climate%20Change%20in%20Croatia.pdf.
[100] Cindric, Ksenija, Maja Telisman Prtenjak, Ivana Herceg-Bulic, Domagoj Mihajlovic, and Zoran Pasaric. "Analysis of the extraordinary 2011/2012 drought in Croatia." *Theoretical and Applied Climatology* 123, no. 3-4 (February 2016): 503-522.
[101] ReliefWeb. "Floods in Serbia, Bosnia and Herzegovina, and Croatia 23 May 2014." https://reliefweb.int/report/serbia/floods-serbia-bosnia-and-herzegovina-and-croatia-23-may-2014.
[102] Ivancan-Picek, Branka. "Analysis of catastrophic floods affecting Croatia in May 2014." Croatian Meteorological and Hydrological Service. https://www.preventionweb.net/files/38803_sin4768801358gal-8vs4m7sj73jvufatkhk[1].pdf.
[103] Linsak, D. T et al. "The Impact of the Natural Hazard Flooding in East Part of Croatia-Reducing Possible Consequences." Journal of Remote Sensing & GIS 5, no. 1 (2016).
[104] Strauss, Ben, Claudia Tebaldi, and Remik Ziemlinski. "Sea level rise, storms & global warming's threat to the US coast." Climate Central. http://slr.s3.amazonaws.com/SurgingSeas.pdf.
[105] Landau, Seth, Susan Legro, and Sandra Vlasic. "Human Development Report Croatia 2008: A Climate for Change." United Nations Development Programme. http://hdr.undp.org/sites/default/files/nhdr_2008_en_croatia.pdf.
[106] Peric, Joze, and Zvonimira Sverko Grdic. "Economic Impacts of Sea Level Rise Caused by Climate Change." *Tourism in Southern and Eastern Europe 3* (2015): 285-294.
[107] *Ibid*.
[108] Grisogono, Branko (Professor, University of Zagreb). Interview by A.Causevic. Skype call. Stockholm, April 8, 2019.
[109] Lange, Michael A., and Anita Markovic. "Climate Trends and Risks in Croatia." Konrad-Adenauer-Stiftung. https://www.kas.de/c/document_library/get_file?uuid=a4305515-bf1a-524f-6357-3000d6e53f5e&groupId=252038.
[110] Landau, Seth, Susan Legro, and Sandra Vlasic. "Human Development Report Croatia 2008: A Climate for Change." United Nations Development Programme. http://hdr.undp.org/sites/default/files/nhdr_2008_en_croatia.pdf.
[111] Ancic, Branko, Jelena Pudak, and Mladen Domazet. "Do we see climate change in Croatia? Research of attitudes on some of the aspects of climate change in Croatian society." *Croatian Meteorological Journal* 51, no. 51 (2016): 27-45.