PRIMJENA OKVIRA DPSIR ZA PROCJENU EKOLOŠKIH PROBLEMA S NAGLASKOM NA GOSPODARENJE OTPADOM IZAZVANO STACIONARNIM TURIZMOM U JADRANSKOJ HRVATSKOJ

APPLICATION OF THE DPSIR FRAMEWORK TO ASSESS ENVIRONMENTAL ISSUES WITH AN EMPHASIS ON WASTE MANAGEMENT DRIVEN BY STATIONARY TOURISM IN ADRIATIC CROATIA

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Složenost turističkog sektora ogleda se u raznovrsnosti gospodarskih i socijalnih aktivnosti. Posljedično, njihova provedba smatra se pokretačima koji uzrokuju različite pritiske i utjecaje na okoliš. Osnovni preduvjet za praćenje napretka prema održivom upravljanju turizmom je kontinuirano praćenje podataka i sveobuhvatni okvir procjene, kao što je okvir DPSIR (pokretač-pritisak-stanje-utjecaj-odgovor, prema engl. *Driver-Pressure-State-Impact-Response*) (u nastavku tekst DPSIR). Među ekološkim izazovima DPSIR-a komunalni otpad kao posljedica turističkih aktivnosti identificiran je kao jedan od glavnih ekoloških izazova. U ovom istraživanju provedena je analiza utemeljena na dokazima odabranih pokazatelja kako bi se razmotrio DPSIR razvijen s naglaskom na održivo gospodarenje otpadom. Ovaj holistički pristup osigurava utemeljenu evaluaciju i odgovarajuće mjere kao odgovor društva na dugoročno rješavanje glavnih okolišnih izazova povezanih s intenzitetom turizma. Uz to, autori su istražili moguće smjerove za razvoj veće održivosti gospodarenja otpadom u turizmu Jadranske Hrvatske, uzimajući u obzir primjere dobre prakse na otoku Krku. Istraživanje i procjena odabranih pokazatelja potvrdila je da sezonalnost turizma utječe na okoliš. Također se pokazalo da visoki intenzitet turizma ima izravan utjecaj na infrastrukturu gospodarenja otpadom koja je uglavnom uspostavljena za ograničen broj stanovnika. Stoga autori predlažu umjereni intenzitet turizma kao najpovoljniju opciju, čime se osigurava održivo gospodarenje otpadom koji stvara manji pritisak na infrastrukturu gospodarenja otpadom i okoliš. Naposljetku, ovim je radom kreiran novi pokazatelj koji istražuje održivost gospodarenja komunalnim otpadom.

Ključne riječi: održivost turizma, DPSIR, održivo gospodarenje otpadom, okolišni pokazatelji, komunalni otpad, Jadranska Hrvatska

The complexity of the tourism sector relies on a variety of economic and social activities. Consequently, those are drivers that result in a variety of pressures and impacts on the environment. In order to track the progress towards sustainable tourism management, continuous data monitoring and a comprehensive assessment framework, such as the DPSIR - Driver-Pressure-State-Impact-Response, are a fundamental prerequisite. Among the environmental challenges within the DPSIR framework, municipal waste generated by the Croatian tourist industry is identified as one of the major environmental issues. In this research, evidence-based analysis using selected indicators within DPSIR framework was carried out with the emphasis on sustainable waste management. This holistic approach ensures a sound evaluation and adequate measures as a social response to address the main environmental issues regarding tourism intensity in the long term. In addition, the authors explored possible directions of more sustainable waste management in tourism for the Adriatic region of Croatia, considering the examples of the good practices implemented on the Island of Krk. Research and evaluation of selected indicators confirmed that tourism seasonality has an impact on the environment and revealed that high tourism intensity has a direct impact on the waste management infrastructure that is mostly established for a limited number of residents. Therefore, the authors suggest moderate tourism intensity as the most favourable option, resulting in a more sustainable waste management options, which produces less environmental pressure on the waste management infrastructure and the environment. Finally, through the research a new indicator was created, which explores sustainability of municipal waste management.
Key words: tourism sustainability, the DPSIR framework, sustainable waste management, environmental indicators, municipal waste, Adriatic Croatia

UVOD

Povećavanjem blagostanja u industrijaliziranim državama raste i broj proizvoda te usluga. Paradigma proizvodnje i potrošnje dovodi do stvaranja velikih količina svih vrsta otpada (Salhofer i dr., 2008.). Zbog toga je u mnogim gospodarskim sektorima, tako i u turizmu, stvaranje otpada identificirano kao jedno od glavnih okolišnih izazova. Mnogi autori ističu kako neodrživo gospodarenje otpadom u turizmu utječe na okoliš (Shamshiry i dr., 2011.; Manomaivibool, 2015.; Koski-Karell, 2019.). Turizam je sektor koji pruža ekonomsku korist svim dionicima, no zahtijeva prostor, okoliš i ljudske resurse. Nedostatak ravnoteže između navedena tri stupa može ugroziti atraktivnost i razvoj turističkih odredišta (Williams, Ponsford, 2009.).

Za prepoznavanje sistemskih uzročno-posljedičnih veza dostupni su različiti modeli i analitički okviri. Jedan od njih je DPSIR: pokretači (D) – pritisci (P) – stanje (S) – učinci (I) – odgovori (R). Navedeni je okvir nastao iz okvira PSR: pritisak (P) – stanje (S) – odgovor (R), koji je prvotno razvila Organizacija za ekonomsku suradnju i razvoj (OECD, 1993.). Zbog ograničenja PSR-a, UN-ova Komisija za održivi razvoj 1997. godine razvila je novi okvir nazvan DSR: pokretač (D) – stanje (S) – odgovor (R) (Carr i dr., 2007.). PSR i DSR ne adresiraju temeljne uzroke odgovora društva na promjene u okolišu. Stoga Europska agencija za okoliš (EEA) određuje model DPSIR kao najprihvatljiviji okvir za istraživanje ranih znakova promjena ekonomskih i socijalnih aktivnosti koje mogu utjecati na stanje okoliša, ali i za davanje odgovora društva na te promjene (Smeets, Weterings, 1999.). Uz to, DPSIR se može koristiti kao alat za proučavanje percepcije i stavova zajednice vezano uz razvojne projekte. Daje mogućnost naglašavanja skupova podataka i definiranja odgovarajućih pokazatelja ključnih za praćenje napretka u odnosu na ciljeve te za komuniciranje složenih ekoloških problema (EEA, 2014.).

Prema M. Mateusu i F. J. Campuzanu (2008.), DPSIR je praktično sredstvo za interpretaciju složenih okolišnih, ekonomskih i socijalnih odnosa koji se javljaju u obalnome području. Primjenom ovoga pristupa autori su zaključili kako postoji

INTRODUCTION

The rising level of prosperity in industrialized countries results in an increasing number of products and services. The paradigm of production and consumption inevitably generates higher quantities of all kinds of waste (Salhofer et al., 2008). Consequently, waste generation has been identified as one of the major environmental challenges in many economic sectors, and therefore in tourism, as well. Many authors stress that unsustainable waste management in tourism affects the environment (Shamshiry et al., 2011; Manomaivibool, 2015; Koski-Karell, 2019). In general, tourism is a sector that provides economic benefit to all stakeholders, but also requires environmental, spatial, and human resources. Lack of the balance between those three pillars could jeopardize the attractiveness and development of tourist destinations (Williams, Ponsford, 2009).

There are various models and analytical frameworks available to recognize systemic causal-effect relations. One of those is the Driver-Pressure-State-Impact-Response (DPSIR) framework developed originally from the Pressure-State-Response (PSR) framework by the Organization of Economic Cooperation and Development during 1994 (OECD, 1993). Due to limitations of the PSR framework, the UN Commission on Sustainable Development created a new framework called Driving Force-State-Response (DSR) framework during 1997 (Carr et al., 2007). Neither the PSR nor the DSR framework address the underlying facts behind responses in the changes of the environment. Therefore, the European Environment Agency (EEA) defines the DPSIR framework that examines early signs of changes in economic and social activities that may influence environmental conditions, but also provide responses of society (Smeets, Weterings, 1999). In addition, the DPSIR framework could be used as a tool to study community perception and attitudes regarding development projects. It offers the possibility to prioritize data sets and define appropriate indicators, which are essential for tracking the progress against the targets and for communicating complex environmental issues (EEA, 2014).

According to M. Mateus and F. J. Campuzano (2008), the DPSIR framework is a practical tool for

krhka ravnoteža između značajnih pritisaka koji su posljedica ljudskih aktivnosti, kao što su gospodarenje otpadom, i svojstava ekosustava. S. Giulietti i dr. (2016.) navode kako osim prostorne dimenzije, sezonalnost turizma ima velik utjecaj na infrastrukturu (tj. ceste i parkirna mjesta) i usluge (tj. gospodarenje otpadom i opskrbu vodom), što može ugroziti održivost destinacije. D. Styles i dr. (2013.) raspravljaju o važnosti optimizacije gospodarenja otpadom kao o najboljoj praksi upravljanja okolišem u turizmu. Predlažu uspostavu ekološki prihvatljivog upravljanja mjestima, korištenje obnovljivih izvora energije te osiguranje objekata za gospodarenje otpadom. Primjenjujući DPSIR, B. Malekmohammadi i F. Jahanishakib (2017.) utvrdili su da je turizam uzrok promjena u okolišu s obzirom na rastući broj turista te posljedično tome veće količine otpada što može smanjiti kvalitetu staništa. U posljednjem desetljeću u Hrvatskoj je također objavljeno nekoliko znanstvenih radova koji se bave primjenom DPSIR-a na lokalnoj razini (Brečko Grubar, 2010.; Lončar, 2010.) te o upravljanju vodama (Ćosić Flajsig i dr., 2017.; Runko Luttenberger, 2012.). N. Lončar naglašava da na Murteru dolazi do pritisaka zbog intenzivnih turističkih aktivnosti (glavni pokretač) te aktivnosti lokalnog stanovništva (2010.). N. Lončar (2010.) i L. Runko Luttenberger (2012.) ističu nedostatak prikladnih odgovora i napretka što se posebno odnosi na problem neadekvatne komunalne infrastrukture. Potrebno je napomenuti da se stanje i učinci ne prate na odgovarajući način. Pritisci s vremenom rastu, turizam se sve više razvija, dok s druge strane infrastruktura stari, a odgovori su prespori i neučinkoviti.

Prema Okvirnoj direktivi o otpadu (EC, 2008.), komunalni otpad je otpad nastao u kućanstvu i otpad koji je po sastavu sličan onome iz kućanstva, osim proizvodnog otpada i otpada iz poljoprivrede i šumarstva. Revidirana Okvirna direktiva o otpadu (EC, 2018.) donosi izmjenu prema kojoj komunalni otpad uključuje ambalažu, odvojeno prikupljenu ambalažu od komunalnog otpada, kućanski otpad te sličan otpad nastao iz djelatnosti obrta, industrije i institucija, uključujući odvojeno prikupljeni otpad. Europska hijerarhija gospodarenja otpadom (EC, 2008.) temelji se na životnom ciklusu i uključuje pet koraka. Prvi i najvažniji je

interpretation of complex ecological, economic, and social relationships occurring in the coastal region. Applying this approach, they concluded that there is a fragile balance between large scale human drivers such as waste treatment and ecosystem performance. S. Giulietti et al. (2016) stated that apart from spatial dimension, tourism seasonality has a major effect on infrastructure (i.e. roads and parking spaces) and services (i.e. waste management and water supply), which could jeopardize sustainability of destination. In addition, D. Styles et al. (2013) discussed the importance of waste management optimisation as the best environmental management practice in tourism. They suggested establishing an environmentally friendly site management, use of renewable energy sources and provision of waste management facilities. Following the application of the DPSIR model, B. Malekmohammadi i F. Jahanishakib (2017) concluded that tourism is a driver of environmental changes due to the growing number of tourists and, therefore, increased quantities of waste, which could reduce habitat quality. In the last decade in Croatia, there have also been some very good scientific papers dealing with the application of the DPSIR model at the local level (Brečko Grubar, 2010; Lončar, 2010) and on water management (Ćosić flajsig et al, 2017; Runko Luttenberger, 2012). N. Lončar emphasizes that on the Island of Murter the pressures are reflected through intensive tourism activity as a prime driver along with pressures brought by the population (2017). Both N. Lončar (2017) and L. Runko Luttenberger (2012) highlight the lack of suitable responses and positive advances, which particularly refers to the problem of the inadequate municipal infrastructure. It must also be noted that the state and impacts are not adequately monitored, pressures are increasing over time, infrastructure is getting older and tourism is more developed, while the responses are too slow and ineffective.

According to the Waste Framework Directive (EC, 2008), municipal waste is household waste and waste similar in composition to household waste, except the one from agriculture and forestry. Revised Waste Framework Directive (EC, 2018) enacts an amendment stating that municipal waste includes packaging, separately collected packaging from municipal waste, household waste and similar waste from crafts, industry, and insti-

prevencija nastanka otpada. Drugi se odnosi na ponovnu upotrebu i pripremu za ponovnu upotrebu, što osigurava da proizvod bude upotrjebljen za istu svrhu prije nego što postane otpad. Treći korak podrazumijeva recikliranje, što uključuje bilo koji postupak oporabe u kojem se otpadni materijali prerađuju u proizvode, materijale ili tvari u izvorne ili druge svrhe. Četvrti korak odnosi se na oporabu u kojoj se otpad prevodi u određene resurse (električna energija, toplina, kompost i gorivo). Posljednji ujedno i najnepovoljniji korak je odlaganje otpada na odlagališta, spaljivanje, piroliza, rasplinjavanje, uključujući druga krajnja rješenja.

Općenito, nedostatak odgovarajućeg postupanja s komunalnim otpadom u turizmu mogao bi biti glavni izvor okolišnih izazova (Shamshiry i sur., 2011.). S obzirom na rastuću turističku sezonalnost, može se očekivati porast količine komunalnog otpada u turističkim odredištima Jadranske Hrvatske. Kao najzastupljeniji u Hrvatskoj, stacionarni turizam je snažno povezan s navedenim trendom (Weber, Mikačić, 1999.). Stoga je cilj ovoga rada istražiti sezonalnost turizma, kao glavnog pokretača, te gospodarenje otpadom nastalim u stacionarnom turizmu, koji je jedan od ključnih pritisaka na destinacije Jadranske Hrvatske. Osim toga, cilj ovoga istraživanja je obrazložiti uspješnost mjera implementiranih radi održivosti gospodarenja otpadom. U tom su kontekstu odabrani pokazatelji kako bi se potvrdila veza između pritisaka, pokretača i odgovora dobivenih DPSIR-om. Predstavljeni su i relevantni podaci koji prikazuju dobru praksu u zaštiti okoliša na otoku Krku. Fokus je usmjeren na učinkovitost resursa, smanjenje utjecaja na okoliš i maksimizaciju koristi za stanovništvo na otoku.

MATERIJALI I METODE

U DPSIR-u „pokretači“ (D) opisuju specifične potrebe pokretačkih snaga sektora povezanih s proizvodnjom i potrošnjom (Kristensen i dr., 1999.). U odnosu na „pritisak“ (P), „stanje“ (S) pruža opis kvalitete i kvantitete fizičkih (temperatura), bioloških (riblji fond) i kemijskih pojava (emisije zagađivača, otpad). Promjene definirane analizom „stanja“ rezultiraju specifičnim „utjecatutions, including separately collected ingredients. The European waste management hierarchy (EC, 2008) is based on life cycle thinking and includes five steps. The first and more important thing is prevention. The second one is reuse and preparation for reuse by giving the products a second life before they become waste. The third one is recycling which engages any recovery operation where waste materials are reprocessed into the products, materials, or substances whether for the original or other purposes. The fourth step is recovery where waste is converted into resources (electricity, heat, compost, and fuel). The last and less favourable is disposal that includes landfilling, incineration, pyrolysis, gasification, and other finalist solutions.

In general, the absence of appropriate municipal waste treatment in tourism could be the major source of environmental issues (Shamshiry et al., 2011). Related to the growing tourist seasonality, an increase of municipal waste amounts could be expected in Adriatic Croatian tourist destinations. Stationary tourism, as the most represented type of tourism in Croatia, is in a strong relation to these trends (Weber, Mikačić, 1999). Therefore, the objective of this paper was to explore seasonality as the main driver and waste management from stationary tourism, which is one of the key pressures at the destination of Adriatic Croatia. Besides, the aim of this research was to elaborate on the success of measures implemented in sustainable waste management. In this context, other available indicators had already been selected in order to confirm correlation between selected pressure, driver and response obtained by the DPSIR framework. Beside this framework, relevant data were presented to show good practice in environmental performance on the Island of Krk. The focus was placed on resource efficiency, minimization of environmental impacts and maximization benefits for the community of the Island.

MATERIALS AND METHODS

In the DPSIR framework, ‘drivers’ describe specific needs of sectoral driving forces related with consumption and production (Kristensen et al., 1999). Those ‘drivers’ release substances which are the subject of ‘state’ analysis. In relation to the ‘pres-

Tablica 1. *Ključna pitanja DPSIR-a prema fazama*
Table 1 *Key questions of the DPSIR framework by phase*

Ključna pitanja / Key questions	Relevantne faze DPSIR-a / Relevant DPSIR phases
Što se događa? / What is happening?	(S) stanje, (I) utjecaj / (S)tate, (I)mpact
Zašto se događa? / Why is it happening?	(D) pokretački faktor, (P) pritisak / (D)riving factor, (P) ressure
Vidimo li promjene? / Are we seeing changes?	(P) pritisak, (D) pokretačka sila / (P)ressure, (D)riving force
Koliko su učinkoviti odgovori? / How effective are the responses?	(R) odgovor / (R)esponse

Izvor / Source: Rump, 1996.; Kristensen, 1999

jem" na komponente okoliša (zrak, tlo, voda), kao i na promjenu otpornosti ekosustava i dostupnosti prirodnih resursa. „Utjecaji" se mogu očitovati i na društvo poput utjecaja na ljudsko zdravlje i kapital. Procjena utjecaja zahtijeva praćenje i uporabu pokazatelja (Mateus, Campuzano, 2008.). Konačno, DPSIR analizira moguće „odgovore" društva poput zakonodavstva, određivanja prioriteta i ciljeva, oporezivanja, pokazatelja itd.

Kao „odgovor" društva, sustav praćenja je osnova za procjenu „stanja" okoliša i ostalih komponenti DPSIR-a. Svrha specifičnih pokazatelja je prikupiti sveobuhvatne podatke praćenja te pružiti informacije kreatorima politika i javnosti. Pokazatelji bi trebali biti pažljivo konstruirani. Obično se dijele prema pojedinačnim okolišnim temama (tj. zraku, otpadu i biološkoj raznolikosti), ali i prema svakoj od komponenata DPSIR-a. Mnogi autori (Rump, 1996.; Kristensen, 1999.) ističu važnost temeljnih pitanja za određivanje najprikladnijeg pokazatelja (Tab. 1.). Četiri su vrste ključnih pitanja (Tab. 1.).

Stoga je u kontekstu DPSIR-a sezonski stacionarni turizam „pokretač", stvaranje komunalnog otpada u stacionarnom turizmu „pritisak", a gospodarenje komunalnim otpadom je „odgovor" društva.

Za procjenu udjela komunalnog otpada u stacionarnom turizmu u ukupnim količinama komunalnog otpada nastalog u Jadranskoj Hrvatskoj, autori su se koristili pokazateljima Komunalnog otpada iz turizma (EC, 2006.). Ova procjena temelji se na:

- izračunu koji uzima u obzir ukupan broj noćenja turista
- broju stanovnika i ukupnom komunalnom otpadu proizvedenom u svakoj županiji
- korekciji od 20 % zbog broja neregistriranih noćenja.

sure', 'state' gives a description of the quality and quantity of physical (temperature), biological (fish stock) and chemical phenomena (emissions of pollutants, waste). The changes that are defined by 'state' analysis result with specific 'impact' occurring on the environmental components (air, soil, water), including alteration of ecosystems resilience and natural resource's availability. It is possible that the 'impacts' are also manifested on society like influence on human health and manufactured capital. The impact assessment requires monitoring and use of indicators (Mateus, Campuzano, 2008). Finally, the DPSIR framework analyses possible 'responses' of the society, such as legislation, prioritisation and target settings, taxation, indicators etc.

As a 'response', the monitoring system is the basis for evaluation of the 'state' of the environment, and other components of the DPSIR framework. The aim of specific indicators is to aggregate those comprehensive monitoring data and to provide brief information to policy makers and to the public. The indicators should be carefully designed. They are usually mainly divided according to the individual environmental topics (i.e. air, waste and biodiversity), but also according to each of the DPSIR components. Many authors (Rump, 1996; Kristensen, 1999) emphasize the importance of the fundamental questions to determine the most appropriate indicator (Tab. 1). There are the four types of key questions (Tab. 1) to be asked.

Therefore, in the context of the DPSIR framework seasonal stationary tourism is 'driver', municipal waste generation from stationary tourism is 'pressure', and the municipal waste management is the 'response' of the society.

In order to estimate the share of municipal waste from stationary tourism in overall municipal waste generated in Adriatic Croatia, the authors used the indicator Municipal waste generated by tourists

Ekvivalent broju stanovnika daje procjenu opterećenja lokalnog sustava gospodarenja otpadom. Izračunava se kao umnožak otpada koji nastaje u turizmu na određenom području i broja stanovnika na tom području, a podijeljen je s ukupnim otpadom proizvedenim na tom području. Razmatra se područje sedam županija Jadranske Hrvatske: Istarske, Primorsko-goranske, Ličko-senjske, Zadarske, Šibensko-kninske, Splitsko-dalmatinske i Dubrovačko-neretvanske županije. Za isto područje razvijen je i drugi pokazatelj koji pruža podatke o načinima obrade otpada za kućanstvo i sličnog otpada (komunalni otpad). Metodologija uključuje tri faze:

- izračun broja turističkih kreveta
- razvrstavanje u tri razreda prema intenzitetu turizma
- analizu komunalnog otpada s obzirom na postupke gospodarenja otpadom.

Metode obrade otpada analizirane su na temelju razreda intenziteta turizma za regiju Jadranske Hrvatske. Za razred 1 odabran je slabi sezonski intenzitet turizma sa stopom manjom od pedeset kreveta na sto stanovnika, dok je razred 2 definiran srednjim intenzitetom turizma sa stopom intenziteta između pedeset i sto kreveta na sto stanovnika. Visoki intenzitet turizma definiran je kao razred 3 u kojem se stopa intenziteta turizma kreće između sto i dvjesto kreveta na sto stanovnika.

Za Jadransku Hrvatsku DPSIR je razvijen prema podacima i informacijama dobivenim iz Izvješća o stanju okoliša u Republici Hrvatskoj (HAOP, 2019.) i godišnjih izvješća o komunalnom otpadu (HAOP, 2016a; HAOP, 2016b; HAOP, 2017.; HAOP, 2018.; MZOE, 2019.). Podaci o procjeni broja turista i bruto godišnjoj stopi zauzetosti preuzeti su s mrežne stranice Državnog zavoda za statistiku (DZS, 2014.; DZS, 2018.), a podaci o sezonalnosti turizma temeljeni na broju komercijalnih noćenja dobiveni su iz informacijskog sustava za registraciju turista (eVisitor, 2014. – 2018.).

Primjena DPSIR-a može se razmotriti i na lokalnoj razini. Kako bi prikazali odnos između ljudskih aktivnosti i okoliša, autori su predstavili studiju slučaja otoka Krka, koja je primjer

(EC, 2006). This estimation was based on:

- calculation that considers the total number of tourist overnights;
- the number of residents and the total municipal waste produced in each county, and
- correction of 20% due to the number of unregistered overnights.

The equivalent to the number of residents provides an estimation of the burden on the local waste management system. It is calculated as the product of waste generated in tourism in the given area and the number of residents in that area, divided by the total waste generated in the area. The area of seven Adriatic Croatian counties was considered, namely: Istria County, Primorje-Gorski Kotar County, Lika-Senj County, Zadar County, Šibenik-Knin County, Split-Dalmatia County and Dubrovnik-Neretva County. For the same area, the second indicator is developed to provide data of waste treatment methods for household and similar waste (municipal waste). The methodology involves three stages:

- calculation of the number of tourist beds;
- classification into three classes according to tourism intensity, and
- analysis of municipal waste by waste management operations.

The waste treatment methods were analysed based on classes of tourism intensity (scenarios) for the region of Adriatic Croatia. Class 1 refers to the low seasonal intensity of tourism with a rate less than 50 beds per 100 residents. Class 2 is defined as a medium tourism intensity with an intensity rate between 50 and 100 beds per 100 residents. High tourism intensity is specified as Class 3, where tourism intensity rate is scaled between 100 and 200 beds per 100 residents.

For the level of Adriatic Croatia, the DPSIR framework has been developed according to data and information obtained from the State of the Environment Report for the Republic of Croatia (HAOP, 2019) and yearly reports on municipal waste (HAOP, 2016a; HAOP, 2016b; HAOP, 2017; HAOP, 2018; MZOE, 2019). Population estimates data on the number of tourists and gross annual occupancy rate in this region was taken

hrvatske održive turističke destinacije. Podaci su dobiveni iz Strateške studije procjene utjecaja na okoliš Primorsko-goranske županije (Dvokut Ecro, 2012.), izvješća (ECA, 2014.; HAOP, SUEZ 2018.), znanstvenih radova (Slavuj i dr., 2009.; Damjanić, 2014.; Damjanić, 2016.), sa službenih stranica grada Krka (URL 1) i s European Climate Initiative EUKI (URL 2). Podaci o sezonalnosti turizma temeljeni na turističkom prometu na otoku Krku preuzeti su iz informacijskog sustava za registraciju turista (eVisitor, 2014. – 2018.). S druge strane, odabrani podaci o gospodarenju otpadom na otoku Krku procijenjeni su na temelju podataka o ukupnom otpadu Primorsko-goranske županije, preuzetih iz Izvješća o komunalnom otpadu za 2018. godinu (MZOE, 2019.). Za studiju slučaja na otoku Krku karta je izrađena uz pomoć Digitalnog atlasa Republike Hrvatske (Državna geodetska uprava, 2011.), Google Earth (URL 3) i Geografskoga informacijskog sustava (ESRI, 2010.).

REZULTATI

Primjena DPSIR-a za procjenu problema gospodarenja otpadom u turizmu

Na Sl. 1. razmatrani su svi elementi DPSIR-a s naglaskom na gospodarenje otpadom u turizmu s visokom sezonalnosti kao glavnim pokretačem.

Razmatranje DPSIR-a u okviru održivoga gospodarenja otpadom rezultiralo je smanjenjem elemenata koji se mogu uzeti u obzir. Pri odabiru elemenata DPSIR-a neka od osnovnih pitanja iz kojih proizlazi njihov odabir su:

- Tko proizvodi otpad?
- Tko upravlja otpadom?
- Koliko otpada nastaje?
- Na koji je način turizam, posebno sezonalnost, pokretač?
- Koji su uspješni odgovori u gospodarenju otpadom?

Korištenje prirodnih resursa, korištenje zemljišta za izgradnju objekata za gospodarenje otpadom, emisije onečišćujućih tvari u zrak, vodu i tlo te emisije stakleničkih plinova prepoznaju

from the Croatian statistical bureau DZS, 2014; DZS, 2018) website, and data for tourism seasonality based on commercial overnights was obtained from the Information System for tourism check-in and check-out registration (e-Visitor, 2014-2018).

The application of the DPSIR model could be also considered at the local level. The authors presented a case study of the Island of Krk as an example of the Croatian sustainable tourist destination with the aim to reflect on the relationship between human activities and the environment. The data was obtained from the Strategic study of the environmental impact assessment of Primorje-Gorski Kotar County (Dvokut Ecro, 2012), reports (ECA, 2014; HOAP, SUEZ, 2018) scientific papers (Slavuj et al., 2009; Damjanić, 2014, Damjanić, 2016) and from the official websites of the town of Krk (URL 1) and the European Climate Initiative EUKI (URL 2). The data on the tourism seasonality based on tourism traffic on the Island of Krk was taken from the Information System for tourism check-in and check-out registration (e-Visitor, 2014-2018). In addition, the data on the selected waste management on the Island of Krk was estimated based on the total waste data of Primorje-Gorski Kotar County, which was taken from the Municipal Waste Report for 2018 (MZOE, 2019). For the case study on the Island of Krk, the maps were made by using Digital Atlas of Republic of Croatia (Državna geodetska uprava, 2011) Google Earth (URL 3) and Geographical Information System (ESRI, 2010).

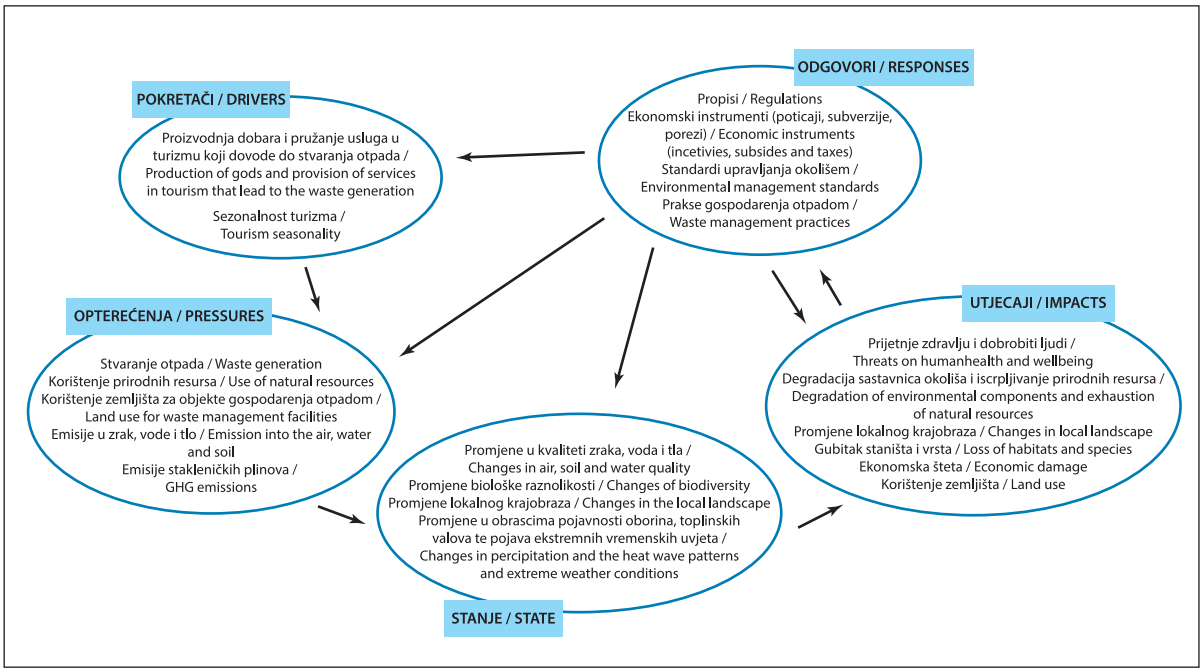
RESULTS

The application of the DPSIR framework to assess the waste management issues in tourism

In Figure 1 all DPSIR elements are considered with an emphasis on waste management in tourism with high seasonality as the main driver.

Consideration of the DPSIR framework within the framework of sustainable, waste management has resulted in a reduction of the elements that can be taken into account. When selecting DPSIR elements, some of the basic issues from which their selection arises were:

- Who produces waste?
- Who manages waste?



Slika 1. *DPSIR za pitanja gospodarenja otpadom u turizmu*
Figure 1 *The DPSIR framework for waste management issues in tourism*
Izvor / Source: EEA, 2014.; MZOE, 2019.

se kao pritisci. Nadalje, stanje okoliša i mogući utjecaji mogu se predvidjeti, no to nije predmet ovoga istraživanja. Fokus istraživanja je na održivom gospodarenju otpadom te odgovoru društva.

Kvantifikacija analize DPSIR-a prema odabranim pokazateljima

Praktična primjena DPSIR-a temelji se na odabranim pokazateljima. Kao što je navedeno, sezonalnost se u Jadranskoj Hrvatskoj značajno povećava (Tab. 2.).

Pojavio se trend rasta bruto godišnje zauzetosti (Sl. 2.) u komercijalnom smještaju (18,4 % u 2018.). To je uglavnom rezultat velike sezonalnosti, turističke aktivnosti i velikog udjela smještaja u kućanstvu (unajmljene sobe/apartmani/kuće). U 2018. godini evidentirana je veća popunjenost u Dubrovačko-neretvanskoj, Istarskoj i Primorsko-goranskoj županiji, ponajviše zbog većeg udjela hotela i sličnog smještaja.

Porasle su količine komunalnog otpada proizvedene u stacionarnom turizmu, posebice od 2014. do 2018. godine, kada su porasle za 62 % zbog sve većeg broja turističkih noćenja (Tab. 3.). Podaci odgovaraju rastućem trendu ekvivalenta broja stanovnika, gdje prema podacima za 2018. godinu

- What quantities of waste are generated?
- In what way is tourism, especially seasonality, a driver?
- What are successful responses in waste management?

The use of natural resources, land use for waste management facilities construction, emissions into the air, water and soil are recognized as pressures, as well as GHG emissions. Furthermore, the state of the environment and possible impacts could be predicted, but they are not the subject of this research. The focus is on sustainable waste management and society's response.

Quantification of the DPSIR analysis by selected indicators

The practical application of the DPSIR framework is based on selected indicators. As previously noted, seasonality in Adriatic Croatia has shown a significant increase (Tab. 2).

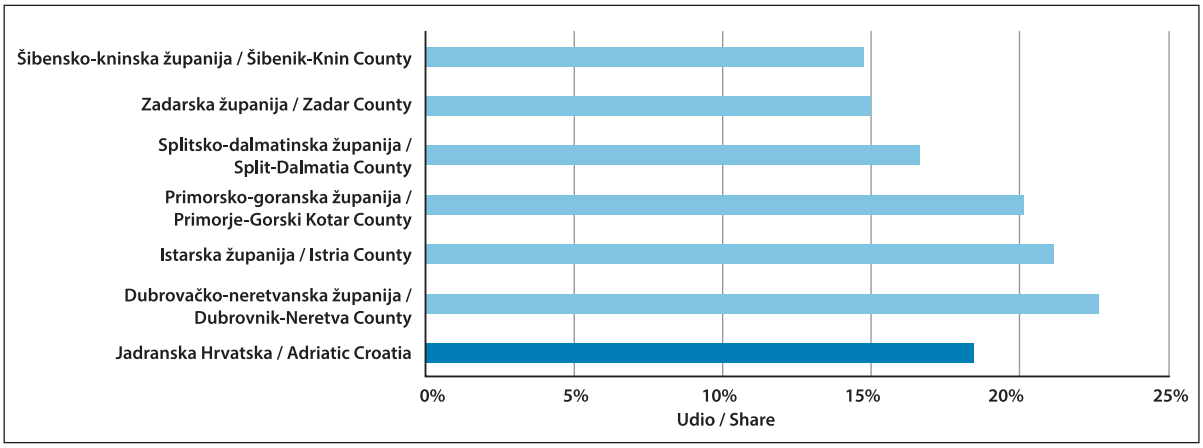
The upward trend of gross annual occupancy rate (Fig. 2) in commercial accommodation occurred (18.4% in 2018). It is mostly the result of high seasonality, tourist activity and high share of household accommodation (rented rooms/apartments/houses). In 2018, a higher occupancy rate was recorded

Tablica 2. *Sezonalnost turizma na temelju broja komercijalnih noćenja u Jadranskoj Hrvatskoj*
Table 2 *Tourism seasonality based of the number of commercial overnights in Adriatic Croatia*

Godina / Year	Sezona[1] / Season	Istarska županija / Istria County	Primorsko-goranska županija / Primorje-Gorski Kotar County	Ličko-senjska županija / Lika-Senj County	Zadarska županija / Zadar County	Šibensko-kninska županija / Šibenik-Knin County	Splitsko-dalmatinska županija / Split- Dalmatia County	Dubrovačko-neretvanska županija / Dubrovnik-Neretva County	Ukupno / Total
2014.	I.	239.381	200.565	12.265	44.533	32.666	105.076	116.423	511.528
	II.	4.588.292	2.558.637	355.848	1.157.722	739.572	2.093.006	1.488.076	8.392.861
	III.	14.214.768	8.976.369	1.609.004	5.829.923	3.661.518	9.522.022	3.859.855	33.458.691
	IV.	502.862	476.852	53.379	151.972	119.173	414.508	419.448	1.635.332
2015.	I.	286.775	247.068	15.426	52.009	38.084	137.549	137.788	627.924
	II.	4.826.040	2.619.355	391.097	1.238.170	737.166	2.261.836	1.531.225	8.778.849
	III.	15.314.806	9.735.637	1.739.728	6.364.225	3.937.010	10.422.110	4.029.372	36.228.082
	IV.	538.940	468.088	52.097	162.468	110.282	467.310	437.506	1.697.751
2016.	I.	420.688	286.719	24.503	69.146	56.874	179.908	182.261	799.411
	II.	4.910.287	2.559.569	426.277	1.258.314	753.516	2.561.461	1.639.856	9.198.993
	III.	17.300.056	10.507.510	1.832.899	6.745.206	4.096.679	11.673.593	4.524.408	39.380.295
	IV.	695.836	547.723	60.839	210.696	123.197	598.675	566.541	2.107.671
2017.	I.	366.543	288.107	28.459	78.179	52.271	197.516	188.016	832.548
	II.	6.166.569	3.154.390	529.457	1.602.258	903.651	3.227.198	2.036.645	11.453.599
	III.	18.288.238	10.977.754	2.019.723	7.383.560	4.386.056	12.771.844	4.911.442	42.450.379
	IV.	699.748	605.410	75.648	227.912	128.961	644.913	630.590	2.313.434
2018.	I.	516.266	305.963	34.790	95.716	67.244	247.883	207.488	959.084
	II.	6.536.372	3.382.897	578.074	1.747.585	975.161	3.642.663	2.200.109	12.526.489
	III.	18.404.829	11.090.230	2.070.560	7.588.431	4.350.010	13.052.976	4.987.555	43.139.762
	IV.	820.828	632.551	89.724	238.407	163.237	769.958	692.183	2.586.060

Izvor / Source: eVisitor, 2014. – 2018.

[1] I. – 1. siječnja – 31. ožujka; II. – 1. travnja – 30. lipnja; III. – 1. srpnja – 30. rujna; IV. – 1. listopada – 31. prosinca / I – 1 January – 31 March; II – 1 April – 30 June; III – 1 July – 30 September; IV – 1 October – 31 December



Slika 2. *Udio bruto godišnje popunjenosti komercijalnog smještaja u primorskim županijama Hrvatske u 2018. godini*
Figure 2 *Share of gross annual occupancy rate in comercial accomodation of coastal Croatian counties in 2018*
Izvor / Source: DZS, 2018.

Tablica 3. *Komunalni otpad iz stacionarnog turizma u županijama Jadranske Hrvatske*
Table 3 *Municipal waste from stationary tourism in Adriatic Croatian counties*

Godina / Year	Količine komunalnog otpada iz stacionarnog turizma u županijama Jadranske Hrvatske (t) / Quantities of municipal waste from stationary tourism in coastal Croatian counties (t)	Udio komunalnog otpada iz stacionarnog turizma u županijama Jadranske Hrvatske u ukupnom komunalnom otpadu proizvedenom u Hrvatskoj (%) / Share of municipal waste from stationary tourism in coastal counties in total municipal waste generated in Croatia (%)	Ekvivalent broju stanovnika / Equivalent to No. of residents
2014.	99.149	5,4	259.552
2015.	112.111	6,0	290.444
2016.	135.396	8,3	345.848
2017.	148.432	9,1	356.807
2018.	159.332	9,3	368.823

Izvor / Source: HAOP, 2016a, HAOP, 2016b, HAOP, 2017.; HAOP, 2018.; MZOE 2019.; EC, 2006.; eVisitor (2014. – 2018.)

stanovnik u prosjeku stvara 1,2 kg komunalnog otpada (MZOE, 2019.).

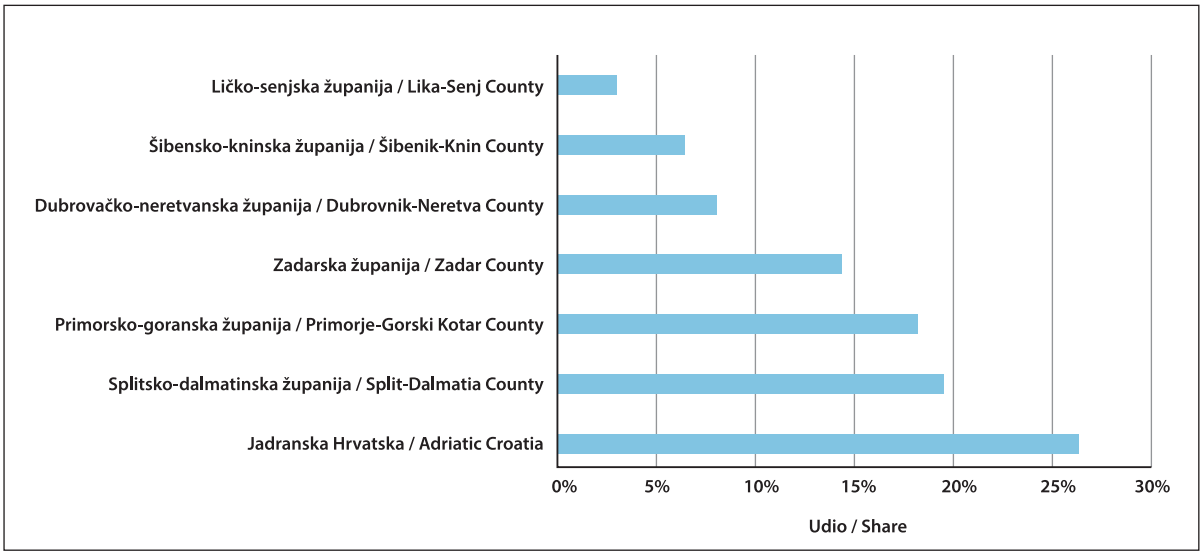
Turizam sunca i mora u priobalnom pojasu prevladava s 96 % turističkog prometa, a količine komunalnog otpada od turizma sa 159.332 tone (Tab. 3.). Podaci pokazuju da u ukupnim količinama komunalnog otpada nastalog iz turizma u sedam županija Jadranske Hrvatske Istarska i Splitsko-dalmatinska županija u 2018. godini zajedno imaju udio od 46,1 % (Sl. 3.).

Učinkovitost odgovora društva kvantificirana je na Sl. 4. Unutar visokog intenziteta turizma (razred 3) povećava se udio manje ekološki prihvatljivih metoda obrade otpada na štetu onih prihvatljivih. Nizak intenzitet turizma (razred 1) također rezultira nepovoljnim rješenjima za obradu otpada zbog najvećeg udjela odlaganja otpada na odlagališta otpada. Ipak, s obzirom na najve-

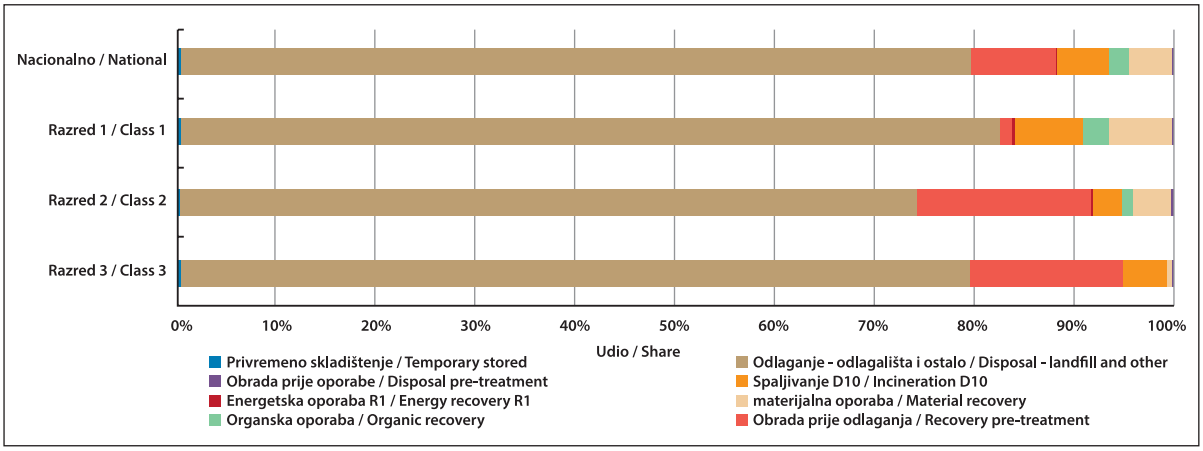
in Dubrovnik-Neretva, Istria and Primorje-Gorski Kotar counties, mostly due to a higher share of hotels and similar accommodation.

Quantities of municipal waste generated in stationary tourism have risen, especially in the period from 2014 to 2018 when they increased by 62% due to the growing number of tourist overnights (Tab. 3). Data are corresponding to a growing trend equivalent to the number of residents, which produce an average of 1.2 kg of municipal waste *per capita* in 2018 (2019).

Coastal tourism prevails with 96% of tourist traffic and quantities of municipal waste from tourism predominate with 159,332 tons (Tab. 3). The data shows the total quantities of municipal waste from tourism generated in seven coastal Croatian counties. Istria County and Split-Dalmatia County together had a share of 46.1% in



Slika 3. *Udio komunalnog otpada u ukupnim količinama otpada iz turizma u primorskim županijama Hrvatske u 2018. godini*
Figure 3 *Share of municipal waste in total amounts of municipal waste from tourism in coastal Croatian counties in 2018*
Izvor / Source: MZOE, 2019.



Slika 4. *Gospodarenje komunalnim otpadom u primorskim županijama Hrvatske u 2018. godini*
Figure 4 *Municipal waste management in Adriatic Croatian counties in 2018*
Izvor / Source: MZOE, 2019.

ći udio oporabe organskog otpada, ovaj scenarij ima prednost u odnosu na razred 2 i razred 3. Razred 2 predstavlja scenarij za umjereni intenzitet turizma i čini se da ima najveći potencijal za održivo gospodarenje otpadom. Evidentno je da ovaj scenarij ima najmanji udio odlaganja otpada, uključujući prihvatljive metode obrade u većim omjerima.

Studija slučaja – otok Krk

Površinom od 405,8 km² otok Krk pripada Primorsko-goranskoj županiji. Jedan je od deset najboljih europskih ekootoka s planom da postane prvi energetski neovisan otok na Mediteranu s „nultom emisijom CO_2“ (URL 2).

2018 (Fig. 3).

The efficacy of society's response is quantified in Figure 4. Within high tourism intensity (Class 3), the share of less environmentally friendly waste treatment methods rises to the detriment of those that are more acceptable. The low tourism intensity (Class 1) also results with unfavourable waste treatment solutions, due to the highest share of landfill disposal. Nevertheless, considering the highest share of organic recovery, this scenario has the advantage compared to Class 2 and Class 3. Class 2 represents a scenario for moderate tourism intensity, and it seems to have the utmost potential for sustainable waste management. It is evident that this scenario has the lowest share of waste disposal including more acceptable waste methods treatment in larger proportions.

Identificiranje elemenata DPSIR okvira u slučaju otoka Krka

Rezultati DPSIR-a razvijenog na otoku Krku (Sl. 5.) otkrivaju specifične pokretače koji stvaraju određene okolišne pritiske i podrazumijevaju osjetljivost prostora.

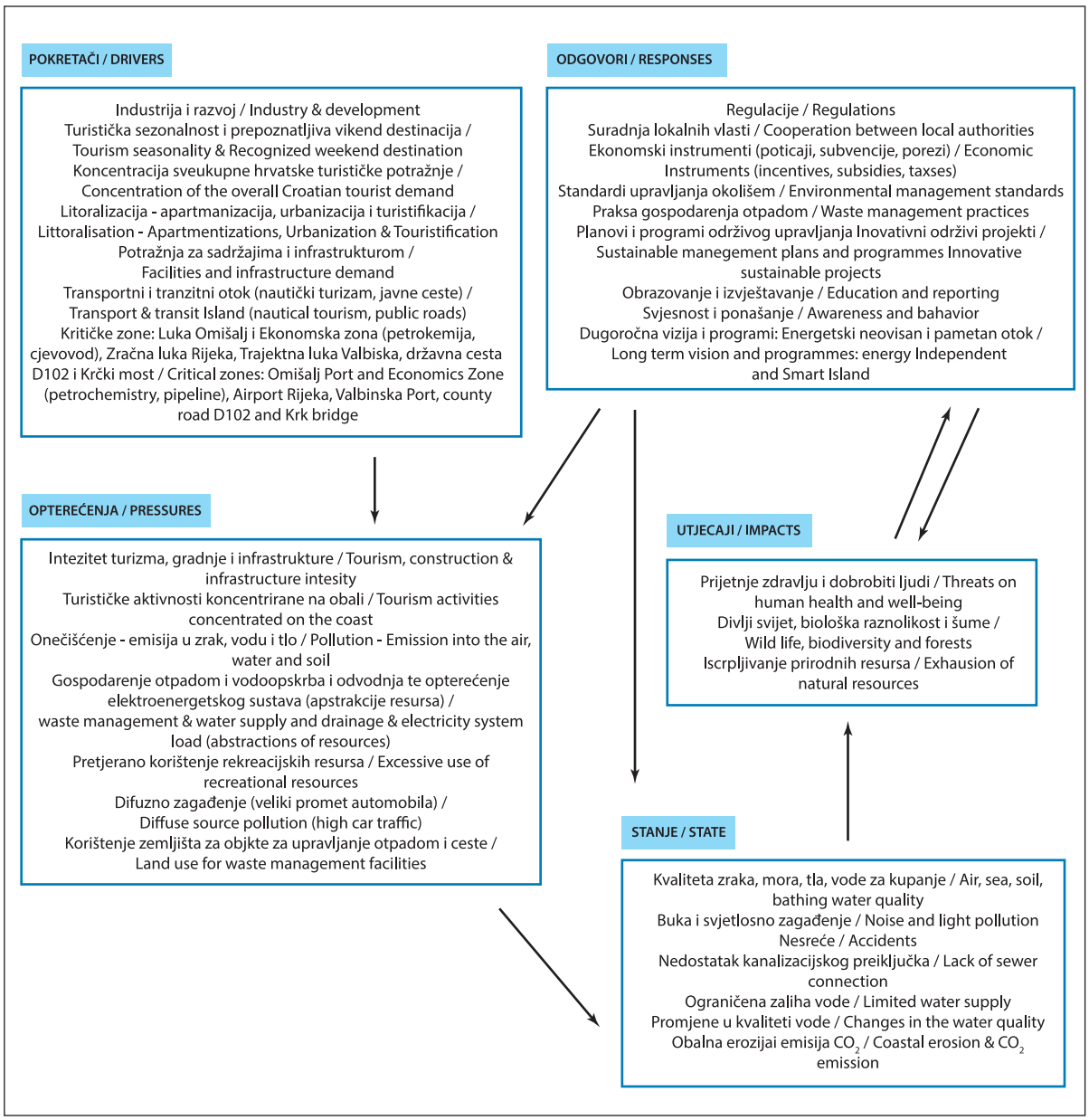
DPSIR za otok Krk rezultat je sinteze općeg DPSIR-a, specifičnosti područja u smislu pritisaka, resursa, ali i produkt organizacije cjelokupnog sustava (u ovom slučaju gospodarenje otpadom, ali i industrija, promet i turizam), prostornog planiranja i reagiranja u svrhu boljeg upravljanja. Elementi DPSIR-a u smislu gospodarenja

Case study on the Island of Krk

The Island of Krk covers an area of 405.8 km², and belongs to Primorje-Gorski Kotar County. It is one of the 10 best European eco-islands with the plan to become the first energy-independent green Mediterranean island with 'zero CO_2 emission' (URL 2).

Identifying the elements of the DPSIR framework in the case of the Island of Krk

The results of the DPSIR model developed on the Island of Krk (Fig. 5) reveal specific drivers that produce certain environmental pressures and



Slika 5. *DPSIR za pitanja okoliša na otoku Krku*
Figure 5 *The DPSIR framework for environmental issues on the Island of Krk*

otpadom određeni su s dva osnovna polazišta – intenzitet turizma i najgušće naseljenih mjesta na otoku. S obzirom na to, utvrđeno je da se njihova uloga opterećenih lokaliteta odražava kroz ulogu pokretača. Pokretači proizlaze iz turističkog i ekonomskog sektora, poput Krčkog mosta, mreže državnih cesta, gospodarske zone Omišalj, trajektne luke Valbiska, ACI Marine Punat i zračne luke Rijeka (Dvokut Ecro, 2012.). Zbog koncentracije stanovništva i razine izgrađenosti naselja, zapadni (Malinska, Njivice) i jugozapadni obalni dio otoka (Krk, Punat) bilježe najveći pritisak na okoliš. Dok značajan, ali ipak manjeg intenziteta, pritisak bilježe i istočni (Vrbnik, Šilo) i južni obalni dio otoka (Baška) (Sl. 6.). S procesom litoralizacije transformacija ruralnih područja pod utjecajem turizma sve je važnija zbog sve veće popularnosti rurifikacije (Damjanić, 2014., 170). Zbog blizine različitih turističkih emitivnih tržišta, ovaj je otok važno turističko i vikend odredište koje pridonosi povećanju turističkog prometa i sezonalnosti (Tab. 4.).

Iako se sezonalnost povećava, prisutan je opadajući trend ukupne količine otpada prikupljenog na Krku (Tab. 5.). Dio se uspješno sakuplja odvojeno (tj. papir, plastika, staklo, metal, glo-

imply sensitivity of space.

The DPSIR framework for Krk is the result of the synthesis of the general DPSIR framework, the specifics of the area, in terms of pressures, resources, but also the product of the organization of the entire system (in this case waste management, but also industry, transport and tourism), spatial planning and response for the purpose of better management. In determining the elements of the DPSIR in terms of waste management, it was necessary to start from two basic starting points – the intensity of tourism and sites that are the most congested sites on the Island. Considering those, it was found that their role of loaded localities is reflected through the role of drivers. Drivers come from tourism and economy sectors, like: The Krk bridge, the network of state roads, Economy zone Omišalj, Ferry port Valbiska, ACI Marina Punat and Rijeka Airport (Dvokut Ecro, 2012). Due to the concentration of the population and the level of settlements construction, the western (Malinska, Njivice) and south-western (Krk, Punat) coastal part of the Island record the highest pressure on the environment, while significant but less intense pressure was recorded in eastern (Vrbnik, Šilo) and southern coastal part of the Island (Baška) (Fig. 6). Along with the process of littoralization, the trans-

Tablica 4. *Sezonalnost turizma na temelju turističkog prometa na otoku Krku*
Table 4 *Tourism seasonality based on tourism traffic on the Island of Krk*

Godina / Year	Sezona[2] / Season	Broj komercijalnih noćenja na otoku Krku / No. of commercial overnights on the Island of Krk	Broj turističkih dolazaka na otok Krk / No. of tourist arrivals on the Island of Krk
2016.	I.	5.676	1.958
	II.	230.781	49.667
	III.	875.313	138.447
	IV.	28.629	6.201
2017.	I.	6.976	1.104
	II.	301.183	64.023
	III.	938.225	142.897
	IV.	65.642	7.928
2018.	I.	6.600	2.116
	II.	336.828	71.570
	III.	931.097	147.199
	IV.	42.931	9.053

Izvor / Source: eVisitor (2014. – 2018.)

[2] I – 1. siječnja – 31. ožujka; II- 1. travnja – 30. lipnja; III – 1. srpnja – 30. rujna; IV – 1. listopada – 31. prosinca / I – 1 January – 31 March; II – 1 April – 30 June; III – 1 July – 30 September; IV – 1 October – 31 December

mazni otpad, tekstil i bio-otpad), a dio se tretira na održiv način, poput odvojenog skupljanja komunalnog biootpada. Biootpad karakterizira visoki ugljični otisak (ECA, 2014.). Ovisno o lokalnim uvjetima, poput prehrambenih navika stanovništva, kulturi uzgoja biljnih sorti, klimi, životnom standardu i stupnju gospodarskog razvoja, biootpad predstavlja 30 – 40 % mase komunalnog otpada (MZOE, 2019.). Taj udio je znatno veći (do 80 %) u mediteranskim zemljama, zbog veće potrošnje voća i povrća i učinaka turizma pa se turističkim objektima preporučuje korištenje manjih uređaja za kompostiranje bez obveze dobivanja dozvole i s manje administrativno zahtjevnih postupaka kao kod primjerice energetske obnove (HAOP, SUEZ, 2018.). Ukupna količina otpada prikupljenog na otoku Krku u posljednje tri godine stagnira, no kontinuirano raste udio otpada nastalog zbog turističkih aktivnosti (Tab. 5.) što dokazuje da je sistemski odgovor društva od najveće važnosti u održivom gospodarenju otpadom.

Intenzivno korištenje prostora rezultiralo je fenomenom osjetljivosti prostora koji je osnovni resurs destinacije što pridonosi eroziji obalnog područja. U usporedbi s drugim obalnim odredištima u Hrvatskoj, otok Krk se ističe visokom koncentracijom ukupne turističke potražnje što je kroz desetljeća dovelo do ubrzavanja procesa litoralizacije, intenzivne urbanizacije i izgradnje apartmana duž obalnog otočnog područja, a te trendove slijeformation of rural areas under the influence of tourism is becoming increasingly important owing to the growing popularity of ruralisation (Damjanić, 2014, 170). Due to the proximity of various emitting tourist markets, this island is an important tourist and weekend destination that contributes to the increase in tourist traffic and seasonality (Tab. 4).

Although seasonality is increasing, there is a descending trend of the total waste amount collected on the Island of Krk (Tab. 5). Some of the quantities are successfully collected separately (i.e., paper, plastic, glass, metal, bulky waste, textiles, and bio-waste) and some of them are treated in a sustainable manner, like separate collection of municipal bio-waste. A high carbon footprint (ECA, 2014) characterizes bio-waste. Depending on local conditions such as the eating habits of the population, the culture of growing plant varieties, climate, living standards and the degree of economic development, bio-waste represents between 30% and 40% of the mass of municipal waste (MZOE, 2019). This share is significantly higher (up to 80%) in Mediterranean countries, due to higher consumption of vegetables and fruits and effects of tourism, so it is recommended for touristic facilities to use smaller mobile devices for composting without the obligation to obtain a permit, and with less administratively demanding procedures such as for energy recoveries (HAOP, SUEZ, 2018). As for waste, the total amount of waste collected on the Island of Krk in the last three years has stagnated, however there is a continuous increase in the share of

Tablica 5. *Odabrani podaci gospodarenja otpadom na otoku Krku od 2016. do 2018. godine*
Table 5 *Selected waste management data on the Island of Krk from 2016 to 2018*

Godina / Year	Ukupno prikupljeni komunalni otpad (t)* / Total collected municipal waste (t)*	Vrste otpada** odvojeno prikupljeni iz komunalnog otpada (t) / Types of waste** separately collected from municipal waste (t)	Odvojeno prikupljeni bio-otpad iz komunalnog otpada (t) / Separately collected bio-waste from municipal waste (t)	Otpad prikupljen iz vrtova i parkova (t) / Waste collected from gardens and parks (t)	Ukupno kompostirane količine otpada (t) / Total quantities composted (t)	Procijenjene količine otpada iz stacionarnog turizma (t) / Estimated quantities of waste from stationary tourism (t)	Udio otpada iz stacionarnog turizma u ukupnom otpadu Primorsko-goranske županije (%) / Share of waste from stationary tourism in total waste of Primorje-Gorski Kotar County (%)
2016.	20.826,00	8.343,00	3.957,41	866,41	5.282,00	3.613,36	14,85
2017.	19.200,56	9.360,16	2.238,00	1.122,00	5.584,00	3.735,17	15,91
2018.	19.971,00	12.062,00	5.594,00	1.195,00	5.594,00	3.897,99	16,44

Izvor / Source: MZOE, 2019.[3]

[3] Bilješka. *Ponikve d.o.o. jedina je tvrtka koja kompostira u Primorsko-gorskoj županiji / Note. * Ponikve d.o.o. is the only company that composts in the Primorje-Gorski Kotar County.

** papir, plastika, staklo, metal, glomazni otpad, tekstil, biootpad / **paper, plastic, glass, metal, bulky waste, textiles, bio-waste

de infrastrukturni razvoj i turizam (Slavuj i dr., 2009.). Kontrolirana, ali očita degradacija krajolika rezultira krčenjem šuma i gubitkom biološke raznolikosti zbog izgradnje industrijske, turističke i prometne infrastrukture. Osim što je prepoznat kao destinacija za odmor i kao ekonomski prosperitetna destinacija s dobro povezanim mjestima, otok Krk je i važan prometni koridor. Otok Krk povezuje kopno s ostalim otocima u Primorsko-goranskoj županiji te je zrakoplovno povezan s EU odredištima. Iako bi se otok Krk mogao smatrati homogenom cjelinom u smislu upravljanja prostornim i održivim razvojem, nekoliko mjesta je izdvojeno (Sl. 6.).

Radi se o područjima na kojima se odvijaju najintenzivnije turističke (Njivice, Malinska, Krk, Punat, Baška) te prometne (Omišalj, Krčki most, državne ceste) djelatnosti, s velikom koncentracijom stanovništva. Jedino se Omišalj ne može povezati s intenzivnim turizmom već s industrijskom djelatnošću (naftni terminal o Omišlju).

Odgovori društva za održivu tranziciju otoka Krka

Tvrtka Ponikve d.o.o. 2005. godine uspostavila je ekološki sustav gospodarenja otpadom na cijelom otoku. To je bilo prvo cjelovito rješenje u Hrvatskoj s ciljem prikupljanja i recikliranja što je moguće više otpada. U posljednjih deset godina provedene su mnoge druge ekološke aktivnosti: postavljanje većih spremnika za biootpad, karton i papir te postavljanje drugih spremnika poput otpadnog tekstila i obnova reciklažnih dvorišta. Nadalje, od 2014. godine provodi se projekt „Od vrata do vrata“ radi povećanja razine recikliranja i odvajanja prikupljenoga komunalnog otpada. U 2018. godini udio odvojeno sakupljenog otpada premašuje 55 % ukupnih količina otpada, što gotovo ispunjava cilj Europske unije od 60 % do kraja 2022. godine (URL 3). Uspjeh tvrtke Ponikve d.o.o. rezultat je dugotrajne kvalitetne suradnje s lokalnim vodstvom, komunalnim redarima, lokalnim udrugama i stanovništvom. Vizija otoka Krka predstavljena je kroz različite edukativne i poticajne programe (npr. Otočna rožica, doniranje komposta kućanstvima, dijeljenje kanti za smeće), ekološke radionice i aktivnosti

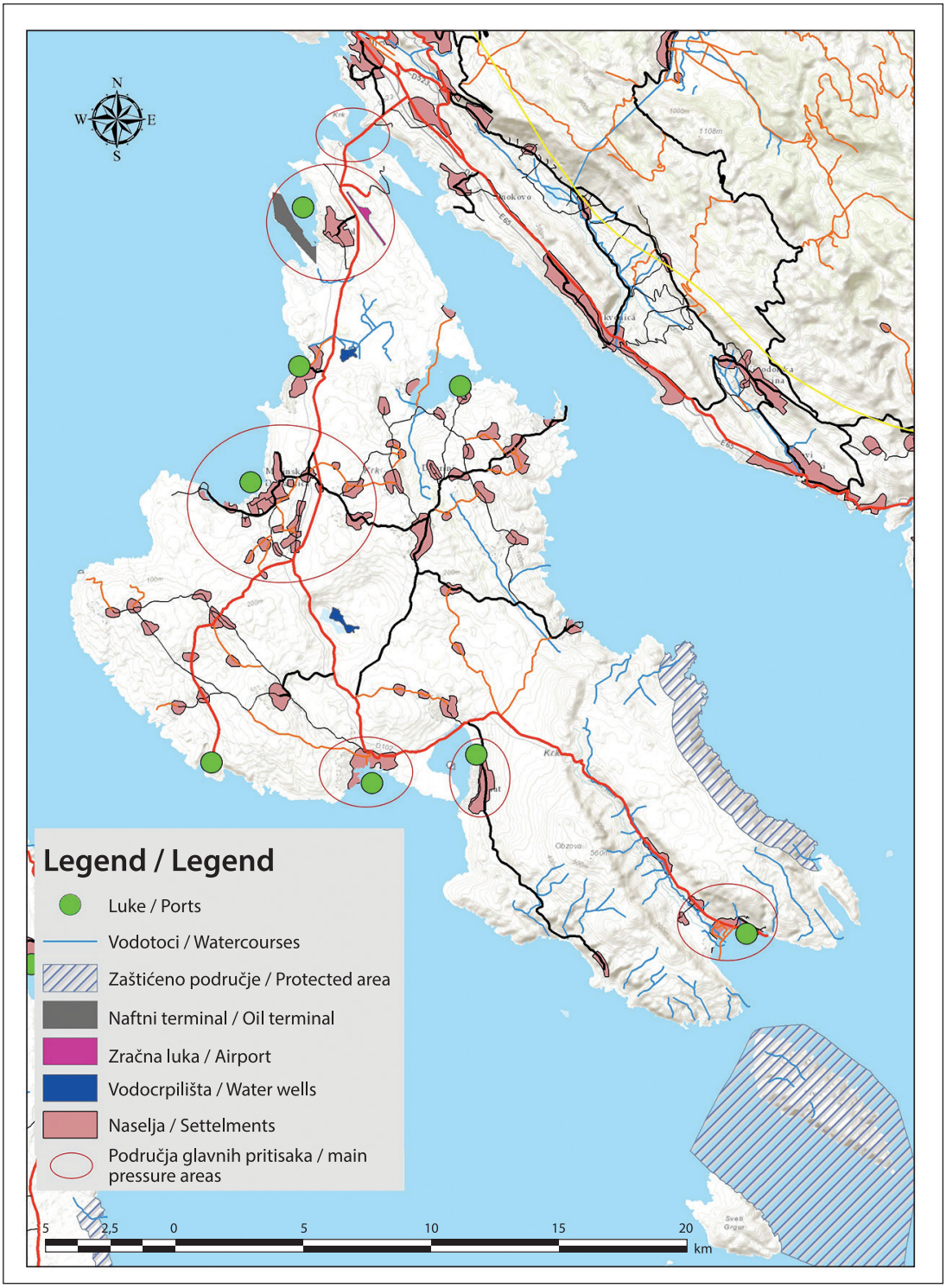
waste generated by tourist activities (Tab. 5), proving that the system response of the society is of utmost importance in sustainable waste management.

Due to the phenomenon of space sensitivity, the intensive use of space has occurred. It contributes to the erosion process of the coastal area. Compared to other coastal destinations in Croatia, the Island of Krk stands out for its high concentration of overall tourist demand, which has accelerated the processes of littoralisation, intensive urbanization and apartments construction along the coastal island area over the decades, and these trends were followed by the infrastructural development and touristification (Slavuj et al., 2009). Controlled, but obvious landscape degradation results in deforestation and loss of biodiversity due to construction of the industrial, tourism and transport infrastructure. Apart from being recognized as a holiday destination and an economically prosperous destination with well-connected places, the Island of Krk is also an important transit traffic corridor. The Island of Krk connects the mainland with other islands in Primorje-Gorski Kotar County and the county with the EU destinations by air. Although the Island of Krk could be considered as a homogeneous entity for spatial and sustainable development management, several critical locations are excluded (Fig. 6).

Again, those are areas with the most intensive tourism (Njivice, Malinska, Krk, Punat, Baška) and transport activity (Omišalj, Krčki most, state roads), but also with high concentration of the population. Only one area cannot relate to intensive tourism, but with industrial activity (Oil terminal in Omišalj).

Society responses for the sustainable transition of the Island of Krk

Since 2005, the company Ponikve d.o.o. has established an ecological waste management system on the entire island. This was the first complete solution in Croatia with the aim to collect and recycle as much waste as possible. In the last ten years, a variety of other ecological activities that have been carried out on: the installation of larger containers for biowaste, cardboard and paper, the installation of other containers such as waste textiles and reconstruction of recycling yards. Moreover, since 2014 the project *Door-to-Door* has been implemented with the aim



Slika 6. *Mjesta glavnih pritisaka na otoku Krku*
Figure 6 *Locations of main pressures on the Island of Krk*

čišćenja; izrađuju se i promotivni obrazovni materijali o recikliranju s edukativnim videom koji pokazuje važnost prikupljanja otpada. Postoje i drugi brojni ambiciozni, inovativni i moderni projekti i studije. Usmjereni su na integraciju solarnih elektrana i vjetroelektrana, LED tehnologija, elektromobilnost, dijeljenje vozila, postrojenja za bioplin. Navedeno upućuje na to da će

of increasing the level of recycling and separation of collected municipal waste. In 2018 the share of the separated waste exceeded more than 55% of total quantities of municipal waste, which almost meets the EU goal of 60% by the end of 2022 (URL 3). The success of the company Ponikve d.o.o. is the result of long-term quality cooperation with local leadership, municipal wardens, local associations, and the pop-

otok Krk postati lider u energetskoj tranziciji u ovom dijelu Mediterana (URL 3). Novoosnovane tvrtke Otok Krk energija i Smart Island Krk također će pridonijeti ovoj dugoročnoj održivoj energetskoj viziji. Osim toga, u 2019. godini Eko otok Krk dobio je mnoštvo nagrada, poput Žutog okvira za održivi razvoj, znanost i obrazovanje za provedbu cjelovitoga ekološkog sustava gospodarenja komunalnim otpadom. Uz to, 2016. godine Green Destination Award proglasio je ovaj otok jednom od najboljih sto zelenih destinacija na svijetu. Uspjeh programa Eko otok Krk može se pripisati aktivnom i trajnom sudjelovanju te savjesnom ponašanju i svijesti poslovnog sektora (Damjanić, 2016., 156).

RASPRAVA

DPSIR se s odabranim pokazateljima razvio u široko korišten alat za analizu i prenošenje znanja o povezanosti okoliša, gospodarstva i društva. Stoga bi se utjecaji turizma na okoliš mogli mjeriti na svim prostornim razinama – nacionalnim, regionalnim i lokalnim. Pomoću DPSIR-a mapirano je nekoliko važnih pokretača u Jadranskoj Hrvatskoj (Sl. 1.). Kao glavni pokretač koji može biti uzrokom izazova povezanih s okolišem odabrana je sezonalnost. Zbog rastućeg trenda sezonske turističke ponude, u ovom je istraživanju gospodarenje otpadom izdvojeno kao ključni pritisak. Prema hijerarhiji gospodarenja otpadom, ovo je pitanje važno na razini cijele Europske unije pa su autori istražili uzročno-posljedičnu vezu između trendova u razvoju turizma i količine komunalnog otpada proizvedenog u stacionarnom turizmu Jadranske Hrvatske (sedam županija Jadranske Hrvatske). Uz prikazani regionalno razvijeni DPSIR, otok Krk je istražen na lokalnoj razini kako bi se prepoznao sistemski uzročno-posljedični učinak odnosa DPSIR-a i učinaka na okoliš.

B. Malekmohammadi i F. Jahanishakib (2017.) također su istraživali odnos turizma kao pokretača i sve većih količina komunalnog otpada kao pritiska na turističke destinacije te utvrdili njihovu međusobnu povezanost. To je u skladu s tvrdnjom S. Giulietti i dr. (2017.) koji su zaključili

ulation. The vision of the Island of Krk is presented through various educational and incentive programs (e.g. *Island Flower,* donating compost to households, sharing pocket waste bins), eco workshops and cleaning activities, promotional educational materials on recycling with an educational video showing the importance of waste collection. Furthermore, the number of ambitious, innovative, and modern projects and studies dedicated to the integration of solar power plants and wind farms, LED technology, electro-mobility, vehicle sharing, biogas plants indicate that the island will become a leader in the energy transition in this part of the Mediterranean (URL 3). The newly established companies *Otok Krk Energija* and *Smart Island Krk* will also contribute to this long-term sustainable energy vision. In addition, in 2019 *The Eco Island of Krk* project received many awards, such as *Yellow Framework for Sustainable Development, Science and Education* for the implementation of a comprehensive ecological system of municipal waste management. In addition, in 2016 the Green Destination Award proclaimed this island as one of the 100 greenest destinations in the world. The success of the program *Eco Island of Krk* can be attributed to the active and permanent participation and conscientious behaviour and awareness of the business sector (Damjanić, 2016, 156).

DISCUSSION

The DPSIR framework accompanied with selected indicators has evolved into a widely used tool for analysis and communicating the knowledge of the connection between the environment, economy, and society. Therefore, the environmental impacts of tourism could be measured in every spatial scale - national, regional, and destination. Several important drivers in Adriatic Croatia were mapped using the DPSIR framework (Fig. 1). Seasonality was chosen as the main driver that could cause specific environmental issues. In relation to the growing trend of tourism seasonality, waste management was singled out as a key pressure in this research. According to the *Waste Management Hierarchy*, this issue is important at the EU level, so authors explored the causal relationship between trends in tourism development and the quantities of municipal waste

da je visoka sezonalnost značajan pokretač različitih pritisaka, osobito na gospodarenje otpadom u turističkim odredištima. Podaci predstavljeni u ovom istraživanju pokazuju isti obrazac. U Jadranskoj Hrvatskoj sezonalnost je znatno veća u ljetnoj sezoni (Tab. 2., sezona II. i III.), a bruto popunjenost (Sl. 2.) ima trend rasta. Udio komunalnog otpada iz stacionarnog turizma i procijenjeni ekvivalent broja stanovnika (Tab. 3.) također je u porastu, što upućuje na povezanost sezonalnosti kao pritiska na kapacitete za gospodarenje otpadom, kao i pritisaka na okoliš.

Porast udjela komunalnog otpada od 2014. do 2019. godine za 62 % značajan je i može se pripisati povećanju turističkog prometa u županijama Jadranske Hrvatske. Procjenjuje se da je u tom razdoblju udio komunalnog otpada od turizma u ukupnoj količini komunalnog otpada povećan s 5,4 % na 9,3 % (Tab. 3.). Prema podacima dostupnima na županijskoj razini (Sl. 3.), očito je da su količine komunalnog otpada u porastu, osobito u Istarskoj i Splitsko-dalmatinskoj županiji koje primaju najveći broj turista tijekom ljetne sezone. Budući da je postala važno pitanje za uglavnom ograničene kapacitete obrade komunalnog otpada, sezonalnost bi se mogla smatrati „pritiskom".

Radi rješavanja ovoga izazova, na Sl. 4. predstavljen je novi pokazatelj koji istražuje metode obrade otpada u županijama Jadranske Hrvatske. Podaci upućuju na potrebu za učinkovitijim i održivim gospodarenjem komunalnim otpadom, posebno tijekom sezone II. i III. Koristeći se ovim pokazateljem, autori istražuju odgovor društva namijenjen „rješavanju" sezonalnosti kao specifičnog pritiska. Prema scenarijima intenziteta turizma (razred 1 – 3) i podacima o gospodarenju otpadom, ovaj pokazatelj nudi osnovu za raspravu o trenutačnom stanju i mogućim rješenjima. Analiza se odnosi na stupanj intenziteta turizma (razred 1 – 3). Kako bi pristupile rješavanju ovih izazova, županije su primijenile europsku hijerarhiju gospodarenja otpadom. Nažalost, najmanje povoljni postupci navedeni tek na petom mjestu ove hijerarhije primjenjuju se u najvećoj mjeri. U 2018. godini prevladavalo je odlaganje otpada na odlagalište (79,4 %), kao i obrada prije odlaganja i spaljivanja (8,6 %). Međutim, neki postupci koji su okolišno prihvatljiviji imaju manji udio u količini otpada

from stationary tourism in Adriatic Croatia (seven coastal Croatian counties). Apart from this regional developed DPSIR model, the Island of Krk was also explored at the local level in order to recognize systemic causal effect of the DPSIR relations and the environmental performance.

B. Malekmohammadi and F. Jahanishakib (2017) also explored interrelation between tourism as a driver and the increasing quantities of municipal waste as the pressure on habitats in tourism destinations, and they found a close connection. This is in line with the statement of S. Giulietti et al. (2017), who concluded that high seasonality represents a significant driver of a variety of pressures, particularly on waste management service at the tourist destinations. Data presented in this research show the same pattern. In Adriatic Croatia seasonality is significantly higher in the summer season (Tab. 2, seasons II and III) and the gross occupancy rate (Fig. 2) has an upward trend. The share of municipal waste from stationary tourism and estimated equivalent to the number of residents (Tab. 3) are also on the rise, which implies additional evidence for interrelationship between seasonality as a 'pressure' on the waste management capacities and, therefore, on the environment.

The increase of the share of municipal waste from 2014 to 2019 by 62% is significant and it could be attributed to the increase of tourist traffic in the counties of Adriatic Croatia. In this period, it is estimated that the share of municipal waste from tourism in total quantities of municipal waste increased from 5.4% to 9.3% (Tab. 3). According to the data scaled at the county level (Fig. 3), it is obvious that the volumes of municipal waste are on the rise, especially in Istria County and Split-Dalmatia County which, after all, receive the largest number of tourists during the summer season. Since seasonality became an important issue for mostly limited municipal waste treatment capacities that are established at the tourist destination, it could be considered as a 'pressure'.

To tackle this issue, a new indicator that explores waste treatment methods in the counties of Adriatic Croatia is presented in Figure 4. The data indicate the necessity for a more efficient and sustainable municipal waste management, especially during the seasons II and III. Using this indicator, authors explore the social response intended to address seasonality as

iz stacionarnog turizma: materijalna oporaba (5,2 %), obrada prije oporabe (4,7 %) i organska oporaba otpada (2 %). Kako bi se izbjegao neodrživi razvoj turizma, potrebno je razmotriti uzročno-posljedične veze između ponude i zahtjeva turističkih aktivnosti, uzimajući pritom u obzir njihove okolišne, prirodne resurse i socijalne posljedice.

Stoga autori sugeriraju da je razred 2 najpovoljnija opcija, gdje umjereni intenzitet turizma rezultira održivim mogućnostima gospodarenja otpadom. To je u skladu s tvrdnjama autora D. Styles i dr. (2013.) koji ističu važnost optimizacije gospodarenja otpadom kao najbolje prakse upravljanja okolišem u turizmu. Uz to, W. Chaabane i dr. (2019.) sugeriraju da su turističke ustanove ključne za predlaganje rješenja za sprječavanje nastanka otpada, minimiziranje, sortiranje i pružanje edukativnih programa. Ovi su autori prepoznali kako su odlučivanje i uključenost stanovništva ključne prepreke. Da bi istražili kako prevladati takve prepreke, autori predstavljaju dobru praksu otoka Krka.

Otok Krk je destinacija u kojoj društvo prepoznaje da gospodarstvo ima temelje na prirodnom kapitalu te da je iznimno važno održivo gospodarenje otpadom. Održivo gospodarenje otpadom često zahtijeva oboje; i prevenciju i odvojeno prikupljanje, što bi moglo povećati učestalost odvoza. Prekomjerni kapacitet privremenih skladišta u kojima se čuvaju različite odvojene vrste otpada također može biti problem. Za otoke je ponekad potreban čest odvoz na kopno radi odlaganja ili recikliranja. Za one koji nemaju odgovarajuće skladišne prostore, to bi moglo povećati troškove javnih usluga. Ipak, na otoku Krku postoje rješenja koja se temelje na kružnom gospodarstvu i cjelovitim rješenjima s ciljem prikupljanja i recikliranja što je moguće više otpada. Stoga se može naglasiti da su pokretači, pritisci i utjecaji isti kao i u drugim dijelovima Jadranske Hrvatske (zbog visokog intenziteta razvoja turizma još i gori). No stanje okoliša se poboljšava visokokvalitetnim odgovorima koji djeluju na smanjen broj utjecaja. Dobra praksa otoka Krka otkriva da bi donositelji politika sa stanovnicima, turističkim sektorom i svim zainteresiranim dionicima mogli pružiti adekvatne odgovore kako bi se spriječili pritisci okoliša na lokalnoj razini.

a specific 'pressure'. According to tourism intensity scenarios (Class 1-3) and waste management data, this indicator offers a basis for the discussion about current state and possible solutions. The analysis refers to the degree of tourism intensity (Class 1 to 3). Generally speaking, to address this challenge, counties have applied the European Waste Management Hierarchy. Unfortunately, the less favourable operations listed as the fifth step of this hierarchy had the largest share. In 2018, disposal-landfill (79.4%) and disposal pre-treatment prior to landfilling and incineration (8.6%) was predominant. However, some procedures that are more environmentally friendly have a smaller share in the total amount of waste from stationary tourism: material recovery (5.2%), recovery pre-treatment (4.7%) and organic recovery (2%). In order to avoid unsustainable development of tourism, it is necessary to consider causal-effect relations between tourism supply and activity demands, concerning their consequences on the environment, natural resources and the society.

Therefore, the authors suggest that Class 2 is the most favourable option, where moderate tourism intensity results with more sustainable waste management options. This is in line with D. Styles (2013) that stress the importance of waste management optimisation as the best environmental management practice in tourism. In addition, W. Chaabane et al. (2019) suggest that tourism establishments are crucial to propose solutions for waste prevention, minimization, sorting at source and the provision of educational programs. They recognized that decision-making and resident's involvement are the key barriers. In order to explore how to overcome such obstacles, the authors presented the good practices of the Island of Krk.

Namely, the Island of Krk is a destination where the society recognizes that the economy has a strong basis in natural capital, and that the sustainable waste management is of outmost importance. Sustainable waste management often requires both – waste prevention and separate collection, which could increase the frequencies of waste collection by utility services. Overcapacity of temporary storage facilities in which different separate types of waste are stored can also be an issue. For islands, it sometimes requires frequent transfer to the mainland for disposal or recycling. For those without adequate

ZAKLJUČAK

DPSIR je svrhovit alat za mapiranje određenih ekonomskih, okolišnih i socijalnih pitanja na regionalnoj i odredišnoj (lokalnoj) razini. Procjena ovoga okvira moguća je korištenjem ili razvijanjem relevantnih pokazatelja. Procjena temeljena na pokazateljima osnova je za preporuke i praktične mogućnosti.

U ovom se istraživanju DPSIR pokazao učinkovitim za razmatranje specifičnih odnosa između „pokretača", „pritisaka" i „odgovora" u kontekstu tema o turizmu i okolišu. Odabrani pokazatelji otkrivaju međusobnu povezanost stacionarnog turizma kao „pokretača" i stvaranja komunalnog otpada kao „pritiska". Budući da su podaci o turističkom prometu i komunalnom otpadu visokokvalitetni i dostupni na godišnjoj razini, procijenjena je njihova međusobna povezanost za područje Jadranske Hrvatske. S tim u vezi, predviđaju se tri scenarija turističkog intenziteta, a razvijen je i pokazatelj „odgovora" društva.

U okviru DPSIR-a razmatrani su pokazatelji poput sezonalnosti (Tab. 2.), bruto godišnje stope zauzetosti u komercijalnom smještaju (Sl. 2.) i količine komunalnog otpada (Tab. 3.). Radi pružanja dodatnih dokaza o međusobnoj povezanosti stacionarnog turizma kao „pritiska" i infrastrukturnih kapaciteta za gospodarenje otpadom, količina komunalnog otpada i ekvivalent broja stanovnika razmatrani su u Tab. 3. Procjena ovih podataka potvrdila je tezu da sezonalnost turizma utječe na okoliš, ali i proširila ovo istraživanje. Naime, kreiran je novi pokazatelj koji istražuje održivost gospodarenja komunalnim otpadom (Sl. 4.). Podaci otkrivaju da visoki intenzitet turizma ima izravan utjecaj na infrastrukturu gospodarenja otpadom, koja je uglavnom uspostavljena za ograničen broj stanovnika (Tab. 3.). Stoga autori predlažu razred 2 kao najpovoljniju opciju, gdje umjereni intenzitet turizma rezultira održivim mogućnostima gospodarenja otpadom i stvara manji pritisak na infrastrukturu gospodarenja otpadom i na okoliš.

Općenito, veza između sezonalnosti u stacionarnom turizmu i neodrživoga gospodarenja otpadom mogla bi ugroziti atraktivnost turističkih odredišta, no ipak postoje odgovarajuće primijenjene smjernice održivoga gospodarenja otpadom i pristorage facilities this could result in increased costs for public services. Nevertheless, on the Island of Krk there are solutions based on the circular economy and complete solutions with the aim to collect and recycle as much waste as possible. Therefore, we can emphasize that drivers, pressures, and impact are the same as in other parts of Adriatic Croatia (and even worse due to high intensity of tourism development), but the state of the environment is enhanced through high quality responses, which are recurrently having a positive impact on reducing the number of impacts. The good practices of the Island of Krk reveals that policy-makers with residents, the tourism sector and with all interested stakeholders could provide the adequate 'responses' to prevent environmental pressures at the local level.

CONCLUSION

The DPSIR framework is a purposeful tool for mapping specific economic, environmental, and social issues at the regional and destination (local) level. Evaluation of this framework is possible by using or developing relevant indicators. Indicator-based assessment is the foundation for recommendations and practical options.

In this research, the DPSIR framework has proven to be an effective model for considering the specific relations between 'driver,' 'pressure' and 'response' in the context of tourism and environmental topics. Selected indicators reveal interrelationship between stationary tourism as a 'driver' and municipal waste generation as 'pressure'. Since the data for tourist traffic and municipal waste are high quality and available on an annual basis, an evaluation of their interrelationship was made for Adriatic Croatia area. In this regard, three scenarios of tourist intensity are envisaged, and the 'response' indicator was developed.

Widely used indicators such as tourism seasonality (Tab. 2), gross annual occupancy rate in commercial accommodation (Fig. 2), and quantities of municipal waste (Tab. 3) were considered based on the DPSIR framework. In order to provide additional evidence for the interrelationship between stationary tourism as a pressure and the waste management infrastructural capacities, the amount of municipal waste and

mjeri dobre prakse, poput otoka Krka. Preporuka je zamijeniti nepovoljne opcije zbrinjavanja otpada u Jadranskoj Hrvatskoj i osigurati mjere za okolišno prihvatljiva rješenja gospodarenja otpadom prema hijerarhiji gospodarenja otpadom. Osim mogućnosti prevencije otpada, prednost bi se trebala dati ponovnoj upotrebi i recikliranju nužnim za rješavanje izazova u području gospodarenja otpadom i za poticanje kružnoga gospodarstva. Količine odloženog otpada potrebno je smanjiti te ih sigurno odlagati. Nadalje, sveukupno smanjenje količina otpada trebalo bi usmjeriti prema boljoj učinkovitosti resursa te prema održivim obrascima proizvodnje i potrošnje. Osim toga, preporučuje se edukacija i suradnja među svim dionicima u sektoru turizma i okoliša kako bi se unaprijedila održivost, posebno na regionalnoj i lokalnoj razini.

ZAHVALA

Ovaj rad ostvaren je u sklopu internog znanstvenog projekta Instituta za turizam: Razvoj integralnog okvira pokazatelja i prihvatnog (nosivog) kapaciteta koji podržava Institut za turizam.

the equivalent of number of residents was considered in Table 3. Evaluation of this data confirmed the thesis that tourism seasonality has an impact on the environment, but also expanded this research. Namely, a new indicator that explores sustainability of municipal waste management was created (Fig. 4). Data reveals that high tourism intensity has a direct impact on the waste management infrastructure, which is mostly established for a limited number of residents (Tab. 3). Therefore, the authors suggest Class 2 as the most favourable option, where moderate tourism intensity results in sustainable waste management options and produces less environmental pressure on the waste management infrastructure and the environment.

Generally, the connection between seasonality in stationary tourism and unsustainable waste management could jeopardize the attractiveness of tourist destinations, but still there are the appropriately applied sustainable waste management guidelines and examples of good practice, like on the Island of Krk. In that manner, the recommendation is to replace unfavourable options of waste disposal in Adriatic Croatia and to provide measures for more environmentally friendly waste management solutions, according to the Waste Management Hierarchy. Besides the option of waste prevention, preference should be given to reuse and recycling, which are necessary to tackle waste management issues and to foster a more circular economy. The quantities of disposed waste should be minimised and safely disposed of. Furthermore, overall reduction in the amount of waste should be mainstreamed to better resource efficiency and with the shift towards more sustainable production and consumption patterns. In addition, education, and cooperation among all stakeholders in tourism and environment sectors is recommended to enhance sustainability transition, especially at the regional and destination scale.

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