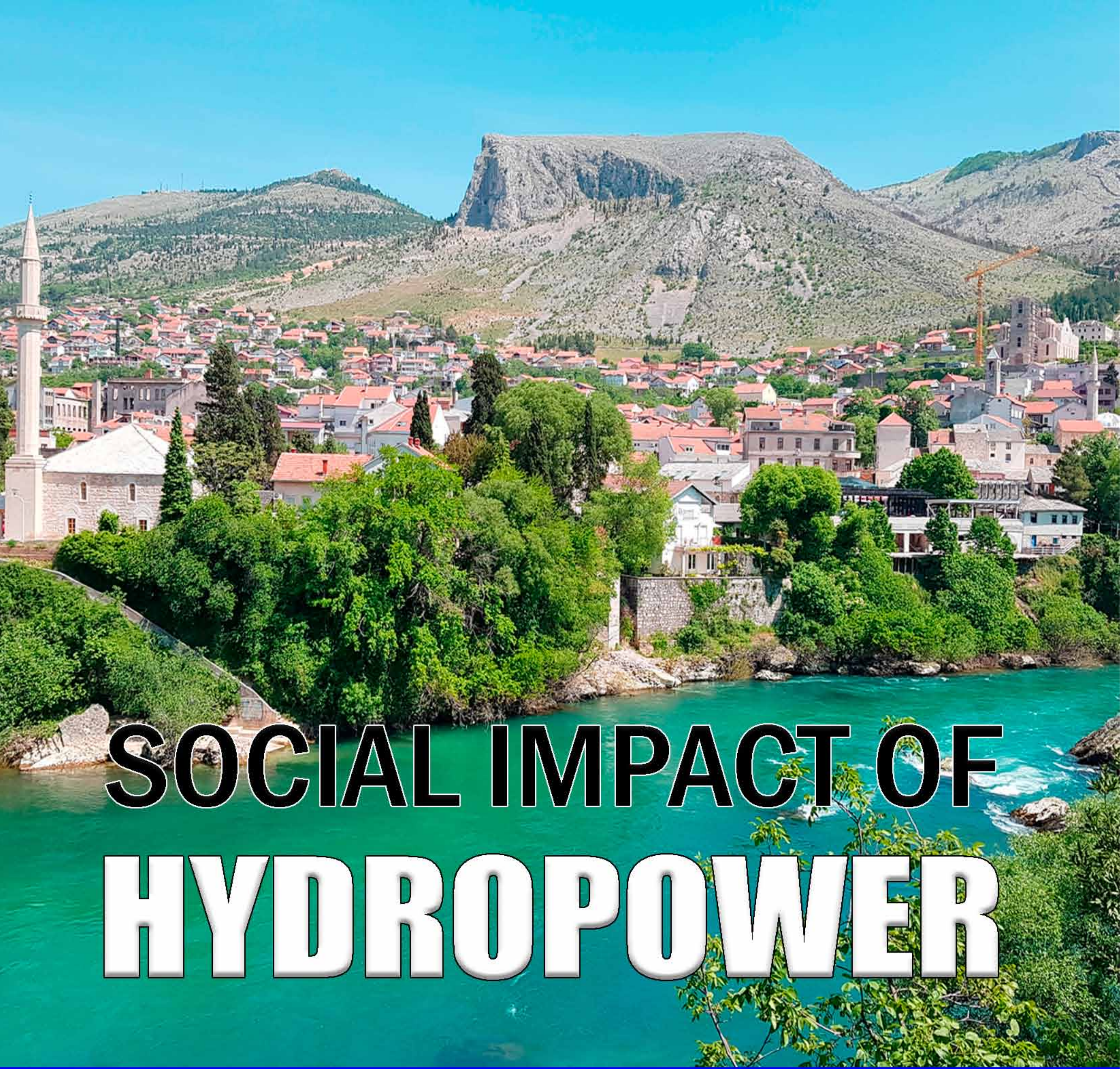


SOCIAL IMPACT OF HYDROPOWER

Quantitative Impact Assessment for the Balkan Countries

RiverWatch

CALTUS INSTITUTE NAMIBIA

euroNATUR

save the blue heart of europe

Manfred Hermsen Stiftung für Natur und Umwelt

SOCIAL IMPACT OF

HYDROPOWER

Quantitative Impact Assessment for the Balkan Countries

Project Duration 01/02 - 31/05/2020
CALTUS Institute Namibia
www.caltusinstitute.org
info@caltusinstitute.org

This publication was produced as part of the “Save the Blue Heart of Europe” campaign (www.balkanrivers.net), organized by Riverwatch – Society for the Protection of Rivers – and EuroNatur – European Nature Heritage Foundation. The study was funded by Manfred-Hermsen-Stiftung foundation.

The findings, interpretations and conclusions expressed in this report are entirely those of the authors.

CALTUS Institute is a young Namibian organization that provides high-quality education and consultancy services in the fields of entrepreneurship, project management, business development and marketing, statistical and geo-spatial analysis, mentorship and capacity building as well as graphics and web-design. Its work enables young Namibian professionals to further develop their skills and contribute to the development of the country.

Acknowledgements
The team of authors from CALTUS Institute Namibia would like to express their gratitude to Dr. Robert Luetkemeier from ISOE – Institute for Social- Ecological Research who acted as voluntary scientific advisor of this project. Furthermore, we would like to thank Dr. Bryan Tilt form Oregon State University for contributing his expertise on social impacts of dams and his valuable feedback on the study design.

Cover Image: The town of Mostar in Bosnia and Herzegovina along the Neretva river. Credit: Theresa Schiller.

Protest action at Rakitnica stream in Serbia on August 15th 2020. Credit: Jovan Đerić

Authors
Jaimaya Mubondo
Enrico Bezuidenhoudt

Content

Abbreviations

EU	European Union
ES	Ecosystem Services
ESIA	Environmental and Social Impact Assessment
GDP	Gross Domestic Product
GIS	Geographical Information System
HPP	Hydropower Plant
IPA	Instrument for Pre-accession Assistance
LAU	Local Administrative Unit
LHP	Large Hydropower Plant
MW	Megawatt
NCP	Nature's Contributions to People
SDG	Sustainable Development Goals
SHP	Small Hydropower Plant
SEE	South East Europe
SES	Social-Ecological System
R	Modelling Software Environment
SII	Social Impact Intensity
SIM	Social Impact Model
TWh	Terrawatt hours
WCD	World Commission on Dams
WWF	World Wide Fund for Nature

Protest against daming the Vjosa river in Tirana. Credit: Besjana Guri, EcoAlbania

Rapuni, Albania. Credit: Bankwatch

Executive Summary

This study carried out a model-based assessment of social impacts from hydropower plants in the Balkan countries. The results provide a first estimate of how many people may potentially be affected by hydropower plants in the countries of Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo, Montenegro, North Macedonia, Serbia and Slovenia. The notion 'potentially affected' refers to the likelihood that rural people may experience changes in their lives and traditional livelihoods due to hydropower development. Though qualitative knowledge on social impacts exists, current Environmental and Social Impact Assessments (ESIA) are considered to rarely account for the inherent complexity, resulting in social impacts to be often narrowly defined and hence, inadequately taken into account during the planning processes.

The study focuses on the Balkan rivers, also known as "the Blue Heart of Europe", with their high ecological value and the essential ecosystem services they provide to the local population. Based on a comprehensive inventory of more than 4,600 hydropower plants (HPPs) that are already operating, currently under construction or planned for the future, we have developed the 'Social Impact Model' that acknowledges the multi-faceted effects of hydropower development on the population. The model incorporates spatial data on hydrological characteristics, population distribution and land use activities and can be applied to the entire region and to each individual country. It serves to derive first estimates of how many people are potentially affected by the large number of hydropower plants in the Balkan region.

To our knowledge, this study is the first of its kind. It does not only focus on social impacts of large hydropower projects but also considers the cumulative effects of smaller plants.

Background

The development of hydropower projects in the Balkan region poses a risk to the region's pristine landscapes and river ecosystems. Hence, biodiversity and rural people's livelihoods are potentially threatened. Changes in ecosystem conditions brought about by

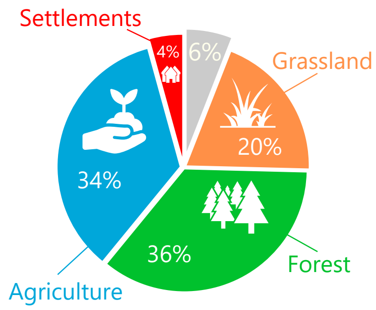


Figure 1b: The proportions of land uses that are impacted by hydro-power plants in the Balkan region.

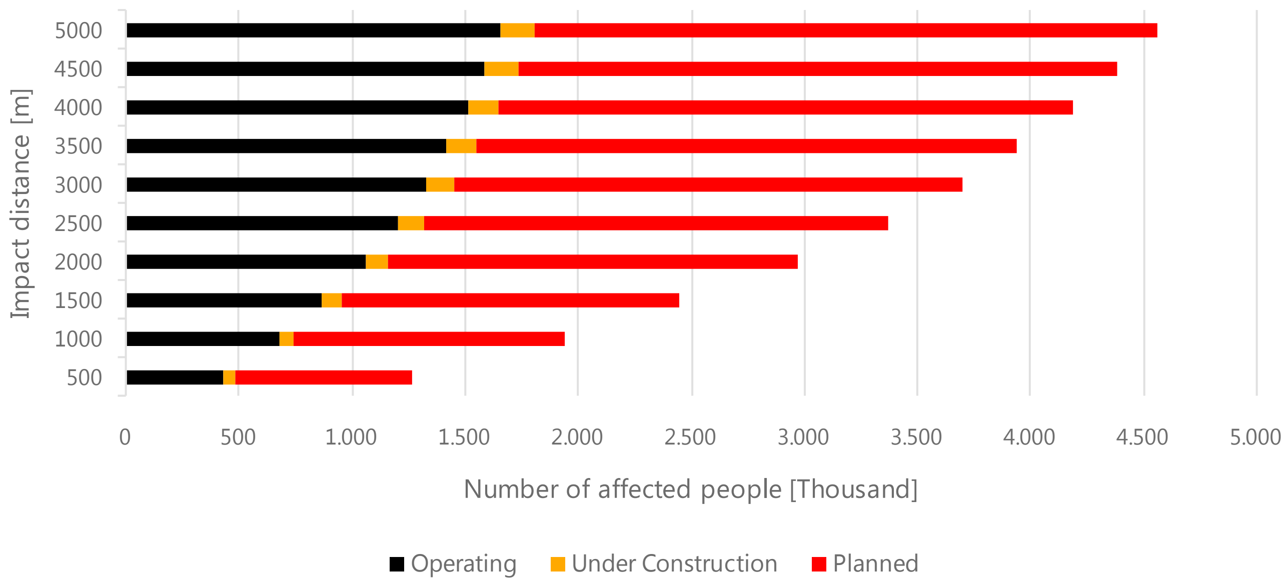


Figure 1a: Potentially affected population by hydropower plants that are currently operating, under construction and planned in the Balkan region. Metrics were obtained from extrapolating the 'Social Impact Model' results.

Protest action at Rakitnica stream in Serbia on August 15th 2020. Credit: Jovan Đerić

hydropower plants alter the natural hydrological regimes. The HPPs divert water, often leaving river beds almost dry and subsequently affecting communities who depend on river ecosystem services. The potential environmental effects can create social impacts that are highly diverse and specific to certain communities and consequently, traditional livelihoods of rural people are likely to change in terms of environmental, agricultural, economic and sociocultural activities.

Key findings

Our 'Social Impact Model' indicates that in the entire Balkan region, 470,000 people are potentially affected by currently operating hydropower plants. This number would increase to about 1.3 million if we assume that all HPPs that are now under construction and planned would go into operation in the future (Figure 1a). This means that about 3% of the 42 million inhabitants of the Balkan region would potentially experience alterations of their livelihoods.

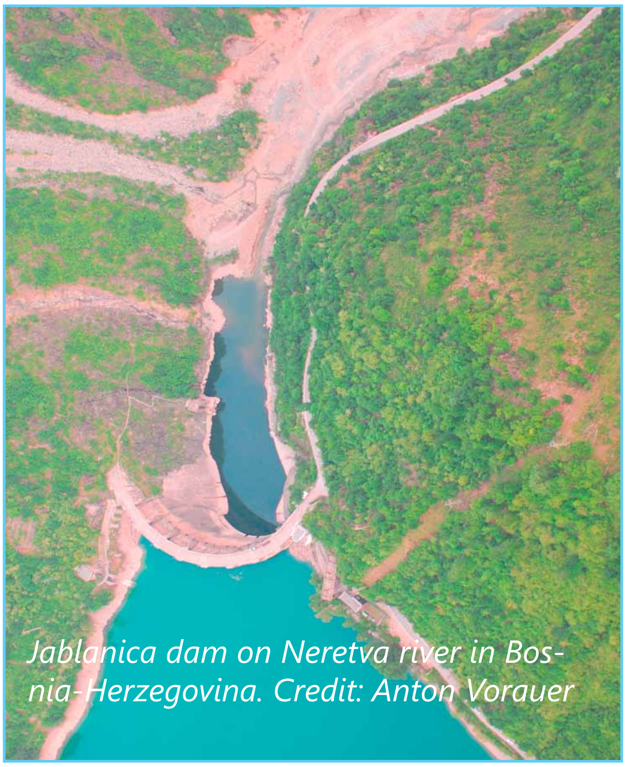
These numbers can be considered as conservative estimates as they represent the number of people who live close to impacted river sections. Assuming that the effects of hydropower development spread into the landscape for a few kilometres, which is likely to be the case especially for larger hydropower plants, the number increases to about 4.6 million people or 11% of the region's total population (Figure 1a).

Furthermore, the results show, as indicated in figure 1b, that 34% of the impacted landscape along rivers that are altered by hydropower plants is used for agricultural activities such as irrigation or livestock watering. Another 56% of the impacted landscape is composed of forests and grass- and shrublands, which constitutes an important natural resource for people who are living in the region's villages as they use it for hunting, harvesting timber, wild fruits and medicinal plants. The Balkan region is well-known for its rich and diverse cultural heritage, that specifically builds upon long-term human-nature interaction. In combination with the region's mountainous landscapes, this is what makes the Balkan countries attractive for national and international tourists who come for hiking, angling, canoeing and experiencing the cultural diversity that is closely connected to the rivers.

Way forward

The 'Social Impact Model' developed in this study is a first attempt to provide quantitative metrics of potentially affected people. Though the model assumptions are built on empirical insights from the scientific literature, the estimates have to be treated with caution due to the general application of the model. Future work is necessary to look deeper into the validity of the presented estimates. Specifically we suggest: (i) further improving the model by incorporating parameters such as altitude and terrain characteristics; and (ii) calibrating the model by empirically assessing the degree of affectedness in the region itself, using first hand data. Nevertheless, we consider our model results to be a reliable first quantitative estimate of the social impacts from hydropower plants in the Balkan region.

"About 1,200 Hydro Power Plants currently operating and another 3,400 plants in the planning or construction phase"



Jablanica dam on Neretva river in Bosnia-Herzegovina. Credit: Anton Vorauer

1. Introduction

European rivers are experiencing an increasing pressure due to human actions resulting in water pollution, changes in flow regimes and river morphology (Grizzetti et al., 2017). The Balkan rivers are regarded as the last free flowing rivers in Europe that offer a tremendous ecological value and are hence considered as the 'Blue Heart of Europe' (EuroNatur and RiverWatch, 2015). Today, however, many of these river lifelines are facing risks due to the rapid development of hydropower plants, especially small facilities with power capacities of less than 10MW (Schwarz, 2019a) as shown in figure 2. This process of hydropower expansion is a global phenomenon with hotspots in the Balkan region, South America, West Africa and Asia, primarily triggered by the socio-political shift towards green energy production (Zarfl et al., 2015). Despite its controversial role in the context of climate

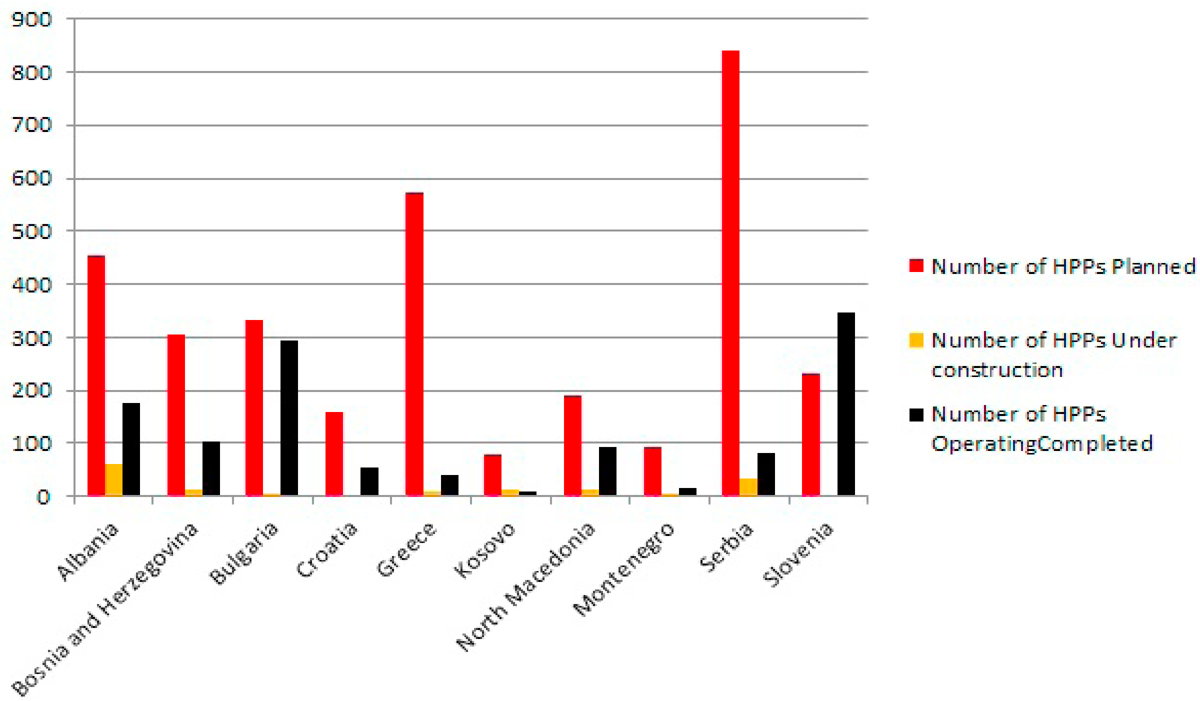


Figure 2. Total number of hydropower plants in the Balkan countries as inventorized by Schwarz 2019b.

Drinjaca river, Bosnia and Herzegovina. Credit: Amel Emric

Kosovo Albanians and Serbs protest against the construction of a hydropower plant, in the village of Donja Bitinja, near Brezovica, Kosovo, 11.10.2019. Credit: Reuters/Laura Hasani

change mitigation (e.g. significant greenhouse gas emissions from reservoirs) (Lu et al., 2020); many European countries pursue hydropower expansion as an energy strategy to become carbon neutral (IHA, 2019). In 2018, Europe produced about 643TWh of electricity from hydropower accounting for 17% of total electric energy produced (IHA, 2019, p. 80). Therefore, hydropower is the most important renewable energy source in Europe with the largest capacities currently installed in Norway, Turkey, France, Italy and Spain (IHA, 2019, p. 79). Schwarz (2019a) found around 30,000 HPPs all over Europe of which around 21,000 currently exist, 8,500 are at the planning stage and around 300 are under construction (Schwarz, 2019a, p. 4).

While hydropower provides energy to industries, the public sector and households predominantly in urban centres, evidence from around the world shows that hydropower plants have impacts on the environment and rural societies in multiple ways (Couto and Olden, 2018; Zarfl et al., 2015). The potential impacts on the environment were already assessed by a large body of scientific literature (Kelly-Richards et al., 2017; Lange et al., 2018; Martínez et al., 2020). Likewise, there are existing studies that have assessed the social impacts of hydropower in qualitative ways to understand the trajectories of influences (Adams, 1985; Jager et al., 2015; Jumani et al., 2017; Colchester 2000). In this context, the 'Dam Impacts Database', maintained by the Oregon State University, provides a huge repository of social impact studies from all over the world (Oregon State University, 2020). However, despite this available knowledge in scientific literature, small hydropower plants rarely undergo comprehensive Environmental Impact Assessments (EIA) or even full Social Impact Assessments (SIA) (Égré and Senécal, 2003; Kirchherr and Charles, 2016). The EIA and SIA would necessitate, the full understanding of the impact which hydropower development is having on the livelihoods of rural societies in terms of economic, social, cultural and health issues that are likely to arise.

Smaller HPPs often follow a 'diversion-scheme' configuration of abstracting water from the original river stream at a certain point and returning it after several kilometres. The river sections between these points are often dewatered and suffer from water shortages especially during low flow periods. The cumulative effect of small hydropower plants (SHP), therefore, may exceed the effect of a single large hydropower plant (LHP) (Jager et al., 2015; Kibler and Tullos, 2013). HPPs are interrupting the river continuum, dewatering river sections and impounding free-flowing rivers, leading to negative impacts on biodiversity, especially on migrating fish species and other aquatic communities (Lange et al., 2018).

This is of particular importance for Balkan countries with their pristine landscapes (Weiss, 2018) and environments of high biodiversity (Milovanovic and Djordjevic-Milosevic, 2016) as well as large proportions of people living in rural settings whose livelihoods are strongly connected to natural resources and ecosystem services (Lampietti et al., 2009; Stojcheska et al., 2016).

The Balkan countries transformed from socialist to market economies in the 1990s and struggled with violent conflicts around the dissolution of Yugoslavia (Dabrowski and Myachenkova, 2018). Until now, a large share of the population has focused on subsistence agriculture with a strong dependence on natural resources and ecosystem services (Lampietti et al., 2009). In particular the importance of river ecosystems for cultural and religious practices as well as their contributions to traditional medicine are critical. For instance, trees along rivers are often sources of traditional medicine that is used to treat diseases and heal wounds (Jarić et al., 2018).

Current inventories of existing and planned hydropower plants for the Balkan region indicate an increasing pressure on rivers. Huđek et al. (2019) found around 600 small HPPs (<1MW) operating in the region and another 1,300 plants being in the planning stage (Huđek et al., 2020, p. 3). Schwarz (2019b) indicated that about 1,200 plants were currently operating and another 3,400 plants were in the planning or construction phases (Schwarz, 2019b). Although most of these hydropower plants are rather small, with a capacity of below 10MW, their large number can have significant impacts on the social and ecological conditions of the region. These impacts may be critically devastating in the Balkan water-dependent ecosystems as many rivers were found to be in a pristine state (EuroNatur and RiverWatch, 2015) and the riparian ecosystems are considered to be sensitive to damming activities (Schneider et al., 2017).

Scientist Bernd Gerken with locals from the village of Kut during the Science Week in 2017 at the Vjosa, Albania. Credit: Gregor Subic

Likewise, hydropower projects that have recently been planned within National Parks can be a critical threat to ecosystem functioning and the attractiveness of nature for tourists (Schwarz 2019a).

Although the qualitative knowledge is available on social impacts from hydropower in general, the question that remains unanswered is: "how many people are actually affected by the foreseen HPP expansion?". This question has proved difficult to answer because the river ecosystems provide a multitude of benefits to society in the form of provisioning (e.g. drinking water, fish), regulating (e.g. flood control, water retention), supporting (e.g. nutrient cycling, soil fertility) and cultural ecosystem services (e.g. recreation, spiritual aspiration) (MEA, 2005). Only few studies have attempted this and tried to estimate the number of people who are potentially affected by the expansion of hydropower generation. However, Richter et al. (2010) has tried to assess the impact of large hydropower plants worldwide (Richter et al., 2010), but no studies are currently available for small hydropower plants, nor for the Balkan region.

Against this background, the current study seeks to assess the number of people potentially affected by hydropower development in the Balkan countries. It follows a spatial approach and develops a semi-automated procedure to provide quantitative estimates for all the countries under consideration in the region and for specific case studies. The term 'potentially affected' refers to the fact that hydropower plants are likely to alter local people's lives and livelihoods in multiple ways (Kirchherr and Charles, 2016). Although positive impacts are sometimes found in temporal employment, flood control and the potential for recreational activities, the body of literature on social impacts rather emphasizes the negative consequences for people (Kirchherr et al. 2016, Kelly-Richards et al. 2017, Mayeda and Boyd 2020, Vanclay 2002). As river flow is altered and increasingly fragmented, numerous ecosystem functions are affected, leading to multiple, often intertwined negative social impacts. This is not least reflected by recent protests in the Balkans, highlighting the fears and concerns of the population about hydropower development (e.g. Armstrong 2020).

"Let me flow!" About 350 people blocked a bridge on the Neretvica river, Bosinia and Herzegovina, on June 1st and prevented the start of construction. Credit: Svjetlana Panic

2. Social Impacts

Hydropower plants alter hydrological and environmental conditions during construction and particularly during operation. These diverse ecological impacts change the ecosystem services which people obtain from river ecosystems and also there are changes in livelihoods for the very people who are living within the proximity of the rivers. Since rural people are utilizing natural resources in diverse ways, the impacts from HPPs on their livelihood, may be positive or negative (Kirchherr and Charles, 2016) and can potentially have effects on the following practices:

- Agriculture: Floodplain and adjacent farming practices for subsistence may be adapted due to changes in water availability (e.g. potential for irrigation, livestock watering), soil fertility (e.g. hampered nutrient provision from changed flooding patterns and increased erosion) and altered biodiversity (e.g. pest control).
- Economy: While short-term employment opportunities may be created during construction works, the tourism sector (e.g. hiking, biking, kayaking) may experience long-term changes (e.g. reduced attractiveness of the 'pristine environment', new opportunities due to 'new lake landscapes'), resulting in altered opportunities for economic activities (e.g. hunting, fishing, water sports and other outdoor activities).
- Health: The changes in hydrology and ecosystems may affect the availability of non-timber forest products (e.g. medicinal plants), may support new disease vectors (e.g. mosquito-related due to standing water) and may change the level of flood protection. In addition, the potential for local recreation may be altered.
- Culture: Alterations in the environment may potentially affect peoples' aesthetic and spiritual satisfaction. Traditional celebrations that are closely connected to the environment and provide symbolic identification with 'home' may be impaired.

The following sub-sections will provide an overview on the socio-economic background of the Balkan region in order to carve out potential livelihoods impacts.

2.1. Socio-economic transformation

Most of the countries under consideration in this study were part of Yugoslavia except for Albania, Greece and Bulgaria. The socio-economic transformation from socialist to market economies by the beginning of the 1990s was an unprecedented change for all Eastern European countries, resulting in a turbulent economic and societal decade (Roaf et al., 2014). The Western Balkan countries struggled with violent conflicts around the dissolution of Yugoslavia, which resulted in casualties and further hampered the transformation to market economic conditions (Dabrowski and Myachenkova, 2018; Farkas, 2017). Since the 2000s, however, global economic development and prospects towards EU-memberships resulted in rapid development. Economic indicators for this period show increasing income levels and reductions in poverty rates and thus a tendency towards convergence with other EU member states (Dabrowski and Myachenkova, 2018). This process was, however, stronger for those Balkan countries that became members of the EU (Farkas, 2017; Roaf et al., 2014). With the financial crisis around 2008, most Balkan countries experienced an economic downturn with lower growth rates and rising poverty levels (Dabrowski and Myachenkova, 2018). Today, the EU is the most important trade partner for all Balkan countries, strongly linking their economic development to that of the European Union member states. Therefore, current economic conditions can be considered as favorable again, though the region is still volatile to disruptive events (World Bank Group, 2019), such as the Corona pandemic that is currently slowing down economies worldwide. According to the World Bank Group (2020), the region's growth in Gross Domestic Product (GDP) for 2020 may contract between 3 and 5.7%, depending on the magnitude and the duration of the COVID-19 outbreak in Europe (World Bank Group, 2020). The region has adopted measures to cushion the economic and social impacts among the people, but limited fiscal buffers turn out to be a major constraint.

2.1.1 Agricultural sector

Closely linked to the overall economic development of the region is the role of the agricultural sector in most Balkan countries that remains a major backbone for people, especially in rural areas. Small-scale subsistence agriculture is dominant in these areas with small farm sizes of less than 5 hectares (Lampietti et al., 2009; Stojcheska et al., 2016). During the initial transition period, people focused on subsistence agriculture due to macro-economic uncertainty (Latruffe et al., 2008). Volk (2010) asserts that in 2008, between 6.4 to 13.2% of the countries' workforce was engaged in agriculture, forestry and fishery while these numbers only present the official statistics. The proportion of people being active in small-scale family farming is considered significantly higher (Volk, 2010). Compared to other EU member states, farm sizes are smaller and the share of family farms is higher (EUROSTAT, 2019). Major crops grown are cereals that cover between 40 and 65% of the arable land with additions of vegetables and fruits. In addition, a wide range of livestock farming is practiced for beef and milk production but also pigs, sheep and goats play a role for local farming communities (Volk, 2010, pp. 2–3).

Neretva River in Mostar, BiH. Credit: Theresa Schiller

Confluence of Krupa and Zrmanja Rivers, Croatia. Credit: Goran Safarek

A Bridge hangs over almost dry Rapuni River . Credit: Pippa Gallop

Share of urban population over time

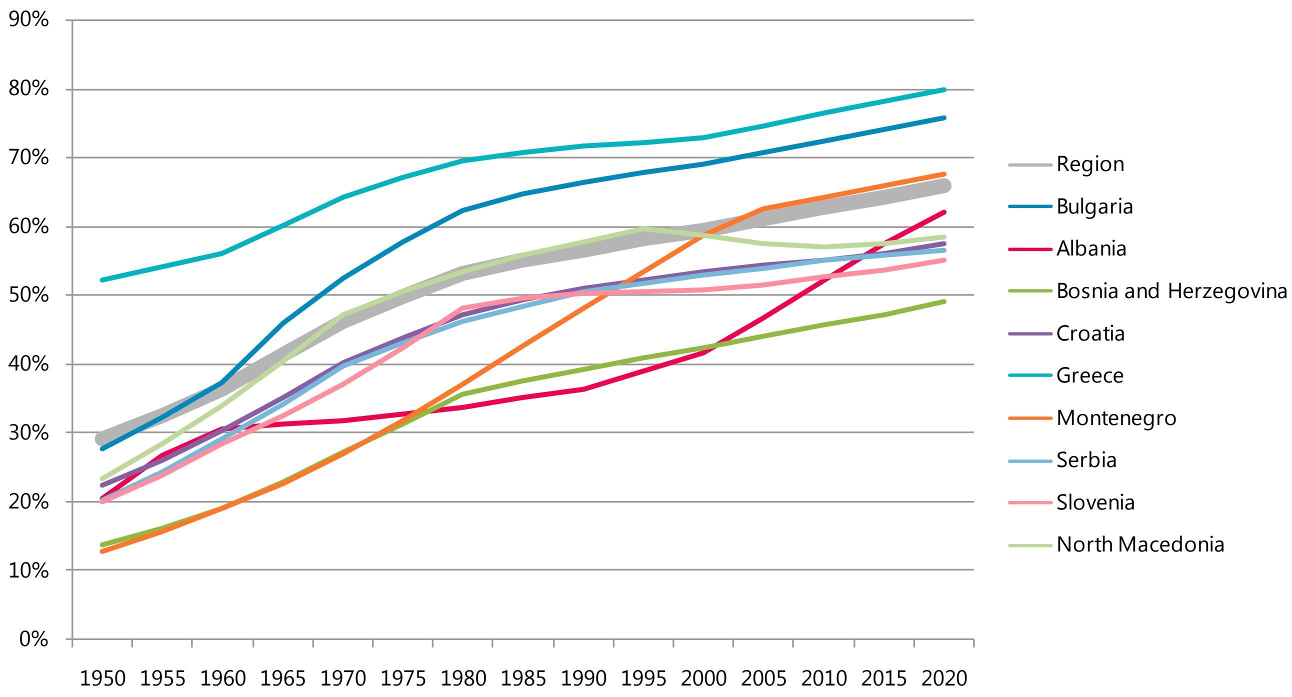


Figure 3: Share of urban population over time (UN-DESA, 2018).

"Cultural ecosystem services are regarded as equally important when evaluating the contributions of nature to people"

2.1.2 Rural-urban migration

The structure of the agricultural sector is considered as one of the reasons for rural-urban migration patterns (Stojcheska et al., 2016), which can be recognized in national statistics that present the proportion of urban and rural population sizes. Figure 3, presents time series data for the study region (except Kosovo) on how the level of urbanization changed since 1950. All countries show an increase in urban population of varying pace. On average, the level of urbanization increased to about 66% today, which is still about 10 percentage points below the average urbanization level of the European Union member states. The statistics, however, deviate among the countries with

Wild rivers symposium rafting. credit: Nick St. Oegger.

Villagers of Kut, Vjosa river. credit: Ulrich Eichelmann

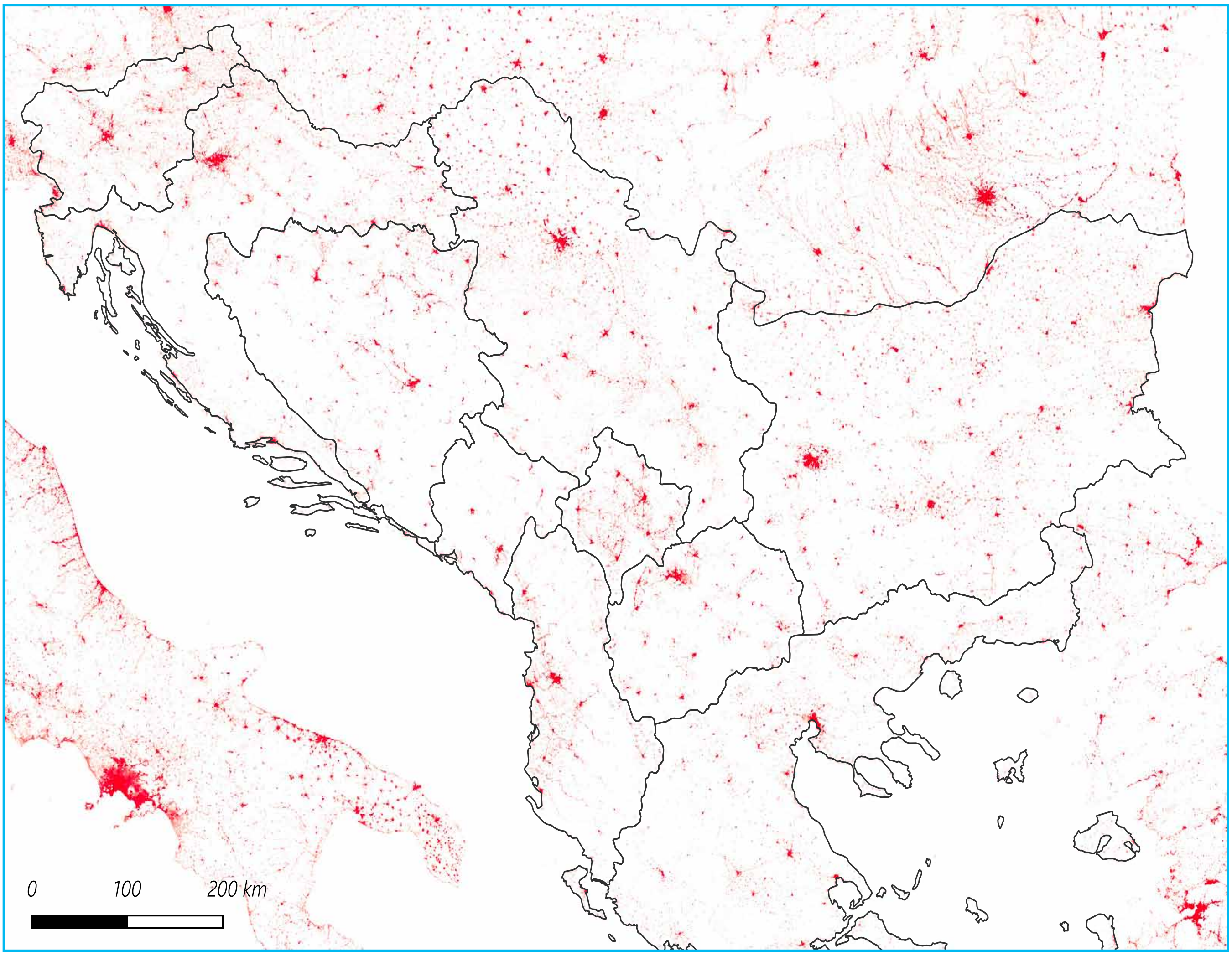


Figure 4: Population in the study area presented on a raster grid of 250m spatial resolution (GHSP, 2020).

Bosnia and Herzegovina only showing an urban population of about 49%, while Greece even exceeds the average value of the EU with 79% (UN-DESA, 2018).

One key feature of the region and a result of the 'rural-urban' migration process is the growth of large urban centres. This can be seen in Figure 4, that depicts the population density with a high spatial resolution of 250 metres (GHSP, 2020). For all countries in the study area, their respective capital cities can be easily identified as the largest agglomeration within the country borders. Among these capital cities, smaller towns can be identified but the general pattern of one large city and multiple smaller ones persists. This confirms the above-mentioned data of a large share of the population living in low density regions of the countries. This prevalence of rural areas receives the attention of national governments and particularly of the European Union as the EU is funding potential member states under its 'Instrument for Pre-accession Assistance' (IPA) scheme (European Commission (EC), 2019; Vujicic et al., 2012).

Overall, the rural population in the study area still makes up a significant share of the total population and so nature-dependent livelihoods prevail. However, the development of hydropower projects may foster the urbanisation process due to induced livelihood changes in rural areas. Ledec & Quintero (2003) assert that involuntary displacement of people is often the main adverse social impact.

Against this background, various protest events could be recognized in the past months. For instance, community members from Rakita village in southeastern Serbia protested together with activists against the installment of a HPP at Rakita river (Armstrong 2020).

2.1.3 Water management

Generally, water management in all Balkan countries remains a critical issue. For a well-founded overview on the countrys' specific challenges in water management as well as key characteristics of the hydrological conditions, the interested reader is referred to a recently published book by Negm et al. 2020. The authors highlight some key challenges for the region such as the need for an expansion of water supply and sanitation infrastructure as still, full coverage of these services is not achieved (Negm et al., 2020). Recent statistics from the United Nations Sustainable Development Goals (SDG) monitoring service confirm this. While most countries can provide safe access to drinking water for more than 90% of their population (except Albania with only 69% in 2015), access to safe sanitation is still low. In this regard, only around one fourth of the population in Serbia and Bosnia and Herzegovina has access to safe sanitation services. For some countries (Montenegro, North Macedonia and Kosovo) no figures were even available (Ritchie et al., 2018). Alongside the water and sanitation challenge, Skoulikidis (2009) outlines the increasing demand for irrigation water in agriculture that may put an additional pressure on the limited water resources in the future (Skoulikidis, 2009).

2.1.4 Tourism sector

The tourism sector is quickly evolving. Compared to 2017, all Balkan countries saw a strong increase in tourist arrivals of up to around 16% in Albania in 2018 (UNWTO, 2020). Tourist attractions are for instance the mountainous regions of Albania, Kosovo and Montenegro which show great potential for offering hiking experiences to tourists (Lehmann and Gronau, 2019) as well as the rich and diverse cultural heritage of the region (Kudumovic, 2020). While the region offers high potential for a range of tourist attractions and experiences such as sport fishing, kayaking, camping and culinary enjoyment, further options may exist in expanding 'agri-tourism'. In this regard, smallholder farmers have the opportunity to provide international tourists with experiences in farm life including accommodation, catering and the sale of local handicraft products (Lampietti et al., 2009).

A man standing next to the water driven millstone that can not run anymore because of lack of water. (Source: Bankwatch)

2.2. Impacts on local livelihoods

Impacts on society from hydropower development may occur during the planning, construction and operation phases. In this study, we particularly consider those impacts that occur from HPP operations as these particularly alter hydrological and environmental conditions, which thus create social impacts on livelihoods of the rural population.

Hydropower plants interfere with the hydrological and adjoining (eco-) systems in multiple ways leading to various ecological impacts. Dams are often constructed with a focus on key functions that should be maximized as for instance energy production, flood control, navigation, drinking water and irrigation provision (Zarfl et al., 2015). With the maximization of these services, ecosystems are being altered or changed completely with significant impacts on biodiversity (Lange et al., 2018). Grilli et al. (2016) conducted an expert survey on the potential impacts of large and small hydropower plants in the Alpine region. They found negative impacts of HPPs on forestry and agricultural products, water supply, air quality, habitat quality and landscape aesthetic (Grilli et al., 2016). Huđek et al. (2019) criticize the lack of official monitoring stations in the vicinity of HPPs, wherefore their impact on river flow, fish and macro invertebrates is difficult to assess (Huđek et al., 2020). The International Energy Agency (2000) categorizes the impacts of small and large hydropower plants on environmental systems along (i) the prevention of fish migration, (ii) the loss of terrestrial habitats, (iii) the changes in water quality and (iv) the modification of water flow (IEA, 2000). Small hydropower plants are often preferred over larger ones as i.a. their ecological impacts are regarded as small. Their cumulative effects, however, may even surpass the impacts of large hydropower plants (Benejam et al., 2016). In this regard, most of SHPs do not create large reservoirs but divert water from the main reach towards powerhouses from where the water is returned back to the main river. Hence, the major impacts exist in the residual flow reaches between the point of abstraction and the point where water is returned. These impacts include (i) reduced discharge and dewatered river sections, (ii) altered sediment deposition and nutrient cycling as well as (iii) changed fish and invertebrate communities (Lange et al., 2018).

If these ecological impacts are taken as background information and a more comprehensive perspective on hydropower impacts is taken, HPPs affect societies in various ways as the primary ecological impacts of e.g. river flow alterations, fish migration prevention and flooding may have impacts on people who live from river ecosystems. Studies are available that carved out various aspects of social impacts from hydropower. For instance, Richter et al. (2010) conducted a study on LHPs worldwide and their impact on the riparian population. They used broad assumptions on e.g. impaired food security of the population and conducted a spatial analysis to provide a population count of potentially affected people (Richter et al., 2010). Jumani et al. (2017) worked on social impacts in a case study in India in which they tried to assess the social consequences of dams. They found increased incidences of Human-Elephant Conflicts as the SHPs altered the riparian vegetation wherefore elephants searched for new habitats that consequently overlapped with human settlements (Jumani et al., 2017).

Boat tour on Vjosa river, Albania. Credit: Nick St. Oegger.

2.2.1 Social-ecological systems

Social-ecological systems (SES) approaches are increasingly being considered in science and practice to account for these kinds of complex problems in which multiple societal actors and a range of ecosystem functions are included (Liu et al., 2007; Mehring et al., 2017; Ostrom, 2009). Within these systems, the concept of ecosystem services gained popularity in the past decades to translate ecological processes and their alterations into benefits to or negative outcomes for society (Daily, 1997). Therein, ecosystems provide a range of services to society in the form of provisioning, supporting, regulating and cultural services that underpin people's well-being (MEA, 2005). More recently, the concept of 'Nature's Contributions to People' (NCP) took off that builds upon the ecosystem services narrative but more specifically highlights the need to consider people's needs and desires as well as traditional and local knowledge systems when assessing the role of nature for people (Díaz et al., 2018).

2.2.2 River ecosystems

River ecosystems provide a range of ecosystem services to societies and numerous scientific studies have been conducted to assess and even value them. For instance, Espécie et al. (2019) conducted a comprehensive literature review on how renewable power generation may influence the ability of landscapes to provide services to society (Espécie et al., 2019). Likewise, Briones-Hidrovo et al. (2019) carried out a case study in Ecuador on the hidden costs of hydropower development on ecosystem services levels (Briones-Hidrovo et al., 2019). In the European context, Grilli et al. (2016) assessed ecosystem services levels as influenced by the expansion of renewable energy techniques in the Alpine region via an expert-based survey (Grilli et al., 2016). For the Balkan region, Ioana-Toroimac et al. (2020) assessed the perceptions of river ecosystem services among youths and found a significant lack of knowledge on which services people derive from river ecosystems (Ioana-Toroimac et al., 2020). Similarly, Weber et al. (2017) conducted a study on how rivers and streams are perceived and reproduced in the media landscape. They found a predominance of provisioning ecosystem services with a focus on water quantity and quality as well as fish and vegetation issues associated to rivers (Weber et al., 2017).

As a brief but still comprehensive introduction to the range of ecosystem services that rivers provide to society, Yeakly et al. (2016) compiled a preliminary list of services, depending on the specific location along a river stream (Yeakley et al., 2016). For instance, provisioning ecosystem services such as water for domestic purposes (public water supply) or agricultural use (irrigation) are relevant benefits people primarily receive especially in lower reaches of streams when larger floodplains are created that provide high-fertility soils for agriculture and where population densities increase. Upstream, provisioning services are rather associated to the use of naturally high-quality drinking water and aquatic organisms that may be utilized either for consumption or for medical purposes. The latter being an important and often neglected aspect of the potential of medicinal plants that are water-dependent and thus only found along rivers (Rexhepi et al., 2013; Tsioutsiou et al., 2019) that may be at risk of drying due to altered discharge patterns (Jarić et al., 2018). Regulating ecosystem services can be found in the natural ability of riparian wetlands to buffer floods and provide an adequate river discharge all year round. Furthermore, they are responsible for local climate regulation and the maintenance of water quality due to their filtration capacity. Supporting ecosystem services from rivers can be specifically found in their role of habitat creation for certain species as well as the replenishment of soil fertility during regular flooding events.

2.2.3. Cultural ecosystem services

While these first three categories provide a comprehensive picture of how rivers support people in terms of their physical needs, an important ecosystem services category goes beyond the material benefit. Cultural ecosystem services are regarded as equally important when evaluating the contributions of nature to society. When viewing and experiencing a landscape, people obtain a non-material value and find enjoyment in doing this. Hence, cultural ecosystem services may span the field of traditional food and belief systems as well as religious practices. They also cover the more tangible benefits of recreational value in hiking, angling and kayaking. In other words, multiple benefits arise that support people along a river both in their aesthetic satisfaction but also in terms of the economic benefit they may obtain e.g. by offering touristic experiences to others.

Research uncovered that the decision for hydropower plant constructions and their operations often violates the rights of the local indigenous communities who rely on free-flowing rivers to preserve their cultural identity and way of life (Dye, 2019). As a result, community members end up giving away historic locations where their cultures have been formed and nurtured. Cultural heritage assets that are threatened by HPPs can be found in (i) underground remains of significant historical importance and (ii) buildings or places of cultural, spiritual or religious meanings, created or used by recent/current generations (cemeteries, places of worship, symbolic markers, etc.) (Cernea, 2004).

Against this background of ecosystem services and benefits people may obtain from a river landscape, the ecological impacts of HPPs can be translated into the social dimension. Here the assumption is that in their pristine or current state, the river system in the Balkan region provides rural people who live along the streams with adequate levels of ecosystem services. If hydropower plants are built, these will disrupt the environmental system to a certain extent. The alterations of river system characteristics will then have an effect on ecosystem service levels that people normally obtain and thus, we consider those people as 'potentially affected'.

Dry bed of the Ribnica River, Podgorica, Montenegro Photo: Paul McClure, www.flickr.com

3. Methods

This study seeks to generate a first estimate of the number of potentially affected people in the ten Balkan countries. Since a quantification of social impacts has rarely been done before, this study takes up previous approaches (e.g. Richter et al. 2010) and further develops these to generate a reproducible and semi-automated procedure that primarily builds upon statistical and spatial data. The study hence constructs a basic model and outlines opportunities for future developments and improvements. The following sections will provide a brief introduction to (i) the 'Social Impact Model' (SIM) developed, (ii) its application to the comprehensive inventory on current and future HPPs in the region (Schwarz, 2019b) and (iii) the limitations of the study. For more detailed information on the methods applied, the interested reader is referred to section 6 at the end of this report.

3.1. Social impact model

While a large body of scientific and grey literature assessed the social impacts of HPPs in a qualitative manner based on detailed case studies (section 2.2), only few attempts were made to estimate the number of people potentially affected by hydropower projects. Only Richter et al. (2010) approached this challenge and quantified the social impacts from the 7,000 largest dams worldwide,

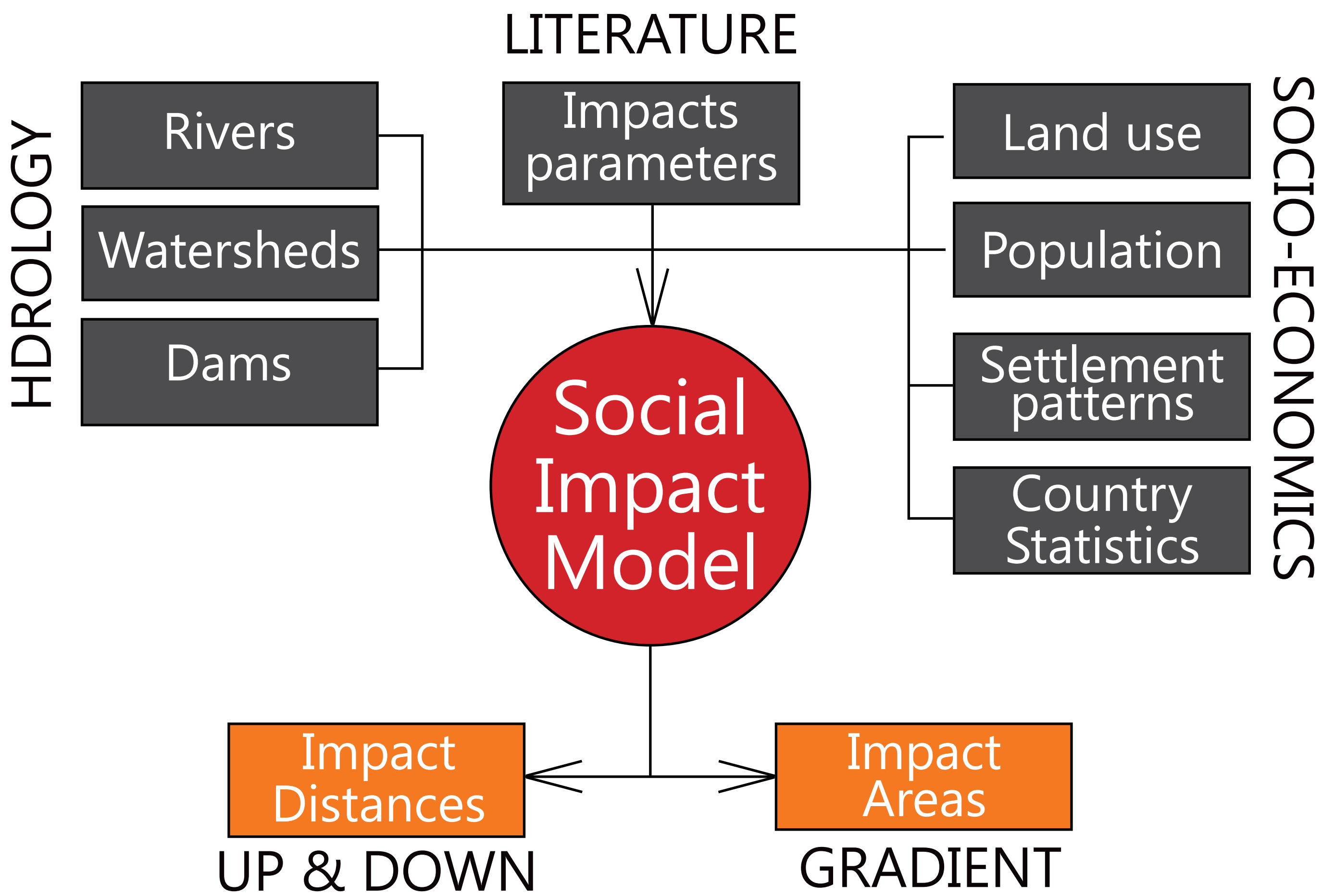


Figure 5: Conceptualization of the 'Social Impact Model' developed for this study. Grey boxes indicate the input parameters and orange boxes depict the two key output variables.

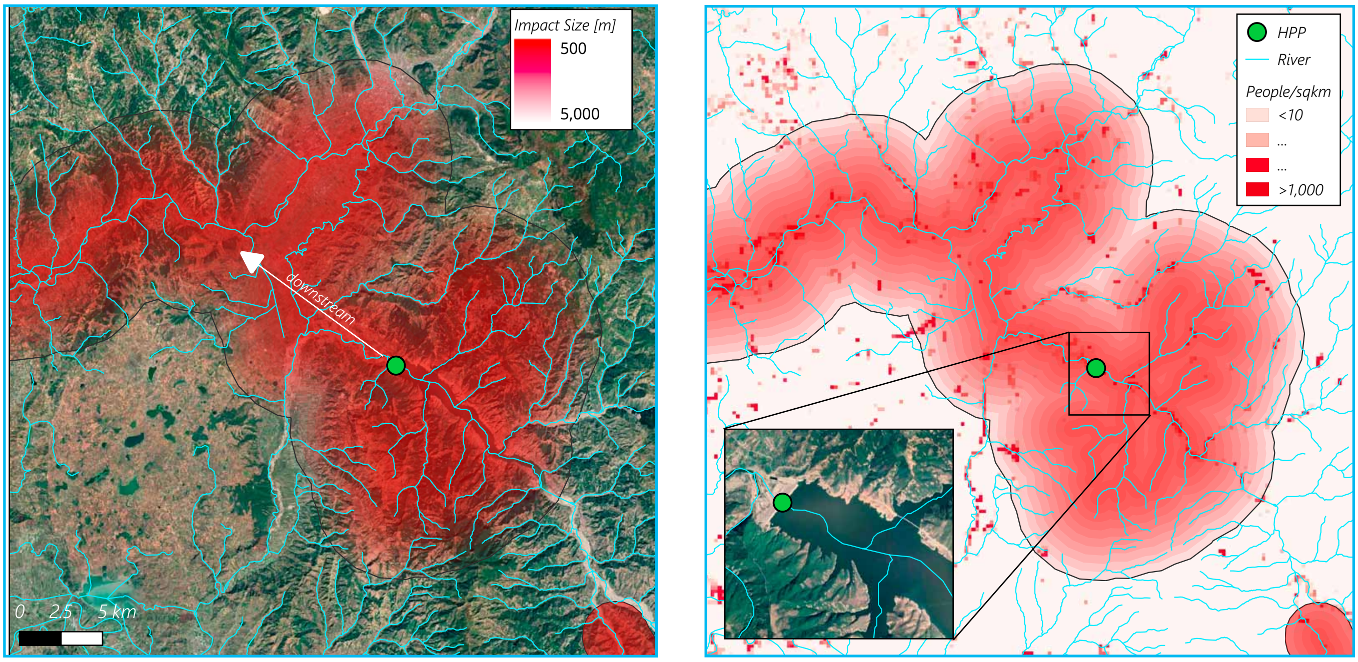


Figure 6: Example of the SIM application to a dam with an upstream reservoir in Albania. With increasing distance from the river, the impact intensity is reduced (red colour gradient left side). The population figures are spatially explicit and only those people are counted that fall within the Impact Area.

using a spatial modelling technique (Richter et al., 2010). They found that worldwide about 472 million people may potentially be affected by large HPPs.

In this study, we build upon their basic methodology and further develop the approach by constructing a 'Social Impact Model' (Figure 5) that can be applied to the inventory on HPPs, created by Schwarz (2019b), to generate a first estimate of the potentially affected population. The basic assumption we follow is that HPPs alter the level of ecosystem services provision available to the riparian population both in an up- and downstream direction from the location, where river water is either held back by a reservoir wall, or diverted from the original river stream by a 'diversion-scheme' configuration. This means that for a certain length up- and downstream of the HPP's location, river ecosystem services are potentially changed and people who normally make use of the various kinds of provisioning, regulating and cultural ecosystem services (Yeakley et al., 2016) potentially experience alterations in their livelihoods. Agricultural (e.g. floodplain farming, irrigation, livestock watering) and economic (e.g. tourism, hunting, fishing, forestry) as well as cultural (e.g. swimming, traditional festivals) and health practices (e.g. collection of medicinal plants) that are carried out by the population along affected river streams are impaired or even completely prohibited by the altered hydrological regime and associated changes in the adjoining ecosystems. We further assume that those people who live closer to the impacted river sections are more likely to experience effects than those people living further away.

Based on these basic assumptions, we constructed a spatially explicit model that semi-automatically identifies the up- and downstream impacted river sections based on a HPP's location along a river and graded according to its installed power capacity. Based on the review of scientific literature on how far up- and downstream ecological impacts can be recognized, the model declares certain river sections as affected by HPPs. Though, information on these 'Impact Distances' are rarely available in the literature, we build our parameters on a study by Kibler and Tullos (2013) who investigated this for hydropower development in China (Kibler and Tullos, 2013). While more information on this can be obtained from section 6, the 'Impact Distance' downstream ranges between 860m and 86km and its equivalent for the upstream section which ranges between 90m and 8.5km, and all graded according to a plant's power capacity.

In addition to the 'Impact Distances', the SIM declares the landscape along the impacted river sections as potentially affected, assuming a distance gradient from 500m up to 5km on each side of the river, again graded by a plant's power capacity. These final 'Impact Areas' can be overlain with recent spatial data products that depict the population distribution (GHSP, 2020) and the current land use types in the Balkan countries with a high spatial resolution of 250m and 100m, respectively. Figure 6, illustrates this process using an example from Albania. The SIM enables us to generate estimates of how many people live close to impacted river sections (within a 500m distance) and how this number changes with increasing distance from the river (up to the 5km). In this regard, we follow the work of Richter et al. (2010) by only focusing on the rural population as their livelihoods are closely connected to natural resources and river ecosystem services than those of inhabitants in urban environments (Milovanovic and Djordjevic-Milosevic, 2016; Richter et al., 2010). The term 'rural' includes both small villages as well as small towns but excludes larger cities. Furthermore, we can estimate, which land uses are critically impacted by HPPs to draw conclusions on potential livelihood impacts for the population.

3.2. Model application

The finalized SIM provides both population estimates and an area count of certain land use classes that are potentially impacted by HPPs. It may thus be possible to apply the model to all HPPs that were recorded in the comprehensive inventory by Schwarz (2019b). However, the location information of the planned HPPs in this database carries uncertainty as the precise location may not be accurate due to missing or vague information in the original sources from which Schwarz (2019b) compiled the inventory. Hence, if the SIM would be applied to all the data, biased results would emerge as the model requires high-accuracy information of a HPP's location to generate credible results.

For this reason, the project team performed a spatial validation process of those HPPs in the database that are classified as currently operating. For the Balkan region, Schwarz (2019b) declares about 1,200 plants as currently operating, so we used recent spatial imagery to validate the hydropower plants' location information. We were able to validate about 500 of these dams as structures where water is either held back or diverted from the original water course. The remaining point data could not be validated due to multiple reasons like outdated satellite imagery, forest cover and topographic shadows. Nevertheless, the sample size is considered adequate to provide a representative subset of HPPs for which the SIM can be applied.

The results of the 'Social Impact Model' applied to this subset of HPPs provides estimates of how many people are potentially affected by the different hydropower plant classes. As the total installed capacity of the validated subset sums up to about 4,700MW, we were able to generate an indicator called 'Social Impact Intensity' (SII) that depicts the number of people affected per MW of installed power. The SII now provides the opportunity to extrapolate the findings from the validated subset of plants to all HPPs of the Schwarz 2019b) database. In other words, with the SII parameter, the potentially affected population and the impacted land use classes can be extrapolated for all hydropower plants that are planned to be implemented in the future. The basic assumption here is that the characteristics of future HPPs do not differ from those currently in operation.

3.3. Limitations

Since the objective of this study is to generate a first estimate of potentially affected people in the Balkan region using a spatial approach, generalizations and assumptions are required that are based on recent literature insights. Of course, these generalizations are intended to render the SIM as applicable as possible to the overall conditions in the Balkan region, with the potential drawback that local particularities may not be adequately represented from case to case. This is a general shortcoming of broad modelling approaches but we consider this as an acceptable drawback against the study's intention to provide a regional overview on potentially affected people. Hence, the study results can only be considered as a first estimate that will require further investigations to verify the hypothesized population figures.

In this sense, potential improvements for future research to enhance the quality of the population estimates may be found in three major fields: First, the 'Social Impact Model' can be further developed to include more parameters like altitude, terrain features and discharge volumes. Second, input data quality can be enhanced by obtaining more accurate population and land use figures, as well as hydrological parameters and more information on the HPPs under consideration (e.g. technical configuration). Third, local field studies may be necessary to verify the basic assumption that altered ecosystem services levels generate impacts on people's livelihoods (e.g. in which distance from the river do people experience changes?).

4. Results

Our study indicates that currently, at least **470,000 people are potentially affected by operating HPPs in the Balkan region. However, if all planned HPPs become reality, between 1.3 and 4.6 Million people** would potentially experience livelihoods alterations (Figure 7a). This is based on the 'Social Impact Intensity' indicator, which finds that 42 – 151 people may potentially be affected with each additional MW of power installed. The following sub-sections will provide more details on (i) our estimates for the entire Balkan region, (ii) the individual countries (iii) and on specific case studies that shed light on how the model can be applied locally. The case studies specifically provide examples of the SIM application to show the impacts of larger HPPs (Albania), of small hydropower plants that operate in a cascading scheme (Bosnia and Herzegovina) and small plants that divert water for several kilometres from the original stream (Croatia).

4.1. Potentially affected population

In this study, we consider the rural population that lives within a certain distance to an affected river as potentially experiencing changes in their livelihood. The reason for livelihood changes are HPP-induced alterations of ecosystem services that change the traditional way people obtain benefits from nature. From the application of our 'Social Impact Model' to the verified subset of currently operating HPPs, we find that between 470,000 to 1.7 million people are potentially affected (black bars in Figure 7a). The lower end of this estimate depicts the population that lives closer to affected river stretches in an 'Impact Area' of only 500m. We consider these people as 'most affected'.

With increasing distance to an impacted river we assume that impacts on livelihood are less likely. Nevertheless, our model results suggest that within a 5km distance, the number of people affected increases from 42 to 151 per MW of installed power. Since the validated subset of operating HPPs can be considered a representative sample, the 'Social Impact Intensity' indicator can be regarded as a reliable estimator for the number of people potentially impacted in the future.

Apart from population figures, the 'Social Impact Model' also provides estimates on which land uses may potentially be affected by hydropower operations and their respective proportions within the 'Impact Area'. Here we assume that land uses provide some spatially explicit indication of economic and agricultural activit-

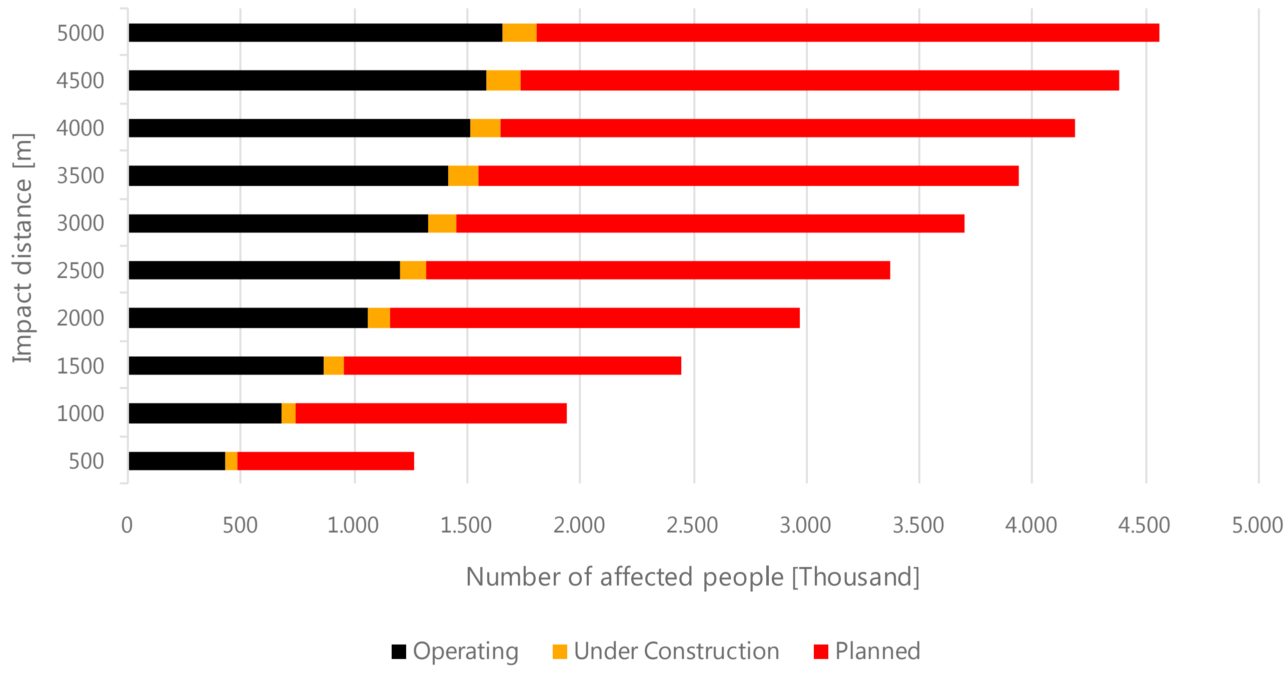


Figure 7a: Potentially affected population by currently operating HPPs, plants that are under construction and plants that are planned in the Balkan region.

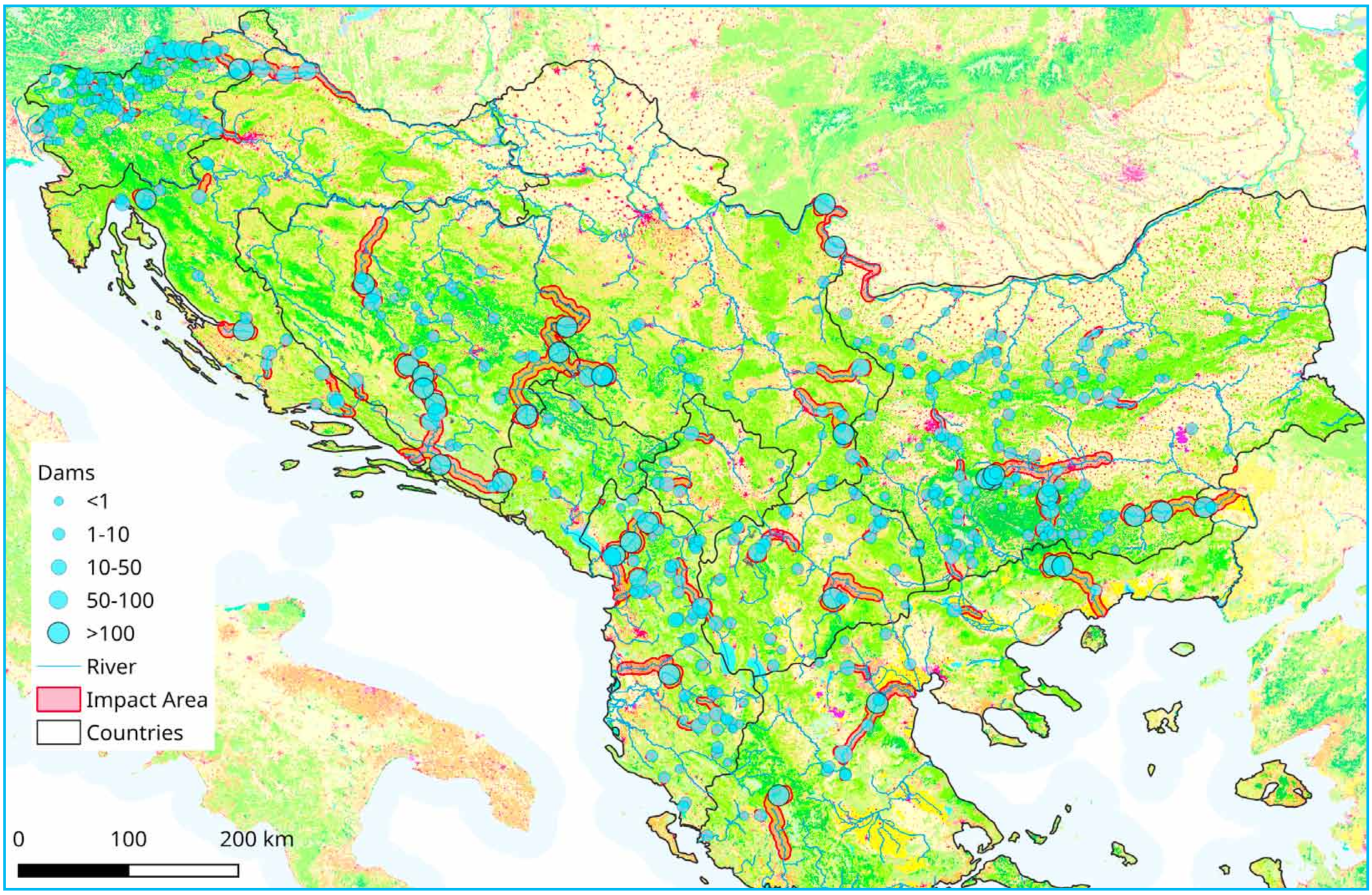


Figure 8: Impact Areas in the Balkan region. Only the validated subset of dams is presented with the associated impact areas alongside the land use classes from the CORINE land cover data.

ies of societies in the Balkan region. Figure 7b confirms that agricultural areas are often located close to river streams due to favourable soil conditions and options for irrigation. About 34% of the 'Impact Area' is currently used for agricultural plots that are

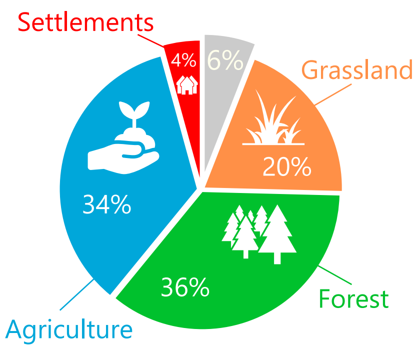


Figure 7b: The proportions of land use classes present within the 'Impact Area' in the Balkan region.

the building blocks of livelihoods for most people. As HPP operations will alter the hydrological system and the adjoining ecosystems, impacts on local agricultural practices are likely, requiring smallholders to adapt to new conditions. Likewise, 20% of the 'Impact Area' is made up of grass- and shrublands while an additional 36% is covered by forests. These rather pristine landscapes are valuable for the local population as they provide important livelihood components such as non-timber forest-products (e.g. fruits, wildlife) and medicinal plants for own consumption and trade (Rexhepi et al., 2013; Tsioutsiou et al., 2019). In addition, these landscapes particularly attract international tourists. If these areas are inundated due to reservoirs, cut off from groundwater supply due to diverted rivers or impacted from hydropower construction and operation works, this may reduce the tourism value of these landscapes and hence lower income opportunities for local people.

The 'Social Impact Model' essentially provides spatially delineated areas as major output for which we assume that people may potentially experience alterations of their traditional livelihoods if they live within these 'Impact Areas'. Figure 8 presents an overview map on the Balkan region and depicts these areas that are combinations of up- and downstream impacted river sections as well as gradients of impacts into the landscape. These results are based on the subset of HPPs that has been visually validated via spatial imagery. The map shows both larger and smaller impact structures as well as areas that merge into one another.

While the first can be attributed to single HPPs on a certain river stretch, the latter represents multiple HPPs that are built along the same river stream, only a few kilometres apart from each other. In these cases, up and dowstream 'Impact Distances' merge. This can be visually identified for the Drava river in the north of Slovenia and for the Neretva river in Bosnia and Herzegovina, for instance. The map also indicates that the sample of HPPs used to calibrate our 'Social Impact Model' is well distributed across the Balkan region and thus covers a broad range of landscapes, hydrological regimes and socio-economic as well as settlement patterns. This means, the 'Social Impact Intensity' indicator builds upon a representative sample of hydropower plants, so that the extrapolation of these results to the entire database of planned HPPs may provide a reliable first estimate.

4.2. Country results

The results of the 'Social Impact Model' can be evaluated for each country individually, enabling comparisons between them to find social impact hot-spots (Figure 9).

Overall, the bar chart indicates that Albania and Bosnia and Herzegovina stand out showing the largest number of potentially affected people. It also becomes obvious that most of these people will be affected by HPPs that are in the planning stage. The following sub-sections will provide more detailed information on the population estimates for each country and will put these findings into a larger context of local socio-economic conditions, partly via case studies.

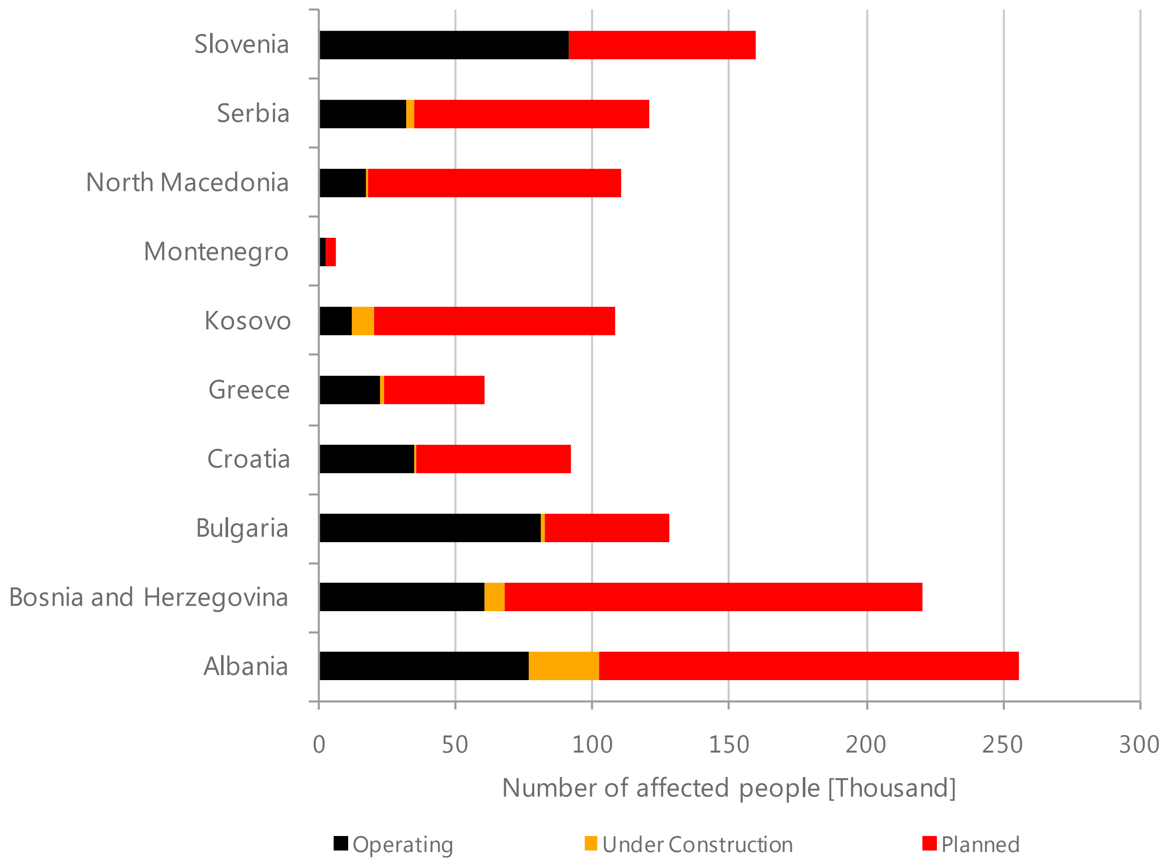


Figure 9: Number of potentially affected people per country according to project status for the 500m 'Impact Area'.

4.2.1. Albania

Albania, located at the heart of the Balkan region, along the Mediterranean coast, belongs to those countries most affected by current and future hydropower development. According to Schwarz (2019b), about 175 HPPs are currently operating in Albania while another 513 are either under implementation or planned for the future. Based on the 'Social Impact Model', we assume that in total, between 256,000 to 841,000 people are potentially affected by these HPPs as indicated in Figure 10a. To be specific 76,574 are affected by operating plants, 25,529 are affected by HPPS currently under construction and 153,754 would be affected by planned projects. Taking the lower end of this estimate here, this means that about 9% of the country's total population may experience livelihood alterations from hydropower expansion. The 'Social Impact Intensity' indicator ranges between 53 to 174 people per MW of installed power and is hence slightly larger than the region's average. Likewise, the share of potentially affected people living closer to impacted rivers is higher with 30%. The 'Impact Area', as shown in figure 10b, is made up of agricultural plots, forests as well as grass and shrublands to rather equal shares, indicating a balanced impact on the associated economic and cultural utilizations of these areas.

The potential impacts on agriculture are critical to the livelihoods of the rural population which makes up a significant share of the total population. The agricultural sector stands out by contributing 18.4% to GDP which is the largest share among all Balkan countries. This is also reflected by the relatively high proportion of people working in the agricultural sector, while even more are potentially involved via family farms. Subsistence agriculture on small plots of 1.2ha on average is an indication for the strong dependence of rural people on natural resources (Cela et al., 2010).

In accordance with this observation, recent research points to the importance of medicinal plants for the rural population (Rexhepi et al., 2013) which may be hampered if water-dependent ecosystems are altered. In addition, the tourism sector shows more than 5 million international tourists arriving each year, providing nearly 50% of the country's export earnings (The World Bank, 2020). Hence, the country's pristine landscapes are a critical asset for its attractiveness for international tourists.

QUICK COUNTRY INFORMATION

Population: 2.87 million
Rural: 42%
GDP/capita: 5,268 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 18.4% (EU: 1.7%)
Employment in agriculture: 37% (EU: 4%)
Tourism (% of exports): 48.2%
International tourists: 5.3 million
Source: World Bank Open Data 2020

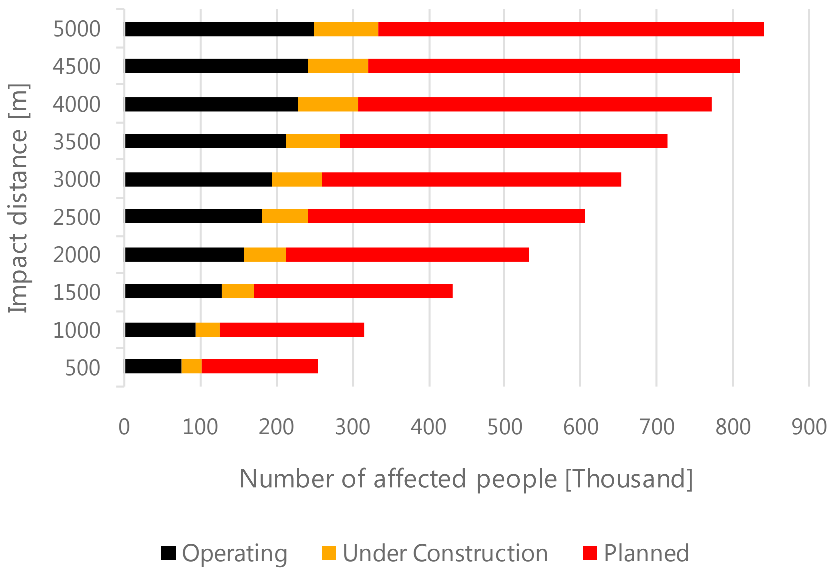


Figure 10a: Potentially affected population in Albania by HPPs operating, under construction and planned.

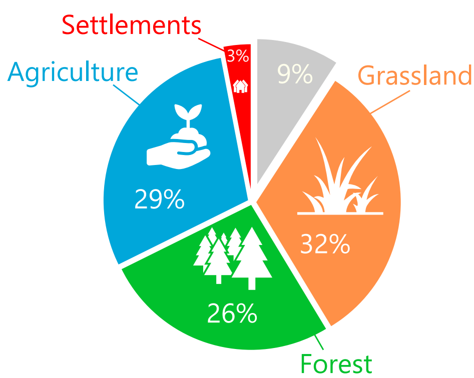


Figure 10b: Proportions of land uses impacted by HPPs in Albania.

4.2.2. Bosnia and Herzegovina

QUICK COUNTRY INFORMATION-
Population: 3.32 million
Rural: 24.583%
GDP/capita: 6,066 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 5.9% (EU: 1.7%)
Employment in agriculture: 15% (EU: 4%)
Tourism (% of exports): 12.7%
International tourists: 1 million
Source: World Bank Open Data 2020

Bosnia and Herzegovina is the country in the Balkan region, that is likely to experience the most extensive development of hydropower, if all HPPs planned will be realized. According to the Schwarz (2019b) database, the country will then have more than 5,000MW of installed power. Today, about 103 HPPs are operating, while another 318 are planned for the future with most of these having small capacities of below 10MW. The 'Social Impact Model' estimates that between 220,000 and 521,000 people are potentially affected by this increase in hydropower infrastructure. Reflecting the lower end of this estimate against the total population, about 6% of the country's residents may experience respective changes (Figure 11a). To be specific 60,317 are affected by operating dams, 6,976 are affected by dams currently under construction and 152,775 would be affected by planned dams.

Compared to the regional numbers, the 'Social Impact Intensity' indicator finds a larger proportion of the affected population (42%) living closer to impacted rivers. In terms of land use impacts, the highest proportion of the 'Impact Area' is covered with forest which corresponds to the fact that Bosnia and Herzegovina has one of the largest forested areas in the entire region (Figure 11b).

The SIM results are an indication for significant potential impacts on the population, especially against the current socio-economic conditions of the country. More than half of the population lives in rural settings and is hence closely connected to ecosystem conditions. Economic performance remains low with the agricultural sector providing significant official employment opportunities and is likely to be the building block for communities (e.g. family farming) (Bajramovic et al., 2010). Especially livestock farming (sheep, goats and pigs) is important due to the hilly landscape that prevents larger-scale farming activities. The tourism sector gained importance over the last years as the number of international tourists increased from 171,000 in the year 2000 up to more than 1 million people in 2018 (The World Bank, 2020). Despite potential positive effects in certain tourism segments (e.g. recreational value of newly created lake landscapes), hydropower development may put key attractors for international tourists such as the country's pristine landscape of forested hills and natural river ecosystems (Milicevic et al., 2018) as well as cultural heritage sites and landscapes (Kudumovic, 2020) at risk.

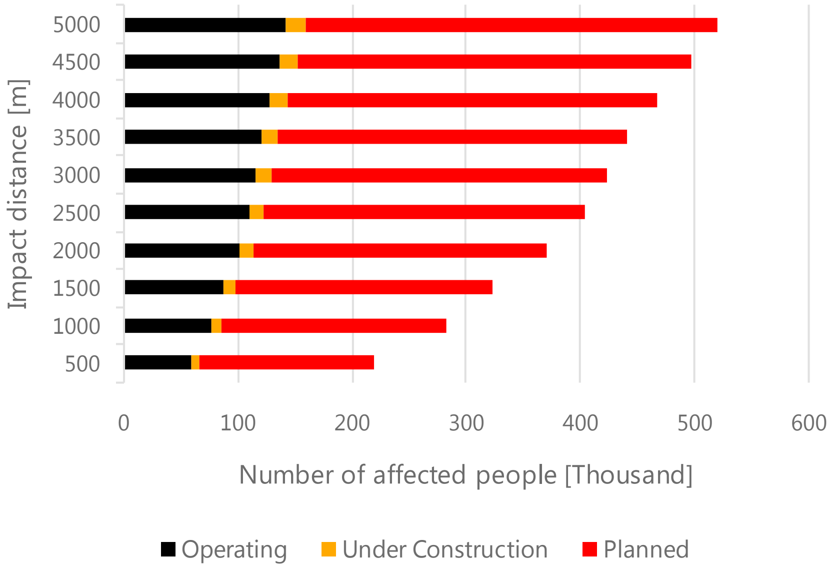


Figure 11a: Potentially affected population in Bosnia and Herzegovina by HPPs operating, under construction and planned.

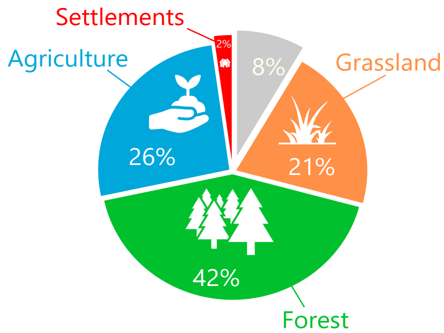


Figure 11b: Proportions of land uses impacted by HPPs in Bosnia and Herzegovina.

4.2.3. Bulgaria

QUICK COUNTRY INFORMATION

Population: 7 million
Rural: 39.95%
GDP/capita: 9,272 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 3.7% (EU: 1.7%)
Employment in agriculture: 6% (EU: 4%)
Tourism (% of exports): 11.7%
International tourists: 9.3 million
Source: World Bank Open Data 2020

Bulgaria is the second-largest country in the Balkan region under consideration of this study with a total population of more than 7 million people and about a quarter of them living in rural settings. According to the Schwarz (2019b) database, nearly 300 HPPs are currently operating in the country with almost an equal number of HPPs planned for the future. Most of these future hydropower plants have rather small capacities of less than 10MW so that the currently installed power of approximately 2,400MW will be increased by an additional 56%.

The 'Social Impact Model' results show that between 128,000 to 577,000 people may be affected by all HPPs that are listed in the inventory, while most of these people are already potentially affected by currently operating dams (Figure 12a). Compared to the previous countries and to the regional average, a smaller share of the affected population lives close to impacted rivers with only 22%. Nevertheless, the land use statistics, in figure 12b indicate that 7% of the 'Impact Area' is made up of direct human settlement structures – together with Slovenia the largest proportion among all countries under consideration. In addition, agriculture is being significantly affected as 41% of the 'Impact Area' is utilized for crop cultivation or livestock.

Though agriculture plays a smaller role for the Bulgarian economy than for the previous countries, the large agricultural areas affected by hydropower indicate a strong impact on the rural population's livelihoods. In addition, as grass and shrublands as well as forests constitute nearly half of the affected area, also the ecological value of the landscape as a tourist attraction may be impacted.

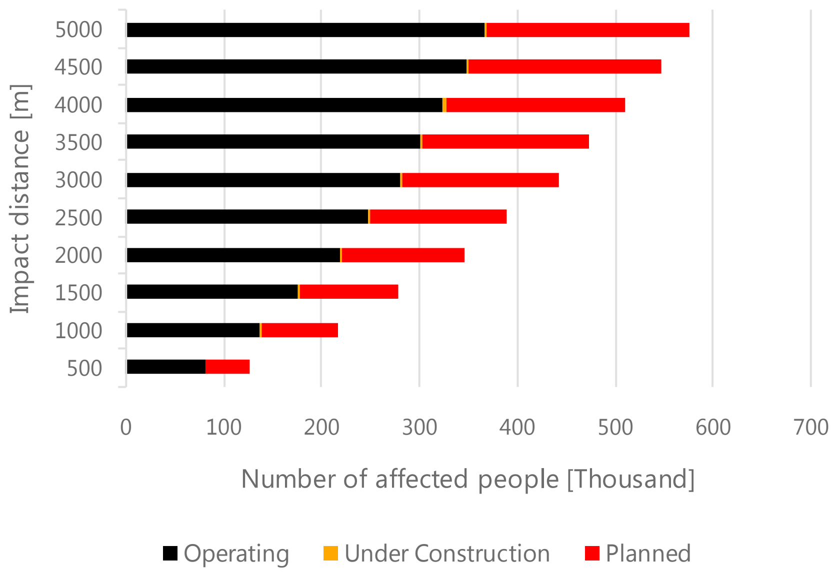


Figure 12a: Potentially affected population in Bulgaria by HPPs operating, under construction and planned.

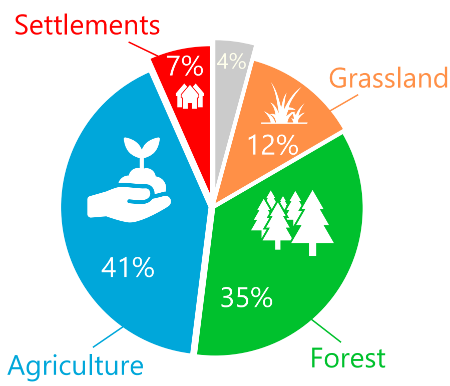


Figure 12b: Proportions of land uses impacted by HPPs in Bulgaria.

4.2.4. Croatia

QUICK COUNTRY INFORMATION

Population: 4.09 million
Rural: 39.6%
GDP/capita: 14,915 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 2.9% (EU: 1.7%)
Employment in agriculture: 6% (EU: 4%)
Tourism (% of exports): 39.3%
International tourists: 16.6 million
Source: World Bank Open Data 2020

Together with Bulgaria, Greece and Slovenia, Croatia is member of the European Union, and generates significantly higher economic output than most of the Balkan countries. For Croatia, the database by Schwarz (2019b) states 55 HPPs as currently operating while the planned HPPs add up to about 158 and two additional ones that are currently under construction. In relation to the country's population size and economic performance, the number of hydropower plants is rather low while the total installed capacity of around 3,500MW ranges among the region's average. The 'Social Impact Model' suggests that despite the relatively small number of HPPs in the country, between 92,000 to 685,000 people are potentially affected (Figure 13a). This means, the SII indicator shows a significantly larger spread of intensity than the previous countries and the regional average. While close to rivers, only 26 people/MW are affected, this number increases to about 194 within the 5,000m distance. Hence, only 13% of the affected people are likely to be 'strongly' affected. In terms of land uses, again the agricultural plots make up the largest share of the 'Impact Area', indicating a potential threat for traditional farm-based livelihoods.

While the agricultural sector (Figure 13b) in the Pannonian and peri-Pannonian region in the country's north-east is well developed for grain farming and livestock production, the mountainous regions of the country rather show smallholder agriculture for subsistence purposes with generally small farm sizes (Mikus et al., 2010).

Cattle farming constitutes the main activity among the large share of rural population and thus, grazing grounds and water availability are critical to their livelihoods. Croatia is also well known for international tourists for its attractive landscape, especially along the mountainous Mediterranean coast. With more than 16 million international arrivals per year, the tourism sector contributes almost 40% to the country' export revenues (The World Bank, 2020).

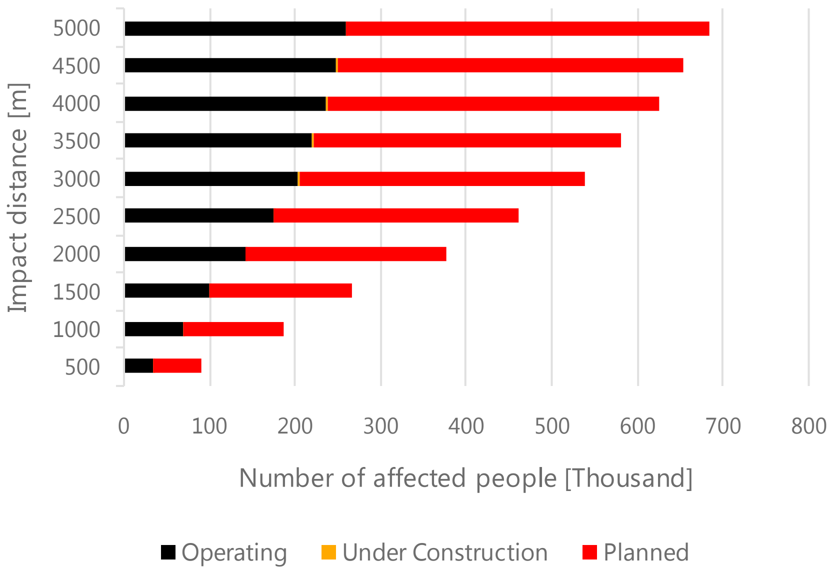


Figure 13a: Potentially affected population in Croatia by HPPs operating, under construction and planned.

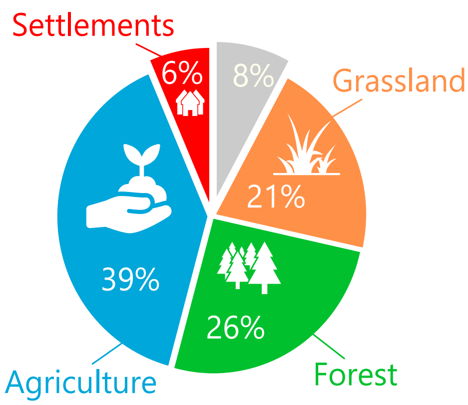


Figure 13b: Proportions of land uses impacted by HPPs in Croatia.

4.2.5. Greece

Greece is the biggest country under consideration of this study in multiple ways – in terms of population size, economic performance and area. According to the database on HPPs from Schwarz (2019b), which only considers the northern part of the country, only 42 plants are operating. Though another 583 are planned or currently under construction, the total installed power if all plants would be realized only adds up to about 2,300MW. This is significantly less than smaller countries in the region are facing like Albania (4,800MW) or Bosnia and Herzegovina (5,000 MW). Our 'Social Impact Model' results indicate that despite the large population of the country, only 60,000 to 394,000 people are potentially affected (Figure 14a).

On the one hand this stems from the smaller number of HPPs and lower capacities of these (97% <10MW) and from the settlement patterns on the other hand. In this regard, the 'Social Impact Intensity' indicator reveals that only 26 people are affected per MW of power installed close to the rivers. Overall, this means that only 15% of the affected population may likely experience 'strong' livelihood changes due to close vicinity to impacted rivers.

In accordance to the previous countries, a large share of the 'Impact Area' is made up of agricultural land and more than half is composed of grass and shrublands as well as forested areas (Figure 14b). Recent research on the use of 87 medicinal plant taxa confirms for the country's north their high importance for both own consumption and local and national trade and hence income generation (Tsioutsiou et al., 2019). Major interventions into the ecosystem via hydropower development may change habitat suitability for respective plant taxa. In addition, the country's tourism sector is an important cornerstone of the national economy with about 30 million tourists entering the country every year (The World Bank 2020). However, this tourism focuses on the islands in the Mediterranean Sea rather than the inland part for which the inventory from Schwarz (2019b) depicts the HPPs.

QUICK COUNTRY INFORMATION

Population: 10.7 million
Rural: 31.36%
GDP/capita: 6,066 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 3.72% (EU: 1.7%)
Employment in agriculture: 12% (EU: 4%)
Tourism (% of exports): 26.4%
International tourists: 30.1 million
Source: World Bank Open Data 2020

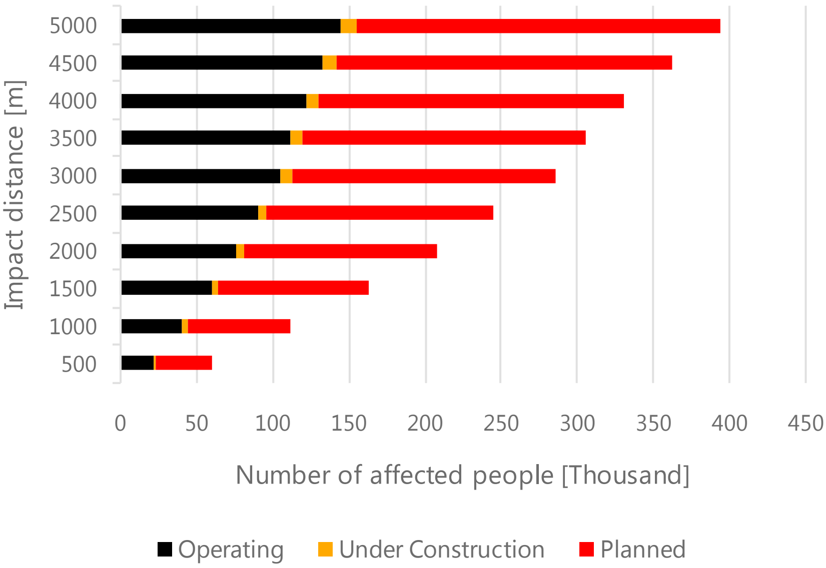


Figure 14a: Potentially affected population in Greece by HPPs operating, under construction and planned.

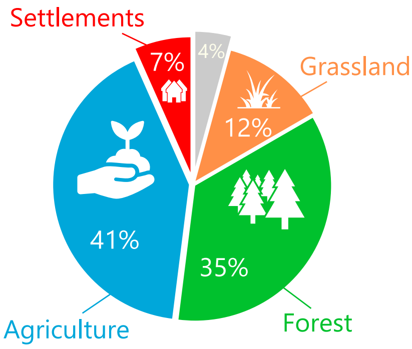


Figure 14b: Proportions of land uses impacted by HPPs in Greece.

4.2.6. Kosovo

QUICK COUNTRY INFORMATION

Population: 1.8 million
Rural: 24.31%
GDP/capita: 4,302 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 7.17% (EU: 1.7%)
Employment in agriculture: ---% (EU: 4%)
Tourism (% of exports): --- %
International tourists: --- %
Source: World Bank Open Data 2020

As the youngest country in the Balkan region, Kosovo declared its independence from the Republic of Serbia in 2008, having experienced years of violent conflicts before (Nushi, 2010). Against this background it is rather unsurprising that Kosovo today has the least developed economy in the region. Two-thirds of the population lives in rural environments and the agricultural sector plays a critical role for the economy as a whole and for livelihood maintenance. According to the database from Schwarz (2019b), 11 HPPs are currently operating while an additional number of 94 is planned or under construction, resulting in a total installed power capacity of around 900MW if all go into operation.

For Kosovo, the 'Social Impact Model' suggests that between 108,000 to 267,000 people may potentially be affected by hydropower development, the lower end of this estimate corresponding to about 6% of the country's population (Figure 15a). While agricultural plots are again heavily impacted, forests make up the largest proportion of the 'Impact Area' (Figure 15b), rendering the threat for forest ecosystems from HPPs (e.g. via changes in groundwater flow patterns) as critical for the economy and for livelihood maintenance. Furthermore, since HPP development in a national park is ongoing (Vejnovic & Gallop 2018), the region's attractiveness for tourism and associated income opportunities may decline.

The country's agricultural sector is characterized by small farms (81% below 2ha) and a high level of subsistence with crops mainly produced for own consumption (Nushi, 2010). Agriculture is mostly practiced in valleys as well as the plains of the north-east for cereals and fodder production. Livestock hence plays an important role for most smallholders and so does watering of animals. Overall, specialized crops (e.g. wine, fruits) are often irrigated and thus, alterations of water availability may negatively affect agricultural opportunities.

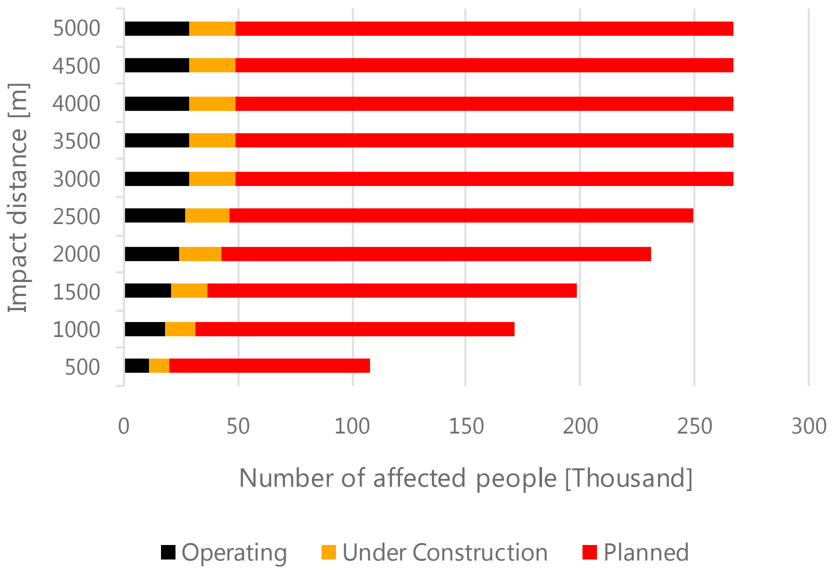


Figure 15a: Potentially affected population in Kosovo by HPPs operating, under construction and planned.

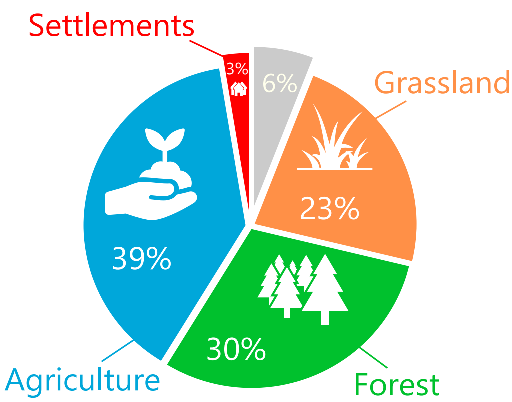


Figure 15b: Proportions of land uses impacted by HPPs in Kosovo.

4.2.7. Montenegro

QUICK COUNTRY INFORMATION

Population: 0.6 million
Rural: 25.93%
GDP/capita: 8,846 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 6.73% (EU: 1.7%)
Employment in agriculture: 8% (EU: 4%)
Tourism (% of exports): 52.2%
International tourists: 2.0 million
Source: World Bank Open Data 2020

Montenegro is the smallest country in the Balkan region in terms of population size but outperforms other countries in terms of its economy (The World Bank, 2020). Currently, about 16 HPPs are operating and another 98 are either planned or already under construction according to the database from Schwarz (2019b). If all these plants would come into operation, this would result in a capacity of 1,700MW with most of the plants being in low capacity classes of below 10MW. The 'Social Impact Model' indicates for Montenegro that only a small number of people may potentially be affected by hydropower development (Figure 16a). The model suggests that between 6,000 to 35,000 people may experience livelihood changes, resulting in a small 'Social Impact Intensity' indicator of only 3 to 18 people/MW. This number may be biased since only few of the verified dams are actually located within Montenegro, so the sample size from which to build the national figures may not be as reliable as the sample sizes for the other countries. Likewise, the results for the composition of the 'Impact Area' have to be treated with caution as only 13% are declared as agricultural plots while about 76% are characterized as forested and grass and shrubland area (Figure 16b).

Though official agricultural statistics only indicate that 8% of the total work force is engaged in agriculture, the share of family workers is considered higher (Markovic and Markovic, 2010). Especially the high importance of tourism is critical to the country's economy with more than 2 million tourists arriving each year.

On the one hand, hydropower development may particularly impact on the pristine landscapes of forest and grassland areas and may hence impair its attractiveness for international tourists. On the other hand, opportunities may be created to further develop certain tourism sectors that make use of lake landscapes that may be created (e.g. boating, swimming).

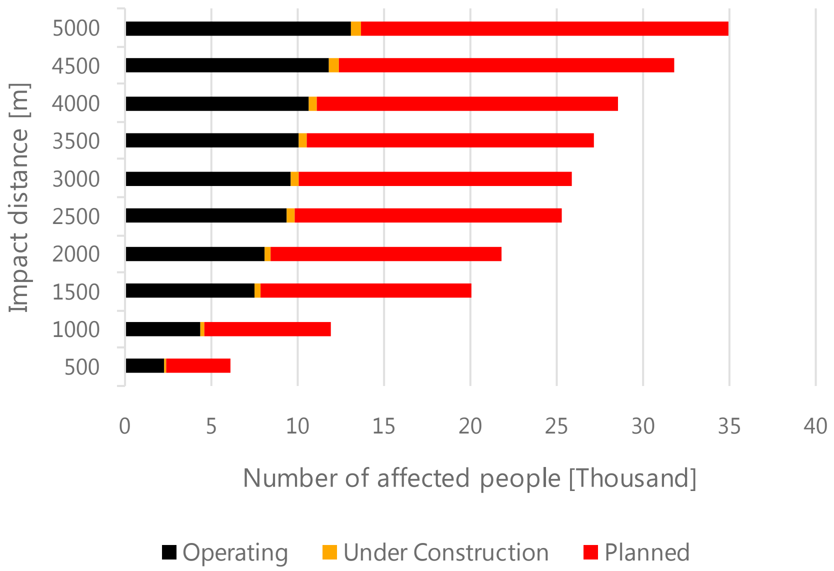


Figure 16a: Potentially affected population in Montenegro by HPPs operating, under construction and planned.

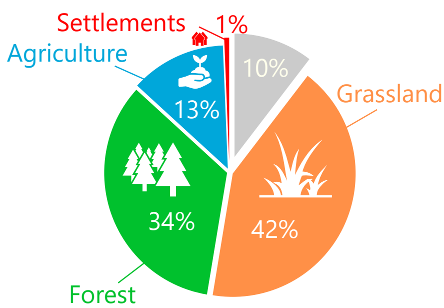


Figure 16b: Proportions of land uses impacted by HPPs in Montenegro.

4.2.8 North Macedonia

The landlocked country of North Macedonia sits right at the heart of the Balkan region, north of Greece, bordering Albania in the west, Kosovo and Serbia in the north and Bulgaria in the east. According to the database from Schwarz (2019b), the country has about 94 currently operating dams with an installed capacity of around 740MW, which will be increased to a total of nearly 2,000MW if all of the 204 planned HPPs go into operation. Hydropower development in North Macedonia shows a similar pattern as in all other Balkan countries with small plants of below 1 to 10MW that constitute the bulk of hydropower projects. The 'Social Impact Model' reveals for North Macedonia that between 110,000 to 272,000 people are potentially affected by all HPPs of the Schwarz (2019b) inventory (Figure 22). 40% of these people live in close vicinity to the rivers and may hence experience a 'stronger' impact on their livelihoods. Compared to the other countries and the regional average, this indicates more intense consequences. The red colour in the bar chart of Figure 17a shows that the largest proportion of the population will be affected by future hydropower projects. As we have already seen for most of the previous countries, agricultural plots make up a significant share of the 'Impact Area' in North Macedonia, while grass- and shrublands as well as forested areas contribute almost half to this area (Figure 17b).

Rural livelihoods are commonly found in North Macedonia with 43% of the population living in sparsely populated areas. The agricultural sector was important after the transition from the socialist economic system towards a market economy due to large-scale failure of the industrial sector (Dimitievski et al., 2010). This importance remains until today with 80% of all farms being in private ownership, mainly for subsistence purposes. Likewise, the importance of natural resources was recently confirmed by research into the use of medicinal plants for the rural population (Rexhepi et al., 2013).

QUICK COUNTRY INFORMATION

Population: 2.08 million
Rural: 23.74%
GDP/capita: 6.084 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 7.2% (EU: 1.7%)
Employment in agriculture: 15% (EU: 4%)
Tourism (% of exports): 5.1%
International tourists: 0.7 million
Source: World Bank Open Data 2020

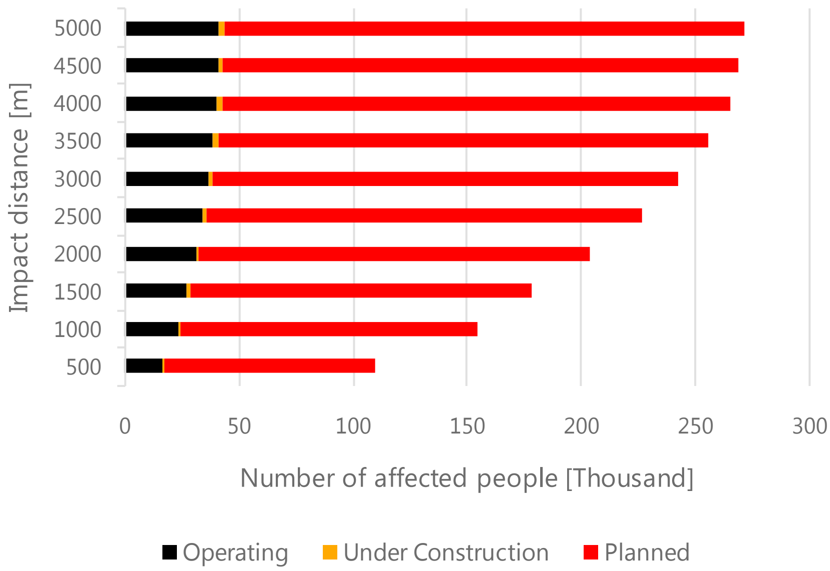


Figure 17a: Potentially affected population in North Macedonia by HPPs operating, under construction and planned.

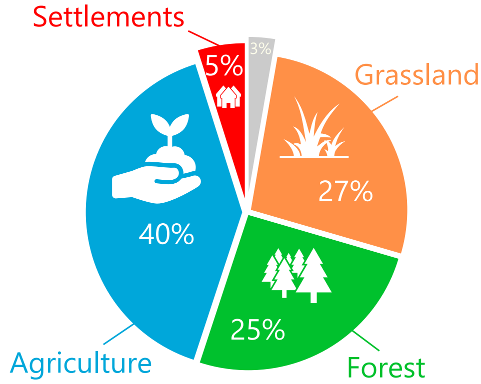
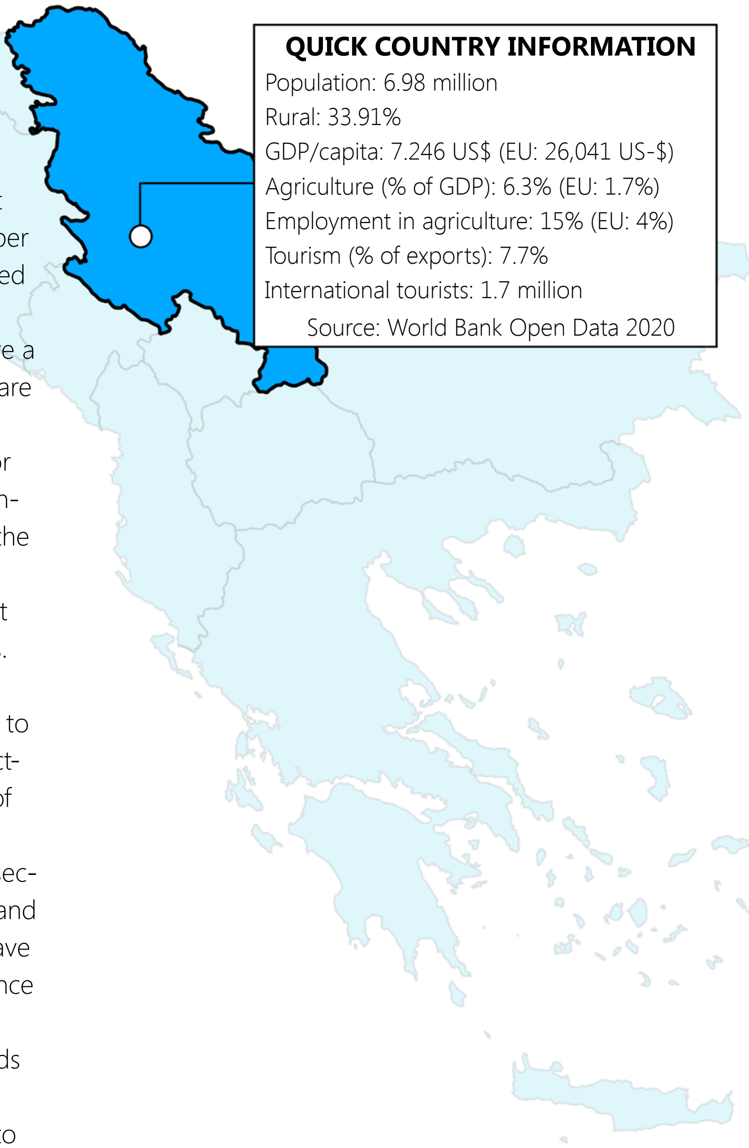


Figure 17b: Proportions of land uses impacted by HPPs in North Macedonia.

4.2.9. Serbia



QUICK COUNTRY INFORMATION

Population: 6.98 million
Rural: 33.91%
GDP/capita: 7.246 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 6.3% (EU: 1.7%)
Employment in agriculture: 15% (EU: 4%)
Tourism (% of exports): 7.7%
International tourists: 1.7 million
Source: World Bank Open Data 2020

According to the database from Schwarz (2019b), Serbia is the country in the Balkan region, that will experience most hydropower development in the future in terms of the number of planned HPPs. In this regard, about 851 plants are intended to be built, adding to the 82 existing ones and the 33 HPPs that are currently under construction. In total, Serbia will have a total installed capacity of 3,900MW when all of these plants are operating – only Albania and Bosnia and Herzegovina show larger power capacities. The 'Social Impact Model' reveals for Serbia that between 121,000 and 485,000 people may potentially be affected by this development (Figure 18a). Overall, the Serbian statistics obtained from the 'Social Impact Intensity' indicator are in line with the regional average showing about 30 people/MW affected when living close to impacted rivers. They constitute 25% of all potentially affected people in the country. Overall, the lower population estimate corresponds to about 1.4% of the total population. From a land use perspective, forests stand out as constituting the largest proportion of the 'Impact Area' (Figure 18b).

Similar to its neighbouring countries, Serbia's agricultural sector is an important backbone for both the official economy and for the livelihoods of rural people. About 75% of all farms have less than 5ha of land and thus primarily provide for subsistence agriculture (Bogdanov and Bozic, 2010). Hydropower development with reduced water availability during the dry periods of the year as well as impaired opportunities for livestock watering may negatively affect the rural population's ability to maintain their nature-based livelihoods.

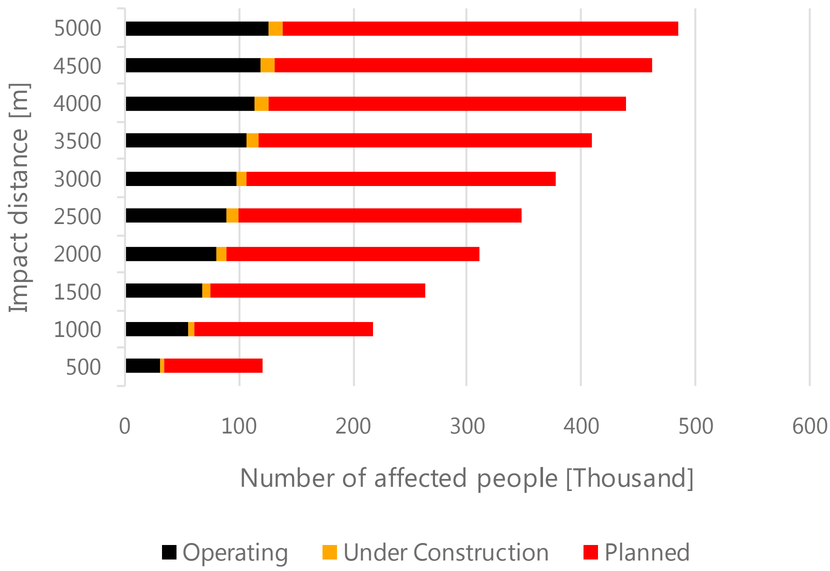


Figure 18a: Potentially affected population in Serbia by HPPs operating, under construction and planned.

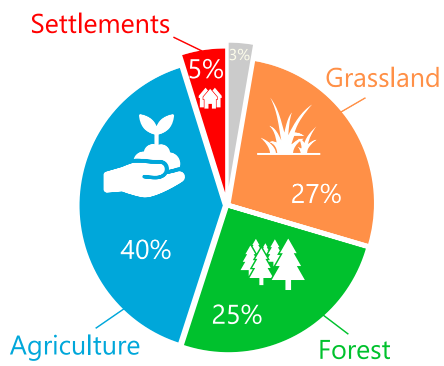
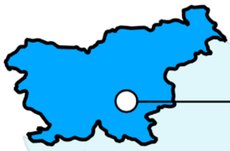


Figure 18b: Proportions of land uses impacted by HPPs in Serbia.

4.2.10. Slovenia



QUICK COUNTRY INFORMATION

Population: 2.7 million
Rural: 47.01%
GDP/capita: 26,042 US$ (EU: 26,041 US-$)
Agriculture (% of GDP): 2.11% (EU: 1.7%)
Employment in agriculture: 5% (EU: 4%)
Tourism (% of exports): 7.3%
International tourists: 4.4 million
Source: World Bank Open Data 2020

Slovenia is member of the European Union since 2004 and has the highest GDP per capita among the Balkan countries. According to the database from Schwarz (2019b), about 345 dams are currently operating in the country, providing a total installed power capacity of around 1,600MW. Another 236 plants are planned or already under construction that will add an additional 1,200MW. The results of the 'Social Impact Model' suggest that between 159,000 to 481,000 people are potentially affected by hydropower development (Figure 19a). About 33% of these live close to the impacted rivers while the 'Social Intensity Indicator' reveals that in terms of absolute numbers, about 56 people are considered to be impacted by each MW of power. Together with Kosovo and North Macedonia, this is the highest value for the entire region. Considering the land use classes that fall within the 'Impact Area' it turns out that only little grass and shrubland is impacted while forested areas make up the largest proportion of it. Agricultural plots are also significantly affected with 39% of the total 'Impact Area' (Figure 19b).

The country experienced steady economic growth from the 1990s until 2008 with the world economic crisis hampering its performance (The World Bank, 2020). Compared to the other countries, the agricultural sector of Slovenia contributes least to the national economy while still 5% of people are officially engaged. Its role for the 46% of the population that lives in rural settings is however, higher. With about 4.4 million tourists each year, the tourism sector is important, especially due to the close vicinity to Western European countries.

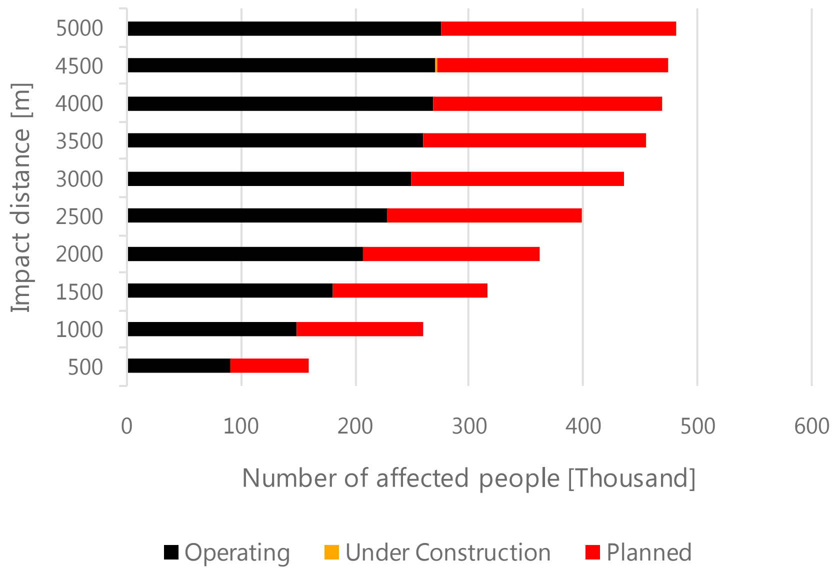


Figure 19a: Potentially affected population in Slovenia by HPPs operating, under construction and planned.

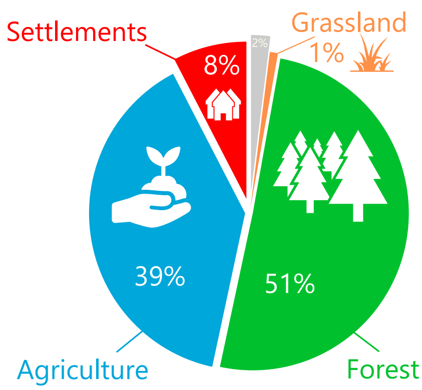


Figure 19b: Proportions of land uses impacted by HPPs in Slovenia.

4.3 Case Studies

4.3.1 Case study: Vjosa, Pocem and Kalivac hydropower projects, Albania

In Albania, there are two large HPPs (Pocem and Kalivac) that are planned to be constructed along the lower sections of the Vjosa river. The 'Social Impact Model' that was used in this study indicates that if both HPP projects become operational they may affect the livelihoods of about 4,000 people who live closer to the river (within a 500m distance). But the farther away people live from the river, the lesser could be the impact on their livelihood. The results indicate that up to 24,000 people (within 5,000m distance) may experience changes in their traditional way of living.

Albania hosts some of the most important river systems that are considered as pristine (EuroNatur and RiverWatch, 2015). One of these river systems is the Vjosa river that drains the southern Albanian mountainous inland region into the Mediterranean Sea. While the headwaters are characterized by canyons, narrow valleys and fast flowing river sections, the lower reaches are characterized by meandering riverbeds that sometimes show widths of several kilometers. This braided river configuration is a key feature of (rather) pristine river systems that are rarely being found in Europe today (RiverWatch and EuroNatur, 2018). Overall, the pristine state of the Vjosa river is considered highly valuable wherefore a petition was initiated by international scientists to stop hydropower development (Balkanrivers.net, 2019). Reports by international media made the concerns of the local population and environmentalists explicit in recent years (Nika

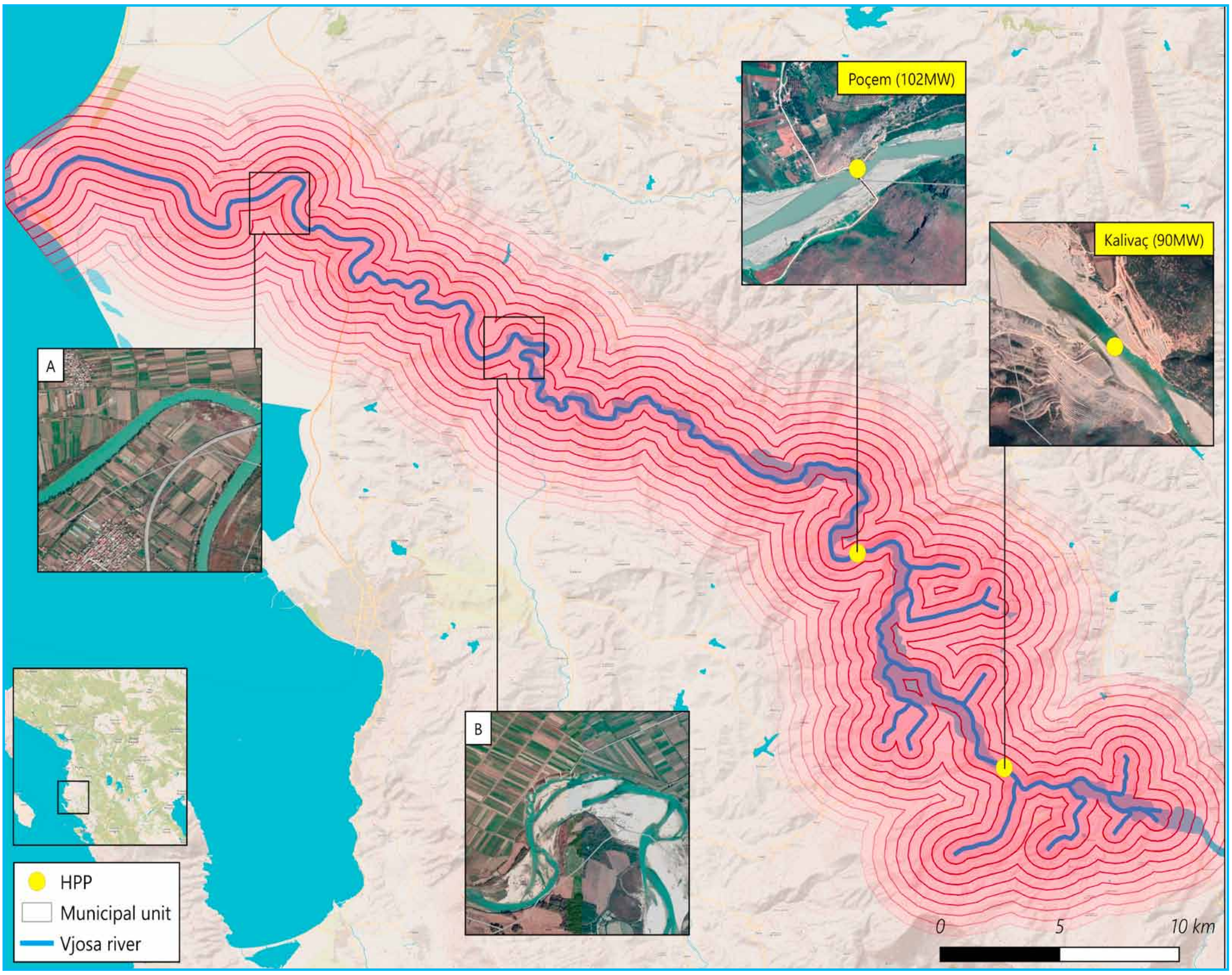
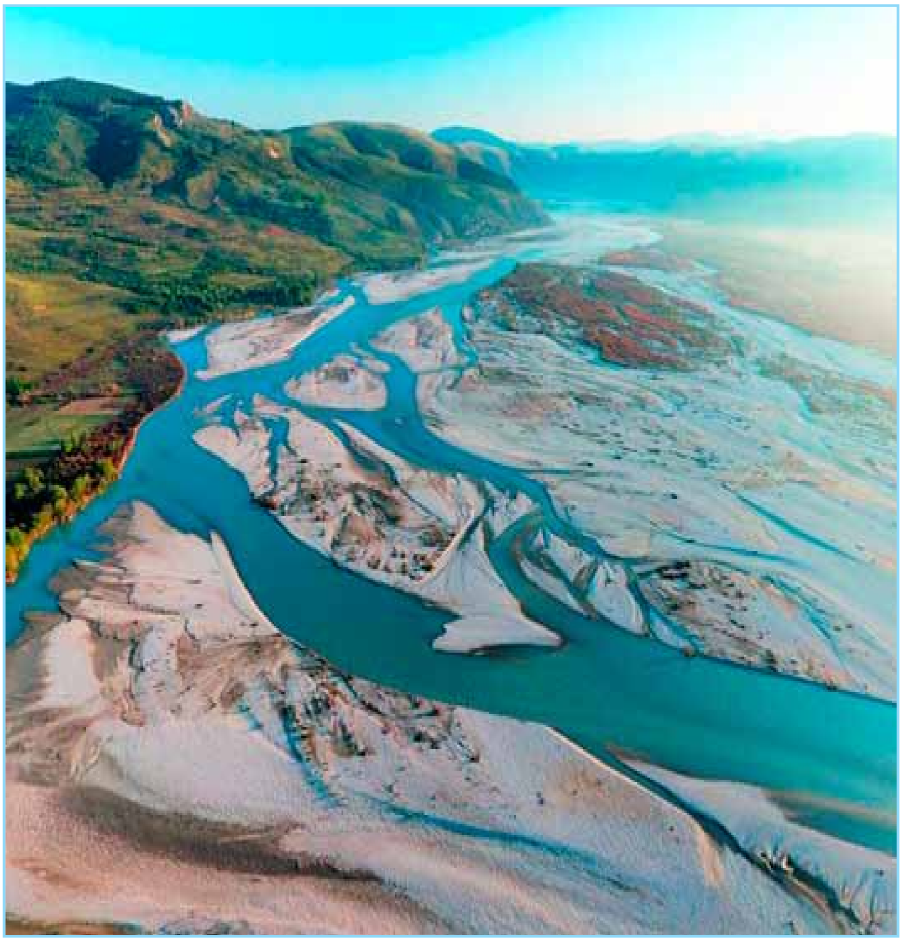


Figure 20: Two larger hydropower projects - Kalivac and Pocem - are currently planned along the middle reaches of the Vjosa river in Albania." The panels 'A' and 'B' indicate agricultural land use practices along the river.

et al., 2016; Wendle, 2016).

The Kalivac hydropower project near the town of Tepelena was initially started in 1997 but with only slow progress wherefore no fundamental constructions works were carried out until today. While the Albanian government was in favour of the project over the last years, recent statements of the country's president could be interpreted as a change of policy (EuroNatur 2020). The Kalivac HPP is intended to hold a power capacity of about 111MW with a dam wall height of 45m and an estimated water reservoir covering about 16km^2 (Abkons, 2019).

Nearby, in a distance of about 15km downstream, another large HPP is planned to be constructed – the Pocem hydropower project. The Albanian government issued the concession in 2016 for the construction of a 102MW hydropower plant that potentially creates a water reservoir of about 23.5km^2(GR Albania, 2017; Nika et al., 2016). Both HPP projects will interfere with the natural hydrological regime of the Vjosa river and hence alter key ecosystem services the population currently utilizes. While positive effects may be generated such as an enhanced potential to mitigate floods, negative impacts are likely for ecosystems and peoples' livelihoods as outlined in the Environmental and Social Impact Assessment (ESIA) report for the Kalivac HPP (Abkons, 2019). The assessment reports for both projects remain, however, vague when it comes to concrete numbers of potentially affected people. While the ESIA report for Kalivac HPP provides broad regional population statistics without providing a clear population count of potentially affected people, the Pocem ESIA report does not provide any information in this regard. Especially the Pocem ESIA report (GR Albania, 2017) was criticized by NGOs and scientists for not complying with international legal standards (Nika et al., 2016).



Planned location of the Pocem hydropower plant at the Vjosa river in Albania. Source: Gregor Subic.

Figure 20 presents an overview on the geographical settings of the two HPP projects along the Vjosa river in southern Albania. The plants in the east of the map potentially create upstream 'Impact Areas' that cover part of the main river and its tributaries. The downstream 'Impact Areas' of both HPPs merge into one and extend down to the mouth of the river which is located about 60km downstream of Poçem HPP. Since both projects will have large power capacities and are assumed to strongly interfere with the hydrological system, their impacts are likely to be experienced until the river's mouth due to e.g. altered flow and temperature regimes, changed sediment transportation and erosive power (Abkons, 2019).

The panels 'A' and 'B' in Figure 20 indicate that the inhabitants of the area practice agriculture along the flat alluvial plains of the river which is confirmed by the Kalivac ESIA report (Abkons, 2019). This agricultural utilization intensifies further downstream. In addition, many villages and small towns are located close to the Vjosa river, only a few hundred meters away from ecosystem conditions (e.g. groundwater levels, water-dependend vegetation, wildlife) and hence, the dam-induced alterations will be experienced by the riparian population in their economic, agricultural and socio-cultural practices. Especially the high touristic and recreational value of the Vjosa river system (known for water sports such as kayaking and rafting) may be at risk.

4.3.2 Case study: Neretvica river, Bosnia and Herzgegovina

The Neretvica river is located in central Bosnia and Herzegovina, west of the city of Sarajevo. On a length of approximately 30km, the Neretvica runs into the Jablanica reservoir of the Neretva river, as indicated in Figure 21. The river has not yet been developed for hydropower generation, but the public utility 'PE Elektroprivreda Bosne I Hercegovine' (EPBiH) intends to construct 15 small HPPs along the Neretvica river. Some of these plants will have a diversion scheme configuration with water abstraction points in the headwaters and their powerhouses sitting further downstream on the river, resulting in dewatered river sections in between (MacDonald, 2017). This cascade of hydropower plants will have a total power capacity of about 26MW when completed, with each of the plants having individual capacities of below 1 and up to 10MW (MacDonald, 2017).

The hydropower development process along the Neretvica river resulted in protests of the local population, particularly during the ongoing Corona crisis of 2020. Several hundreds of people demonstrated against commencing construction works that were considered as being illegal at the current stage of the permitting process. Local people consider the anticipated alterations of hydrological conditions as severely impacting flora and fauna conditions as well as drinking water supply for local villages (Arnika, 2020; Spasic, 2020a, 2020b).

Overall, the region along the Neretvica river is less densely populated as compared to other parts of the country. This hilly area is mainly covered by patchy forests, grasslands and agricultural plots with few villages in between. According to the ESIA that was carried out for the intended 15 HPPs along the river, stakeholder consultations revealed that the river was primarily used by the local population for fishing, angling and swimming as well as waste water dilution. Irrigation and livestock watering were not found to be important factors in water utiliz-

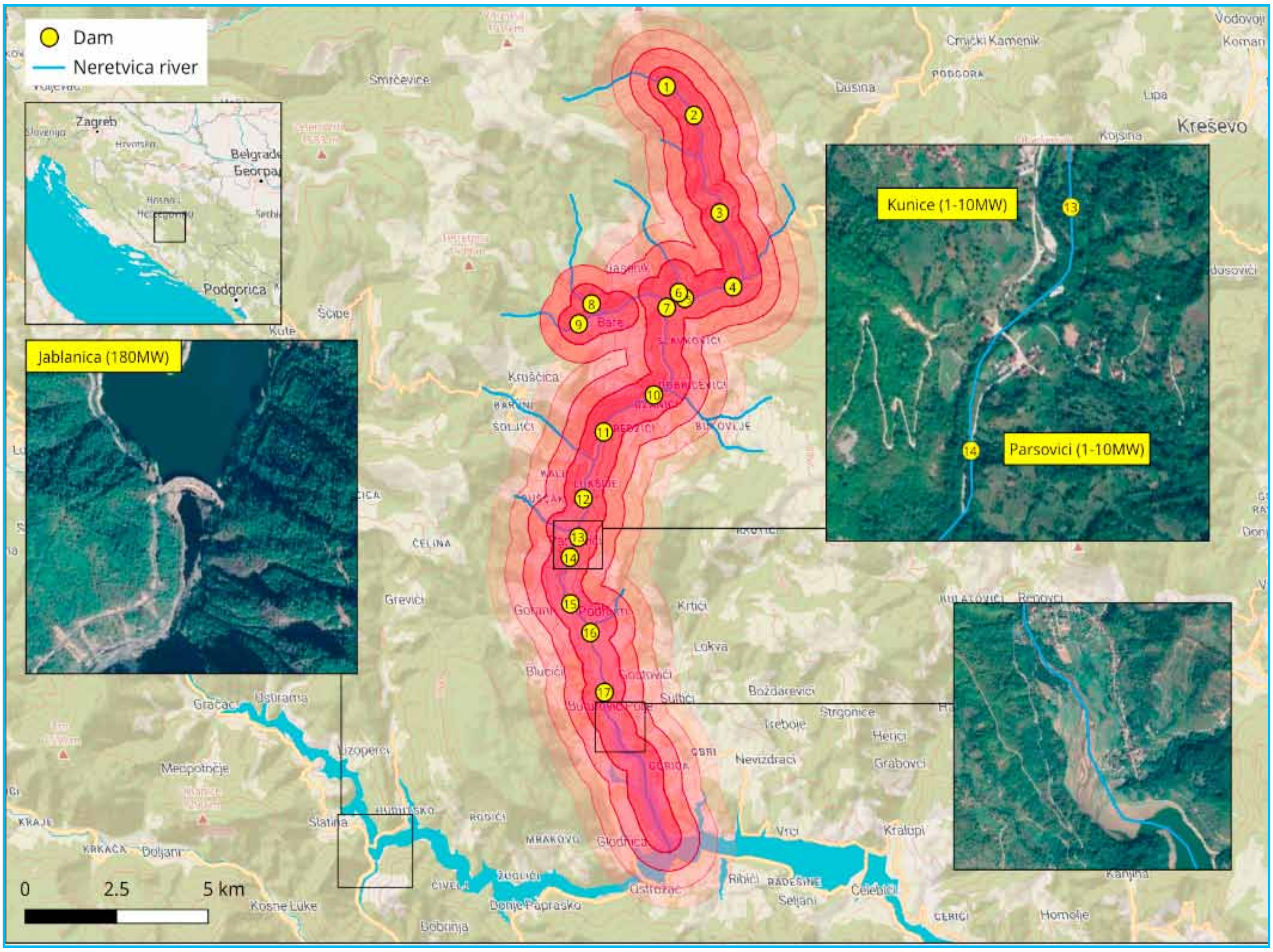


Figure 21: Small hydropower plants planned along the Neretvica river in Bosnia and Herzegovina. While the official ESIA report mentions 15 HPPs that are planned, the database by Schwarz (2019b) depicts 17 projects along the river.

ation. Since the river is not suitable for water sports, its potential for tourism was considered to be low. As a result, the ESIA study estimated that about 523 people are potentially affected from hydropower development along the Neretvica river (MacDonald, 2017).

When applying the 'Social Impact Model' to this case study, it becomes apparent that the small HPPs under consideration are likely to create 'Impact Areas' that merge into one as the plants are located close to one another. The cascading configuration suggests that if all HPPs would go into operation, hydrological changes and hence ecosystem services alterations need to be expected for almost the entire length of the river. This means that all people along the river are likely to experience changes in their livelihoods – their daily economic and social routines and cultural practices may need to be adapted to the new conditions. This may go beyond the tangible effects assessed by the ESIA report (MacDonald, 2017), since water flow changes may trigger ecosystem responses (e.g. groundwater level changes) that could result in further changes in peoples' livelihoods (e.g. drinking water supply).

As a result, our model suggests that about 360 people are potentially affected when considering the area close to the river (500m distance). This number increases to about 1,100 people when the 'Impact Distance' increases to a maximum of 2km from the river stream. Hence, the model results are close to the assessment results of MacDonald (2017) and can be considered as a reasonable reproduction of the empirical results. Nevertheless, the population data used here must be interpreted with caution when applied to small case studies like the Neretvica river (see section 6).

4.3.3 Case study: Golubic hydropower plant, Croatia

The Golubic HPP in Croatia is a typical example of a smaller HPP that follows a 'diversion-scheme' configuration which normally results in dry riverbeds. In general, the country's hydropower sector is expanding due to the perceived positive economic effects of hydropower (Kaček et al., 2019). The Golubic hydropower plant is located at the Butisnica river in the country's south and is already operating since 1981 and has a power capacity of 7.5MW (GEO, 2020). As can be seen in Figure 22, a small reservoir lake was created by the dam in the north from where water is diverted for about 1.2km along the western part of the original river stream. This diversion-scheme setting transports water via an open channel to a point from where the water is fed into a pipeline. This pipeline supplys water to two turbines in a powerhouse after which the water is released back to the original river stream.

The visual interpretation of the satellite image indicates that the river section below the dam is largely dewatered as the size of the original river increases again, after the diverted water is returned. This means, the actual river that may provided the riparian population with the opportunity of drinking water provision, irrigation and livestock watering was potentially altered in favour of electricity generation. The 'Social Impact Model' automatically identified this area as being potentially affected with about 400 people living in the closest zone (500m) and about 700 people living in the largest zone for this HPP category (2,000m). About 50% of the 'Impact Area' is utilized for agricultural purposes while another 43% are covered with forest and grassland. The 'Impact Area' identified by the 'Social Impact Model' extends further downstream beyond the point where water is returned from the powerhouse, as evidence suggests that the hydropower impact is likely to be experience for several kilometres downstream (e.g. altered water temperature and sediment loads).

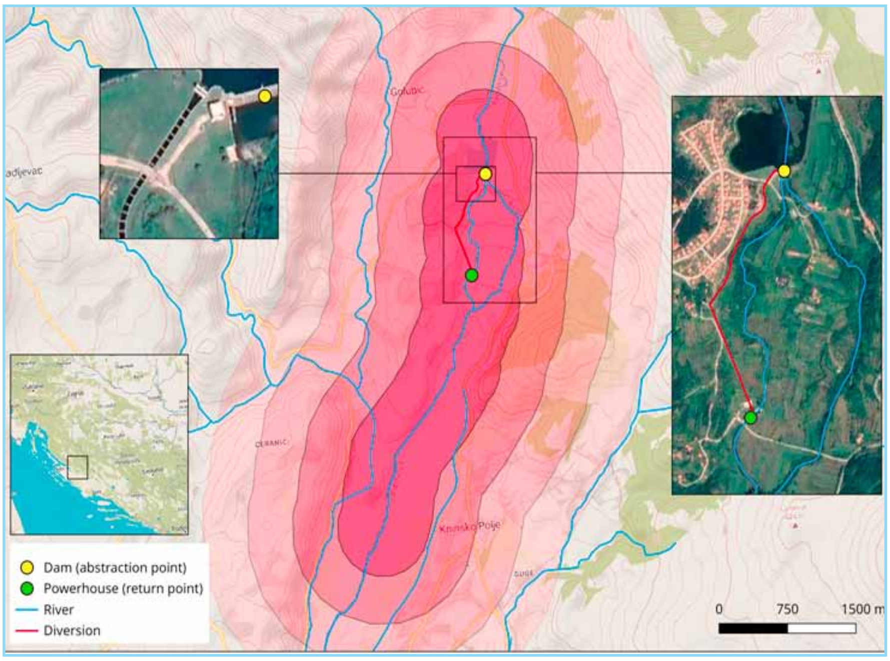


Figure 22: Golubic hydropower plant in southern Croatia at the Butisnica river. Water is diverted via an open channel towards the powerhouse while the original stream carries less water, especially during the dry season.

5. Conclusions

This study made a first attempt to estimate the number of people potentially affected by hydropower development in the Balkan countries. We developed the so called 'Social Impact Model' that draws on generalized assumptions on the up- and downstream impacts of hydropower plants and makes use of available spatial data for its semi-automated procedure to provide respective population estimates

Hydropower-induced changes in hydrology and the associated reduction in ecosystem services create impacts on the livelihoods of people that are diverse and may even affect people who live further away from a river. Although, HPPs can potentially provide benefits to local communities, negative impacts are more likely that can critically affect livelihood conditions. Traditional practices of farming, livestock herding, hunting, fishing/angling, using certain forest products and recreational activities may be restricted due to changed hydrological and ecological conditions. Recent protests in the Balkan countries against certain hydropower projects are a sign for the population's fears and concerns in this regard.

Based on our work and the wider literature review, we would like to draw three major conclusions and provide an outlook for future research on social impacts

- Hydropower development in the Balkan region is likely to have an impact on **1.3 to 4.6 Million people.** This means that about **3 to 11% of the region's entire population** may be confronted with potential livelihood changes. Against this background, strategies for hydropower development should critically reflect their contributions to national energy supply targets on the one hand and their benefits for local ecological and social sustainability targets, on the other hand.
- The social impacts from hydropower go beyond the most obvious tangible impacts of direct displacement due to inundated upstream areas. Our case studies and the overall literature underpin that the **indirect effects of hydropower affect a larger share of the population** due to changes brought about in agricultural, economic, cultural and health practices.
- Current social impact assessments do not account for these multi-faceted impacts from hydropower development. Taking a **full social-ecological perspective** is likely to reveal a broader and more nuanced picture on how people benefit from or bear the damages and costs from hydropower projects, locally.

Overall, we do not want to suggest that assessing the diverse social impacts from hydropower in a specific case is easy to do, but we would rather emphasize the need to develop respective tools that account for this diversity. Our 'Social Impact Model' is one of these tools that can support respective assessments and point to certain hot spot areas that require more in-depth analyses. Quantitative assessments like ours, however, carry uncertainty due to the large spatial focus and limited qualitative insights into social impacts from the study area. We used generalized assumptions on 'Impact Distances' and 'Impact Areas' that stem from previous case studies, but more empirical information is required for the Balkan region to put the assumptions on a valid and representative basis. Hence, we would argue for further research in this direction of understanding the social impacts on people's livelihoods in order to calibrate quantitative models such as the 'Social Impact Model'.

We give our life, not our river! Protest slogan in Rakita village, Serbia. Credit: Sanja Kljajic.

6. Detailed Methodology

Section 3 gave a brief overview on the general method applied in this study. To provide the interested reader with deeper insights, the current section will expand the aforementioned information with a focus on (i) the data sources utilized, (ii) the accuracy of spatial population figures, (iii) the spatial validation procedure, (iv) the 'Social Impact Model' parameters of 'Impact Distance' and 'Impact Area' as well as (v) the 'Social Impact intensity' indicator and (vi) the extrapolation process.

6.1 Data sources

The study builds upon multiple data repositories to represent relevant environmental and societal variables. The data utilized are freely available from online platforms of different institutions so that the performed method can be replicated. Table 1 provides an overview of the relevant variables and their specific parameters and sources. The data were obtained, quality-checked and pre-processed to be used as input for the semi-automated procedures developed.

Table 1: Overview on datas utilized for the spatial analysis.

Domain	Variable	Resolution	Date	Source
Population	National statistics	Country	2019	EUROSTAT, World Bank
	Population estimates	250m	2019	European Commission (EC) Global Human Settlement Project
	Rural/Urban Classific-ation	1km	2016	European Commission (EC) Global Human Settlement Project
	Borders	National/ Sub-national	2019	EUROSTAT, Natural Earth
Environment	River network	---	2019	Copernicus Land Monitoring Service
	Watersheds	---	2010/ 2023	Copernicus Land Monitoring Service, FAO GeoNetwork
	Satellite imagery	<1m	2010-2020	Google Maps, Bing Maps
	Land use	100m	2018	CORINE, Copernicus Land Monitor-ing Service

Man on field. Credit: Eledia Bundo

The land cover data utilized in this study is a high-resolution data product from the Copernicus Land Monitoring Service – the CORINE land cover classification. For the European continent, this product classifies the region according to the 44 classes presented in Figure 23 with a 100m grid resolution.

Most important for the Balkan region are the groups of 'artificial surfaces' as they indicate direct human built infrastructure, 'agricultural areas' of various kinds due to the high importance of agriculture for the Balkan countries, 'forests' and 'shrub and herbaceous vegetation' with their importance for local livelihoods in terms of forest-products and hunting activities as well as being the key elements of the pristine landscape of the Balkans.

CORINE land cover classification

1. Artificial Surfaces

1.1 Urban fabric

- 1.1.1 Continuous urban fabric
- 1.1.2 Discontinuous urban fabric

1.2 Industrial, comercial and transport units

- 1.2.1 Industrial or commercial units
- 1.2.2 Road and rail networks and associated land
- 1.2.3 Port areas
- 1.2.4 Airports

1.3 Mine, dump and construction sites

- 1.3.1 Mineral extraction sites
- 1.3.2 Dump sites
- 1.3.3 Construction sites

1.4 Artificial, non-agricultural vegetated areas

- 1.4.1 Green urban areas
- 1.4.2 Sport and leisure facilities

2. Agricultural areas

2.1 Arable land

- 2.1.1 Non-irrigated arable land
- 2.1.2 Permanently irrigated land
- 2.1.3 Rice fields

2.2 Permanent crops

- 2.2.1 Vineyards
- 2.2.2 Fruit trees and berry plantations
- 2.2.3 Olive groves

2.3 Pastures

- 2.3.1 Pastures

2.4 Heterogeneous agricultural areas

- 2.4.1 Annual crops associated with permanent crops
- 2.4.2 Complex cultivation patterns
- 2.4.3 Land principaly occupied by agriculture

3. Forest and seminatural areas

3.1 Forest

- 3.1.1 Broad-leaved forest
- 3.1.2 Coniferous forest
- 3.1.3 Mixed forest

3.2 Shrub and/or herbaceous vegetation associations

- 3.2.1 Natural grassland
- 3.2.2 Moors and heathland
- 3.2.3 Sclerophyllous vegetation
- 3.2.4 Transitional woodland/shrub

3.3 Open spaces with little or no vegetation

- 3.3.1 Beaches, dunes, sands
- 3.3.2 Bare rock
- 3.3.3 Sparsely vegetated areas
- 3.3.4 Burnt areas
- 3.3.5 Glaciers and perpetual snow

4. Wetlands

4.1 Inland wetlands

- 4.1.1 Inland marshes
- 4.1.2 Peatbogs

4.2 Coastal wetlands

- 4.2.1 Salt marshes
- 4.2.2 Salines
- 4.2.3 Intertidal flats

5. Water bodies

5.1 Inland waters

- 5.1.1 Water courses
- 5.1.2 Water bodies

5.2 Marine waters

- 5.2.1 Coastal lagoons
- 5.2.2 Estuaries
- 5.2.3 Sea and ocean

Figure 23: Showing the CORINE land cover classification.

6.2 Accuracy of population data

Population numbers were extracted from a raster product that provides population estimates worldwide on a 250m grid. It was compiled by the European Commission Global Human Settlement Project (GHSP) and constitutes one of the most recent and up-to date population data products currently available (GHSP, 2020).

Table 2: Population estimates from grid product in comparison with official statistics from World Bank for 2015.

Country	Grid estimate	World Bank	Accuracy [%]
Macedonia	2,087,926	2,079,328	99.59
Albania	2,877,862	2,880,703	99.90
Kosovo	1,892,657	1,801,800	95.20
Greece	10,363,363	10,820,883	95.59
Republic of Serbia	7,004,564	7,095,383	98.70
Croatia	3,929,035	4,203,604	93.01
Slovenia	2,091,784	2,063,501	98.65
Bulgaria	7,227,054	7,177,991	99.32
Montenegro	603,608	622,159	96.93
Bosnia and Herzegovina	3,838,643	3,429,361	89.34
Total	41,916,496	42,174,713	99.38

The GHSP combines information domains from official census data via satellite imagery and further open spatial data repositories. It utilizes a fully automated process to conflate the relevant information and provide a consistent data product, depicting the population distribution for the year 2015 (GHSP, 2020).

After intersecting the spatial population estimates with administrative boundaries of the countries in the study area, the population estimates could be derived on a per-country basis (Table 2). It reveals, that nearly 42 million people inhabit the entire study area with the largest population in Greece, Serbia and Bulgaria. In order to assess the accuracy of these estimates, they were compared to official international statistics from the World Bank (The World Bank, 2020). Overall, the accuracy of the spatial data can be considered suitable as most country figures show an accuracy of above 95%. Only the results for Bosnia and Herzegovina deviate from this with only 89% of accuracy.

While the accuracy of the spatial population data can be considered as high on the country level, it had to be tested if it also reproduces official population statistics on finer spatial scales. For this purpose, the smallest available administrative units in the European Union were chosen for which population figures are available – the Local Administrative Units (LAU). Overall, the spatial data and the official statistics correlate well. On average, the deviation between official statistics and spatial estimates is marginal with

The Jablanica Dam on the Neretva River in Bosnia and Herzegovina. (Source: www.en.wikipedia.org/wiki/Jablanica_Dam) only about 1% difference. Against this background, the GHSP population product is considered suitable for the current study to depict population counts in the Balkan countries.

6.3 Spatial validation

The database from Schwarz (2019b) constitutes the most comprehensive and most recent inventory of HPPs for the Balkan countries. It distinguishes hydropower projects in terms of their actual or intended installed power capacity and their current project status as depicted in Figure 24. It becomes obvious that most HPPs are in a planning stage, especially for the countries of Greece and Serbia where this is true for around 90% of all projects inventoried.

Since the planned HPPs in the Schwarz (2019b) database were primarily compiled from literature reports, their exact spatial locations carry uncertainty due to preliminary project stages and often vague location details. Since the study's intended spatial approach requires highly accurate spatial data on HPP locations, only those hydropower plants were considered for model calibration that are currently operating. We thus visually checked more than 1,200 HPPs of the database via recent satellite imagery in order to validate their location data and to make sure that the model will only be calibrated with reasonable cases where people are affected by currently operating HPPs.

Using this validation procedure, we were able to confirm the location of about 44% of the HPPs classified as currently operating. This does not mean that the remaining number of HPPs have wrong location data since multiple reasons may exist that prevented us from verifying their location such as outdated and low-resolution satellite imagery, topographic shadows and vegetation cover. Nevertheless, we consider the sample size of about 500 HPPs as reasonable to calibrate the SIM with a representative set of cases that covers all relevant power capacity classes in the Balkan countries.

Vjosa river, Albania. Credit: Gabriel Singer.

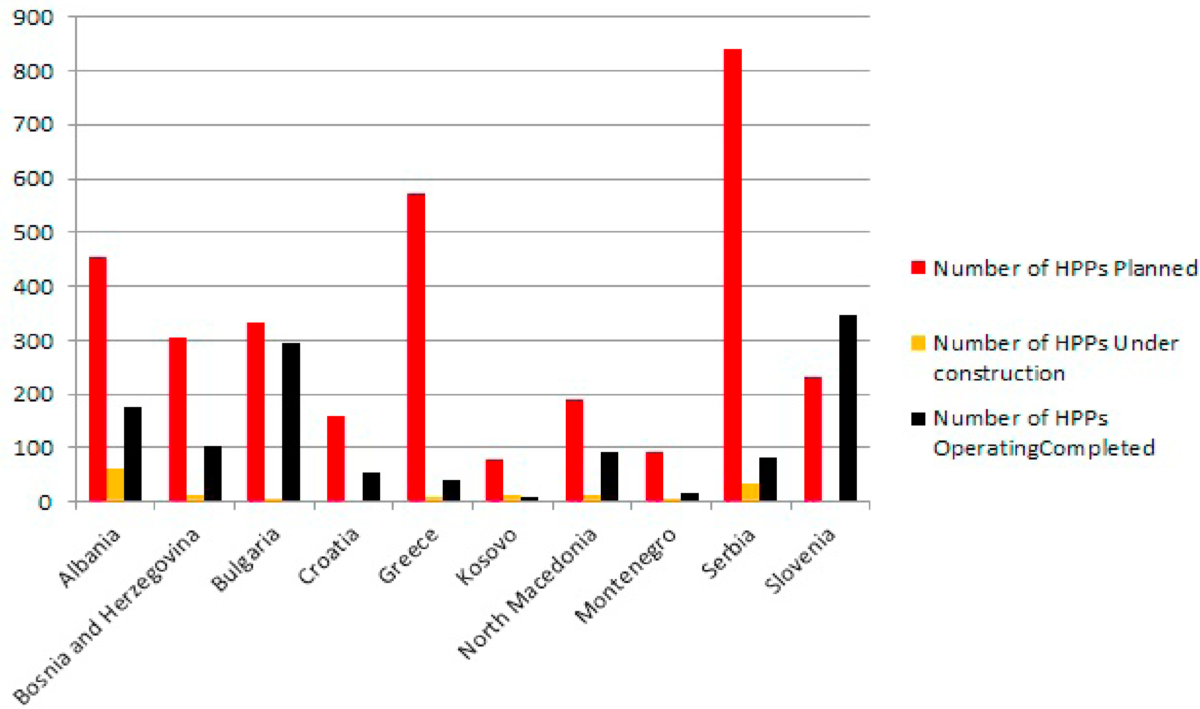


*Figure 24: Number of hydropower plants per country, classified according to their current project status (*Schwarz 2019b)

6.4 Social Impact Model

Assessing the number of people potentially impacted by HPPs is a task that has not yet been carried out frequently. The only study that performed comparable research is the one from Richter et al. (2010). They analysed about 7,000 LHPs worldwide to estimate the number of potentially affected people (Richter et al., 2010). Other studies that consider the impacts of HPPs conventionally focus on their impacts on biodiversity and flow regime changes (Josimovic and Crncevic, 2012; Lange et al., 2018; Zeleňáková et al., 2018) and the social impacts in a qualitative manner (Adams, 1985; Gyau-Boakye, 2001; Jumani et al., 2017). Most of the research on the impacts of HPPs on society stays rather conceptual (Jager et al., 2015).

The methodology applied by Richter et al. (2010) comes closest to what this study intended to carry out. Their approach builds upon the assumption that a hydropower plant of higher capacities (>100 MW) will have a noticeable impact on the entire river downstream of the HPP location where water is impounded. Along these river segments downstream the plant location, they assume that all people are potentially affected who live in rural settings within a vicinity of 10km to the river and on slopes of below 1 degree. Tough the latter assumption on the role of slopes must be critically questioned (though people live on higher slopes does not necessarily mean they do not utilize river ecosystem services), their assumption of a 10km buffer along rivers seems to be a reasonable first approximation in the cases where large hydropower plants are considered.

We regard this procedure as a valid starting point for this study but see the necessity to further develop the methodology as the impacts of HPPs on the landscape and hence the ecosystem services vary with specific hydropower plant configurations. Therefore, this study assumes that all HPPs have both up- and downstream impacts on the environment. While the downstream impact is one of the most obvious effect due to e.g. dewatered channels (Kibler and Tullos, 2013) and negative impacts on aquatic organisms (Lange et al., 2018), upstream impacts are also relevant, primarily due to reservoir lakes that may evolve (depends on the specific plant configuration) and the inhibition of fish migration (Benejam et al., 2016; Bilotta et al., 2016).

For putting this approach into practice, a semi-automated analysis procedure was developed in a combined use of Geographic Information Systems (GIS) and the numerical modelling environment 'R'. Therein, a process was implemented to (i) identify the up- and downstream river sections from the respective HPP locations, (ii) assign capacity-oriented 'Impact Distances' over which a HPP impacts the river sections, (iii) implement specific 'Impact Areas' along the affected river sections that represent the influence of the HPP on the landscape and (iv) calculate the number of people that live within the impacted area and obtain the land use statistics therein. Here, we define this semi-automated procedure as the 'Social Impact Model' that can be applied to any point location data (representing HPPs) and corresponding line data (representing river stretches).

To indicate the impact of a HPP on the population, the following two key variables – 'Impact Distance' and 'Impact Area' – are defined and parametrized according to literature information. Figure 5 (section 3.2) provides a visual impression of how these two variables interact and enable us to estimate the number of people potentially affected.

6.4.1 Impact Distance

This variable describes the distance along a river that is potentially impacted by the operation of HPPs, measured from the location where water is either held back (impounded) by a reservoir wall or diverted from the original river stream towards a powerhouse. The 'Impact Distance' extends both up- and downstream and hence represents the effects on the alteration of river discharge (e.g. reduction of low flow, alteration of sedimentation, water temperature changes, ecological changes) on the one hand and the alteration of ecological habitat connectivity (e.g. fish migration), on the other hand. The 'Impact Distance' hence varies based on the specific configuration of the HPP under consideration. In this regard we take up the only variable available from the Schwarz (2019b) database to distinguish the HPPs which is the actual or intended installed power capacity. We utilize this variable to scale the 'Impact Distances', assuming that HPPs with lower capacities have shorter 'Impact Distances', while it increases with rising power capacities. Unfortunately, the scientific literature provides only little evidence on how to define this gradient of 'Impact Distances' in the up- and downstream direction. While Richter et al. (2010) solely considered the downstream impact and assumed that the entire downstream part of the river is potentially affected by HPP operations, we think that this assumption does not hold true for the small HPPs under consideration of this study in the Balkan region. Since the current hydropower plants are a lot smaller, we rather fall back on one of the few studies that quantified hydropower impacts. Kibler & Tullos (2013) carried out an assessment on hydropower impacts in a watershed in China and obtained quantitative data on how far certain HPPs impact up- and down-stream parts of the river (Kibler and Tullos, 2013). From their study, we condensed relevant parameters for our 'Impact Distance' parameter in a way that we can determine a distance per MW of installed power as presented in table 3.

Overall, the downstream distances are longer than the corresponding upstream distances as the literature suggests that downstream impacts on ecosystems extent far beyond the HPP location. The upstream distances are shorter due to average reservoir lake sizes that may evolve for the respective capacity classes. In our model, HPPs with small capacities of below 1MW only create 'Impact Distances' of 860m downstream and 90m upstream. These figures go up to about 86km and 8.5km for HPPs that are classified as having more than 100MW of installed power. The parametrization for these large hydropower plants corresponds to the way Richter et al. (2010) configured their model.

Against the background of scarce information in the literature on respective quantitative parameters, we consider this approach of grading the 'Impact Distances' along capacity classes and the specific values we condensed from Kibler & Tullos (2013) as a reasonable first step. Further studies may look closer at this table in order to adapt it to the actual conditions in the Balkan region – a task which is very interesting and valuable but which went beyond the scope of this study.

Table 3: Assigned impact distances by HPP capacity

HPP capacity	Impact distance downstream [m]	Impact distance upstream [m]
< 1	860	90
1 – 10	4.300	430
10 – 50	25.800	2.550
50 – 100	64.500	6.380
> 100	86.000	8.500

6.4.2. Impact Area

While the 'Impact Distance' indicates the extent to which HPPs are affecting a river, the 'Impact Area' suggests the spatial extent into the landscape that stems from the effects HPPs may have on river ecosystem services. The assumption here is that the population utilizes a range of ecosystem services from a river (e.g. provisioning, regulating and cultural services). However, with increasing distance from the river, the relevance of the services for societal well-being decreases. While Richter et al. (2010) assumed that all rural people within a 10km buffer zone along a river obtain these services and are hence potentially affected (Richter et al., 2010), this study assumes a more nuanced approach. Hence, a distance gradient was constructed that increases with the capacity classes, as depicted in table 4.

Table 4: Assigned 'Impact Area' distances by HPP capacity.

HPP capacity	500	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000
< 1	x	x								
1 – 10	x	x	x	x						
10 – 50	x	x	x	x	x	x				
50 – 100	x	x	x	x	x	x	x	x		
> 100	x	x	x	x	x	x	x	x	x	x

Against the background of the spatial resolution of the population raster product (250m) we consider a step-wise gradient of 500m as a suitable procedure. This means that for each of the capacity classes, the 'Impact Area' is characterized by a sequence of several 500m buffers along the impacted river sections. For each of the classes, this enables us to calculate the population numbers and the land use statistics in a transparent way and provide an indication of how many people may potentially experience alterations of their livelihoods as they live closest to affected rivers.

6.4.3 Technical Implementation

For technical implementation of the 'Social Impact Model', this study combined GIS software (QGIS) with the numerical and statistical modelling environment 'R'. While data preparation was conducted using QGIS tools, the model itself was implemented in the 'R' environment using various l

ibraries that enable us to create routes from HPP points towards the outlet of a watershed (downstream 'Impact Distance') and towards the various sources upstream a HPP's

location. 'Impact Distances' and 'Impact Areas' were automatically created by this procedure including the zonal statistics to obtain the population estimates per 'Impact Area' and the corresponding land use statistics. These model results were analysed and worked up as the 'Social Impact Intensity' indicator, explained in the following section.

6.5 Social Impact Intensity

The study's initial idea to apply the 'Social Impact Model' to all HPPs in the Schwarz (2019b) database could not be realized due to the uncertainty attached especially to the location data of the planned dams. Hence, the decision was taken to calibrate the model using a verified subset of currently operating HPPs and extrapolate the results to the entire database.
In doing so, the key figure obtained from the 'Social Impact Model' is the 'Social Impact Intensity' indicator that describes, how many people are potentially affected per MW of installed power. This indicator was generated for the entire region and for the individual countries in order to uncover and account for local particularities. The SII was presented as a range depicting people/MW in the closest 'Impact Area' (500m) against the number of people/MW in the largest 'Impact Area' (5,000m). This way, conclusions may be drawn on the severity of HPP impacts as for people living closer to impacted rivers, the overall HPP effect may be larger than for people who live further away.

The 'Social Impact Intensity' indicator was then applied to all HPPs in the database from Schwarz (2019b) in order to extrapolate the findings and carve out how many people may be affected now due to operating HPPs and how this number would change if all HPPs would go into operation. Of course, this extrapolation constitutes an approach with high uncertainty as we assume that the spatial impact patterns that we see among the validated HPPs will be reproduced by all future HPPs in a similar way. Furthermore, 'Impact Areas' may overlap since HPPs are often build in a cascading fashion along rivers so that downstream 'Impact Areas' of one HPP may be upstream 'Impact Areas' of another HPP, simultaneously. This effect is typical for the Balkan region and can already be seen in the validated subset of HPPs and thus, the effect is incorporated into the SII indicator, but not in an explicit manner.

Despite these limitations of the approach, we consider it an adequate way forward against the background of limited data availability and time as well as unavailable local observations.

6.6 Methodological way forward

We would like to carve out potential methodological ways forward on how to improve the accuracy/reliability of the 'Social Impact Model' results. First, the model may be further improved by incorporating more environmental parameters such as altitude, terrain data and discharge volumes. Second, the particular parameters of 'Impact Distances' and 'Impact Areas' critically depend on a HPPs concrete configuration, if water is impounded or if water is rather diverted from the original river stream. As this information was not available in the Schwarz (2019b) database, we generated broad assumptions to account for both key types. More information on a plant's configuration would hence offer to specify the model and provide more targeted results. Third, improvements in the approach critically depend on more first-hand empirical evidence from the Balkan region itself. In this study we relied on literature information on people's dependence on river ecosystem services which constitutes a valid first approach but this potentially varies among and within the countries. We attempted to account for this variance by reviewing official statistics on agricultural practices and the importance of tourism, but more empirical evidence on livelihood structures with clear spatial assignments would improve the model. Access to household and/or agricultural census surveys would be one potential way forward in this regard.

7. References

Abkons, 2019. ESIA - Hydropower Plant Kalivaç. ESIA Scoping Assessment Report for the Proposed Kalivaç HPP. abkons, Tirana.

Adams, W.M., 1985. The Downstream Impacts of Dam Construction: A Case Study from Nigeria. Trans. Inst. Br. Geogr. 10, 292. https://doi.org/10.2307/622179

Armstrong, M., 2020. Villagers in Serbia tear out hydropower pipes in protest over river. Euronews, Serbia. www.euronews.com

Arnika, 2020. More than 300 people blocked the bridge on the Neretvica river: Ready to give their life for her!

Bajramovic, S., Ognjenovic, D., Nikolic, A., 2010. Review of agriculture and agricultural policy in Bosnia and Herzegovina, in: Volk, T. (Ed.), Agriculture in the Western Balkan Countries. Leibniz-Institut für Agrarentwicklung in Mittel- und Osteuropa, IAMO, pp. 63–92.

Balkanrivers.net, 2019. Petition of Scientists for the Vjosa River.

BCO, 2018. European broadband funding for the Western Balkans. Broadband Competence Offices (BCO) Network, European Commission (EC), Brussles.

Benejam, L., Saura-Mas, S., Bardina, M., Solà, C., Munné, A., García-Berthou, E., 2016. Ecological impacts of small hydro power plants on headwater stream fish: from individual to community effects. Ecol. Freshw. Fish 25, 295–306. https://doi.org/10.1111/eff.12210

Bilotta, G.S., Burnside, N.G., Gray, J.C., Orr, H.G., 2016. The Effects of Run-of-River Hydroelectric Power Schemes on Fish Community Composition in Temperate Streams and Rivers. PLOS ONE 11, e0154271. https://doi.org/10.1371/journal.pone.0154271

Bogdanov, N., Bozic, D., 2010. Review of agriculture and agricultural policy in Serbia, in: Volk, T. (Ed.), Agriculture in the Western Balkan Countries. Leibniz-Institut für Agrarentwicklung in Mittel- und Osteuropa, IAMO, pp. 189–218.

Briones-Hidrovo, A., Uche, J., Martínez-Gracia, A., 2019. Estimating the hidden ecological costs of hydropower through an ecosystem services balance: A case study from Ecuador. J. Clean. Prod. 233, 33–42. https://doi.org/10.1016/j.jclepro.2019.06.068

Cela, R., Marku, S., Imami, D., 2010. Review of agriculture and agricultural policy in Albania, in: Volk, T. (Ed.), Agriculture in the Western Balkan Countries, Studies on the Agricultural and Food Sector in Central and Eastern Europe. Leibniz-Institut für Agrarentwicklung in Mittel- und Osteuropa, IAMO, pp. 37–62.

Cernea, M.M., 2004. Social Impacts and Social Risks in Hydropower Programs: Preemptive Planning and Counter-risk Measures.

Colchester, Marcus. „Sharing Power. Dams, Indigenous Peoples and Ethnic Minorities". Prepared for the World Commission on Dams (WCD). WCD Thematic Reviews. Cape Town: World Commission on Dams (WCD), 2000.

Couto, T.B., Olden, J.D., 2018. Global proliferation of small hydropower plants - science and policy. Front. Ecol. Environ. 16, 91–100. https://doi.org/10.1002/fee.1746

Dabrowski, M., Myachenkova, Y., 2018. The Western Balkans on the road to the European Union, Policy Contribution. Bruegel, Brussels.

Daily, G., 1997. Nature's services: Societal dependence on natural ecosystems, 1st ed. Island Press, Washington D.C. Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R.T., Molnár, Z., Hill, R., Chan, K.M.A., Baste, I.A., Brauman, K.A., Polasky, S., Church, A., Lonsdale, M., Larigauderie, A., Leadley, P.W., van Oudenhoven, A.P.E., van der Plaat, F., Schröter, M., Lavorel, S., Aumeeruddy-Thomas, Y., Bukvareva, E., Davies, K., Demissew, S., Erpul, G., Failler, P., Guerra, C.A., Hewitt, C.L., Keune, H., Lindley, S., Shirayama, Y., 2018. Assessing nature's contributions to people. Science 359, 270–272. https://doi. org/10.1126/science.aap8826

Dimitievski, D., Georgiev, N., Simonovska, A., Martinovska, A., Stojceska, M., Kotevska, A., 2010. Review of agriculture and agricultural policy in FYR Macedonia, in: Volk, T. (Ed.), Agriculture in the Western Balkan Countries. Leibniz-Institut für Agrarentwicklung in Mittel- und Osteuropa, IAMO, pp. 145–164.

Dye, B.J., 2019. Heritage dammed: water infrastructure impacts on world heritage sites and free flowing rivers ; civil society report to the UNESCO World Heritage Committee and parties of the World Heritage Convention.

Égré, D., Senécal, P., 2003. Social impact assessments of large dams throughout the world: lessons learned over two decades. Impact Assess. Proj. Apprais. 21, 215–224. https://doi.org/10.3152/147154603781766310

Espécie, M. de A., de Carvalho, P.N., Pinheiro, M.F.B., Rosenthal, V.M., da Silva, L.A.F., Pinheiro, M.R. de C., Espig, S.A., Mariani, C.F., de Almeida, E.M., Sodré, F.N.G.A. dos S., 2019. Ecosystem services and renewable power generation: A preliminary literature review. Renew. Energy 140, 39–51. https://doi.org/10.1016/j.renene.2019.03.076

EuroNatur 2020. BREAKING NEWS: Albanian PM Rama reacts – Kalivaç will not be built. [WWW Document]. URL https://www.euronatur.org/aktuell/detail/news/breaking-news-albanian-pm-rama-reacts-kalivac-will-not-be-built/ (accessed 14.10.2020).
EuroNatur, RiverWatch, 2015. Save the Blue Heart of Europe. Balkan Rivers under attack from Hydropower Lobby. EuroNatur Foundation, RiverWatch, Vienna.
European Commission (EC), 2019. Communication on EU Enlargement Policy (Cummunication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions). European Commission (EC), Brussels.
EUROSTAT, 2019. Agricultural statistics - family farming in the EU, Statistics explained. EUROSTAT, Brussels.
Farkas, B., 2017. Market Economies of the Western Balkans Compared to the Central and Eastern European Model of Capitalism. Croat. Econ. Surv. 19, 5–36. https://doi.org/10.15179/ces.19.1.1
GEO, 2020. Global Energy Observatory (GEO).
GHSP, 2020. Global Human Settlement Project. Population data [WWW Document]. Eur. Comm. Glob. Hum. Settl. Proj. URL https://ghsl.jrc.ec.europa.eu/index.php (accessed 2.15.20).
GR Albania, 2017. Profound environmental impact assessment report for the construction of HPP Poçem. GR Albania.
Grilli, G., Balest, J., De Meo, I., Garegnani, G., Paletto, A., 2016. Experts' opinions on the effects of renewable energy development on ecosystem services in the Alpine region. J. Renew. Sustain. Energy 8, 013115. https://doi.org/10.1063/1.4943010
Grizzetti, B., Pistocchi, A., Liquete, C., Udias, A., Bouraoui, F., van de Bund, W., 2017. Human pressures and ecological status of European rivers. Sci. Rep. 7. https://doi.org/10.1038/s41598-017-00324-3
Gyau-Boakye, P., 2001. Environmental Impacts of the Akosombo Dam and Effects of Climate Change on the Lake Levels. Environ. Dev. Sustain. 3, 17–29. https://doi.org/10.1023/A:1011402116047
Huđek, H., Žganec, K., Pusch, M.T., 2020. A review of hydropower dams in Southeast Europe – distribution, trends and availability of monitoring data using the example of a multinational Danube catchment subarea. Renew. Sustain. Energy Rev. 117, 109434. https://doi.org/10.1016/j.rser.2019.109434
IEA, 2000. Implementing agreement for hydropower technologies and programmes. Annex III. Hydropower and the environment: Present context and guidelines for future action. (Subtask 5 Report), Volume II: Main Report. International Energy Agency (IEA).
IHA, 2019. Hydropower status report. International Hydropower Association (IHA), London.
Ioana-Toroimac, G., Zaharia, L., Neculau, G., Constantin, D.M., Stan, F.I., 2020. Translating a river's ecological quality in ecosystem services: An example of public perception in Romania. Ecohydrol. Hydrobiol. 20, 31–37. https://doi.org/10.1016/j.ecohyd.2019.10.005
Jager, H.I., Efroymson, R.A., Opperman, J.J., Kelly, M.R., 2015. Spatial design principles for sustainable hydropower development in river basins. Renew. Sustain. Energy Rev. 45, 808–816. https://doi.org/10.1016/j.rser.2015.01.067
Jarić, S., Kostić, O., Mataruga, Z., Pavlović, D., Pavlović, M., Mitrović, M., Pavlović, P., 2018. Traditional wound-healing plants used in the Balkan region (Southeast Europe). J. Ethnopharmacol. 211, 311–328. https://doi.org/10.1016/j.jep.2017.09.018
Josimovic, B., Crncevic, T., 2012. The development of renewable energy capacities in Serbia: Case study of three small hydropower plants in the "Golija" biosphere reserve with special reference to the landscape heritage. Renew. Energy 48, 537–544. https://doi.org/10.1016/j.renene.2012.06.015
Jumani, S., Rao, S., Machado, S., Prakash, A., 2017. Big concerns with small projects: Evaluating the socio-ecological im pacts of small hydropower projects in India. Ambio 46, 500–511. https://doi.org/10.1007/s13280-016-0855-9
Keček, D., Mikulić, D., Lovrinčević, Ž., 2019. Deployment of renewable energy: Economic effects on the Croatian economy. Energy Policy 126, 402–410. https://doi.org/10.1016/j.enpol.2018.11.028
Kelly-Richards, S., Silber-Coats, N., Crootof, A., Tecklin, D., Bauer, C., 2017. Governing the transition to renewable energy: A review of impacts and policy issues in the small hydropower boom. Energy Policy 101, 251–264. https://doi.org/10.1016/j.enpol.2016.11.035
Kibler, K.M., Tullos, D.D., 2013. Cumulative biophysical impact of small and large hydropower development in Nu River, China: Biophysical Impact of Small and Large Hydropower. Water Resour. Res. 49, 3104–3118. https://doi.org/10.1002/wrcr.20243
Kirchherr, J., Charles, K.J., 2016. The social impacts of dams: A new framework for scholarly analysis. Environ. Impact Assess. Rev. 60, 99–114. https://doi.org/10.1016/j.eiar.2016.02.005
Kirchherr, Julian, Huw Pohlner, und Katrina J. Charles. „Cleaning up the Big Muddy: A Meta-Synthesis of the Research on the Social Impact of Dams". Environmental Impact Assessment Review 60 (September 2016): 115–25. h ttps://doi.org/10.1016/j.eiar.2016.02.007.

Kudumovic, L., 2020. Cultural Landscape Preservation in Bosnia and Herzegovina in the Frame of Tourism Development. TEM J. 740–749. https://doi.org/10.18421/TEM92-42

Lampietti, J.A., Lugg, D.G., Van der Celen, P., Branczik, A., 2009. The Changing Face of Rural Space: Agriculture and Rural Development in the Western Balkans. The World Bank. https://doi.org/10.1596/978-0-8213-7931-8

Lange, K., Meier, P., Trautwein, C., Schmid, M., Robinson, C.T., Weber, C., Brodersen, J., 2018. Basin-scale effects of small hydropower on biodiversity dynamics. Front. Ecol. Environ. 16, 397–404. https://doi.org/10.1002/fee.1823

Latruffe, L., Davidova, S., Desjeux, Y., 2008. Perpetuation of subsistence farming in Western Balkans: The role of factor market imperfections. Presented at the The 82nd Annual Conference of the Agricultural Economics Society, Royal Agricultural College.

Ledec G. and Quintero J. D; (2003):Good Dams and Bad Dams: Environmental Criteria for Site Selection of Hydroelectric Projects. The World Bank; Latin America and the Caribbean Region.

Lehmann, T., Gronau, W., 2019. Tourism development in transition economies of the western Balkans. Z. Für Tour. 11, 45–64. https://doi.org/10.1515/tw-2019-0004

Liu, J., Dietz, T., Carwpenter, S.R., Folke, C., Alberti, M., Redman, C.L., Schneider, S.H., Ostrom, E., Pell, A.N., Lubchenco, J., Taylor, W.W., Ouyang, Z., Deadman, P., Kratz, T., Provencher, W., 2007. Coupled human and natural systems. AM BIO J. Hum. Environ. 36, 639–649. https://doi.org/10.1579/0044-7447(2007)36[639:CHANS]2.0.CO;2

Lu, S., Dai, W., Tang, Y., Guo, M., 2020. A review of the impact of hydropower reservoirs on global climate change. Sci. Total Environ. 711, 134996. https://doi.org/10.1016/j.scitotenv.2019.134996

MacDonald, M., 2017. Neretvica River Small Hydropower Plants Project Supplementary ESIA (Scoping Report). European Bank for Reconstruction and Development.

Markovic, B., Markovic, M., 2010. Review of agriculture and agricultural policy in Montenegro, in: Volk, T. (Ed.), Agriculture in the Western Balkan Countries. Leibniz-Institut für Agrarentwicklung in Mittel- und Osteuropa, IAMO, pp. 165–188.

Martínez, Y., Álvarez-Troncoso, R., Garrido, J., 2020. Impact of small-scale hydropower stations on macroinvertebrate communities for regulated rivers. Limnetica 39, 317–334. https://doi.org/10.23818/limn.39.21

Mayeda, A.M., und A.D. Boyd. „Factors Influencing Public Perceptions of Hydropower Projects: A Systematic Literature Re view". Renewable and Sustainable Energy Reviews 121 (April 2020): 109713. https://doi.org/10.1016/j.rser.2020.109713.

MEA (Ed.), 2005. Ecosystems and human well-being: Synthesis. Millennium Ecosystem Assessment (MEA), Island Press, Washington D.C.

Mehring, M., Bernard, B., Hummel, D., Liehr, S., Lux, A., 2017. Halting biodiversity loss: how social–ecological biodiversity research makes a difference. Int. J. Biodivers. Sci. Ecosyst. Serv. Manag. 13, 172–180. https://doi.org/10.1080/21513732.2017.1289246

Mikus, O., Mesic, Z., Cerjak, M., 2010. Review of agriculture and agricultural policy in Croatia, in: Volk, T. (Ed.), Agriculture in the Western Balkan Countries. Leibniz-Institut für Agrarentwicklung in Mittel- und Osteuropa, IAMO, pp. 93–122.

Milicevic, M., Galic, M., Vidovic, R., Zeljko, Z., 2018. Pilot research of the level informal economy in tourism sector of federation of Bosnia and Herzegovina. Presented at the 24th Biennial International Congress on Tourism and Hospitality Industry (THI), Opatija.

Milovanovic, J., Djordjevic-Milosevic, S., 2016. Biodiversity and rural livelihood in the Western Balkans. Belgrad.

Negm, A.M., Romanescu, G., Zelenakova, M. (Eds.), 2020. Water Resources Management in Balkan Countries, Springer Water. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-22468-4

Nika, O., Wieser, C., Schiller, T., 2016. The Pocem Hydropower Project (Factsheet). Balkanrivers.net.

Nushi, M., 2010. Review of agriculture and agricultural policy in Kosovo under UNSCR 1244/99, in: Volk, T. (Ed.), Agriculture in the Western Balkan Countries. Leibniz-Institut für Agrarentwicklung in Mittel- und Osteuropa, IAMO, pp. 123–144. Oregon State University, 2020. Dam Impacts Database.

Ostrom, E., 2009. A general framework for analyszing sustainability of social-ecological systems. Sci. Mag 419–422. https://doi.org/10.1126/science.1172133

Rexhepi, B., Mustafa, B., Hajdari, A., Rushidi-Rexhepi, J., Quave, C.L., Pieroni, A., 2013. Traditional medicinal plant knowl edge among Albanians, Macedonians and Gorani in the Sharr Mountains (Republic of Macedonia). Genet. Resour. Crop Evol. 60, 2055–2080. https://doi.org/10.1007/s10722-013-9974-3

Richter, B.D., Postel, S., Revenga, C., Scudder, T., Lehner, B., Churchill, A., Chow, M., 2010. Lost in development's shadow: The downstream human consequences of dams. Water Altern. 3, 14–42.

Ritchie, Roser, Mispy, Oritz-Ospina, 2018. Measuring progress towards the Sustainable Development Goals (Database), SDG-tracker.org. United Nations.

RiverWatch, EuroNatur, 2018. Eco-Masterplan for Balkan Rivers. Drawing a line in the sand. RiverWatch, EuroNatur, Vienna, Radolfzell.
Roaf, J., Atoyan, R., Joshi, B., Krogulski, K. (Eds.), 2014. 25 years of transition: post-communist Europe and the IMF, Regional economic issues Special report. IMF, Washington, DC.
Schneider, C., Flörke, M., De Stefano, L., Petersen-Perlman, J.D., 2017. Hydrological threats to riparian wetlands of international importance – a global quantitative and qualitative analysis. Hydrol. Earth Syst. Sci. 21, 2799–2815. https://doi.org/10.5194/hess-21-2799-2017
Schwarz, U., 2019a. Hydropower pressure on European rivers. The Story in numbers. FLUVIUS, WWF, RiverWatch, EuroNatur, GEOTA, Vienna.
Schwarz, U., 2019b. Spatial dataset on HPP locations in the Balkan countries (including Northern Greece and excluding Turkey). (Provided by RiverWatch in February 2020). Fluvius, Vienna.
Skoulikidis, N.Th., 2009. The environmental state of rivers in the Balkans—A review within the DPSIR framework. Sci. Total Environ. 407, 2501–2516. https://doi.org/10.1016/j.scitotenv.2009.01.026
Spasic, V., 2020a. Investors taking advantage of corona crisis to build five small HPPs in BiH. Balk. Green Energy News.
Spasic, V., 2020b. NGOs file lawsuits against small hydropower plants on Neretva, Neretvica rivers. Balk. Green Energy News.
Stojcheska, A.M., Kotevska, A., Bogdanov, N., Nikolić, A., 2016. How do farmers respond to rural development policy challenges? Evidence from Macedonia, Serbia and Bosnia and Herzegovina. Land Use Policy 59, 71–83. https://doi. org/10.1016/j.landusepol.2016.08.019
The World Bank, 2020. World Bank Open Data [WWW Document]. URL https://data.worldbank.org/
Tsioutsiou, E.E., Giordani, P., Hanlidou, E., Biagi, M., De Feo, V., Cornara, L., 2019. Ethnobotanical Study of Medicinal Plants Used in Central Macedonia, Greece. Evid. Based Complement. Alternat. Med. 2019, 1–22. https:// doi.org/10.1155/2019/4513792
UN-DESA, 2018. World Urbanization Prospects 2018 [WWW Document]. U. N. Dep. Econ. Soc. Aff. UN-DESA Popul. Dyn. URL https://population.un.org/wup/DataQuery/ (accessed 2.13.20).
UNWTO (Ed.), 2020. Yearbook of Tourism Statistics, Data 2014 – 2018, 2020 Edition. World Tourism Organization (UNWTO). https://doi.org/10.18111/9789284421442
Vanclay, Frank. „Conceptualising Social Impacts". Environmental Impact Assessment Review 22, Nr. 3 (Mai 2002): 183–211. https://doi.org/10.1016/S0195-9255(01)00105-6.
Vejnovic, I., Gallop P., 2018. Financing for hydropower in protected areas in Southeast Europe: 2018 update. EuroNatur Foundation, RiverWatch, Vienna.
Volk, T. (Ed.), 2010. Agriculture in the western Balkan countries, Studies on the agricultural and food sector in Central and Eastern Europe. Leibniz-Institut für Agrarentwicklung in Mittel- und Osteuropa, IAMO, Halle (Saale).
Vujicic, M., Ristic, L., Vujicic, M., 2012. European integration and rural development policy of the Republic of Serbia and West Balkan countries. Bulg. J. Agric. Sci. 4, 519–530.
Weber, M.A., Caplan, S., Ringold, P., Blocksom, K., 2017. Rivers and streams in the media: a content analysis of ecosystem services. Ecol. Soc. 22, art15. https://doi.org/10.5751/ES-09496-220315
Weiss, S., 2018. Balkan Rivers. Endangered Fish Species. Distribution and threats from hydropower development (Report to Euronatur and RiverWatch). EuroNatur Foundation, RiverWatch, Graz.
Wendle, J., 2016. Europe's Last Wild River is About to Get Dammed. Time.
World Bank Group, 2020. The Economic and Social Impact of COVID-19. Setting the stage (Western Balkans Regular Economic Report No. 17). World Bank Group.
World Bank Group, 2019. Rising Uncertainties. Western Balkan (Regular Economic Report No. 16). World Bank Group.
Yeakley, A.J., Ervin, D., Chang, H., Granek, E.F., Dujon, V., Shandas, V., Brown, D., 2016. Ecosystem services of streams and rivers, in: Gilvear, D.J., Greenwood, M.T., Thoms, M.C., Wood, P.J. (Eds.), River Science. John Wiley & Sons, Ltd, Chichester, UK, pp. 335–352.
Zarfl, C., Lumsdon, A.E., Berlekamp, J., Tydecks, L., Tockner, K., 2015. A global boom in hydropower dam construction. Aquat. Sci. 77, 161–170. https://doi.org/10.1007/s00027-014-0377-0
Zeleňáková, M., Fijko, R., Diaconu, D., Remeňáková, I., 2018. Environmental Impact of Small Hydro Power Plant—A Case Study. Environments 5, 12. https://doi.org/10.3390/environments5010012

Kravice waterfall, Bosnia and Herzegovina. Credit: Goran Safarek.