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RAZPRAVE PAPERS

Jana Breznik*, Tajan Trobec**

POSKUS OCENE KAKOVOSTI PODTALNICE V VODONOSNIKU OB MISLINJI

Izvirni znanstveni članek
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Izvleček

Vodonosnik ob Mislinji zaradi majhne izdatnosti in dejstva, da se ne uporablja za vodooskrbo, ni vključen v redni državni monitoring kakovosti podzemnih voda. V članku na primeru devetih vzorčnih mest (zasebnih vodnjakov in vrtin) analiziramo vrednosti osnovnih fizikalno-kemijskih parametrov vode, na podlagi katerih preliminarno ocenjujemo njeno kakovost. Ugotavljamo, da se v podtalnici odražajo antropogeni vplivi, ki so izrazitejši v bližini območij strnjene kmetijske obdelave ter ob večjih naseljih. Pri večini vzorcev so prisotne povišane vrednosti nitratov in kloridov, pri nekaterih pa se v višjih koncentracijah pojavljajo tudi druga merjena onesnažila. Glede na aktualni Pravilnik o pitni vodi je kar pet od devetih vzorcev neustreznih, oziroma zgolj pogojno ustreznih, kar pomeni, da je podtalnica v vodonosniku ob Mislinji morda že preveč onesnažena, da bi nanjo lahko računali kot na možni rezervni vodni vir za vodooskrbo.

Ključne besede: podtalnica, medzrnski vodonosnik, Mislinjska dolina, Mislinja, kakovost podtalnice, fizikalno-kemijske analize vode

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1 UVOD

Podzemna voda predstavlja pomemben vir sladke vode, ki se lahko uporablja za pitje, namakanje, v industrijski proizvodnji itd. Površinska in podzemna voda sta med seboj povezani. Slednja predstavlja primarni vir za napajanje izvirov in vodotokov ter ohranjanje pretoka v strugah v času brez padavin, zaradi česar je tudi z ekološkega vidika izjemno pomemben člen vodnega kroga. Po drugi strani pa se podzemna voda, poleg z neposrednimi padavinami nad vodonosnikom, v času visokih voda napaja tudi s površinskimi vodami (Brunke, Gonser, 1997).

Slovenija je s podzemno vodo bogata država. Njene dinamične zaloge po starejših ocenah znašajo 50,4 m^3/s ali okoli 10 % skupnega internega odtoka (Uhan, Kranjc, 2003). Po novejših ocenah je, zaradi spremenjene metodologije izračunavanja obnovljivih zalog, podzemne vode v Sloveniji še bistveno več. V tridesetletnem obdobju 1991–2020 so obnovljive zaloge podzemne vode znašale 187,55 m^3/s oziroma 37 % celotnega internega odtoka (Andjelov in sod., 2021).

Podzemna voda se pojavlja v različnih oblikah. V prodno-peščenih nanosih ob naših večjih rekah (Sava, Drava, Mura, Soča, Savinja ...) se v vodonosnikih z medzrnsko poroznostjo pojavlja kot podtalnica (Uhan, Kranjc, 2003). Območja podtalnice so zaradi naravnih danosti, kot so nižinska lega, uravnan relief, razpoložljivi vodni viri in kakovostne prsti, gosto poseljena, zaradi česar so tam prisotni tudi številni pritiski na okolje (Ambrožič in sod., 2008).

Onesnažila večinoma vstopajo v vodonosnik s površja točkovno, linijsko ali razpršeno (Jamnik in sod., 2014). Onesnažena podzemna voda ob uporabi za vodooskrbo predstavlja resno grožnjo za zdravje, hkrati pa negativno vpliva tudi na ekosistem in vodne vire, ki se napajajo iz vodonosnika (Fetter, 1999). Zaradi intenzivnega kmetijstva (Lampič, Rutar, 2019), prisotnosti podtalnice plitvo pod površjem in velike okoljske občutljivosti (Špes in sod., 2002) so v Sloveniji z onesnažili (predvsem z nitrati) najbolj onesnaženi nekateri vodonosniki z medzrnsko poroznostjo v severovzhodnem delu Slovenije (Spodnja Savinjska dolina, Dravsko in Ptujsko polje ter vodonosniki ob Muri) (Gacin, Mihorko, 2012; Kemijsko stanje ..., 2021).

Iz mreže opazovalnic za monitoring kakovosti podzemne vode (DRSV, 2021) je razvidno, da se v Sloveniji analize podtalnice izvajajo predvsem na območjih obsežnejših nižinskih vodonosnikov z medzrnsko poroznostjo (Ljubljansko polje, Kranjsko-Sorško polje, Spodnja Savinjska dolina, Krško-Brežiško polje ...). Tam se podtalnica tudi v večji meri uporablja za vodooskrbne in druge namene, hkrati pa je zaradi številnih pritiskov tudi bolj izpostavljena onesnaževanju. Tak način monitoringa pa zapostavlja manjše vodonosnike, kot je na primer vodonosnik ob reki Mislinji, ki je tudi osrednje območje našega preučevanja.

Zaradi majhnega vodozbirnega zaledja osrednjega vodotoka – Mislinje ter razmeroma tankega nanosa proda in peščene gline (Mioč, 1978) Mislinjska dolina nima večjih

zalog podtalnice. Podtalnica se na tem območju tudi ne uporablja za vodooskrbo nižinskih naselij, saj se ta praviloma oskrbujejo z vodo iz zajetij v okoliškem vzpetem svetu (GURS, 2021), temveč zgolj za zalivanje, namakanje in pranje. Posledično se v Mislinjski dolini ne izvajajo analize na podtalnici, zaradi česar tudi ne vemo, kakšno je njeno dejansko količinsko in kakovostno stanje. Pa vendar lahko glede na relativno gosto poselitev, prisotnost intenzivnega kmetijstva s poudarkom na hmeljarstvu ter številnih industrijskih obratov sklepamo, da so pritiski na podtalnico v vodonosniku ob Mislinji razmeroma veliki in bi lahko vplivali na slabšo kakovost vode.

Glede na razdelitev Slovenije na telesa podzemne vode (Pravilnik o določitvi ..., 2018) se Mislinjska dolina uvršča v vodno telo *podzemne vode Vzhodne Alpe*, ki je glede na obstoječe analize v dobrem kemijskem stanju (Kemijsko stanje ..., 2021). Pri tem je treba poudariti, da je to vodno telo izjemno velika in heterogena enota, saj poleg Mislinjske doline vključuje še celotno Pohorje, Kozjak in Strojno ter del Vitanjskih Karavank in je zato povsem neustrezno za ocenjevanje kakovosti podtalnice v vodonosniku ob Mislinji. Poleg tega je kemijsko stanje tega vodnega telesa (z izjemo merilnega mesta Zgornja Vižinga na Radeljskem polju ob Dravi) ocenjeno na podlagi analize vode zajetij v okoliškem vzpetem svetu (Mislinja MZ-4/95 v Vitanjskih Karavankah, Mrzli studenec na Pohorju, Ojstrica pri Dravogradu na Kozjaku). Zaradi zgostitve antropogenih pritiskov predvsem v nižjem svetu ni merodajno za dolinsko dno, kjer se nahaja vodonosnik ob Mislinji. Po našem védenju, kot tudi po zagotovilih predstavnikov Oddelka za meritve podzemnih voda, Sektorja za hidrometrijo, Urada za okoljska merjenja na ARSO (Frantar, 2021) morebitni drugi, podrobnejši elaborati ali meritve kakovosti podtalnice v Mislinjski dolini niso bili izdelani.

Glede na to, da so po naši oceni pritiski na podtalnico v Mislinjski dolini razmeroma veliki, hkrati pa uradni podatki o njeni kakovosti ne obstajajo, je glavni namen raziskave ugotoviti, kako se vplivi iz okolja odražajo na kakovosti podtalnice. V ta namen smo na izbranem območju v obstoječih vodnjakih in zasebnih vrtinah na devetih lokacijah vzorčili podtalnico in izvedli analize za izbrane osnovne fizikalno-kemijske parametre vode. Poleg podtalnice smo na treh lokacijah analizirali tudi vodo reke Mislinje, kar nam je omogočilo medsebojno primerjavo površinskih voda in podtalnice na tem območju.

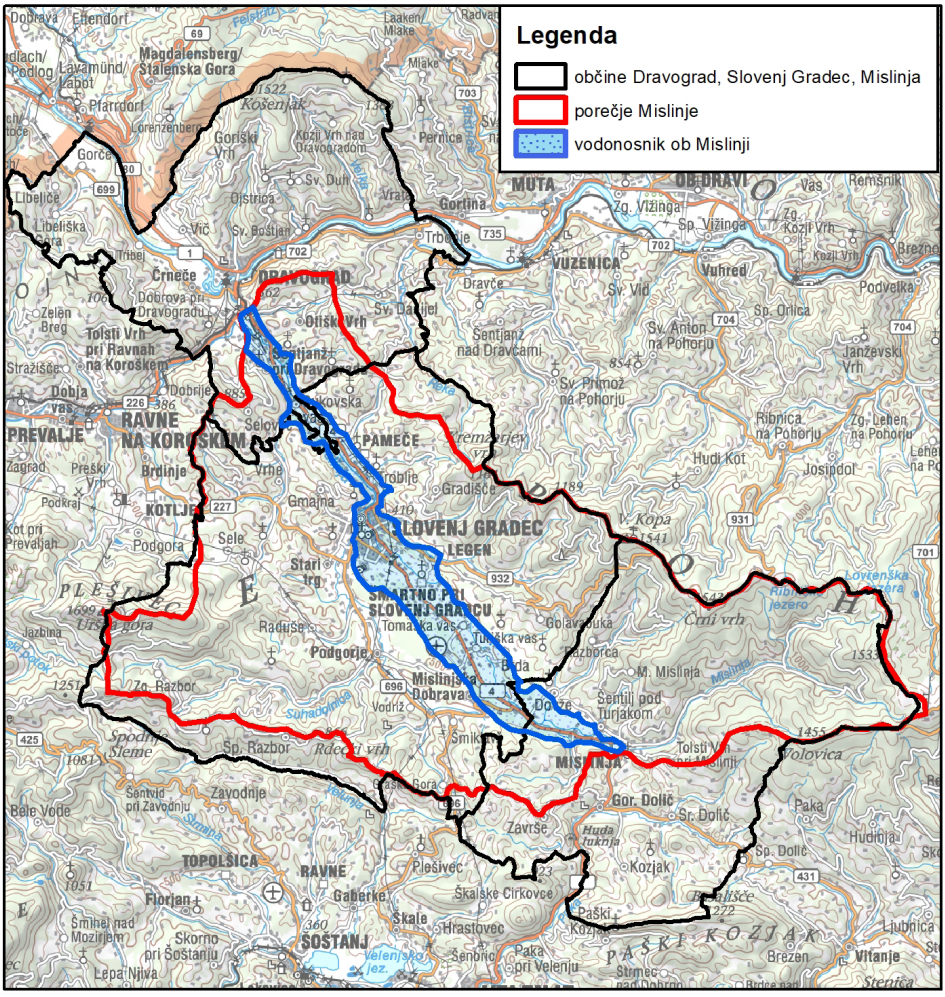
2 GEOGRAFSKI ORIS MISLINJSKE DOLINE

Preučevano območje predstavlja ravninsko dno Mislinjske doline, pod katerim se je v kvartarnih sedimentih ob Mislinji (Mioč, 1978) izoblikoval manjši vodonosnik (slika 1).

Mislinjska dolina leži med Pohorjem in vzhodnimi odrastki Karavank ter se uvršča med predalpske pokrajine. Nastala je ob labotski prelomni coni, ki poteka v dinarski smeri (Mioč, 1978). V upravnem smislu spada pod Koroško statistično regijo in je razdeljena med občine Mislinja, Slovenj Gradec in Dravograd. Dolga je 22 km ter v najširšem delu, ob sotočju Mislinje s Suhodolnico, do 5 km široka. Vodonosnik ob

Mislinji leži ob srednjem in spodnjem toku reke, med naseljema Mislinja in Otiški Vrh, kjer se Mislinja izliva v Mežo. Njegova površina znaša okoli 24 km^2 (Hidrogeološka karta, 2009). Je del telesa *podzemne vode Vzhodne Alpe*, podrobneje del kvartarnega, medzrnskega vodonosnika ob Dravi, Mislinji in Meži, ki se glede na hidrogeološko klasifikacijo uvršča v kategorijo *lokalnih, nezveznih, izdatnih oziroma obširnih, vendar nizko do srednje izdatnih* vodonosnikov (Gacin, Mihorko, Krajnc, 2009). Območje nad vodonosnikom ob Mislinji v povprečju prejme okoli 1200–1300 mm

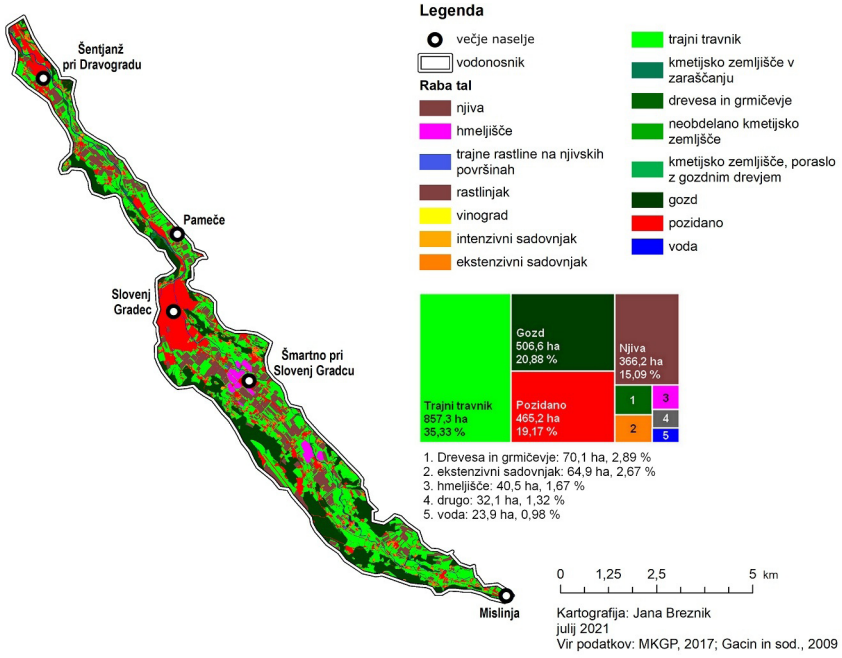
Slika 1: Preučevano območje vodonosnika ob Mislinji.



padavin letno (ARSO, 2021a). Na njem prevladujejo distrične in evtrične rjave prsti (KIS, 2021). Osrednji vodotok Mislinjske doline je hudourniška reka Mislinja (Gams, 1976), ki izvira na Pohorju in ima alpski dežno-snežni pretočni režim (Frantar, Hrvatin, 2005). Njen povprečni pretok v obdobju 1981–2010 pri Dovžah znaša 1,9 m^3/s, pri Otiškem Vrhu pa 4,6 m^3/s (ARSO, 2021b). Po meritvah državnega monitoringa kakovosti vode je v dobrem kemijskem stanju (ARSO, 2017; ARSO, 2020).

Dno Mislinjske doline je zaradi ugodnih naravnih danosti (uravnan relief, zmerno podnebje, dostop do vodnih virov, kakovostne prsti) naseljeno že od neolitika (Djura Jelenko, 2010). Prevladujejo manjša do srednje velika podeželska naselja. Najširši del doline – Slovenjgraška kotlina (ob sotočju Suhadolnice in Mislinje) – pa je po podatkih Statističnega urada Republike Slovenije (2016) z več kot 250 prebivalcev/km^2 eno gosteje poseljenih območij v Sloveniji (mesto Slovenj Gradec je imelo v letu 2016 gostoto poselitve 1317 prebivalcev/km^2). Naravno- in družbenogeografske značilnosti se kažejo tudi v rabi tal. Nad vodonosnikom ob Mislinji je največ travniških površin (35 % območja vodonosnika), za katere je tako kot za njivske površine (15 %) in hmeljišča (1,7 %) značilna intenzivna kmetijska raba. Hmeljišč je sicer relativno malo, a so zgoščena v okolici Šmartna pri Slovenj Gradcu. Precej velik je tudi delež pozidanih površin, ki predstavljajo skoraj petino območja (19 %). Z gozdom (21 % površine) so večinoma porasla le robna območja vodonosnika (slika 2).

Slika 2: Raba tal na območju vodonosnika.

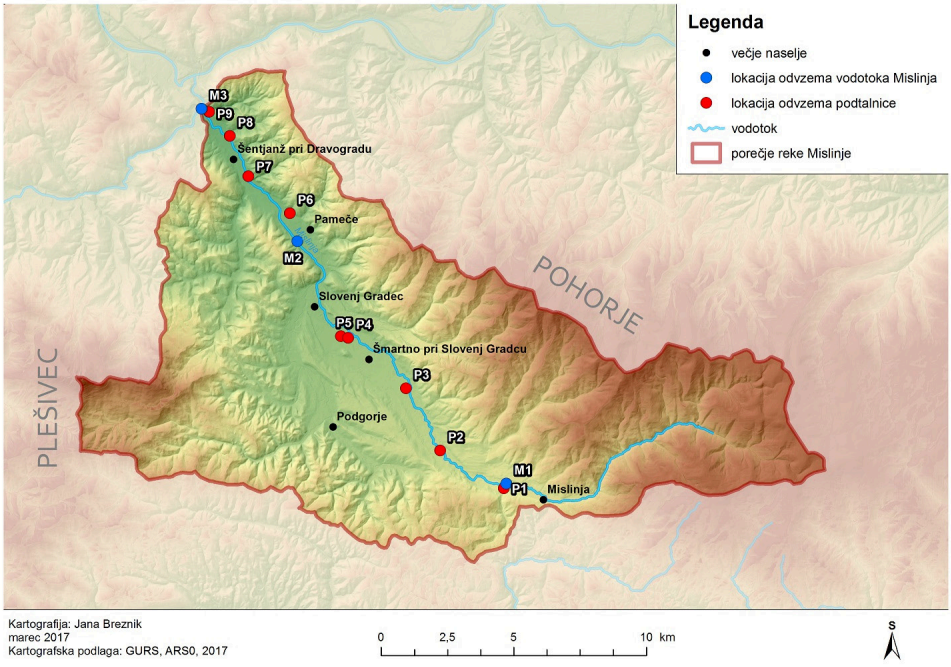


3 METODE

Na podlagi podatkov o vodnih dovoljenjih (ARSO, 2016) ter s preučitvijo prostorskega obsega vodonosnika glede na litološke značilnosti območja (Gacin, Mihorko, Krajnc, 2009; Mioč, 1978), smo izbrali čim bolj reprezentativne in prostorsko ustrezno razporejene lokacije za odvzem vzorcev podtalnice iz zasebnih vrtin in vodnjakov. Vzorčenje podtalnice na zasebnih vrtinah in vodnjakih se ob upoštevanju metodoloških priporočil in zavedanju objektivnih omejitev uvršča med uveljavljene pristope preliminarnega ocenjevanja kakovosti podtalnice na območjih, kjer se uradni monitoring kakovosti ne izvaja (Metodologija za opredelitev ..., 2021). Lokacije smo določili od točke, kjer Mislinja priteče iz Mislinjskega jarka v dolino, tj. pri naselju Mislinja, do njenega izliva v Mežo v Otiškem Vrhu (slika 1). Na podlagi podatkov iz evidence vodnih dovoljenj smo glede na priporočila za vzorčenje iz vodnjakov in vrtin (Metodologija za opredelitev ..., 2021) poskušali izbrati take lokacije, kjer se voda čim bolj redno uporablja, npr. kjer imajo vodne črpalke ali pa vodo pogosto uporabljajo za zalivanje, pranje in ostalo rabo.

Enkratno vzorčenje je potekalo 22. in 23. oktobra 2016. Vzorce smo odvzeli na dvanajstih lokacijah (slika 3). Na devetih lokacijah smo vzorčili podtalnico, na preostalih treh pa reko Mislinjo. Pred odvzemom vzorca podtalnice smo na zasebnih vrtinah, opremljenih s črpalkami, pustili vodo teči približno pet minut in šele nato izvedli vzorčenje. Na ta način smo odstranili morebitni vpliv zastajanja vode v sistemu na njene merjene fizikalno-kemijske lastnosti. Za potrebe nadaljnjih terenskih in laboratorijskih analiz smo odvzeli vzorce po dva litra ter poseben vzorec za določanje biokemijske potrebe po kisiku (BPK 5). Na lokaciji smo z električnim merilcem izmerili temperaturo vode, pH, prevodnost in vsebnost kisika. Na popisni list smo zapisali tudi druge značilnosti in okoliščine, ki so se nanašale bodisi na odvzeti vzorec bodisi na lokacijo in vplive v neposredni bližini (organoleptične lastnosti vode, pokrovnost in raba tal, razdalja od površja do podtalnice ter globina, na kateri je bil vzorec odvzet). Pri pridobivanju nekaterih informacij tehnične narave so nam pomagali tudi lastniki vrtin oziroma vodnjakov. Lokacije odvzemov so predstavljene v preglednicah 1 (odvzemi na vodotoku Mislinja) in 2 (odvzemi podtalnice). Primera vodnjakov sta prikazana na sliki 4.

Slika 3: Izbrane lokacije za vzorčenje podtalnice na vodonosniku ob Mislinji in na Mislinji.



Preglednica 1: Predstavitev lokacij odvzemov na vodotoku Mislinja.

Lokacija	Opis lokacije odvzema	Pretežna dejanska raba v okolici 500 m od odvzema
M1	• začetek srednjega toka (ob začetku doline) • manjše zgostitve prebivalstva	• trajni travniki – 58 % • gozd – 13 % • njiva ali vrt 11 % • pozidano in sorodno zemljišče 11 % • ostale rabe – 7 %
M2	• ob industrijski coni Pameče	• trajni travniki – 37 % • gozd – 26 % • pozidano in sorodno zemljišče – 20 % • ostale rabe – 17 %
M3	• pred sotočjem z reko Mežo – v neposredni bližini industrijske cone Otiški Vrh ter večje zgostitve prebivalstva • pomemben tudi vpliv kmetijstva	• pozidano in sorodno zemljišče – 40 % • trajni travniki – 15 % • njiva ali vrt – 13 % • gozd – 13 % • ostale rabe – 19 %

Preglednica 2: Predstavitev lokacij odvzemov podtalnice.

Lokacija	**Vrsta**	**Globina**		**Opis lokacije odvzema**	**Pretežna dejanska raba v okolici 500 m od odvzema**	**Priključenost lokacije odvzema na javno kanalizacijsko omrežje (stanje ob odvzemu vzorca)**
		vodnjaka oz. vrtine	od površja do nivoja podtalnice			
P1	vodnjak	2,5 m	*	• zaselek Straže (naselje Mislinja) • vodnjak starejši in redkeje uporabljan • neposredno ob glavni cesti (Slovenj Gradec – Velenje)	• trajni travniki – 47 % • gozd – 27 % • pozidano in sorodno zemljišče – 11 % • ostale rabe – 15 %	ne (ima možnost priključitve, aglomeracija)
P2	vodnjak	3,5 m	na dan odvzema 1,83 m	• vodnjak za potrebe toplotne črpalke • redno vzdrževan in uporabljan • lokacija neposredno ob vodotoku Mislinja – možen večji vpliv površinskega toka na podtalnico (lastnik opaža močno nihanje temperature podtalnice glede na letni čas) • pretežno kmetijsko območje	• trajni travniki – 51,5 %, • gozd – 25 % • pozidano in sorodno zemljišče – 8 % • ostale rabe – 15,5 %	ne (ni del aglomeracije)
P3	vrtina	*	*	• mlajša vrtina (2 leti), a razmeroma redko uporabljana – predvsem v namene namakanja in napajanja živine – aktivna kmetija z usmeritvijo v živinorejo – možnost vpliva dejavnosti lastnika na kakovost podtalnice • hmeljišča v neposredni okolici	• trajni travniki – 47 % • njiva ali vrt – 25 % • pozidano in sorodno zemljišče – 10 % • hmeljišče – 7 % • ostale rabe – 11 %	da

Lokacija	Vrsta	Globina		Opis lokacije odvzema	Pretežna dejanska raba v okolici 500 m od odvzema	Priključenost lokacije odvzema na javno kanalizacijsko omrežje (stanje ob odvzemu vzorca)
		vodnjaka oz. vrtine	od površja do nivoja podtalnice			
P4	vodnjak	*	*	• v okolici naselja Slovenj Gradec • lastnik se ukvarja z avtoprevozništvom – voda se uporablja za pranje voznega parka – možnost vpliva dejavnosti lastnika na kakovost podtalnice • v neposredni bližini ene največjih hmeljarskih družin • v okolici nekaj kmetij • vodnjak star okoli 20 let	• trajni travniki – 43 % • njiva ali vrt – 33 % • pozidano in sorodno zemljišče – 12 % • hmeljišče – 5 % • ostale rabe – 7 %	ne (priključen 2019)
P5	vodnjak	5 m	običajno okoli 4 m	• v okolici naselja Slovenj Gradec • vodnjak star okoli 50 let • neposredna bližina prometnice (Slovenj Gradec – Velenje)	• trajni travniki – 40 % • njiva ali vrt – 36 % • pozidano in sorodno zemljišče – 19 % • ostale rabe – 5 %	ne (priključen 2020)
P6	vrtina	6,8 m	*	• naselje Pameče • lastnik se ukvarja z avtoprevozništvom – voda se uporablja za čiščenje voznega parka in za toplotno črpalko – možnost vpliva dejavnosti lastnika na kakovost podtalnice • lokacija pod pobočjem – tokovi s pobočij lahko vplivajo na kvaliteto podtalnice • pretežno kmetijsko območje	• trajni travniki – 44 % • njiva ali vrt – 20 % • gozd – 10 % • pozidano in sorodno zemljišče – 10 % • ostale rabe – 16 %	ne (ni del aglomeracije)

Lokacija	**Vrsta**	**Globina**		**Opis lokacije odvzema**	**Pretežna dejanska raba v okolici 500 m od odvzema**	**Priključenost lokacije odvzema na javno kanalizacijsko omrežje (stanje ob odvzemu vzorca)**
		vodnjaka oz. vrtine	od površja do nivoja podtalnice			
P7	vodnjak	3,5 m	na dan odvzema 2,12 m	• naselje Otiški Vrh (južni del) • lastnik se ukvarja s kmetijstvom (živinoreja) • pretežno kmetijsko območje • okoli 20 let star vodnjak, redno uporabljan	• trajni travniki – 41,5 % • gozd – 21 % • njiva ali vrt – 12 % • pozidano in sorodno zemljišče – 11 % • ostale rabe – 14,5 %	ne (ni del aglomeracije)
P8	vrtina	6 m		• naselje Otiški Vrh • v neposredni bližini vodotoka Mislinja (30 m) • okoli 20 let stara vrtina – redno uporabljana • lokacija pod pobočjem – tokovi s pobočij lahko vplivajo na kvaliteto podtalnice	• pozidano in sorodno zemljišče – 40 % • gozd – 24 % • trajni travniki – 24 % • ostale rabe – 12 %	ne (del aglomeracije, kanalizacija še ni izgrajena)
P9	vodnjak	4,5 m	na dan odvzema 3,16 m	• naselje Otiški Vrh (sever) • voda se uporablja redno za potrebe toplotne črpalke • neposredna bližina industrijske cone Otiški Vrh – v zalednem območju vodnjaka • neposredna bližina glavne ceste Dravograd–Slovenj Gradec • neposredna bližina kemične čistilnice in avtoprevozništva • močno pozidano območje	• pozidano in sorodno zemljišče – 39 % • trajni travniki – 19 % • gozd – 18 % • drevesa in grmičevje – 10,5 % • njiva ali vrt – 5 % • ostale rabe – 8,5 %	ne (del aglomeracije, kanalizacija še ni izgrajena)

*Opomba: *podatek ni na voljo (globine od površja do nivoja podtalnice ni bilo možno izmeriti/lastnik nima informaciji o globini vrtine/vodnjaka).*

Slika 4: Primer vrtine (a – vzorčna lokacija – vrtina P6) in vodnjaka (b – vzorčna lokacija – vodnjak P9) na izbranih lokacijah.

V laboratoriju smo izvedli analize vsebnosti nitratov, nitritov, amonija, kloridov, sulfatov in fosfatov. Določili smo tudi biokemijsko potrebo po kisiku in trdoto vode. Za analize nitratov, nitritov, amonija, kloridov, sulfatov in fosfatov so bili uporabljeni terenski testerji Visocolor eco. Ti so cenovno dostopni in omogočajo enostavno uporabo z vizualnim odčitavanjem vrednosti koncentracije posameznih parametrov. Določevanje trdote smo izvedli s standardno metodo titracije z EDTA (Boyd, 2015). Določali smo karbonatno, skupno, kalcijevo in magnezijevo trdoto. V laboratoriju smo po standardni metodi določili tudi vrednost biokemijske potrebe po kisiku (Boyd, 2015).

Pridobljene podatke smo zbrali v evidenčni preglednici ter izrisali grafikone in karte, ki so nam omogočili prostorsko preučitev kakovosti vode odvzetih vzorcev. Ker vodonosnik ob Mislinji predstavlja tudi potencialni vir pitne vode, smo dobljene rezultate merjenih fizikalno-kemijskih parametrov primerjali z izbranimi mejnimi vrednostmi, podanimi v Pravilniku o pitni vodi (Uradni list RS, št. 19/04, 35/04, 26/06, 92/06, 25/09, 74/15 in 51/17). Vrednosti so prikazane v preglednici 3.

Preglednica 3: Izbrani parametri in mejne vrednosti po Pravilniku o pitni vodi (Uradni list RS, št. 19/04, 35/04, 26/06, 92/06, 25/09, 74/15 in 51/17).

Parameter	**Mejna vrednost parametra/specifikacija**	**Enota**
Amonij	0,50	mg/l
Nitrat	50	mg/l
Nitrit	0,50	mg/l
Klorid	250	mg/l
Sulfat	250	mg/l
Električna prevodnost	2500	µS/cm pri 20°C

Parameter	Mejna vrednost parametra/specifikacija	Enota
Koncentracija vodikovih ionov (pH vrednost)	med 6,5 in 9,5	enote pH
Barva	sprejemljiva za potrošnike in brez neobičajnih sprememb	
Motnost	sprejemljiva za potrošnike in brez neobičajnih sprememb	
Vonj	sprejemljiv za potrošnike in brez neobičajnih sprememb	

4 REZULTATI MERITEV IN ANALIZ

V nadaljevanju so podrobneje predstavljene vrednosti merjenih fizikalno-kemijskih parametrov, ločeno za vzorce podtalnice in vzorce Mislinje. V preglednici 4 in na slikah 5 so vzorci vodotoka Mislinja prikazani s temnejšo podlago, vzorci podtalnice pa s svetlejšo podlago.

4.1 Rezultati meritev za vzorce odvzete na Mislinji

Na vzorcih Mislinje smo za posamezne parametre pridobili naslednje rezultate:

- Vonj, barva in motnost vode so najbolj očitni in najlažje opazni parametri, iz katerih lahko sklepamo na kakovost vode. So izjemnega pomena, saj je ravno njihova neustreznost pogosto povod za nadaljnje analize kakovosti vode. Na območju vodotoka Mislinja nismo zaznali posebnosti pri nobenem izmed teh parametrov (preglednica 4).
- Najnižjo temperaturo je imela Mislinja v zgornjem delu Mislinjske doline (6,5 °C). Po toku navzdol je zaradi toplejšega ozračja ob vzorčenju temperatura naraščala do 10,7 °C (v spodnjem toku) (preglednica 4, slika 5a).
- Zaznano je rahlo naraščanje pH na Mislinji po toku navzdol, vendar so razlike med vzorci majhne (preglednica 4, slika 5a).
- Vsebnost raztopljenega kisika v vodi je pri Mislinji najvišja v zgornjem toku (8,6 mg/l), a po toku navzdol le malo upade (preglednica 4, slika 5b).
- Rezultati analize biokemijske potrebe po kisiku kažejo na stabilne vrednosti na Mislinji (nihanje med 4,6 do 5,6 mg/l) (preglednica 4, slika 5b).
- Nitrati so bili prisotni v vseh preučevanih vzorcih. Zaslediti je trend naraščanja vsebnosti nitratov po toku navzdol (od 3 mg/l v zgornjem toku in 10 mg/l v spodnjem toku Mislinje) (preglednica 4, slika 5c).
- Vsebnost nitritov je znašala med 0 in 0,03 mg/l. Njihova vsebnost se je po toku navzdol povečevala (preglednica 4, slika 5d).

- Vsebnost amonija je bila pod mejo zaznavnosti (preglednica 4, slika 5d).
- Pri Mislinji vsebnosti kloridov ne presegajo 7 mg/l, se pa po toku navzdol nekoliko povečujejo (preglednica 4, slika 5c).
- Vsebnost fosfatov in sulfatov je bila pri vseh vzorcih manjša od meje zaznavnosti, ki znaša pri fosfatih 0,1 mg/l, pri sulfatih pa 0,25 mg/l (preglednica 4, slika 5d).
- Pri trdoti vode je opazen očiten trend naraščanja vrednosti po toku navzdol. Opazen je prehod iz zelo mehke v mehko in zmerno trdo vodo (2,8 °NT do 8,9 °NT) (preglednica 4, slika 5e).
- Električna prevodnost je odvisna od prisotnosti elektrolitov v vodi. Ker med njimi izrazito prevladujeta kalcijev in magnezijev karbonat, ki kot hidrogenkarbonat opredeljujeta karbonatno trdoto, sta trdota in prevodnost med seboj precej povezani, večje razlike med vrednostmi pa nakazujejo na prisotnost preostalih elektrolitov (nitrati, nitriti, fosfati, amonij, sulfati idr.). Tudi pri električni prevodnosti je prisoten pozitiven trend vrednosti po toku navzdol (med 114,8 µS/cm in 314 µS/cm) (preglednica 4, slika 5e).

4.2 Rezultati meritev za vzorce podtalnice vodonosnika ob Mislinji

Ob analiziranju vzorcev podtalnice iz vodonosnika ob Mislinji smo za posamezne parametre dobili naslednje rezultate:

- Med parametri vonj, barva in motnost smo pri vzorcih P2 in P7 zaznali posebnosti pri parametrih barva in motnost. Vzorca sta bila rumeno obarvana in motna (preglednica 4), kar lahko nakazuje na onesnaženost in različne primesi.
- Temperatura podtalnice se je gibala med 10,7 °C in 14,3 °C. Med vzorci podtalnice je imel najnižjo temperaturo vode vzorec P2 (10,7 °C), ki se nahaja v neposredni bližini Mislinje (oddaljenost 31 m). Lastnik navaja izrazito nihanje temperature podtalnice (Obreza, 2016). Izražen je majhen trend naraščanja temperature po toku navzdol (preglednica 4, slika 5a).
- pH se je pri vseh vzorcih podtalnice gibal med 7 in 8. Opazen je rahel trend upadanja pH po toku navzdol, a ni statistično značilen. Izstopajo vzorci P2, P3 in P8, ki imajo višji pH (preglednica 4, slika 5a).
- Med vzorci se vsebnost raztopljenega kisika precej razlikuje (vsebnosti od 2,8 mg/l do 6,1 mg/l). Prisoten je tudi trend upadanja vsebnosti raztopljenega kisika v vodi po toku navzdol (preglednica 4, slika 5b).
- Rezultati analize biokemijske potrebe po kisiku kažejo, da se vrednosti od lokacije do lokacije močno spreminjajo (od 2,26 do 9,81 mg/l). Opazna sta izrazita viška v vzorcih P5 in P8. Opazen je tudi trend naraščanja biokemijske potrebe po kisiku po toku navzdol, kar nakazuje na večjo organsko onesnaženost podtalnice ob spodnjem toku Mislinje (preglednica 4, slika 5b).
- Nitrati so bili prisotni v vseh preučevanih vzorcih. Povečane vrednosti smo zasledili v vzorcih P4 in P5, ki dosegata 50 mg/l, kar hkrati predstavlja mejno vrednost

po Pravilniku o pitni vodi (Uradni list RS, št. 19/04, 35/04, 26/06, 92/06, 25/09, 74/15 in 51/17). Ta vzorca se nahajata v neposredni bližini Slovenj Gradca. Zasledi je trend naraščanja vsebnosti nitratov po toku navzdol. Trend zaradi izstopajočih vrednosti P5 in P4 ni statistično značilen (preglednica 4, slika 5c).

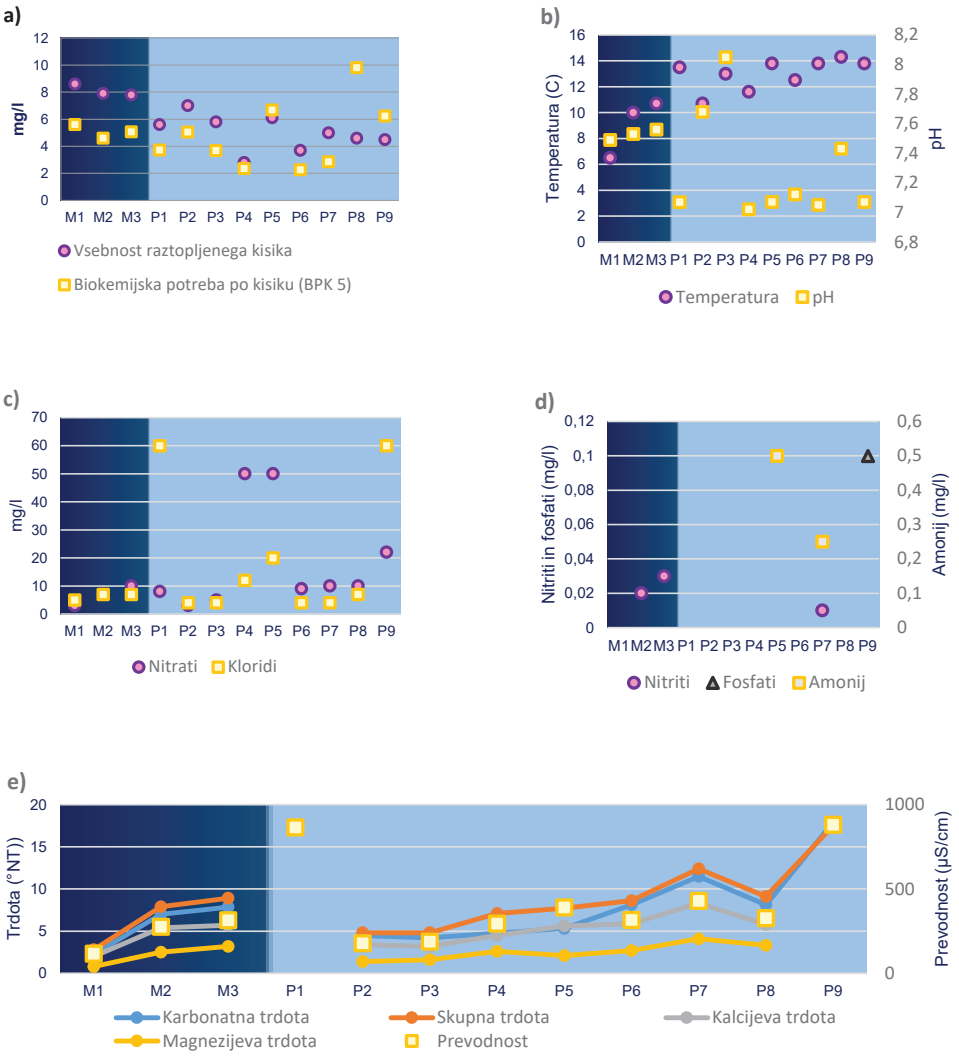
- Vsebnost nitritov v vzorcih podtalnice je bila, z izjemo vzorca P7 (0,01 mg/l), pod mejo zaznavnosti (preglednica 4, slika 5d).
- Prisotnost amonija smo zasledili zgolj pri dveh vzorcih podtalnice (P5 in P7). V vzorcu P5 je vrednost znašala 0,5 mg/l, s čemer je bila dosežena mejna vrednost glede na Pravilnik o pitni vodi (Ur.l. RS št.:19/04, 35/04, 26/06, 92/06, 25/09 in 74/15). V preostalih vzorcih je bila vsebnost amonija pod mejo zaznavnosti (preglednica 4, slika 5d).
- Kloridi so bili prisotni pri vseh vzorcih, pri čemer sta močno izstopala vzorca P1 z vsebnostjo kloridov več kot 60 mg/l (zgornja meja zaznavnosti) in P9 z vsebnostjo kloridov 60 mg/l. Vsebnosti kloridov v vzorcih podtalnice ne sledijo splošnemu trendu, opazno je ponovno povečanje vsebnosti kloridov v vzorcih P4 in P5 z 12 mg/l oziroma 20 mg/l, ki se nahajata v okolici Slovenj Gradca (preglednica 4, slika 5c).
- Fosfate smo zasledili zgolj v vzorcu P9, kjer je njihova vrednost znašala 0,1 mg/l, kar je hkrati tudi spodnja meja zaznavnosti uporabljenega testa. Povsem možno je torej, da so bili fosfati v zmernih količinah prisotni tudi pri drugih vzorcih, a jih z manj občutljivim testom nismo zaznali (preglednica 4, slika 5d).
- Vsebnost sulfatov je bila pri vseh vzorcih manjša od meje zaznavnosti, ki znaša 25 mg/l (preglednica 4).
- Pri trdoti vode je opazen očiten trend naraščanja vrednosti po toku navzdol. Opazen je prehod iz zelo mehke v mehko in zmerno trdo vodo (med 4,8 °NT do 17,5 °TN). Zaradi anomalije pri laboratorijski analizi (karbonatna trdota je bila višja od skupne) smo za vzorca P1 in P9 prikazali le skupno trdoto. Predvidevamo, da so pri teh dveh vzorcih prisotne povečane vrednosti onesnažil (najverjetneje kloridov), ki vplivajo na rezultat analize trdote. Posebnost je mogoče zaznati tudi pri električni prevodnosti, saj imata vzorca močno povečano vrednost v primerjavi z ostalimi vzorci (preglednica 4, slika 5e).
- Pri parametru električne prevodnosti je prisoten pozitiven trend vrednosti po toku navzdol. Meritve se gibljejo med 177 µS/cm in 880 µS/cm. Najvišji in močno izstopajoči vrednosti električne prevodnosti smo izmerili v vzorcih P1 in P9 (864 µS/cm oziroma 880 µS/cm), kar je verjetno posledica visoke vsebnosti klorida (preglednica 4, slika 5e).

Preglednica 4: Rezultati analiz fizikalno-kemijskih parametrov na posameznih merilnih mestih.

	Vzorci vodotoka Mislinja			Vzorci podtalnice iz vodonosnika ob Mislinji								
Oznaka V Parameter	**M1**	**M2**	**M3**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
Vonj	brez	brez	brez	brez	brez	brez	brez	brez	brez	brez	brez	brez
Barva	brez	brez	brez	brez	rahlo rumena	brez	brez	brez	brez	rahlo rumena	brez	brez
Motnost	brez	brez	brez	brez	motna	brez	brez	brez	brez	motna	brez	brez
Temperatura (°C)	6,5	10	10,7	13,5	10,7	13	11,6	13,8	12,5	13,8	14,3	13,8
pH	7,49	7,53	7,56	7,07	7,68	8,05	7,02	7,07	7,12	7,05	7,43	7,07
Vsebnost raztopljenega kisika (mg/l)	8,6	7,9	7,8	5,6	7	5,8	2,8	6,1	3,7	5	4,6	4,5
BPK 5(mg/l)	5,6	4,6	5,07	3,72	5,04	3,69	2,35	6,68	2,26	2,86	9,81	6,24
Nitrati (mg/l)	3	7	10	8	3	5	50	50	9	10	10	22
Nitriti (mg/l)	0	0,02	0,03	0	0	0	0	0	0	0,01	0	0
Amonij (mg/l)	< 0,25	< 0,25	< 0,25	< 0,25	< 0,25	< 0,25	< 0,25	0,5	< 0,25	0,25	< 0,25	< 0,25
Kloridi (mg/l)	5	7	7	> 60,00	4	4	12	20	4	4	7	60
Fosfati (mg/l)	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	0,1
Sulfati (mg/l)	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0
Karbonatna trdota (°NT)	2,24	7	7,84	*14,56**	4,48	4,2	4,76	5,32	8,12	11,48	8,12	*17,92**
Skupna trdota	2,8	7,9	8,9	*13,70**	4,8	4,8	7,1	7,7	8,6	12,4	9,1	*17,50**
Kalcijeva trdota (°NT)	2	5,4	5,7		3,4	3,2	4,5	5,6	5,9	8,3	5,8	
Magnezijeva trdota (°NT)	0,8	2,5	3,2		1,4	1,6	2,6	2,1	2,7	4,1	3,3	
Prevodnost (µS/cm)	114,8	275	314	864	177	186,4	293	390	315	428	326	880
Kvalitativna oznaka vode	zelo mehka	mehka	mehka		zelo mehka	zelo mehka	mehka	mehka	mehka	zmerno trda	mehka	

V – vzorec; M1–M3 – merilna mesta na Mislinji; P1–P9 – merilna mesta na podtalnici;
**Vrednosti so kontradiktorne glede na običajne vrednosti za slovenske vode, saj je karbonatna trdota večja od celokupne trdote. Slednje je morda posledica izrazitega onesnaženja s kloridi. Analiza zaradi te anomalije ni bila dokončana.*

Slika 5: Onesnažila, trdota in prevodnost glede na posamezne vzorčne lokacije (v temnejšem delu grafikonov so prikazane vrednosti na vzorčnih mestih Mislinje, v svetlejšem pa na vzorčnih mestih podtalnice).



5 DISKUSIJA

Po mnenju Narshima in sod. (2013, str. 74) je koncentracija nitratov nad 10 mg/l posledica antropogenih vplivov na podtalnico. Na obravnavanem območju v Mislinjski dolini vsebnost nitratov niha med 3 in 50 mg/l, manj kot 10 mg/l smo zaznali le v štirih vzorcih. Povišane vrednosti so tako verjetno v večini primerov posledica antropogenih vplivov. Koncentracija nitratov je najvišja pri vzorcih P4 in P5 na območju med Slovenj Gradcem in Šmartnim pri Slovenj Gradcu. Slednje je sodeč po rabi tal (MKGP, 2017) verjetno posledica intenzivnega kmetijstva s poudarkom na integrirani pridelavi hmelja, ki je najbolj razširjena in skoncentrirana ravno v tem delu doline (slika 2). Na problematiko vpliva hmeljišč na spiranje nitratov v podtalnico opozarja tudi Gale s sodelavci (1999). Prav tako možna, a manj verjetna je onesnaženost vode z nitrati zaradi večje gostote poselitve ter mestoma pomanjkljivo urejene kanalizacije. Širše območje Šmartna pri Slovenj Gradcu in južni del Slovenj Gradca sta bila namreč v večji meri ustrezno kanalizacijsko opremljena šele v času po izvajanju meritev, in sicer med letoma 2017 in 2021, nekatera območja v neposredni bližini vzorčnih mest pa še vedno nimajo ustrezno rešenega vprašanja odvajanje odpadne vode (GURS, 2021).

Naravna prisotnost nitritov v podzemni vodi običajno ne presega 0,3 mg/l (Nitrate and nitrite in drinking-water, 2011). Zaznane vrednosti so bistveno nižje od te meje in so tudi pod mejo vrednosti za pitno vodo. Tako Mislinja kot podtalnica v vodonosniku ob Mislinji z nitriti nista onesnaženi.

Naravna prisotnost amonija v podzemni in površinski vodi je običajno nižja od 0,2 mg/l (WHO, 1996). Večina odvzetih vzorcev ni imela povišanih vsebnosti amonija, izstopata le vzorca P5 in P7. V obeh vzorcih vrednosti presegajo 0,2 mg/l, kar kaže na antropogeni vpliv. Prisotnost amonija v podzemni vodi je običajno posledica kmetijstva, komunalnih odplak ali industrije. V vzorcih P5 in P7 je industrija dovolj oddaljena, da verjetno nima pomembnejšega vpliva na podtalnico. V vzorcu P5, ki se nahaja v bližini Slovenj Gradca, ni izključen vpliv komunalnih odplak, saj v času odvzema lastniki vrtine še niso bili priključeni na javno kanalizacijsko omrežje. Istočasno v vzorcu P4, ki se nahaja v neposredni bližini P5, amonija v večjih koncentracijah nismo zaznali, čeprav tudi tukaj kanalizacija v času vzorčenja še ni bila zgrajena. Možno bi bilo tudi onesnaženje zaradi kmetijstva, ki je najverjetnejši vzrok onesnaženja v vzorcu P7, katerega lastnik ima kmetijo usmerjeno pretežno v živinorejo (preglednica 2).

Bolj problematični so kloridi, katerih vrednosti so bile ponekod visoke, vendar niso presegle mejnih vrednosti za pitno vodo po slovenskih standardih. Po mnenju Kohnove in sod. (2016, str. 112) na antropogene vplive opozarjajo koncentracije kloridov nad 20 mg/l. Višje koncentracije kloridov je bilo moč zaznati v vzorcih P1 in P9, kjer so vrednosti dosegle in verjetno tudi presegle 60 mg/l, saj gre pri tej vrednosti tudi za zgornjo mejo zaznavnosti uporabljenega testa. Takšne koncentracije so, glede na bistveno nižje vrednosti v ostalih vzorcih, najverjetneje posledica točkovnega onesnaževanja, ki bi lahko v vzorcu P9 izviralo iz bližnje industrijske cone, kemične čistilnice ali avtopralnice

(preglednica 2). Vzorec P1 se nahaja v neposredni bližini glavne ceste G1-4 Slovenj Gradec–Velenje (preglednica 2), zato ni izključen niti vpliv uporabe soli pri zimskem vzdrževanju cest. Do podobnih ugotovitev so denimo prišli tudi v študiji *Skrb za pitno vodo* (Jamnik in sod., 2014), kjer so na primeru Ljubljanskega polja ugotovili, da so zmerne koncentracije kloridov posledica komunalnih odpadnih vod in uporabe soli za zimsko vzdrževanje cest. Vsebnost kloridov je bila nekoliko višja tudi v okolici Slovenj Gradca (vzorec P5), za kar bi lahko bile krive komunalne odpadne vode iz tedaj še pomanjkljivo urejenega kanalizacijskega omrežja (GURS, 2021) ter intenzivno kmetijstvo s poudarkom na hmeljarstvu (Gale in sod., 1999) na ožjem vplivnem območju ali prav tako uporaba soli za zimsko vzdrževanje cest.

Vsebnosti fosfatov v podtalnici so nizke, saj se fosfor običajno zadrži v prsti (Welch, Kingsbury, Coupe, 2010). Tudi v Mislinjski dolini v večini vzorcev, tako Mislinje kot podtalnice, fosfatov nismo zaznali v večjih količinah, čeprav potencialni viri onesnaževanja obstajajo: umetna gnojila, hlevski gnoj, detergenti ipd. Razlog za to je lahko tudi razmeroma majhna občutljivost uporabljenega testa z mejo zaznavnosti 0,1 mg/l. Edini vzorec, kjer smo fosfate zaznali (0,1 mg/l), je bil P9. Možni razlog vidimo predvsem v lokalnih vplivih, saj v bližini obratuje avtopralnica (preglednica 2), od koder bi se lahko v podtalnico spirali detergenti.

Sulfati se v naravi pojavljajo predvsem zaradi izpiranja kamnin, zato ima na primer morska voda koncentracije sulfatov 2700 mg/l (WHO, 2004), v tekočih vodah in podtalnici pa so vrednosti običajno bistveno nižje. Kamnine v zaledju reke Mislinje niso vir velike količine sulfatov, prav tako antropogeni vplivi, predvsem kot posledica industrije, niso v večji meri vplivali na njihovo vsebnost v vzorčeni vodi. V vseh vzorcih smo namreč namerili manjše koncentracije od meje zaznavnosti uporabljenega testa (25 mg/l).

Pri biokemijski potrebi po kisiku (BPK 5) vzorci z vrednostjo med 1 in 2 mg/l nakazujejo na z organskimi snovmi neonesnaženo vodo, vzorci z vrednostjo med 3 in 5 mg/l na prisotnost organskega onesnaženja, vzorci z več kot 5 mg/l pa že na večje organsko onesnaženje (Oram, 2017). Povečane vrednosti smo zaznali predvsem pri reki Mislinji, kjer so bile vrednosti okoli 5 mg/l. Zanimivo je dejstvo, da so vrednosti BPK 5 višje tudi v nekaterih vzorcih, odvzetih v zgornjem toku Mislinje. Pri podtalnici vrednosti BPK 5 nad 5 mg/l beležimo v vzorcih P2, P5, P8 in P9. V preostalih vzorcih so vrednosti nižje, kar nakazuje na zmernejše vplive iz okolja.

pH je merilo ravnotežja med koncentracijo vodikovih in hidroksilnih ionov v vodi, nanj pa lahko vplivajo številni dejavniki (Boyd, 2015). Mejna vrednost za pitno vodo znaša 6,5 do 9,5. Vrednosti pH odvzetih vzorcev se gibljejo med 7,02 in 8,05, kar kaže na rahel alkalni značaj voda v Mislinjski dolini.

V podzemni vodi je generalno gledano manj raztopljenega kisika kot v površinskih vodnih virih, kar je posledica oksidacijskih procesov in odsotnosti vira kisika (Rose, Long, 1988). Rezultati analize vsebnosti kisika kažejo na različno prisotnost kisika v podtalnici, saj vrednosti nihajo med 2,8 in 6,1 mg/l. Razlog za večjo prisotnost kisika v nekaterih vzorcih je najverjetneje plitvost vodonosnika ter zatekanje Mislinje,

kjer so vsebnosti raztopljenega kisika nekoliko višje, v vodonosnik. Takšen je verjetno predvsem vzorec P2, ki je (za zgornji tok Mislinje) izkazoval tudi višjo vrednost BPK. Na vsebnost kisika v podtalnici potencialno vplivata tudi njena globina in stik z ozračjem. Tudi v našem primeru se je v povprečju pokazala razlika med vzorci vode iz vodnjakov in vrtin. V vzorcih iz vodnjakov je vsebnost kisika v povprečju nekoliko višja (5,1 mg/l), kar je verjetno posledica neposrednega stika podtalnice z ozračjem. Povprečna vsebnost kisika v vzorcih iz vrtin je nekoliko nižja (4,7 mg/l), kar je verjetno posledica odsotnosti neposrednega stika med podtalnico in ozračjem, saj se voda v vrtinah praviloma zajema iz nekoliko večjih globin. Kljub temu se vsebnost kisika v vzorcih iz vodnjakov in vrtin od vzorčnega mesta do vzorčnega mesta med seboj precej razlikujejo.

Izkazalo se je, da je vplive iz okolja, pogojene s pokrovnostjo in rabo tal na širšem območju vzorčnega mesta, možno povezati z vrednostmi analiziranih parametrov le v določeni meri (npr. vpliv intenzivnega hmeljarjenja in/ali odplak na povišane vrednosti nitratov v vzorcih P4 in P5). Rezultati analize vzorcev namreč ponekod nakazujejo močno odvisnost vrednosti posameznih fizikalno-kemijskih parametrov podtalnice od same mikrolokacije vzorčnega mesta ter od bolj ali manj poznanih vplivov na tej lokaciji (npr. povišane vrednosti kloridov, trdote in električne prevodnosti v vzorcih P1 in P9 zaradi nepoznanega lokalnega vira onesnaževanja ali pa zelo različna vsebnost amonija v vzorcih P4 in P5, ki sta med seboj oddaljena zgolj 180 m zračne razdalje). Slednje je med drugim verjetno tudi posledica metodoloških omejitev, vezanih na vzorčenje iz vodnjakov in zasebnih vrtin, zaradi katerih so rezultati lahko podvrženi morebitnim lokalnim vplivom in posledično le v določeni meri reprezentativno odražajo stanje na širšem območju vodonosnika (Metodologija za opredelitev ..., 2021).

Primerjava fizikalno-kemijskih lastnosti podtalnice in Mislinje je pokazala, da kljub hidrološki povezanosti obeh sistemov vrednosti posameznih parametrov pri eni in pri drugi niso nujno medsebojno primerljive. Pri podtalnici na vrednosti merjenih parametrov namreč poleg antropogenih vplivov s površja v veliki meri vplivajo tudi oddaljenost od površinskih voda in stopnja mešanja površinske vode in podtalnice, hitrost premikanja in obnavljanja podtalnice, izdatnost in globina vodonosnika ter njegova geološka sestava (Fetter, 1999). Podobnosti med sistemoma so se tako pokazale le pri trdoti in električni prevodnosti, vrednosti ostalih parametrov (temperatura, vsebnost kisika, BPK 5 ter vsebnost hranil) pa so se zaradi različne dinamike in zadrževalnih časov vode, trenutnih vremenskih vplivov in različnih samočistilnih sposobnosti precej razlikovale, zaradi česar jih med seboj niti ne moremo primerjati. Trdota vode je bila v obeh sistemih sprva nizka (do 4 °NT), nato pa se je po toku navzdol povečevala (do okoli 10 °NT). Podobno je bil tudi pri prevodnosti (če izvzamemo P1 in P9) pri obeh sistemih prisoten trend naraščanja vrednosti po toku navzdol. Je pa tako za Mislinjo kot za podtalnico značilno, da se gledano v splošnem koncentracija onesnažil po toku navzdol stopnjuje, kar nakazuje na stopnjevanje pritiskov in prisotnost progresivnega onesnaževanja.

Rezultati velike večine analiz fizikalnih in kemijskih parametrov v vzorcih podtalnice (vonj, barva, nitrati, nitriti, amonij, pH, kloridi in sulfati) so pod pragom mejnih vrednosti, podanih v Pravilniku o pitni vodi (Uradni list RS, št. 19/04, 35/04, 26/06, 92/06, 25/09, 74/15 in 51/17). Ko pa obravnavamo posamezen vzorec kot celoto, kjer že zgolj neskladnost enega izmed parametrov vpliva na neskladnost celotnega vzorca, so rezultati še bistveno slabši, saj je kar pet od devetih vzorcev neustreznih oziroma pogojno ustreznih. Vzorec P2 je neustrezen zaradi rahlo rumene barve in motnosti, vzorec P7 prav tako zaradi rahlo rumene barve. Najvišje mejne vrednosti so dosegli vzorci pri nitratih. Vzorca P4 in P5, odvzeta v bližini Slovenj Gradca, dosegata mejno vrednost nitratov (50 mg/l), vzorec P5 pa še dodatno dosega mejno vrednost amonija (0,5 mg/l).

6 ZAKLJUČEK

Podtalnica je zaradi lokacije pod površjem očem skrit vodni vir. Zato je, kljub pomembnosti kot potencialni vir pitne vode, pogosto zapostavljena in slabše raziskana. Še posebej na območjih, kjer njene zaloge niso posebej izdatne in je dandanes ne uporabljajo za lokalno vodooskrbo. Takšne narave je tudi vodonosnik ob Mislinji, ki ga obravnavamo v prispevku. Gre za vodonosnik manjše izdatnosti, ki je za lokalno prebivalstvo pomemben predvsem za zalivanje, namakanje in pranje, ne pa tudi kot vir pitne vode. Zaradi visoke gladine podtalnice (preglednica 2) je ta razmeroma lahko dostopna, kar se odraža v številnih vrtinah in vodnjakih. Čeprav je visoka gladina podtalnice z vidika uporabe prednost, pa ima po drugi strani ob hkratni prepustnosti krovnih plasti za posledico, da se v podtalnico lahko izpirajo znatne količine onesnažil, ki so posledica različnih antropogenih dejavnosti.

V raziskavi smo preučevali fizikalno-kemijske lastnosti podtalnice v vodonosniku ob Mislinji, da bi ocenili njeno kakovost. Izsledki raziskave so preliminarnega značaja, saj je šlo zgolj za enkratno vzorčenje v izbranih zasebnih vrtinah in vodnjakih. Poleg tega smo vzorčili na relativno majhnem številu vzorčnih mest (9) ter analizirali le najosnovnejše fizikalno-kemijske parametre (organoleptične lastnosti, temperatura, pH, vsebnost raztopljenega kisika, nitratov, nitritov, amonija, fosfatov, sulfatov, kloridov, biokemijska potreba po kisiku, električna prevodnost, analiza različnih trdot vode). Iz dobljenih rezultatov lahko torej le okvirno sklepamo na kakovost vode v vodonosniku ob Mislinji, saj ti nikakor ne morejo nadomestiti izsledkov rednega monitoringa.

Podtalnica vodonosnika ob Mislinji je bila glede na organoleptične lastnosti brez vonja ter pri večini vzorcev brez barve in brez motnosti. Izjema sta vzorca P2 in P7, kjer je bila voda motna in rahlo rumenkaste barve. Temperatura je znašala med 10,7 in 13,8 °C, pH pa je bil z vrednostmi med 7,02 in 8,05 rahlo bazičen. Vrednosti v vodi raztopljenega kisika so bile razmeroma nizke (med 2,8 in 6,1), kar je tudi sicer značilnost podzemnih voda. Na podlagi preostalih fizikalno-kemijskih analiz podtalnice v vodonosniku ob Mislinji ugotavljamo, da so med najpogosteje prisotnimi

onesnaževali nitrati, katerih vir je običajno kmetijska dejavnost. Nitrate smo v povečanih koncentracijah zaznali v večini vzorcev, najvišje vrednosti pa smo izmerili na območju intenzivnega kmetijstva v okolici Slovenj Gradca (P4 in P5; 50 mg/l). Pri dveh vzorčnih mestih smo zaznali tudi izrazito povečane vrednosti kloridov (P1 in P9; 60 mg/l), kar je verjetno posledica točkovnega onesnaženja ali soljenja cest. Glede na to, da je 60 mg/l tudi zgornja meja zaznavnosti uporabljenega testa, ni izključeno, da so vrednosti kloridov pri navedenih vzorčnih mestih realno še višje. Nekoliko povišane vrednosti kloridov so bile izmerjene tudi v okolici Slovenj Gradca (P5; 20 mg/l). Druga onesnažila so bila v povečanih koncentracijah prisotna manj pogosto in zgolj v posameznih vzorcih, zaradi česar so najverjetneje posledica lokalnih dejavnikov na ožjem vplivnem območju. Nitrite (P7; 0,01 mg/l) in fosfate (P9; 0,1 mg/l) smo tako zaznali zgolj v enem vzorcu, amonij pa v dveh (P5; 0,5 mg/l in P7; 0,25 mg/l). Sulfati so bili povsod pod mejo zaznavnosti uporabljenega testa, ki je 0,25 mg/l. Onesnaženje z organsko snovjo je najizrazitejše v spodnjem delu doline, kjer vrednost BPK 5 na merilnem mestu P8 doseže maksimalno vrednost 9,81 mg/l. Gledano v splošnem je podtalnica v vodonosniku ob Mislinji po toku navzdol postopno vse bolj onesnažena. Slednje se kaže v upadanju vsebnosti raztopljenega kisika in povečevanju biokemijske potrebe po kisiku in povečevanju vsebnosti nitratov. Po toku navzdol sta naraščali tudi trdota in električna prevodnost.

Na območju vodonosnika ob Mislinji je z vidika vpliva na kakovost podtalnice pomembno predvsem kmetijstvo, ki je prisotno na celotnem območju doline, še posebej zgoščeno pa na območju intenzivnega hmeljarstva pri naselju Šmartno pri Slovenj Gradcu. Možen vir onesnažil je tudi še ne povsem izgrajeno kanalizacijsko omrežje, saj nanj še vedno ni priključenih kar nekaj naselij ali njihovih delov (Otiški Vrh, del Šentjanža pri Dravogradu, Bukovska vas, Mislinjska Dobrava, Brda). Potencialni vpliv na slabšo kakovost podtalnice v Mislinjski dolini predstavljata še industrija (predvsem severno od Slovenj Gradca) ter promet (preko doline poteka glavna cesta, z izgradnjo tretje razvojne osi pa je pričakovati še večje prometne pritiske).

Vodonosnik ob Mislinji je, sodeč po razpoložljivih podatkih o kakovosti in zalogah podtalnice, razmeroma slabo poznan in raziskan. Vseeno pa bi ob ustrezni zaščiti verjetno lahko predstavljal vsaj potencialni rezervni vir pitne vode za širše območje Mislinjske doline. Po drugi strani so naše analize pokazale, da je glede na Pravilnik o pitni vodi (Uradni list RS, št. 19/04, 35/04, 26/06, 92/06, 25/09, 74/15 in 51/17) kar pet od devetih vzorcev neustreznih oziroma zgolj pogojno ustreznih, pri čemer je treba poudariti, da smo analizirali zelo omejeno število parametrov. Povsem verjetno je, da bi podrobnejša analiza vseh parametrov iz omenjenega pravilnika v vzorcih razkrila še več neskladnosti in bi jih bilo neustreznih še več. Rezultati analize tako nakazujejo na zaskrbljujoče dejstvo, da je podtalnica v vodonosniku ob Mislinji trenutno preveč onesnažena, da bi nanjo lahko računali kot na možni rezervni vodni vir za vodooskrbo. Slednje pa je problematično, saj gre za strateški naravni vir, ki bi ga bilo v duhu trajnostnega razvoja treba obvarovati in ohraniti za prihodnje

generacije. Poleg tega je podtalnica vodonosnika ob Mislinji nerazdružljivo povezana tudi s površinsko tekočo Mislinjo, s katero si vodo, vključno z vsemi prisotnimi onesnažili, medsebojno izmenjujeta.

K večjemu zavedanju o onesnaženosti podtalnice v vodonosniku ob Mislinji ter k izboljšanju njene kakovosti bi lahko pripomogla vzpostavitev rednega državnega monitoringa na tem območju. Ta bi povečal zanimanje za to problematiko ter zavedanje prebivalcev in predvsem lokalnih oblasti, ki bi lahko z določenimi ukrepi in spodbudami vplivale na izboljšanje trenutnega stanja. Z rednim monitoringom bi omogočali spremljanje napredka ali poslabšanja stanja podtalnice. Po drugi strani pa je primerljivih medzrnskih vodonosnikov manjšega obsega in izdatnosti, kot je vodonosnik ob Mislinji, v Sloveniji še veliko. Vzpostavitev rednega ali vsaj občasnega monitoringa kakovosti podtalnice v vodonosniku ob Mislinji, ki bi bila med drugim povezana tudi s precejšnjimi investicijami in obratovalnimi stroški, bi tako terjala strateško odločitev na državni ravni in s tem sistemsko spremembo, s katero bi v monitoring vključili tudi nekatere manj izdatne, a zato nič manj pomembne vodonosnike.

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A TEST CASE OF ASSESSING OF GROUNDWATER QUALITY IN THE MISLINJA AQUIFER

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Abstract

The Mislinja aquifer is not included in regular national groundwater quality monitoring due to its low yield and the fact that it is not used for water supply. For this paper, nine sampling sites (private wells and boreholes) were used to analyse the basic physico-chemical parameters of the water, serving as a basis for a preliminary assessment of water quality. We found that the groundwater reflects anthropogenic influences, which are more pronounced in the vicinity of areas of concentrated agricultural activity and in the vicinity of large settlements. Most samples show elevated levels of nitrates and chlorides, while some samples also show elevated levels of other measured pollutants. According to the current Rules on drinking water, five out of nine samples are unsuitable or only conditionally suitable, which means that the groundwater in the Mislinja aquifer may already be too polluted to be considered as a possible backup source for water supply.

Keywords: groundwater, intergranular aquifer, Mislinja Valley, Mislinja, groundwater quality, physico-chemical water analysis

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1 INTRODUCTION

Groundwater is an important source of fresh water that can be used for drinking, irrigation, industrial production and other uses. Surface water and groundwater are interconnected. The latter is the primary source for recharging springs and watercourses and for maintaining the flow in watercourses in times when there is no rainfall, making it an ecologically very important link in the water cycle. Conversely, aside from direct precipitation above the aquifer, groundwater is also recharged by surface water during high water periods (Brunke, Gonser 1997).

Slovenia is a country rich in groundwater. According to older estimates, its dynamic reserves amount to 50.4 m^3/s, or about 10% of the total internal runoff (Uhan, Kranjc, 2003). According to more recent estimates, utilising an amended methodology for calculating renewable reserves, the amount of groundwater in Slovenia is in fact significantly higher. In the 30-year period 1991–2020, the renewable groundwater reserves amounted to 187.55 m^3/s, or 37% of the total internal runoff (Andjelov et al., 2021).

Groundwater comes in many forms. In the gravel-sand deposits alongside Slovenia's major rivers (Sava, Drava, Mura, Soča, Savinja, etc.), groundwater is found in the form of aquifers with intergranular porosity (Uhan, Kranjc, 2003). Due to natural features such as lowland location, flat topography, available water resources and good quality soils, groundwater areas are densely populated and therefore subject to many environmental pressures (Ambrožič et al., 2008).

Pollutants mostly enter an aquifer from the surface through point, linear or diffuse sources (Jamnik et al., 2014). Contaminated groundwater poses a serious threat to health when used for water supply, and also has a negative impact on the ecosystem and water resources that are recharged from the aquifer (Fetter, 1999). The most contaminated (mainly with nitrates) aquifers in Slovenia include certain intergranular porosity areas in the country's north-eastern part (Lower Savinja Valley, Drava and Ptuj fields as well as aquifers along the Mura River) (Gacin, Mihorko, 2012; Kemijsko stanje ..., 2021), as a result of intensive agriculture (Lampič, Rutar, 2019), shallow groundwaters and high environmental sensitivity in these areas (Špes et al., 2002).

Looking at the network of groundwater quality monitoring stations (DRSV, 2021) it is evident that groundwater analysis in Slovenia is mainly carried out in areas of extensive lowland aquifers with intergranular porosity (Ljubljana Field, Kranj-Sora Field, Lower Savinja Valley, Krško-Brežice Field etc.). In these areas groundwater is also used more extensively for water supply and other purposes, while at the same time, faced with multiple pressures it is also more vulnerable to pollution. However, this type of monitoring neglects smaller aquifers, such as the Mislinja aquifer, which is the focus of our study.

Due to the small catchment area of the main watercourse, the Mislinja River, and the relatively shallow deposits of gravel and sandy clay (Mioč, 1978), the Mislinja Valley does not have significant groundwater reserves. Furthermore, groundwater in

the area is not used for the water supply of lowland settlements, which are generally supplied with water from sources in the surrounding uplands (GURS, 2021). Rather it is used exclusively for watering, irrigation and washing. As a result, no groundwater analyses are carried out in the Mislinja Valley, and we therefore do not know what the actual quantity and quality of groundwater is. However, given the area has relatively dense population, intensive agriculture, centred particularly around hop-growing, as well as numerous industrial plants, it can be concluded that the pressures on groundwater in the Mislinja aquifer are relatively high and could be contributing to the deterioration of water quality.

According to the division of Slovenia into groundwater bodies (Pravilnik o določitvi..., 2018), the Mislinja Valley is included in the Eastern Alps groundwater body (*vodno telo podzemne vode Vzhodne Alpe*), which according to existing analyses is in good chemical status (Kemijsko stanje ..., 2021). It should be stressed that this water body is an extremely large and heterogeneous unit, as it includes, in addition to the Mislinja Valley, the whole of the Pohorje, Kozjak and Strojna mountains as well as part of the Vitanjske Karavanke Mountains, and is therefore completely inappropriate for assessing the quality of groundwater in the Mislinja aquifer. In addition, the chemical status of this water body (with the exception of the Zgornja Vižinga monitoring station at Radelje Field on the Drava River) is assessed on the basis of the analysis of water from water sources in the surrounding uplands (Mislinja MZ-4/95 in the Vitanjske Karavanke Mountains, Mrzli studenec on Pohorje, Ojstrica near Dravograd on Kozjak). Given the concentration of anthropogenic pressures predominantly in the lower part of the area, it is not relevant for the valley floor, where the Mislinja aquifer is located. To the best of our knowledge, as well as according to the assurances of the representatives of the Slovenian Environment Agency (Frantar, 2021), no other, more detailed studies or measurements of groundwater quality in the Mislinja Valley have been conducted.

Given that we estimate that the pressures on groundwater in the Mislinja Valley are relatively high and that no official data on groundwater quality exist, the main objective of our study was to determine how influences from the environment are reflected in the groundwater quality. To this end, groundwater was sampled from existing wells and private boreholes at nine locations in the selected area and analysed for specified basic physico-chemical water parameters. In addition to groundwater, water from the Mislinja River was analysed at three locations, which allowed us to compare surface water and groundwater in the area.

2 GEOGRAPHICAL OVERVIEW OF THE MISLINJA VALLEY

The study area encompasses the flat bottom of the Mislinja Valley, beneath which a minor aquifer has formed in Quaternary sediments along the Mislinja River (Mioč, 1978) (Figure 1).

The Mislinja Valley lies between the Pohorje Mountains and the eastern slopes of the Karavanke Mountains, and is classified as a pre-Alpine region. It was formed along the Labot fault zone, which runs in a Dinaric direction (Mioč, 1978). Administratively, it falls within the Carinthian Statistical Region and is divided between the municipalities of Mislinja, Slovenj Gradec and Dravograd. It is 22 km long and up to 5 km wide at its widest part, at the confluence of the Mislinja and the Suhodolnica rivers. The Mislinja aquifer lies along the middle and lower reaches of the river, between the settlements of Mislinja and Otiški Vrh, where the Mislinja River flows into the Meža River. It is part of the Eastern Alps groundwater body (*vodno telo podzemne vode Vzhodne Alpe*), more specifically part of the Quaternary, intergranular aquifer along the Drava, Mislinja and Meža rivers, which according to the hydrogeological classification is a local, unconfined, abundant or extensive, although low to moderate yield aquifer (Gacin, Mihorko, Krajnc, 2009). The area above the Mislinja aquifer receives on average around 1200–1300 mm of precipitation per year (ARSO, 2021a). It is dominated by distric and eutric brown soils (KIS, 2021). The central watercourse of the Mislinja Valley is the Mislinja torrential river (Gams, 1976), which has its source in the Pohorje region and has an alpine rain-snow discharge regime (Frantar, Hrvatin, 2005). Its average discharge in the period 1981–2010 was 1.9 m^3/s at Dovže and 4.6 m^3/s at Otiški Vrh (ARSO, 2021b). According to measurements of national water quality monitoring, it is in a good chemical status (ARSO, 2017; 2020).

The floor of the Mislinja Valley has been inhabited since the Neolithic period, due to its favourable natural conditions (flat topography, moderate climate, access to water resources, good quality soils) (Djura Jelenko, 2010). Small to medium-sized rural settlements predominate. The widest part of the valley is the Slovenj Gradec basin (at the confluence of the Suhadolnica and Mislinja rivers), which according to the Statistical Office of the Republic of Slovenia (Statistični urad ..., 2016) is one of the more densely populated areas in Slovenia, with a population of more than 250 inhabitants/km^2 (the town of Slovenj Gradec had a population density of 1317 inhabitants/km^2 in 2016). Natural and socio-geographical characteristics are also reflected in land use. The area of the Mislinja aquifer is mainly grassland (35% of the aquifer area), which along with arable land (15%) and hop fields (1.7%) are characterised by intensive agricultural use. Although there are relatively few hop fields, they are mainly concentrated in the vicinity of Šmartno pri Slovenj Gradcu. The proportion of built-up areas is also quite high, accounting for almost a fifth of the area (19%). Only the marginal areas of the aquifer are predominately covered with forest (21% of the area) (Figure 2).

Figure 1: Study area of the Mislinja aquifer.

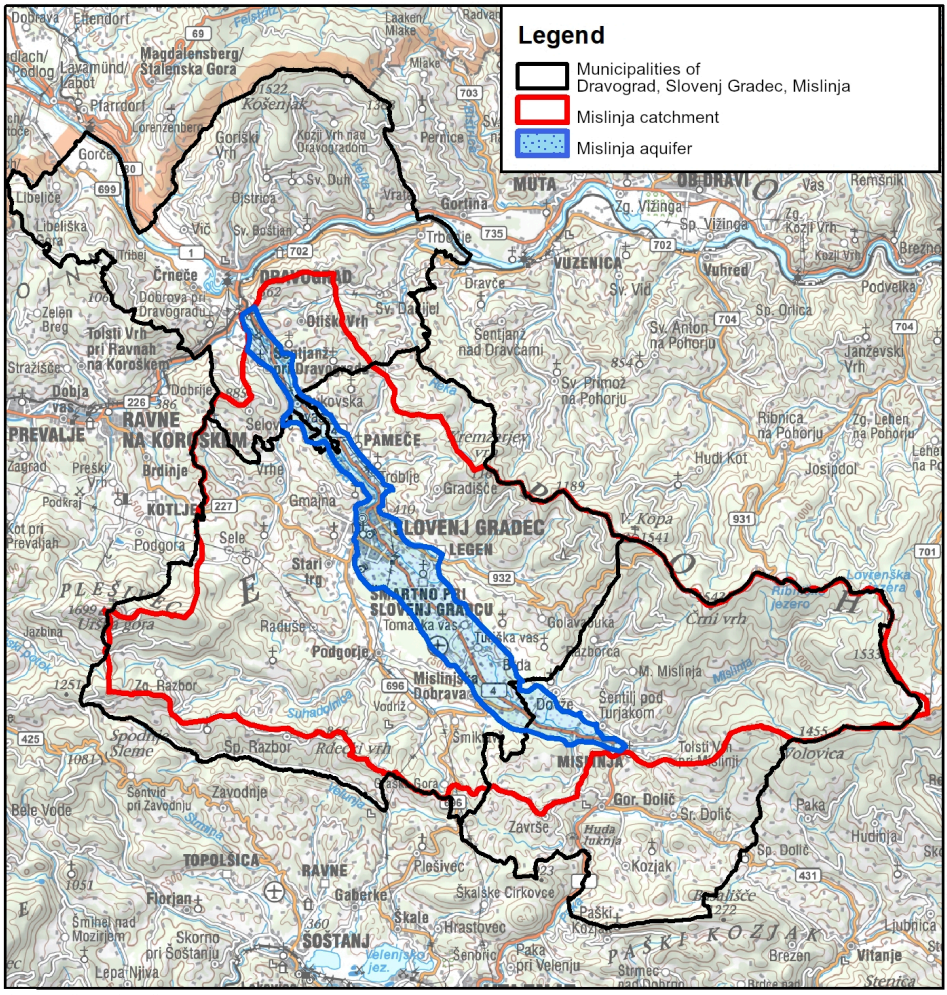
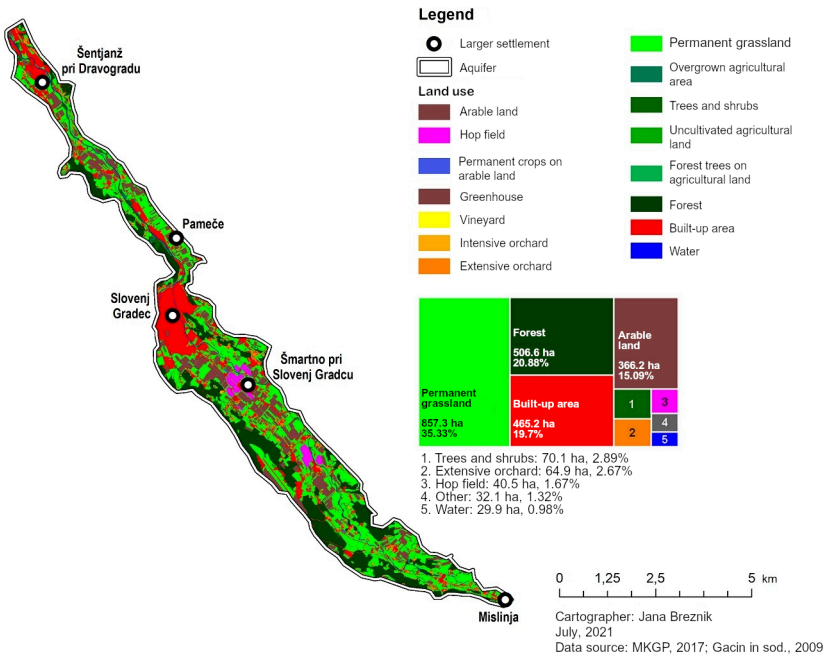


Figure 2: Land use in the aquifer area.



3 METHODS

Based on water permit data (ARSO, 2016) and by examining the spatial extent of the aquifer in relation to the lithological characteristics of the area (Gacin, Mihorko, Krajnc, 2009; Mioč, 1978), we selected the most representative and appropriately spatially distributed locations for groundwater sampling from private boreholes and wells. Groundwater sampling at private boreholes and wells, in accordance with methodological guidelines and cognizant of objective limitations, is one of the established approaches for preliminary assessment of groundwater quality in areas where official monitoring of water quality is not carried out (Metodologija za opredelitev..., 2021). The locations were defined from the headwaters of the Mislinja River at Mislinjski jarek through to the valley, i.e. at the settlement of Mislinja, and to its confluence with the Meža River at Otiški Vrh (Figure 1). Based on data from water permit records, and in accordance with recommendations for sampling of wells and boreholes (Metodologija za opredelitev..., 2021), we tried to select locations where water is used as regularly as possible, e.g. where there are water pumps, or where water is frequently used for watering, washing and other uses.

The one-off sampling took place on 22 and 23 October 2016. Samples were collected at 12 sites (Figure 3). Groundwater was collected at nine sites, while at the remaining

three sites the Mislinja River was sampled. At the private boreholes equipped with a pump, before collecting the samples, we let the water run for about five minutes. In this way, the possible influence of stagnation in the system on the measured physico-chemical properties of the water was eliminated. To enable further field and laboratory analyses, two litre samples of water were taken, as well as a special sample for the determination of the biochemical oxygen demand (BOD 5). At the sites, we measured water temperature, pH, conductivity and oxygen content using an electric sensor. Other characteristics and circumstances relating either to the sample taken or to the site and influences in the immediate vicinity (organoleptic characteristics of the water, land cover and land use, distance from the surface to the water table and depth at which the sample was taken) were also recorded on the inventory sheet. The owners of the boreholes or wells also helped us to obtain some technical information. Locations of sampling sites are presented in Tables 1 (collection sites on the Mislinja watercourse) and 2 (collections sites of groundwater). Examples of wells are shown in Figure 4.

Figure 3: Selected locations for sampling of groundwater from the Mislinja aquifer and water from the Mislinja River.

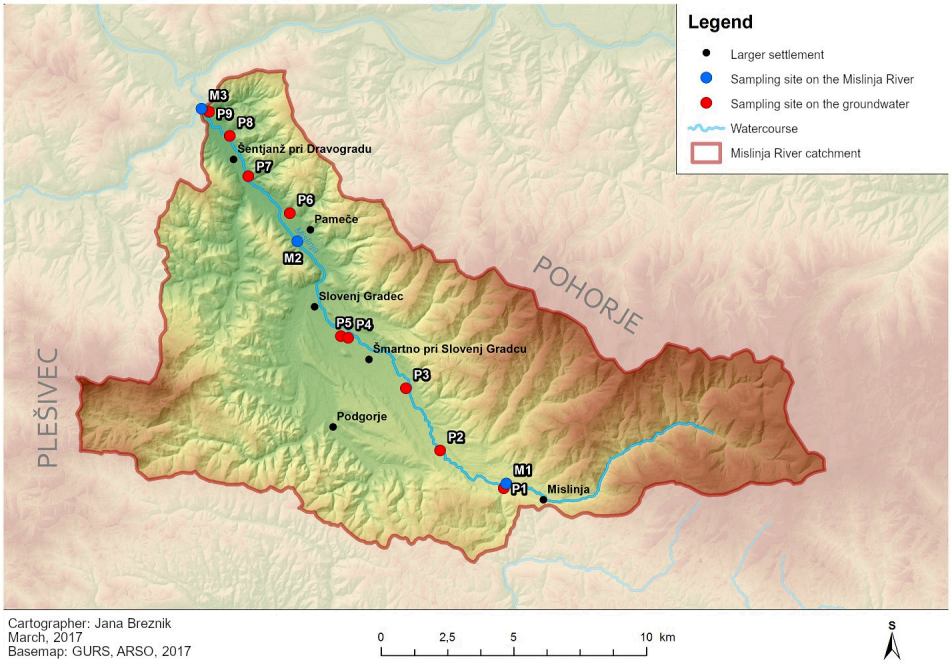


Table 1: Presentation of the sampling sites on the Mislinja watercourse.

Site	**Description of sampling site**	**Predominant actual land use within 500 m of the sampling site**
M1	• the beginning of the middle course (at the start of the valley) • smaller settlements	• permanent grassland – 58% • forest – 13% • arable land or gardens – 11% • built-up area and related surface – 11% • other land uses – 7%
M2	• next to the Pameče industrial zone	• permanent grassland – 37% • forest – 26% • built-up area and related surface – 20% • other land uses – 17%
M3	• before the confluence with the Meža river – in the immediate vicinity of the Otiški Vrh industrial zone and a larger settlement. • the impact of agriculture is also significant	• built-up area and related surface – 40% • permanent grassland – 15% • arable land or gardens – 13% • forest – 13% • other land uses – 19%

Table 2: Presentation of groundwater sampling sites.

Site	**Type**	**Depth**		**Description of sampling site**	**Actual land use within 500 m of the sampling site**	**Sampling site is connected to the public wastewater network (situation at the time of sampling)**
		Wells / boreholes	from the surface to the groundwater level			
P1	well	2,5 m	*	• Straže hamlet (settlement Mislinja) • well older and less frequently used • directly next to the main road (Slovenj Gradec -Velenje)	• permanent grassland – 47% • forest – 27% • built-up area and related surface – 11% • other land uses – %	no (has possibility to be connected, within agglomeration)

Site	Type	Depth		Description of sampling site	Actual land use within 500 m of the sampling site	Sampling site is connected to the public wastewater network (situation at the time of sampling)
		Wells / boreholes	from the surface to the groundwater level			
P2	well	3,5 m	1.83 m at the time of sampling	• a well used for a groundwater heat pump • regularly maintained and used • location directly next to Mislinja watercourse – possible greater impact of surface flow on groundwater (owner observes significant temperature fluctuations in groundwater depending on the season) • predominantly agricultural area	• permanent grassland – 51,5%, • forest – 25% • built-up area and related surface – 8% • other land uses – 15,5%	no (is not part of agglomeration)
P3	borehole	*	*	• newer borehole (2 years old), though relatively rarely used – mainly for irrigation and livestock watering – active farm oriented towards livestock farming – potential for impact of the owner's activities on groundwater quality • hop fields in the immediate surroundings	• permanent grassland – 47% • arable land and gardens – 25% • built-up area and related surface – 10% • Hop fields – 7% • Other land uses – 11%	yes
P4	well	*	*	• in the vicinity of Slovenj Gradec • the owner is a truck carrier – water is used for washing vehicles – potential for impact of the owner's activities on groundwater quality • in close proximity to one of the largest hop-growing families • several farms in the surrounding area • well about 20 years old	• permanent grassland – 43% • arable land and gardens – 33% • built-up area and related surface – 12% • hop fields – 5% • other land uses – 7%	no (connected in 2019)

Site	Type	Depth		Description of sampling site	Actual land use within 500 m of the sampling site	Sampling site is connected to the public wastewater network (situation at the time of sampling)
		Wells / boreholes	from the surface to the groundwater level			
P5	well	5 m	generally about 4 m	• in the vicinity of Slovenj Gradec • a well about 50 years old • in the immediate vicinity of a main road (Slovenj Gradec – Velenje)	• permanent grassland – 40% • arable land and gardens– 36% • built-up area and related surface – 19% • other land uses – 5%	no (connected in 2020)
P6	borehole	6,8 m	*	• Pameče settlement • the owner is a bus operator – water is used for cleaning vehicles and for a groundwater heat pump – potential for impact of the owner's activities on groundwater quality • downslope location – flows from slopes may have an impact on groundwater quality • predominantly agricultural area	• permanent grassland – 44% • arable land and gardens– 20% • forest – 10% • built-up area and related surface– 10% • other land uses – 16%	no (is not part of agglomeration)
P7	well	3,5 m	2.12 m at the time of sampling	• Otiški Vrh settlement (southern part) • owner is engaged in agriculture (livestock farming) • predominantly agricultural area • well, about 20 years old, regularly used	• permanent grassland – 41,5% • forest – 21% • land and gardens - 12% • built-up area and related surface – 11% • other land uses – 14,5%	no (is not part of agglomeration)
P8	borehole	6 m		• Otiški Vrh settlement • in the immediate vicinity of the Mislinja watercourse (30 m) • borehole about 20 years old – regularly used • downslope location – flows from slopes may have an impact on groundwater quality	• built-up area and related surface – 40% • forest – 24% • permanent grassland – 24% • other land uses – 12%	no (within agglomeration, though wastewater infrastructure is yet to be built)

Site	Type	Depth		Description of sampling site	Actual land use within 500 m of the sampling site	Sampling site is connected to the public wastewater network (situation at the time of sampling)
		Wells / boreholes	from the surface to the groundwater level			
P9	well	4,5 m	3.16 m at the time of sampling	• Otiški Vrh settlement (north) • water is used regularly for a heat pump • in the immediate vicinity of the Otiški Vrh industrial zone – in the hinterland of the well • in close proximity to the main road Dravograd – Slovenj Gradec • in close proximity to a dry-cleaner and truck carrier • heavily built-up area	• built-up area and related surface – 9% • permanent grassland – 19% • forest – 18% • trees and shrubland – 10,5% • arable land and gardens– 5% • other land uses – 8,5%	no (within agglomeration, though wastewater infrastructure is yet to be built)

*Note: * data not available (depth from surface to groundwater level could not be measured/ owner has no information on depth of borehole/well).*

Figure 4: Example of a borehole (a – sampling site – borehole P6) and a well (b – sampling site – well P9) at selected sites.

In the laboratory we analysed concentrations of nitrate, nitrite, ammonium, chloride, sulphate and phosphate. We also determined the biochemical oxygen demand and water hardness. Visocolor eco field testers were used for analysis of nitrate, nitrite, ammonium, chloride, sulphate and phosphate. These are affordable and easy to use, with visual readings of the concentration values for each parameter. Hardness determination was performed using the standard titration method with EDTA (Boyd, 2015). We determined carbonate, total, calcium and magnesium hardness. We also determined the biochemical oxygen demand value in the laboratory using a standard method (Boyd, 2015).

The data were compiled in a spreadsheet and graphs and maps were drawn to allow us to spatially examine the water quality of the samples. As the Mislinja aquifer is also a potential source of drinking water, the results of the measured physico-chemical parameters were compared with selected limit values given in the Drinking Water Regulations (Pravilnik o pitni vodi, 2017). The values are shown in Table 3.

Table 3: Selected parameters and limit values according to the Drinking Water Regulation (Pravilnik o pitni vodi, 2017).

Parameter	Limit value for parameter/specification	Unit
Ammonium	0.50	mg/l
Nitrate	50	mg/l
Nitrite	0.50	mg/l
Chloride	250	mg/l
Sulphate	250	mg/l
Electrical conductivity	2500	µS/cm at 20°C
Hydrogen ion concentration (pH value)	between 6.5 in 9.5	pH unit
Colour	acceptable to users and without unusual variations	
Turbidity	acceptable to users and without unusual variations	
Scent	acceptable to users and without unusual variations	

4 RESULTS OF MEASUREMENTS AND ANALYSES

The values of the measured physico-chemical parameters are presented in more detail below, separately for the groundwater and Mislinja watercourse samples. In Table 4 and Figure 5, the Mislinja watercourse samples are shown with a darker background and the groundwater samples with a lighter background.

4.1 Results of measurements on samples taken from the Mislinja watercourse

The following results were obtained for the individual parameters on the Mislinja River samples:

- Scent, colour and turbidity are the most obvious and easily observable parameters that can be used to infer water quality. They are of paramount importance, as their inadequacy is often the trigger for further water quality analyses. In the Mislinja watercourse area, we did not detect any specificities in any of these parameters (Table 4).

- The lowest temperature was in the upper part of the Mislinja Valley (6.5 °C). Downstream, due to the warmer atmosphere at the time of sampling, the temperature rose to 10.7 °C (in the lower reaches) (Table 4, Figure 5a).
- There was a slight increase in pH moving downstream along the Mislinja River, but the differences between samples are small (Table 4, Figure 5a).
- The dissolved oxygen content of the water in the Mislinja River was highest upstream (8.6 mg/l), although moving downstream this value decreases only slightly (Table 4, Figure 5b).
- The results of the biochemical oxygen demand analysis show stable values along the Mislinja River (variation between 4.6 and 5.6 mg/l) (Table 4, Figure 5b).
- Nitrate was present in all the samples studied. There is a trend of increasing nitrate content downstream (from 3 mg/l in the upper reaches and 10 mg/l in the lower reaches of the Mislinja) (Table 4, Figure 5c).
- Nitrite levels ranged between 0 and 0.03 mg/l. Their content increased progressively downstream (Table 4, Figure 5d).
- Ammonium levels were below the detection limit (Table 4, Figure 5d).
- In the Mislinja River, chloride levels did not exceed 7 mg/l, but increase slightly downstream (Table 4, Figure 5c).
- Phosphate and sulphate levels in all samples were below the detection limit of 0.1 mg/l for phosphate and 0.25 mg/l for sulphate (Table 4, Figure 5d).
- In terms of water hardness, there is a clear trend of increasing values downstream. There is a transition from very soft to soft and moderately hard water (2.8 °dH to 8.9 °dH) (Table 4, Figure 5e).
- Electrical conductivity depends on the presence of electrolytes in the water. Since calcium and magnesium carbonate, which define carbonate hardness as a hydrogen carbonate, are the most prevalent of these, hardness and conductivity are quite correlated, with larger differences between values indicating the presence of the remaining electrolytes (nitrates, nitrites, phosphates, ammonium, sulphates, etc.). The electrical conductivity also shows a positive trend downstream (between 114.8 µS/cm and 314 µS/cm) (Table 4, Figure 5e).

4.2 Results of measurements on groundwater samples from the Mislinja aquifer

When analysing groundwater samples from the Mislinja aquifer, the following results were obtained for individual parameters:

- Among the odour, colour and turbidity parameters, we detected specificities in the colour and turbidity parameters for samples P2 and P7. The samples were yellow and cloudy (Table 4), which may indicate contamination and various impurities.
- The groundwater temperature ranged between 10.7 °C and 14.3 °C. Among the groundwater samples, sample P2 (10.7 °C), collected in the immediate vicinity

of the Mislinja River (distance 31 m), had the lowest water temperature. The owner reported that there is pronounced fluctuation of the groundwater temperature (Obreza, 2016). A small upward trend of the temperature downstream is evident (Table 4, Figure 5a).

- The pH of all groundwater samples ranged between 7 and 8. There is a slight downward trend in pH downstream, but it is not statistically significant. Samples P2, P3 and P8 stand out as having a higher pH (Table 4, Figure 5a).
- The dissolved oxygen content varied considerably between the samples (from 2.8 mg/l to 6.1 mg/l). There was also a decreasing trend of dissolved oxygen content in the water downstream (Table 4, Figure 5b).
- The results of the biochemical oxygen demand analysis show that the values vary significantly from site to site (from 2.26 to 9.81 mg/l). There are pronounced peaks in samples P5 and P8. There was also a trend of increasing biochemical oxygen demand downstream, indicating higher organic contamination of the groundwater along the lower reaches of the Mislinja River (Table 4, Figure 5b).
- Nitrates were present in all the samples studied. Increased levels were observed in samples P4 and P5, which reached 50 mg/l, which is also the limit value according to the Rules on drinking water (Pravilnik o pitni vodi, 2017). These samples were collected in the immediate vicinity of Slovenj Gradec. Moving downstream there is an upward trend in nitrate content. The trend is not statistically significant due to the outlying values of P5 and P4 (Table 4, Figure 5c).
- Concentrations of nitrites in the groundwater samples were below the detection limit, with the exception of sample P7 (0.01 mg/l) (Table 4, Figure 5d).
- The presence of ammonium was only observed in two groundwater samples (P5 and P7). In sample P5, the value was 0.5 mg/l, thus reaching the limit value according to the Rules on drinking water (Pravilnik o pitni vodi, 2017). In the remaining samples, the ammonium content was below the limit of detection (Table 4, Figure 5d).
- Chlorides were present in all samples, with P1 having a chloride content of more than 60 mg/l (upper detection limit) and P9 having a chloride content of 60 mg/l. Chloride levels in groundwater samples did not follow a general trend, with a noticeable increase in chloride levels again in samples P4 and P5 with 12 mg/l and 20 mg/l respectively, which were collected at sampling sites located in the vicinity of Slovenj Gradec (Table 4, Figure 5c).
- Phosphate was only detected in sample P9, where it was 0.1 mg/l, which is also the lower detection limit of the test used. It is therefore quite possible that phosphates were also present in moderate amounts in other samples but were not detected by the less sensitive test (Table 4, Figure 5d).
- The sulphate content was below the detection limit of 25 mg/l in all samples (Table 4).

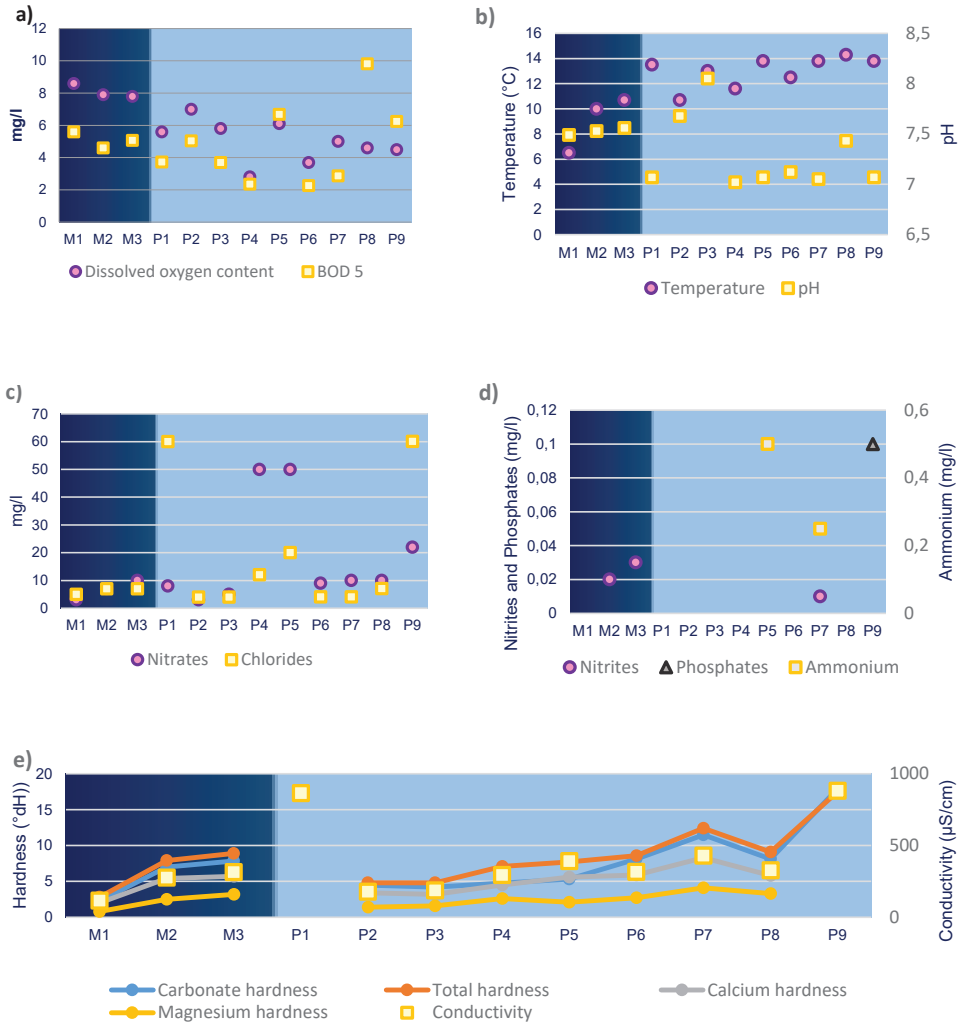
- For water hardness, moving downstream there was a clear trend of increasing values. There was a transition from very soft to soft and moderately hard water (between 4.8 °dH and 17.5 °dT). Due to an anomaly in the laboratory analysis (carbonate hardness was higher than total hardness), only the total hardness is shown for samples P1 and P9. We assume that these two samples have elevated levels of contaminants (most likely chlorides) that affect the result of the hardness analysis. A peculiarity can also be detected in the electrical conductivity, as both samples have a strongly increased value compared to the other samples (Table 4, Figure 5e).
- For the electrical conductivity parameter, there is a positive downstream trend. The measurements range between 177 µS/cm and 880 µS/cm. The highest and strongly outlying values of electrical conductivity were measured in samples P1 and P9 (864 µS/cm and 880 µS/cm, respectively), which is probably due to the high chloride content (Table 4, Figure 5e).

Table 4: Results of analyses of physico-chemical parameters at individual measurement sites.

	Samples from the Mislinja watercourse			Groundwater samples from the Mislinja aquifer								
Code S Parameter	**M1**	**M2**	**M3**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
Scent	None	None	None	None	None	None	None	None	None	None	None	None
Colour	None	None	None	None	slightly yellow	None	None	None	None	slightly yellow	None	None
Turbidity	None	None	None	None	Cloudy	None	None	None	None	Cloudy	None	None
Temperature (°C)	6,5	10	10,7	13,5	10,7	13	11,6	13,8	12,5	13,8	14,3	13,8
pH	7,49	7,53	7,56	7,07	7,68	8,05	7,02	7,07	7,12	7,05	7,43	7,07
Dissolved oxygen content (mg/l)	8,6	7,9	7,8	5,6	7	5,8	2,8	6,1	3,7	5	4,6	4,5
BOD 5(mg/l)	5,6	4,6	5,07	3,72	5,04	3,69	2,35	6,68	2,26	2,86	9,81	6,24
Nitrates (mg/l)	3	7	10	8	3	5	50	50	9	10	10	22
Nitrites (mg/l)	0	0,02	0,03	0	0	0	0	0	0	0,01	0	0
Ammonium (mg/l)	< 0,25	< 0,25	< 0,25	< 0,25	< 0,25	< 0,25	< 0,25	0,5	< 0,25	0,25	< 0,25	< 0,25
Chlorides (mg/l)	5	7	7	> 60,00	4	4	12	20	4	4	7	60
Phosphates (mg/l)	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	< 0,1	0,1
Sulphates (mg/l)	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0	< 25,0
Carbonate hardness (°dH)	2,24	7	7,84	*14,56**	4,48	4,2	4,76	5,32	8,12	11,48	8,12	*17,92**
Total hardness	2,8	7,9	8,9	*13,70**	4,8	4,8	7,1	7,7	8,6	12,4	9,1	*17,50**
Calcium hardness (°dH)	2	5,4	5,7		3,4	3,2	4,5	5,6	5,9	8,3	5,8	
Magnesium hardness (°dH)	0,8	2,5	3,2		1,4	1,6	2,6	2,1	2,7	4,1	3,3	
Conductivity (µS/cm)	114,8	275	314	864	177	186,4	293	390	315	428	326	880
Water quality designation	very soft	soft	soft		very soft	very soft	soft	soft	soft	moderately hard	soft	

S – sample; M1–M3 – measurement sites on the Mislinja River; P1–P9 – measurement sites of groundwater;
**Values are contradictory to the usual values for Slovenian waters, as the carbonate hardness is higher than the total hardness. The latter may be due to the pronounced chloride contamination. The analysis was not completed due to this anomaly.*

Figure 5: Pollutants, hardness and conductivity by sample site (the darker part of the graphs shows the values at the Mislinja River sample sites, and the lighter part shows the values at the groundwater sample sites).



5 DISCUSSION

According to Narsimha et al. (2013, p. 74), nitrate concentrations above 10 mg/l are the result of anthropogenic influences on groundwater. In the studied area nitrate levels vary between 3 and 50 mg/l, with only four samples below 10 mg/l. The elevated values are therefore probably in most cases due to anthropogenic influences. Nitrate concentrations were highest in samples P4 and P5, from sites between Slovenj Gradec and Šmartno pri Slovenj Gradcu. Looking at land use (MKGP, 2017), we can see that the latter is probably due to intensive agriculture, particularly integrated hop production, which is the most common crop and is concentrated in this part of the valley (Figure 2). The issue of the impact of hops farms on nitrate leaching into groundwater is also highlighted by Gale et al. (1999). Nitrate contamination of water is also possible, but less likely, caused by higher population density and, in places, poorly managed sewers. The wider area of Šmartno pri Slovenj Gradcu and the southern part of Slovenj Gradec were only adequately sewered to a greater extent in the post-sampling period between 2017 and 2021, and some areas in the immediate vicinity of the sampling sites still do not have adequately addressed wastewater disposal (GURS, 2021).

Naturally occurring nitrite concentrations in groundwater do not normally exceed 0.3 mg/l (Nitrate and nitrite in drinking-water, 2011). The detected values are significantly below this limit and are also below the limit for drinking water. Thus, the Mislinja River and the groundwater in the Mislinja aquifer are not contaminated with nitrite.

Naturally occurring ammonium in groundwater and surface water is usually below 0.2 mg/l (WHO, 1996). Most of the samples taken did not have elevated ammonium levels, with only samples P5 and P7 standing out. In both samples, the values exceeded 0.2 mg/l, indicating an anthropogenic influence. The presence of ammonium in groundwater is usually linked to agriculture, municipal sewage or industry. In samples P5 and P7, industry is sufficiently distant that it is unlikely to have had a significant impact on groundwater. For sample P5, collected from a site near Slovenj Gradec, the influence of municipal sewage cannot be ruled out, as the borehole owners were not yet connected to the municipal wastewater network at the time of sampling. At the same time, ammonium was not detected in significant concentrations in sample P4, located in the immediate vicinity of P5, although here too the wastewater system had not yet been constructed at the time of sampling. It is also possible that the contamination is due to agriculture, which is the most likely cause of the contamination in sample P7, the owner of which has a farm predominantly oriented towards livestock farming (Table 2).

Chlorides, which were high in some places but did not exceed the limit values for drinking water according to Slovenian standards, were more problematic. According to Kohn et al. (2016, p. 112), chloride concentrations above 20 mg/l are indicative of anthropogenic influences. Higher chloride concentrations could be detected

in samples P1 and P9, where values reached and probably exceeded 60 mg/l, as this value is also the upper detection limit of the test used. Such concentrations, given the significantly lower values in the other samples, are most likely due to point source pollution, which in sample P9 could have originated from a nearby industrial area, dry cleaner or car wash (Table 2). Sample P1 comes from a site in close proximity to the main road G1-4 Slovenj Gradec-Velenje (Table 2), so to some extent the influence of salting for winter road maintenance cannot be excluded. Similar conclusions were also reached, for example, in the study *Skrb za pitno vodo [Caring for Drinking Water]* (Jamnik et al., 2014), where, using the example of Ljubljansko Polje, it was found that moderate chloride concentrations were linked to municipal wastewater and the use of salt for winter road maintenance. Chloride levels were also slightly higher in the vicinity of Slovenj Gradec (sample P5), which could be due to municipal wastewater from the then still poorly developed wastewater network (GURS, 2021) and intensive agriculture, especially hop production (Gale et al., 1999) in the immediate impact area, or it could also be due to the use of salt for winter road maintenance.

Phosphate levels in groundwater are low, as phosphorus is normally retained in the soil (Welch, Kingsbury, Coupe, 2010). In the Mislinja Valley, phosphate was not detected in significant quantities in most samples, be it from the Mislinja River or groundwater, although potential sources of contamination exist: fertilisers, manure, detergents, etc. This may also be due to the relatively low sensitivity of the test used, with a detection limit of 0.1 mg/l. The only sample where phosphate was detected (0.1 mg/l) was P9. We think it is mainly local influences that explain this situation, as there is a car wash in the vicinity (Table 2), from where detergents could be leaching into the groundwater.

Sulphates occur in nature mainly as a result of rock leaching, so for example seawater has sulphate concentrations of 2700 mg/l (WHO, 2004), while liquid water and groundwater typically have much lower levels. The rocks in the hinterland of the Mislinja River are not a source of significant quantities of sulphates, nor have anthropogenic influences, mainly as a result of industry, had a major impact on concentrations of these substances in the sampled water. In fact, all samples recorded concentrations below the detection limit of the test used (25 mg/l).

For the biochemical oxygen demand (BOD 5), samples with values between 1 and 2 mg/l indicate water that is not contaminated with organic matter, samples with values between 3 and 5 mg/l indicate the presence of organic contamination, and samples with values above 5 mg/l indicate higher levels of organic contamination (Oram, 2017). Elevated values were detected especially in the Mislinja River, where the values were around 5 mg/l. Interestingly, BOD 5 values were also higher in some samples taken in the upper reaches of the Mislinja River. For groundwater, BOD5 values above 5 mg/l were recorded in samples P2, P5, P8 and P9. In the remaining samples, the values were lower, indicating more moderate environmental influences.

pH is a measure of the balance between the concentration of hydrogen and hydroxyl ions in water, and can be affected by many factors (Boyd, 2015). The limit for

drinking water is 6.5 to 9.5. The pH values of the samples taken ranged between 7.02 and 8.05, indicating a slightly alkaline character of the waters in the Mislinja Valley.

In general, groundwater contains less dissolved oxygen than surface water sources, due to oxidation processes and the absence of an oxygen source (Rose, Long, 1988). The results of the oxygen content analysis indicate a variable presence of oxygen in groundwater, with values ranging from 2.8 to 6.1 mg/l. The higher oxygen content in some samples was most likely due to the shallowness of the aquifer and the inflow of the Mislinja River, which has slightly higher levels of dissolved oxygen, into the aquifer. This is probably particularly the case for sample P2, which (for the upper reaches of the Mislinja) also showed a higher BOD value. The oxygen content of groundwater is also potentially influenced by its depth and contact with the atmosphere. Likewise in our study, on average we observed differences between water samples from wells and boreholes. The oxygen contents of the well samples were slightly higher on average (5.1 mg/l), which is probably due to the direct contact of the groundwater with the atmosphere. The average oxygen content of the borehole samples was slightly lower (4,7 mg/l), probably due to the absence of direct contact between groundwater and the atmosphere, as water in boreholes is usually collected from slightly deeper depths. Nevertheless, the oxygen content of samples from wells and boreholes varied considerably from one sampling site to another.

It turned out that environmental influences, conditioned by land cover and land use in the wider area of the sample site, can only be linked to the values of the analysed parameters to a certain extent (e.g., the influence of intensive hops farming and/or sewage in the elevated nitrate values in samples P4 and P5). In fact, the results of the analysis of the samples sometimes indicate a strong dependence of the values of individual physico-chemical parameters of groundwater on the micro-location of the sample site itself, and on the more or less known influences at that site (e.g., elevated chloride, hardness and electrical conductivity values in samples P1 and P9 due to an unknown local pollution source, or very divergent ammonium levels in samples P4 and P5, which are only 180 m apart in air distance). The latter is likely due, among other things, to methodological constraints related to sampling from wells and private boreholes, which may make the results subject to potential local influences and consequently only to a certain extent representative of conditions in the wider aquifer area (Metodologija za opredelitev..., 2021).

A comparison of the physico-chemical properties of groundwater and the Mislinja River showed that, although the two systems are hydrologically linked, the values of individual parameters in one and the other are not necessarily comparable. In the case of groundwater, the values of the measured parameters are influenced to a large extent not only by anthropogenic influences from the surface, but also by the distance from surface water and the degree of mixing of surface water and groundwater, the rate of groundwater movement and recharge, the abundance and depth of the aquifer, and its geological composition (Fetter, 1999). Similarities between the two systems were thus

only found for hardness and electrical conductivity, while the values of the other parameters (temperature, oxygen content, BOD 5 and nutrient content) were quite different due to the different dynamics and retention times of the water, the current weather conditions and the different self-cleaning capacities, and therefore cannot be compared with each other. The water hardness in both systems was initially low (up to 4 °dH) and then increased downstream (up to about 10 °dH). Similarly, the conductivity (if P1 and P9 are excluded) showed an increasing trend downstream in both systems. However, it is characteristic for both the Mislinja River and the groundwater that, in general, the concentration of pollutants increases as you move further downstream, indicating an escalation of pressures and the presence of progressive pollution.

The results of the vast majority of analyses of physical and chemical parameters on groundwater samples (odour, colour, nitrate, nitrite, ammonium, pH, chloride and sulphate) are below the limit values set out in the Rules on drinking water (Pravilnik o pitni vodi, 2017). However, when considering the individual sample as a whole, where the non-compliance of one parameter alone affects the non-compliance of the whole sample, the results are significantly worse, with as many as five out of nine samples being non-compliant or conditionally compliant. Sample P2 is non-compliant due to a slightly yellow colour and turbidity, sample P7 is also non-compliant due to a slightly yellow colour. The samples with the highest limit values are for nitrate: samples P4 and P5, taken near Slovenj Gradec, reach the limit value for nitrate (50 mg/l). Furthermore, sample P5 also reaches the limit value for ammonium (0.5 mg/l).

6 CONCLUSIONS

Groundwater is a water source that is out of sight given its location below the surface. As a result, despite its importance as a potential source of drinking water, it is often neglected and less well understood, particularly in areas where its supplies are not abundant and where it is not used for local water supply. This is the case also for the Mislinja aquifer, which is the subject of this paper. Namely, it is an aquifer of low yield, which is utilised by the local population principally for watering, irrigation and washing, but not as a source of drinking water. The high water table (Table 2) makes groundwater relatively easily accessible, as reflected in the numerous boreholes and wells. While the high water table is an advantage in terms of use, on the other hand, the permeability of the covering layers means that significant quantities of pollutants from various anthropogenic activities can be leached into the groundwater.

In this study, we investigated the physico-chemical properties of groundwater in the Mislinja aquifer to assess its quality. The results of the study are preliminary, since it was only based on a one-off sampling of selected private boreholes and wells. In addition, a relatively small number of sampling sites (9) were sampled and only the most basic physico-chemical parameters were analysed (organoleptic properties,

temperature, pH, dissolved oxygen, nitrate, nitrite, ammonium, phosphate, sulphate, chloride, biochemical oxygen demand, electrical conductivity, analysis of various types of water hardness). The results obtained can therefore only provide a rough indication of the water quality of the Mislinja aquifer, as they are no substitute for the results of regular monitoring.

The groundwater of the Mislinja aquifer, based on organoleptic characteristics was odourless and in most samples colourless and clear. The exceptions were samples P2 and P7, where the water was turbid and slightly yellowish in colour. The temperature ranged from 10.7 to 13.8 °C and the pH was slightly alkaline with values between 7.02 and 8.05. Dissolved oxygen values were relatively low (between 2.8 and 6.1), which is also a characteristic of groundwater. Based on the remaining physico-chemical analyses of the groundwater in the Mislinja aquifer, the most frequently occurring pollutants are nitrates, which are usually derived from agricultural activities. Nitrate was detected at elevated concentrations in most samples, with the highest values measured in an area characterised by intensive agriculture in the vicinity of Slovenj Gradec (P4 and P5; 50 mg/l). Two sample sites also showed markedly elevated chloride levels (P1 and P9; 60 mg/l), probably due to point pollution or road salting. Given that 60 mg/l is also the upper detection limit of the test used, it cannot be excluded that the chloride levels at these sample points are in fact even higher. Slightly elevated chloride levels were also measured in the vicinity of Slovenj Gradec (P5; 20 mg/l). Other pollutants were present at elevated concentrations less frequently and only in isolated samples, and are therefore most likely due to local factors in the immediate impact area. For instance, nitrite (P7; 0.01 mg/l) and phosphate (P9; 0.1 mg/l) were only detected in one sample, while ammonium was detected in two samples (P5; 0.5 mg/l and P7; 0.25 mg/l). In all sites sulphates were below the detection limit of the test used, which is 0.25 mg/l. Organic matter contamination was most pronounced in the lower part of the valley, with a maximum value of 9.81 mg/l for BPK 5 at sampling site P8. Overall, the groundwater in the aquifer along the Mislinja is progressively more polluted downstream. This is reflected in a decrease in dissolved oxygen and an increase in the biochemical oxygen demand and an increase in nitrate content. Moving downstream water hardness and electrical conductivity also increased.

In the area of the Mislinja aquifer, agriculture has a particularly significant impact on groundwater quality, as it is present throughout the valley, and is particularly concentrated in the area of intensive hop-growing near the settlement of Šmartno pri Slovenj Gradcu. The wastewater network is also a potential source of pollutants, as several settlements or parts of settlements (Otiški Vrh, part of Šentjanž pri Dravogradu, Bukovska vas, Mislinjska Dobrava, Brda) are still not fully connected to it. Industry (especially north of Slovenj Gradec) and traffic (the main road passes through the valley, and with the construction of the third development axis, even higher traffic pressures are expected) are two additional factors potentially reducing the groundwater quality in the Mislinja Valley.

The Mislinja aquifer is relatively poorly known and explored, judging by the available data on groundwater quality and reserves. However, if properly protected, it could probably represent at least a potential reserve source of drinking water for the wider Mislinja Valley area. On the other hand, our analysis has shown that, according to the Rules on drinking water (Pravilnik o pitni vodi, 2017), as many as five out of nine samples were unsuitable, or only conditionally suitable, and it should be stressed that we have analysed a very limited number of parameters. It is quite likely that a more detailed analysis of all the parameters set out in the Regulation would reveal even more non-compliances in samples, and that even more sites would be inappropriate to use. The results of the analysis thus point to the worrying fact that the groundwater in the Mislinja aquifer is currently too contaminated to be counted on as a possible reserve source for water supply. This is a worrying finding, as drinking water is a strategic natural resource that should be protected and preserved for future generations in the spirit of sustainable development. Moreover, groundwater in the Mislinja aquifer is inextricably linked to the surface water in the Mislinja River, with water, including any pollutants present in it, being exchanged between the two.

The establishment of regular national monitoring in the area could help to raise awareness of groundwater pollution in the Mislinja aquifer and improve its quality. This would increase interest in the issue and raise the awareness of the population and, in particular, of local authorities. The latter have the potential to improve on the situation as it stands by introducing certain measures and incentives. Regular monitoring would make it possible to monitor the progress or deterioration of groundwater conditions. On the other hand, the Mislinja aquifer is but one of many comparable smaller sized and low-yield intergranular aquifers in Slovenia. Namely, the establishment of regular or at least periodic groundwater quality monitoring in the Mislinja aquifer, would entail considerable investment and operational costs, which would necessitate a strategic decision at the national level and so too a systemic change that would enable some more minor, though no less important, aquifers to be included in monitoring.

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UPORABA METODE MAKSIMALNE ENTROPIJE PRI PROUČEVANJU POTENCIALNEGA VPLIVA PODNEBNIH SPREMEMB NA SLOVENSKE GOZDOVE

Izvirni znanstveni članek
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Izvleček

V prispevku je predstavljen razvoj postopka proučevanja potencialnih vplivov podnebnih sprememb na slovenske gozdove v obdobju 2081–2100. Razvoj metodologije temelji na modeliranju ekoloških niš z uporabo metode maksimalne entropije. V raziskavi smo upoštevali dva podnebna scenarija smeri skupnega družbenogospodarskega razvoja (optimističnega SSP1-2,6 in pesimističnega SSP5-8,5). Slovenske gozdove smo razdelili na trinajst gozdnih vegetacijskih tipov. Statistični rezultati so pokazali, da je razvita metodologija primerna za namene tovrstnega proučevanja.

Ključne besede: podnebne spremembe, slovenski gozdovi, metoda maksimalne entropije, Maxent, smeri skupnega družbenogospodarskega razvoja, GIS

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PREDICTING POTENTIAL CLIMATE CHANGE IMPACTS ON SLOVENIAN FORESTS USING THE MAXIMUM ENTROPY METHOD

Abstract

This article presents the development of a methodology for analysing the potential impacts of climate change on Slovenian forests in the period between 2081 and 2100. The development of the methodology is based on the use of Maxent software for modelling ecological niches. In this study, 2 common socio-economic pathway scenarios are used, the optimistic SSP1-2.6 and the pessimistic SSP5-8.5. Slovenian forests are divided into 13 forest vegetation types. The statistical results prove that the developed methodology is suitable for analysing the potential impacts of climate change on Slovenian forests in the period between 2081 and 2100.

Keywords: climate change, Slovenian forests, maximum entropy method, Maxent, shared socioeconomic pathways, GIS

1 UVOD

Zemljino podnebje se danes naglo spreminja (Bertalanič in sod., 2018). Z vidika blaženja in prilagajanja na te spremembe želi znanost odgovoriti na mnoga vprašanja, ki zadevajo potencialne vplive podnebnih sprememb na različne Zemljine naravne in družbene podsisteme (Daddi in sod., 2020). Na tem področju pomembno vlogo igra tudi fitogeografija, saj spremembe podnebja predvsem kot močan stresor že vplivajo na biosfero po celotnem svetu in slovensko območje ni izjema (Bertalanič in sod., 2018). Slovenija je danes gozdnata država z relativno visoko vegetacijsko pestrostjo (Bončina in sod., 2021; Kutnar, Kobler, Bergant, 2009), kar žal ni povsem samoumevno v prihodnosti, saj s spreminjanjem podnebja pričakujemo tudi spremembe rastiščnih pogojev, v katerih uspevajo današnji gozdni vegetacijski tipi (GVT). Tovrstne spremembe je možno oceniti z modeliranjem ekoloških niš. Cilj naše raziskave je bil razvoj postopka proučevanja potencialnih vplivov podnebnih sprememb na slovenske gozdove za obdobje 2081–2100 z uporabo metode maksimalne entropije, ki se v svetu za te namene uporablja vedno pogosteje.

2 TEORETSKA IZHODIŠČA

2.1 Podnebne spremembe v antropocenu

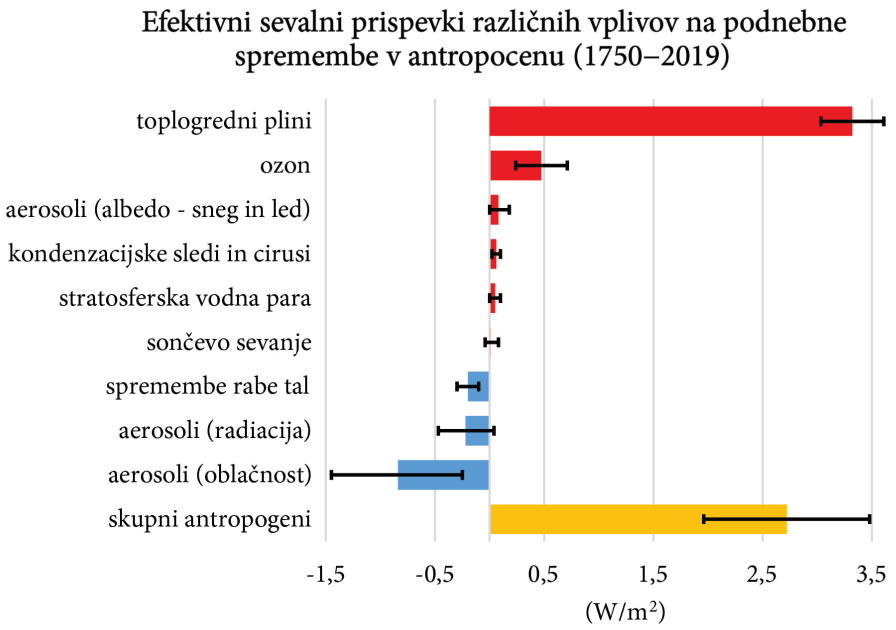
Podnebje je Zemljin podsistem, ki se je v geološki preteklosti z menjavanjem glacialnih in interglacialnih obdobij neprestano spreminjal (Ogrin, 2005). Danes se soočamo z obdobjem intenzivnega segrevanja podnebja, ki ga zaradi povzročitelja, ki ga geološka preteklost do danes ni poznala, ločimo od vseh dosedanjih podnebnih nihanj. V znanosti velja konsenz, da je za spreminjanje podnebja v 20. in 21. stoletju odgovoren človek. Po mnenju mnogih je to tudi eden od glavnih razlogov za nastop novega geološkega obdobja, imenovanega antropocen. Čeprav dogovora o nastopu antropocena v znanosti še ni, mnogi avtorji utemeljujejo, zakaj je uveljavitev tega geološkega obdobja smiselna oziroma celo potrebna. Po mnenju DellaSala in sod. (2018) ima človeštvo na planetarni ravni na okolje tako močan vpliv, da je uveljavitev antropocena kot novega geološkega obdobja upravičena. Ellis (2019) opozarja, da z vidika razvoja biogeografije nastop antropocena označuje dejstvo, da se zaradi obdobja velikih okoljskih sprememb konvencionalni raziskovalni pristopi v biogeografiji za pojasnjevanje različnih procesov izkazujejo za nezadostne in so potrebni prenove. Leichenko in O'Brien (2020) utemeljujeta pomen uveljavitve antropocena tudi skozi izobraževalno prizmo. Uveljavitev obdobja razumeta kot odmik od konvencionalne holocenske obravnave podnebnih sprememb. Menita, da bi s tem miselnim preskokom družba lažje prešla od iskanja konvencionalnih rešitev za morda največji izziv 21. stoletja na bolj inovativne pristope. Predlog uveljavitve antropocena je naveden tudi v zadnjem poročilu Medvladnega foruma za podnebne spremembe (IPCC) (Chen in sod., 2021). Mnenjem omenjenih avtorjev se pisci prispevka pridružujemo, zato v nadaljevanju obravnavamo spreminjanje podnebja kot podnebne spremembe antropocena, ki ga definiramo kot geološko dobo, v kateri človeška vrsta tako močno posega v različne planetarne procese, da lahko njeno delovanje označimo za odločilni dejavnik, saj so njeni vplivi jasno vidni (Results of binding vote …, 2019).

Organizacija združenih narodov je že leta 1992 v Okvirni konvenciji Združenih Narodov o spremembi podnebja *(United Nations Framework convention on Climate Change* oz. UNFCCC*)* podnebne spremembe definirala kot »pojav spreminjanja podnebja, ki je posledica človekovih dejavnosti, ki neposredno in posredno spreminjajo sestavo atmosfere na globalni ravni, pojav pa se od siceršnje spremenljivosti podnebja ločuje po intenzivnosti sprememb v kratkem časovnem obdobju« (OZN, 1992, str. 7). Definicija IPCC je širša. Podnebne spremembe so definirane kot spremembe stanja podnebja, ki jih je mogoče zaznati (npr. z uporabo statističnih metod) na podlagi sprememb v povprečju in/ali spremenljivosti njegovih lastnosti in ki traja daljše obdobje, običajno desetletja ali dlje. Spremembe podnebja so lahko posledica naravnih notranjih ali zunanjih dejavnikov, kot so variabilnost Sončeve aktivnosti, vulkanski izbruhi in trajne antropogene spremembe v sestavi ozračja in rabi tal. UNFCCC torej

razlikuje med podnebnimi spremembami, ki jih lahko pripišemo človekovim dejavnostim, in spremenljivostjo podnebja, ki je del naravnih ciklov, medtem ko IPCC oboje pojmuje kot podnebne spremembe (Mach, Planton, von Stechow , 2014).

Slika 1 za leto 2019 prikazuje dejavnike, ki pozitivno oziroma negativno vplivajo na skupno energetsko bilanco Zemlje. Podnebje se segreva, ker je ta od ravnovesnega referenčnega stanja leta iz 1750, ki predstavlja predindustrijsko obdobje, vedno bolj oddaljena v smeri pozitivne osi. Ključni razlog za to so človekovi izpusti toplogrednih plinov v ozračje, med katerimi prevladujeta predvsem CO_2 in CH_4. Nekateri antropogeni sevalni prispevki na skupno energetsko bilanco planeta vplivajo tudi negativno (aerosoli in spremembe rabe tal), a s tem le blažijo prevladujoči vpliv antropogeno emitiranih toplogrednih plinov (Forster in sod., 2021; Mathez, Smerdon, 2018).

Slika 1: Sevalni prispevki različnih vplivov na podnebne spremembe v letu 2019 glede na predindustrijsko obdobje.

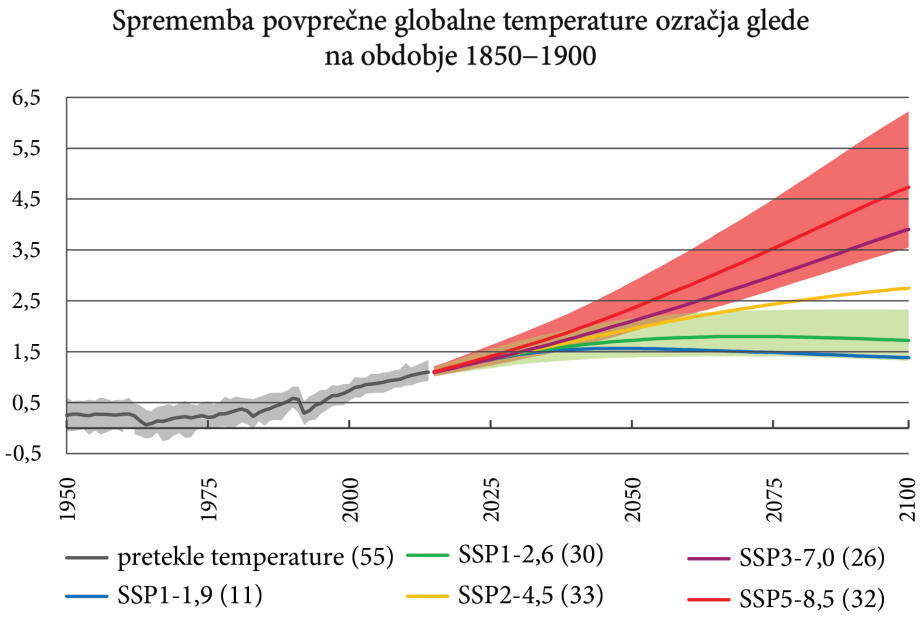


Vir podatkov: Forster in sod., 2021.

2.2 Smeri skupnega družbenogospodarskega razvoja do leta 2100

Zadnje poročilo IPCC iz leta 2021 predstavlja nove podnebne scenarije, imenovane »smeri skupnega družbenogospodarskega razvoja«[1] (*ang. Shared Socioeconomic Pathways* oz. SSP), ki so nasledniki scenarijev RCP (Forster in sod., 2021). Poimenujemo jih glede na ocenjeni efektivni sevalni prispevek ob koncu 21. stoletja, in sicer SSP1-1,9, SSP1-2,6, SSP2-4,5, SSP3-7,0 ter SSP5-8,5. Ti scenariji napovedujejo segrevanje ozračja od 1,5 do 4,8 °C (slika 2). Že njihovo ime nakazuje, da so bili zasnovani na podlagi razumevanja, kako različni družbenogospodarski vzvodi (demografski razvoj, gospodarski razvoj, izobrazbena struktura prebivalstva, stopnja urbanizacije) vplivajo na rabo energije, rabo tal in količino antropogenih izpustov toplogrednih plinov. Dejanski odziv družbe na eksistencialni izziv, ki ga predstavljajo podnebne spremembe, je zaradi mnogih dejavnikov težko napovedati. Zato je pri interpretaciji scenarijev SSP te treba obravnavati kot možne smeri razvoja in ne kot deterministične napovedi (Riahi in sod., 2021).

Slika 2: Hod povprečnih globalnih temperatur glede na pet scenarijev SSP.



Vir podatkov: CEDA, 2021; Lee in sod., 2021.

1 Zaradi novosti termina »Shared Socioceconomic Pathways« v slovenski literaturi še ni uradnega prevoda, zato je termin »smeri skupnega družbenogospodarskega razvoja« predlog uradnega poimenovanja.

Pri proučevanju vpliva podnebnih sprememb na slovenske gozdove smo se odločili, da bomo primerjali potencialne vplive v primeru uresničitve scenarijev SSP1-2,6 in SSP5-8,5. Scenarij SSP1-2,6 imenujemo tudi srednja smer razvoja. Po tem scenariju naj bi se povprečna globalna temperatura v obdobju 2081–2100 zvišala za 2,0 °C (1,3–2,8 °C) glede na obdobje 1850–1900 (Lee in sod., 2021), pri čemer bi družba ogljično nevtralnost dosegla v drugi polovici 21. st. (Chen in sod., 2021). Gre za scenarij, ki je med realističnimi najbolj optimističen. Za ta scenarij smo se odločili, ker verjamemo, da družba z odgovornim kolektivnim odzivom podnebne spremembe lahko omeji na dvig povprečne temperature za 2,0 °C (1,3–2,8 °C) glede na obdobje 1850–1900. Uresničitev cilja Pariškega sporazuma o omejitvi segrevanja ozračja na 1,5 °C predstavlja scenarij SSP1-1,9, a ta ni več uresničljiv (Forster in sod., 2021).

Scenarij SSP5-8,5 je najbolj pesimističen scenarij, po katerem bi družba povsem temeljila na fosilnih gorivih. Povprečna globalna temperatura ozračja bi se v obdobju 2081–2100 zvišala za 4,8 °C (3,6–6,5 °C) glede na obdobje 1850–1900 (Lee in sod., 2021). Čeprav današnji trendi blaženja podnebnih sprememb nakazujejo na to, da svet ne bo ubral poti nadaljnjega razvoja, temelječega na izkoriščanju fosilnih goriv, smo pesimistični scenarij SSP5-8,5 izbrali zato, da proučimo, kaj bi popolno podnebno opustošenje pomenilo za slovenske gozdove.

2.3 Podnebni modeli

Podnebni modeli so kompleksni in napredni matematični sistemi, ki poskušajo v najboljši možni meri razumeti in simulirati delovanje Zemljinega podnebnega sistema na različnih prostorskih ravneh, pri čemer vključujejo različne fizikalne, kemijske in biološke spremenljivke in mehanizme tega sistema ter interakcije med njimi. Glavni cilj razvoja podnebnih modelov je simulacija različnih podnebnih komponent prihodnosti glede na podnebne scenarije. Njihovi rezultati predstavljajo povratno informacijo o posledicah različnih variant razvoja človeške družbe v naslednjih desetletjih, ki vplivajo na potek spreminjanja podnebja (IPCC, 2014). Podnebni modeli, ki smo jih uporabili v razvoju metodologije, izhajajo iz šeste faze cikličnega razvojnega projekta, imenovanega »Primerjava sklopljenih modelov« (CMIP6). Rezultate te faze projekta vsebuje tudi zadnje poročilo IPCC (Lee in sod., 2021).

Podnebni modeli, ki smo jih uporabili pri razvoju metodologije, se imenujejo modeli Zemljinega sistema (angl. *Earth System Models* oz. ESM) in predstavljajo višek razumevanja Zemljinega podnebnega sistema (Taylor, Stouffer, Meehl, 2012). Zadnje poročilo IPCC rezultate modeliranja temperaturnih in padavinskih sprememb iz CMIP6 ocenjuje s kvalitativno oceno »visoka stopnja zaupanja«. Kljub temu velja, da modeliranje padavinskih sprememb vsebuje več negotovosti kot modeliranje temperaturnih sprememb (Lee in sod., 2021). Poleg tega je treba opozoriti tudi na splošne negotovosti ESM, čeprav so tehnično vedno bolj dovršeni. Za modeliranje potencialnih vplivov podnebnih sprememb na slovenske gozdove smo uporabili 3 ESM:

- CNRM-ESM2-1. ESM je razvila ena od evropskih delovnih skupin CMIP6, ki se imenuje CNRM – CERFACS. Izbrani model je nadgradnja CNREM-CM5 iz faze CMIP5 (Séférian in sod., 2019).
- BCC-CSM2-MR. ESM je razvila kitajska delovna skupina CMIP6. Tudi ta model je nadgradnja njegovega predhodnika BCC-CSM1-1 iz CMIP5 (Wu in sod., 2019). Rezultati modela so se že izkazali za učinkovite pri uporabi metode maksimalne entropije na območju Južne Evrope, v katero je bila vključena tudi Slovenija (Jamal in sod., 2021). Za območje Slovenije je tudi Kuralt (2016) že uporabil model BCC-CSM1-1 za proučevanje vpliva podnebnih sprememb na potencialno razširjenost črne vdove (Latrodectus tredecimguttatus).
- MIROC6. ESM je razvila japonska delovna skupina CMIP6, njegov predhodnik pa je CMIP5. Izbran je bil, ker spada med modele, ki najbolje simulirajo cirkulacijo atmosfere na območju Evrope (Fernandez-Granja in sod., 2021).

2.4 Modeliranje ekoloških niš in razširjenosti vrst

Modeliranje razširjenosti vrst je nabor znanstvenih definicij, metod in tehnik, ki razlagajo soodvisnost med prostorsko razporeditvijo živalskih in rastlinskih vrst ter njihovim abiotskim življenjskim okoljem. Modeli razširjenosti vrst (angl. *Species Distribution Models*) so kvantitativne in empirične metode ter orodja, s katerimi iščemo omenjene povezave (Elith, Franklin, 2013). Današnje modeliranje ekoloških vrst sta omogočili dve odločilni veji znanstvenega raziskovanja: sistematično terensko kartiranje vrst živih bitij in njihovega naravnega okolja ter močan metodološki razvoj fizične geografije v povezavi z geografskimi informacijskimi sistemi (vse bolj natančni digitalni modeli nadmorskih višin, prostorske interpolacije, daljinsko zaznavanje itd.) (Elith, Leathwick, 2009).

V znanstveni literaturi se srečujemo z veliko terminološko nedorečenostjo okoli uporabe dveh temeljnih pojmov: »modeliranje razširjenosti vrst« in »modeliranje ekoloških niš«. Geografski terminološki slovar (2021) ekološko nišo definira kot »celoto neživih in živih okoljskih dejavnikov, sestavin ekosistema, ki bistveno vplivajo na preživetje posamezne vrste organizmov in na njeno vlogo v okolju«. Termin »modeliranje ekoloških niš« je primeren za študije, ki obravnavajo potencialne spremembe razporeditve vrst zaradi spremenjenih življenjskih razmer in okoliščin, medtem ko je izraz »modeliranje razširjenosti vrst« primeren za študije, v katerih rezultati modela predstavljajo realno, in-situ stanje razširjenosti izbrane vrste (Townsend Peterson, Soberon, 2012). Pri vprašanju pravilnega izbora termina torej ni odločilen izbor metode, temveč namen modeliranja. V primeru razvoja metodologije, ki jo opisujemo, je zato pravilna uporaba termina »modeliranje ekoloških niš«.

Modeliranje ekoloških niš je temeljilo na naslednjih predpostavkah (De Marco in sod., 2008; Guisan, Thuiller, Zimmermann, 2017):

- Proučevana vrsta v svojem habitatu biva v dinamičnem ravnovesju.

- Razumemo odvisnost pojavnosti vrste od vseh ključnih okoljskih gradientov (temperaturnih, vodnih …), ki omogočajo njeno uspevanje, in jih v relevantni prostorski ločljivosti vključujemo v model.
- Okolje bo vrstam dostopno v enaki meri, kakor je danes.
- V model je zajeta celotna ekološka niša, ki bo ostala stabilna, kot je danes.

Poleg omenjenih teoretskih smo temeljili tudi na štirih metodoloških predpostavkah (Guisan, Thuiller, Zimmermann, 2017):

- Glede na namen raziskave je uporabljena prava metoda modeliranja ekoloških niš.
- Neodvisne spremenljivke ne vsebujejo napak.
- Podatki o prisotnosti vrste so nepristranski.
- Točke z informacijo o prisotnosti vrste so izbrane naključno.

Kritiki opozarjajo tudi na nekatere pomanjkljivosti omenjenih teoretskih predpostavk. Ob drastični spremembi podnebnih razmer vrste izstopijo iz dinamičnega ravnovesja. Z okoljskimi spremembami, med katere spadajo tudi podnebne spremembe, se lahko spremenijo ključni omejevalni dejavniki, ki jih danes ne moremo predvideti. Enako velja za spremembo biotskih odnosov med vrstami in v njih. Ob okoljskih spremembah lahko pričakujemo tudi spremembo genetskih struktur vrst, kar sicer velja predvsem za dolgoročne spremembe in ne nekajdesetletne. Današnji trendi prostorskega obnašanja vrst so lahko ob spremembah življenjskega okolja zamajani ali spremenjeni. Kritiki opozarjajo tudi na to, da so vhodni podatki za modeliranje ekoloških niš lahko prostorsko netočni, kar privede do statistično korektnih, a vsebinsko napačnih rezultatov (Dormann, 2006; Miller, 2010; Sinclair, White, Newell, 2010).

2.5 Metoda maksimalne entropije in programsko orodje Maxent

Poznamo več vrst entropije. Pri razvoju metodologije smo uporabili Shannovo entropijo. Definirana je kot količina, s katero kvantitativno izrazimo negotovost izida določenega poskusa ali sistema. Proučevani sistem sestavljajo določeni mehanizmi. Tiste, ki poznamo, lahko vključimo v izračun entropije kot omejitve (angl. *constraints*). Z njimi zmanjšamo stopnjo negotovosti, ki je del verjetnostne porazdelitve. Po načelu maksimalne entropije se moramo pri izboru najprimernejše verjetnostne porazdelitve odločiti za tisto, ki ob upoštevanju vseh omejitev vsebujejo največjo mero negotovosti oziroma maksimalno entropijo (Penfield, 2013; Jaynes, 1957).

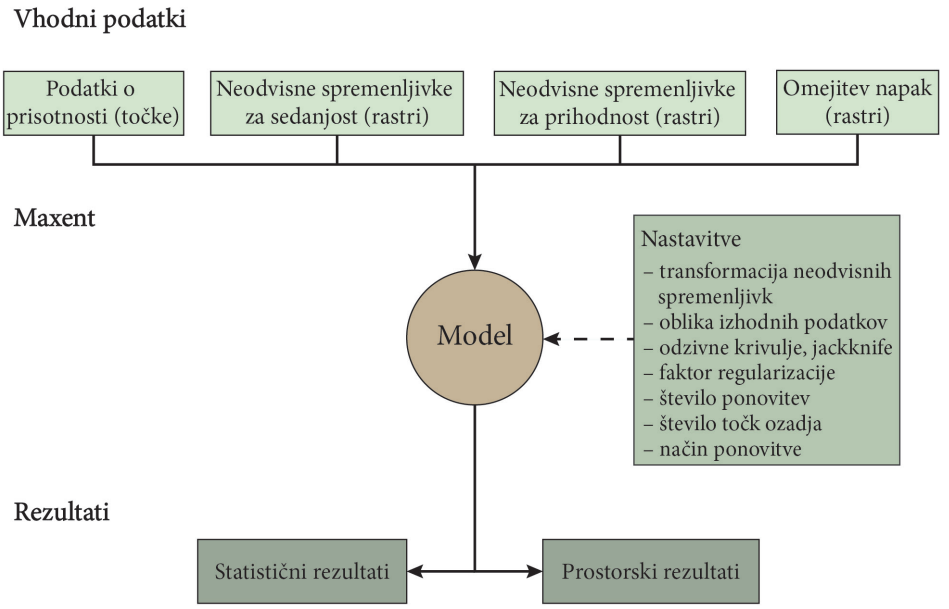
Za modeliranje ekoloških niš z uporabo metode maksimalne entropije smo uporabili programske orodje Maxent. Programsko orodje je bilo razvito leta 2004 in je od takrat brezplačno dostopno na spletu (Phillips, Dudik, Schapire, 2004). V zadnjih letih lahko iz baz znanstvenih objav razberemo močan porast uporabe orodja, ki zanima različne znanstvene discipline (ekologijo, veje fizične geografije, gozdarstvo itd.) (Web of Science, 2022). Maxent je posebno priljubljen za modeliranje ekoloških

niš (Ngarega, Masocha, Schneider, 2021; Saha, Rahman, Alam, 2021; Sun, Long, Jia, 2021; Zhao in sod., 2021; Zhao in sod., 2021).

Ogrodje delovanja programskega orodja Maxent prikazuje slika 3. Vhodne podatke delimo na tri sklope. V prvega umeščamo neodvisne spremenljivke v obliki rastrskih slojev podatkov, ki imajo z vidika Shannove entropije funkcijo omejitev. Ker so odnosi vrst do kombinacije različnih identificiranih dejavnikov (neodvisnih spremenljivk) izredno kompleksni, jih ne moremo razlagati s preprostimi linearnimi funkcijami. Programsko orodje zato izvaja različne transformacije osnovnih neodvisnih spremenljivk. V drugi sklop vhodnih podatkov uvrščamo iste neodvisne spremenljivke, le da vsebujejo vrednosti za prihodnost oz. preteklost. Ta sklop je torej relevanten le v primeru modeliranja ekoloških niš in ne v primeru modeliranja razširjenosti vrst. V tretji sklop spadajo točkovni podatki o prisotnosti vrste na proučevanem območju. Točke morajo biti izbrane naključno. Priporočljivo je upoštevati pravilo palca, ki pravi, da je primerno število točk prisotnosti desetkratnik števila uporabljenih neodvisnih spremenljivk (Guisan, Thuiller, Zimmermann, 2017). Poleg dveh oziroma treh obveznih sklopov vhodnih podatkov je priporočljivo tudi, da v zagon programskega orodja vključimo tudi podatkovni sloj za omejitev napak modeliranja (Barbet-Massin in sod., 2012). Poleg vhodnih podatkov lahko pred zagonom programskega orodja z nastavitvami vplivamo tudi na izvedbo analize in vrsto končnih rezultatov (Merow, Smith, Silander, 2013).

Izhodne podatke modeliranja delimo na statistične in prostorske, v veliki meri pa so odvisni od vhodnih nastavitev. V statističnem delu programsko orodje najprej generira grafikon opustitve in napovedanih površin (slika 5). Na njem so prikazane mere opustitve (angl. *omission rate*) za učne in testne točke. Drugi grafikon, ki ga generira programsko orodje, je najpomembnejši in se imenuje grafikon lastnosti delovanja sprejemnika (angl. *receiver operating characteristics*) oziroma grafikon krivulj ROC (slika 6). Površina pod krivuljo ROC se imenuje AUC (angl. *area under the receiver operating charasteristic curve*), njena vrednost pa je merilo verodostojnosti rezultatov modeliranja (Phillips, 2017; Phillips in sod., 2017). Če vrednost AUC znaša več kot 0,7, lahko rezultate modeliranja označimo kot statistično uspešne (Araujo in sod., 2005). V primeru specifičnih nastavitev programsko orodje izriše tudi odzivno krivuljo za posamezno neodvisno spremenljivko, ki grafično prikazuje odvisnost rezultatov modeliranja od nje. Metoda maksimalne entropije izračuna še doprinos posamezne neodvisne spremenljivke h končnim rezultatom, ki je izražen v odstotkih. Za še natančnejši izračun doprinosa lahko izvedemo tudi analizo Jackknife (Phillips, 2017).

Slika 3: Shematski prikaz delovanja programskega orodja Maxent.



Avtor: Tim Gregorčič, 2022.

2.6 Gozdni vegetacijski tipi Slovenije

V slovenskih gozdovih najdemo 78 poglavitnih gozdnih rastiščnih tipov, pri katerih vsak obsega specifične rastiščne razmere (Bončina in sod., 2021). Vseh 78 gozdnih rastiščnih tipov smo smiselno združili v 13 skupin GVT, kot so to storili Kutnar, Kobler in Bergant (2009, str. 34):

- acidofilna bukovja (GVT1),
- acidofilna rdečeborovja (GVT2),
- podgorska bukovja (GVT3),
- gorska bukovja (GVT4),
- (visoko)gorska bukovja v (pred)alpskem območju (GVT5),
- (visoko)gorska bukovja v (pred)dinarskem območju (GVT6),
- termofilna bukovja (GVT7),
- kolinska hrastova-belogabrovja (GVT8),
- nižinska vrbovja, jelševja in dobovja (GVT9),
- termofilna črnogabrovja, hrastovja, rdečeborovja in črnoborovja (GVT10),
- jelovja (GVT11),
- smrekovja (GVT12) in
- ruševje (GVT13).

Vsak GVT vsebuje gozdne rastiščne tipe, ki so jim skupne podobne rastiščne razmere s posebnim poudarkom na podnebnih dejavnikih. S tem smo se odločili za mezoekološko modeliranje ekoloških niš (MacKey, Lindenmayer, 2001). Združevanje gozdnih rastiščnih tipov je bilo potrebno zaradi statističnih omejitev modeliranja, ki so povezane z majhno površino določenih rastiščnih tipov in razmeroma veliko prostorsko ločljivostjo neodvisnih spremenljivk.

3 METODOLOGIJA

3.1 Nabor neodvisnih spremenljivk

Med neodvisnimi spremenljivkami, ki smo jih uporabili za modeliranje ekoloških niš, so bile najpomembnejše tako imenovane bioklimatske spremenljivke. Te so naštete v preglednici 1. Njihova podrobnejša opisna in kvantitativna predstavitev je na voljo v delu O'Donnella in Ignizia (2012). Gre za izpeljanke osnovnih podnebnih parametrov (povprečna mesečna temperatura zraka, povprečna mesečna maksimalna temperatura zraka, povprečna mesečna minimalna temperatura zraka in mesečna količina padavin), ki služijo za maksimiranje korelacije med prisotnostjo vrste in lokalnimi podnebnimi značilnostmi (Attorre in sod., 2007). Na področju modeliranja ekoloških niš so široko uporabljene (Portilla Cabrera, Selvaraj, 2020; Du in sod., 2021; Zeng in sod., 2021; Saha, Rahman, Alam, 2021). Sloji bioklimatskih spremenljivk za podnebje prihodnosti so na voljo na portalu WorldClim (Fick, Hijmans, 2017).

Preglednica 1: Bioklimatske spremenljivke.

Bioklimatska spremenljivka	Povprečna letna temperatura zraka	Letno povprečje dnevnega temperaturnega hoda	Izotermalnost	Sezonskost temperatur zraka	Najvišja temperatura zraka najtoplejšega meseca
Oznaka	BIO1	BIO2	BIO3	BIO4	BIO5
Bioklimatska spremenljivka	Najnižja temperatura zraka najhladnejšega meseca	Absolutni letni temperaturni hod	Povprečna temperatura zraka najvlažnejšega četrtletja	Povprečna temperatura zraka najbolj sušnega četrtletja	Povprečna temperatura zraka najtoplejšega četrtletja
Oznaka	BIO6	BIO7	BIO8	BIO9	BIO10

Bioklimatska spremenljivka	Povprečna temperatura zraka najhladnejšega četrtletja	Letna količina padavin	Količina padavin najbolj namočenega meseca	Količina padavin najbolj sušnega meseca	Sezonskost padavin
Oznaka	BIO11	BIO12	BIO13	BIO14	BIO15
Bioklimatska spremenljivka	Količina padavin najbolj namočenega četrtletja	Količina padavin najbolj sušnega četrtletja	Količina padavin najtoplejšega četrtletja	Količina padavin najhladnejšega četrtletja	
Oznaka	BIO16	BIO17	BIO18	BIO19	

Vir podatkov: O'Donnell, Ignizio, 2012.

Najmanjša prostorska ločljivost podatkov za prihodnost, ki je bila na voljo, je znašala 2,5 kotne minute. To je za modeliranje na območju Slovenije premalo natančno. Odločili smo se, da bomo prostorsko ločljivost neodvisnih spremenljivk izboljšali na 500 m. Uporabili smo kombinacijo metod, ki so jih razvili Poggio, Simonetti in Gimona (2018). Če ni navedeno drugače, je obdelava prostorskih podatkov potekala z uporabo programskega orodja ArcGIS Pro 2.9.0.

Za Slovenijo smo za obdobje 1970–2000 izračunali vseh 19 bioklimatskih spremenljivk s prostorsko ločljivostjo 500 m. Z ARSO smo pridobili homogenizirane podatke vseh merilnih mest, na katerih so v obdobju 1970–2000 merili omenjene osnovne podnebne parametre (47 merilnih mest za povprečne mesečne temperature, 42 za povprečne mesečne maksimalne temperature, 38 za povprečne mesečne minimalne temperature in 223 za mesečne količine padavin). Ker smo od agencije pridobili mesečne podatke za vsa leta v želenem obdobju, smo najprej izračunali obdobna povprečja. Za izdelavo rastrskih temperaturnih slojev smo uporabili metode Ninyerola, Ponsa in Roura (2000; 2007) in jih prilagodili glede na dejavnike, ki vplivajo na slovenske podnebne razmere. Ker na temperaturne razmere v Sloveniji odločilno vplivajo Sončevo obsevanje, nadmorska višina, reliefne danosti in raba tal (Ogrin, Plut, 2012), smo za izdelavo rastrskih slojev uporabili naslednje neodvisne spremenljivke:

- mesečno kvazisončevo obsevanje (izračunano z orodjem *Solar Radiation*),
- nadmorske višine,
- konkavnost površja (izračunano z orodjem *StochasticDepressionAnalysis* v programskem orodju WhiteboxTools) in
- logaritmirano oddaljenost od morja (izračunano z orodjem *Euclidean Distance* in *Raster Calcualtor*). Ta dejavnik smo preoblikovali z logaritemsko funkcijo, ker so bili determinacijski koeficienti R^2 ob izvajanju multiple linearne regresijske analize v naslednjem koraku tako višji.

Na vseh ustvarjenih rastrskih slojih smo z vsemi točkami, ki so predstavljale lokacije merilnih mest za posamezni temperaturni parameter, izvedli vzorčenje. S pridobljenimi podatki smo s pomočjo programskega orodja SPSS izvedli multiplo linearno regresijsko analizo variante *backward stepwise* (kasneje MLR). S tem smo določili funkcijsko povezanost med relevantnimi podnebnimi dejavniki in mesečnimi vrednostmi treh temperaturnih spremenljivk. Če je MLR spremenljivko ohranila kljub njeni statistični neznačilnosti, smo pozneje izvedli še analizo parcialne korelacije in se glede na njeno statistično (ne)značilnost odločili, ali spremenljivko ohranimo v analizi ali jo izključimo. Parcialno korelacijo je mogoče izračunati le za razmernostne spremenljivke. Konkavnost reliefa je nominalna spremenljivka, zato zanjo nismo mogli izračunati parcialne korelacije. Ko MLR spremenljivke kljub njeni statistični neznačilnosti ni izključila, smo analizo ponovili in spremenljivko izključili sami. Za to smo se odločili, ker za najhladnejše mesece, ko konkavnost reliefa igra največjo vlogo pri distribuciji temperatur, programsko orodje spremenljivke ni vključilo v analizo, ni pa je izključilo v mesecih, ko konkavnost reliefa ne igra pomembne vloge. Izmed vseh analiz vrednost najnižjega determinacijskega koeficienta znaša 0,694. To pomeni, da so izbrane neodvisne spremenljivke v visoki korelaciji z odvisno spremenljivko.

Glede na izračunane regresijske koeficiente smo ustvarili rastrske sloje surovih mesečnih temperaturnih podatkov. Z izbranimi podnebnimi dejavniki in uporabo MLR je pričakovano prišlo do razlik med izmerjenimi in ustvarjenimi vrednostmi. Potrebni so bili popravki surovih podatkov. Izračunali smo razliko med izmerjenimi in napovedanimi vrednostmi ter jih prostorsko interpolirali z metodo *Ordinary Kriging*. Izmed funkcij variograma smo izbrali med sferično, J-Bessel, K-Bessel, racionalno kvadratno, eksponentno, krožno, Gaussovo, tetrasferično, stabilno in učinkom luknje. Izbor funkcije je bil odvisen od tega, katera je v določenem mesecu privedla do najboljših rezultatov. To smo preverili z analizo grafikona navzkrižne preverbe. Ustvarjene sloje interpoliranih razlik smo prišteli slojem surovih mesečnih temperaturnih podatkov in s tem ustvarili končnih 36 temperaturnih slojev.

Za ustvarjanje slojev mesečnih količin padavin smo poskusili uporabiti isto metodo. Na prostorsko razporeditev padavin v Sloveniji najpomembneje vpliva oddaljenost od alpsko-dinarske orografske pregrade (Ogrin, Plut, 2012). Za neodvisne spremenljivke smo uporabili podatke o nadmorski višini, geografski širini, geografski dolžini in oddaljenosti od alpsko-dinarske pregrade. Zaradi multikolinearnosti med slednjima dvema neodvisnima spremenljivkama smo zadnjo iz analiz izključili. Iz rezultatov analize MLR se je izkazalo, da neodvisne spremenljivke močno pripomorejo h končnemu modelu, vseeno pa pojava ne pojasnijo dovolj, da bi bili rezultati uporabni. Ta ugotovitev potrjuje tudi teoretično izhodišče, da je modeliranje padavin bolj kompleksno in manj uspešno od modeliranja temperaturnih razmer (Forster in sod., 2021). Namesto MLR smo padavinske sloje ustvarili neposredno iz prostorske interpolacije vrednosti točk merilnih mest z uporabo metode *Empirical Bayesian Kriging*. Tudi te prostorske interpolacije smo analizirali z grafikoni navzkrižne preverbe in ugotovili, da rezultati dosegajo visoko stopnjo točnosti.

Z ustvarjenimi temperaturnimi in padavinskimi podatki smo nato s programskim orodjem SAGA 8.0.1 izračunali 19 bioklimatskih spremenljivk za obdobje 1970–2000.

S portala WorldClim smo pridobili podatke za vseh devetnajst bioklimatskih spremenljivk za tri izbrane ESM, omenjene v poglavju 1.1.2. Da bi zmanjšali pristranskost končnih rezultatov, ki bi bila posledica izbora zgolj določenega ESM, smo iz njih izračunali povprečne vrednosti. Poleg tega smo s portala pridobili taiste spremenljivke za obdobje 1970–2000. Vsi sloji, ki smo jih pridobili s portala, so imeli prostorsko ločljivost 2,5 kotnih minut. Od bioklimatskih podatkov za prihodnost smo odšteli bioklimatske podatke za preteklost in s tem izračunali relativne razlike. Te smo prišteli prej ustvarjenim slojem bioklimatskih spremenljivk v prostorski ločljivosti 500 m za obdobje 1970–2000 in s tem ustvarili končne sloje, primerne za modeliranje.

Poleg bioklimatskih spremenljivk smo za modeliranje uporabili tudi sloj reakcije prsti. Pri ustvarjanju sloja je šlo zgolj za približek dejanskega stanja, saj metodologija ni temeljila na izmerjenih vrednostih pH, temveč na podlagi teoretskih predpostavk o reakciji tipov prsti. Na podlagi pedološke karte Slovenije (MKGP, 2007) smo določili štiri tipe: avtomorfne prsti s pretežno evtričnimi lastnostmi (litosoli, regosoli, rendzine, jerine, evtrične rjave, rjave pokarbonatne, koluvialno-deluvialne in rigolane prsti), avtomorfne prsti s pretežno distričnimi lastnostmi (izprane, distrične rjave, šotne prsti in rankerji), hidromorfne prsti s pretežno evtričnimi lastnostmi in hidromorfne prsti s pretežno distričnimi lastnostmi. V zadnja dva tipa smo glede na reakcijo umestili razvite in nerazvite obrečne prsti, oglejene ter psevdooglejene prsti (Repe, 2010).

Uspevanje GVT9 je determinirano z velikimi količinami podtalne vode (Bončina in sod., 2021), zato smo pri modeliranju te ekološke niše uporabili še evklidsko oddaljenost od hidrografske mreže (ARSO, 2006) in rezultate indeksa topografskega vlažnosti (TIV), ki smo ga izračunali s programskim orodjem SAGA.

3.2 Končni vhodni podatki

Sloj reakcije prsti smo uporabili pri modeliranju vseh ekoloških niš. Hidrogeografski spremenljivki sta bili, kot že omenjeno, uporabljeni le za modeliranje ekološke niše GVT9. Od 19 bioklimatskih spremenljivk za posamezni vegetacijski tip nikoli nismo izbrali vseh, ki so nam bile na voljo, saj nismo želeli prevelikega prileganja rezultatov. Vključili smo tiste, ki med sabo niso v preveliki pozitivni ali negativni korelaciji. Z 10.000 naključnimi vzorčnimi točkami smo na preučevanem območju vzorčili vrednosti vseh bioklimatskih spremenljivk za obdobje 1970–2000 in s programskim orodjem R Studio izračunali matriko Pearsonovih koeficientov. V primerih, ko je negativna ali pozitivna korelacija med dvema spremenljivkama znašala več kot 0,8 oz. manj kot –0,8, smo eno od njih izločili. Izločiti je bilo treba tisto, ki manj pripomore k točnosti končnih rezultatov. To smo izvedeli tako, da smo izvedli modelno analizo s programskim orodjem Maxent, v katero smo vključili vseh 20 oziroma 22 neodvisnih spremenljivk, in se osredotočili zgolj na rezultate analize Jackknife.

Za podatke o prisotnosti GVT smo uporabili podatke gozdnovegetacijske karte Slovenije v merilu 1 : 100.000 (Košir in sod., 1974; Košir in sod., 2007). Za vse GVT razen za GVT9, GVT11 in GVT13 smo naključno ustvarili 200 točk. Pri omenjenih izjemah smo zaradi majhne površine vegetacijskih tipov na eni strani ter dokaj velike prostorske ločljivosti podatkov na drugi število točk morali zmanjšati na 130. Del GVT8 na skrajnih jugozahodnih območjih države smo priključili GVT10 ter se s tem približali stanju novoopredeljenih območij toploljubnih listnatih gozdov po Bončini in sod. (2021).

Sloje za omejitev napak smo ustvarili z metodo *Sample by Buffered MCP (minimum convex polygon)*, ki je na voljo v zunanji zbirki orodij, namenjenih modeliranju ekoloških niš. Zbirka temelji na programskem jeziku Python in jo je mogoče vključiti v delovni proces v programskem orodju ArcGIS Pro (Brown, 2014).

V naslednjem koraku smo izvedli modeliranje. Za preverjanje točnosti rezultatov smo v nastavitvah določili, da naključno odvzamemo 20 % točk prisotnosti in z njimi izvedemo navzkrižno preverjanje. Modelno analizo smo izvedli za vsak vegetacijski tip in glede na rezultate proučili vrstni red pomembnosti neodvisnih spremenljivk. Ob upoštevanju korelacijskih koeficientov smo na koncu za vsak vegetacijski tip izbrali neodvisne spremenljivke, ki so za model najpomembnejše in ki obenem niso v preveliki medsebojni korelaciji (preglednica 2). Analize Jackknife so pokazale tudi, da v nekaterih primerih vključenost spremenljivke končni rezultat poslabša. To se je zgodilo pri GVT4 (BIO18), GVT7 (BIO6) in GVT11 (BIO7, BIO2). V teh primerih smo ločeno od opisane metodologije spremenljivke *a priori* izključili.

Preglednica 2: Končni izbor neodvisnih spremenljivk za posamezni GVT.

	BIO1	BIO2	BIO3	BIO4	BIO5	BIO6	BIO7	BIO8	BIO9	BIO10	BIO11
GVT1	×	✓	×	×	×	✓	✓	✓	✓	✓	×
GVT2	✓	×	✓	✓	×	×	✓	✓	✓	×	×
GVT3	×	×	✓	✓	✓	✓	✓	✓	✓	×	×
GVT4	×	×	✓	×	×	✓	✓	✓	✓	✓	×
GVT5	×	✓	×	✓	✓	✓	✓	✓	✓	×	×
GVT6	×	×	✓	×	×	✓	✓	✓	✓	✓	×
GVT7	×	×	✓	✓	✓	×	✓	✓	✓	×	×
GVT8	×	×	✓	✓	✓	✓	✓	✓	✓	×	×
GVT9	×	×	✓	×	×	✓	✓	✓	✓	✓	×
GVT10	×	×	✓	✓	×	×	✓	✓	✓	×	✓
GVT11	×	×	×	✓	×	✓	×	✓	✓	×	✓
GVT12	×	✓	×	×	×	✓	✓	✓	✓	✓	×
GVT13	×	✓	×	×	×	✓	✓	✓	✓	✓	×

	BIO12	BIO13	BIO14	BIO15	BIO16	BIO17	BIO18	BIO19	pH prsti	TIV	Odd. od hidro. mreže
GVT1	✓	×	×	✓	×	×	×	×	✓	×	×
GVT2	✓	×	×	✓	×	×	×	×	✓	×	×
GVT3	×	×	×	✓	×	×	✓	✓	✓	×	×
GVT4	×	×	×	✓	×	×	×	✓	✓	×	×
GVT5	×	×	×	✓	×	×	✓	✓	✓	×	×
GVT6	×	×	×	✓	×	✓	×	×	✓	×	×
GVT7	×	×	×	✓	×	×	✓	✓	✓	×	×
GVT8	×	×	×	✓	×	×	✓	✓	✓	×	×
GVT9	×	×	×	✓	×	×	✓	✓	✓	✓	✓
GVT10	×	×	×	✓	×	×	✓	✓	✓	×	×
GVT11	×	×	×	✓	×	×	✓	✓	✓	×	×
GVT12	✓	×	×	✓	×	×	×	×	✓	×	×
GVT13	×	×	×	✓	×	×	✓	✓	✓	×	×

3.3 Modeliranje ekoloških niš

Končne modelne analize smo ponovili z nastavitvami, ki so opisane v poglavju 3.2, a smo od neodvisnih spremenljivk uporabili le izbrane (preglednica 2). Vključili smo še bioklimatske spremenljivke z vrednostmi izbranih podnebnih scenarijev, s čimer smo ustvarili projekcije potencialnih razporeditev ekoloških niš v prihodnosti. Za izboljšanje rezultatov smo pri GVT1 in GVT2 uporabili tudi faktor regularizacije z vrednostjo 0,8. To je bilo potrebno, ker smo ugotovili, da je ob uporabi standardne vrednosti 1 razporeditev ekoloških niš za današnje obdobje preobsežna. To je indikator, da bi bile tudi projekcije ob uporabi regulacijskega koeficienta s to vrednostjo neizbežno manj točne.

Rezultate smo za sintezo združili tako, da smo vse sloje glede na njihove največje vrednosti združili v enega. Od tega sloja smo nato odšteli vse sloje osnovnih rezultatov verjetnosti. Vrednosti 0 so imele celice, kjer je imel posamezni GVT glede na vse ostale verjetnosti drugih tipov največjo možnost razširjenosti ekološke niše. Ta območja smo izluščili in jih obrezali z današnjimi gozdnimi površinami, s čimer smo prišli do končnih rezultatov, ki so primerni za nadaljnje analize sprememb ekoloških niš. Za vizualizacijo rezultatov smo te naknadno še generalizirali.

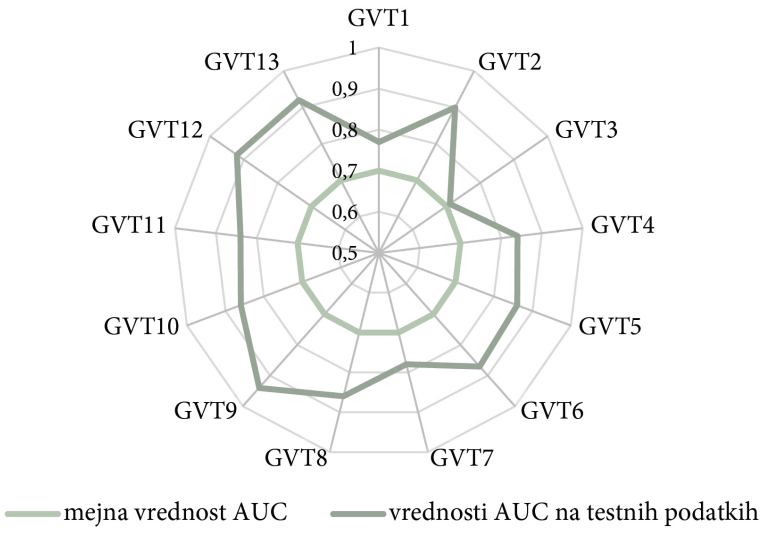
4 REZULTATI

Pri modeliranju ekoloških niš s programskim orodjem Maxent ob upoštevanju vseh predpostavk, ki so navedene v poglavju 1.2., so vse vrednosti AUC za testne podatke znašale več kot 0,7, s čimer lahko rezultate označimo kot statistično uspešne (preglednica 3 in slika 4). GVT3, GVT1 in GVT7 so dosegli zmerno mero statistične uspešnosti (0,80 > AUC > 0,70). GVT4, GVT11, GVT10, GVT8, GVT5 in GVT6 so dosegli dobro mero statistične uspešnosti (0,90 > AUC > 0,80). GVT2, GVT12, GVT13 in GVT9 so dosegli odlično mero statistične uspešnosti (AUC > 0,90) (Araujo in sod., 2005).

Preglednica 3: Vrednosti AUC.

GVT	AUC	GVT	AUC
GVT9	0,94	GVT10	0,86
GVT13	0,92	GVT11	0,84
GVT12	0,92	GVT4	0,84
GVT2	0,90	GVT7	0,78
GVT6	0,87	GVT1	0,77
GVT5	0,86	GVT3	0,71
GVT8	0,86		

Slika 4: Vrednosti AUC.



Avtor: Tim Gregorčič, 2022.

4.1 Študija primera: termofilna črnogabrovja, hrastovja, rdečeborovja in črnoborovja (GVT10)

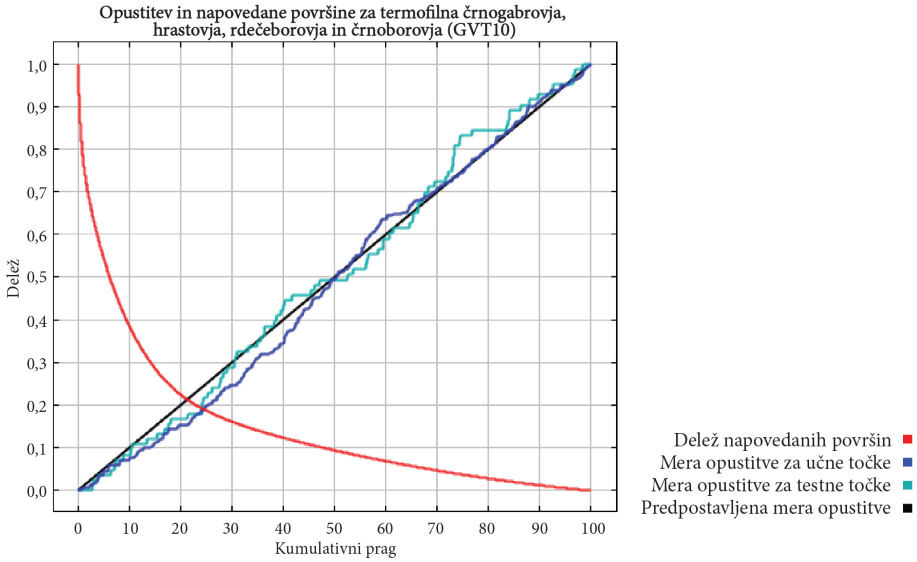
Poglavje 4.1 je na primeru GVT10 namenjeno predstavitvi osnovnih izhodnih podatkov, ki jih proizvede programsko orodje Maxent. Za GVT10 smo se odločili, ker lahko pričakujemo, da bodo njegovi rastiščni pogoji med tistimi, ki bodo doživeli največjo razširitev (Kutnar, Kobler, Bergant, 2009). Osnovni statistični del rezultatov modeliranja ekološke niše za GVT10 prikazujeta grafikona 4 in 5. Pomembna sta za vrednotenje uspešnosti in verodostojnosti modeliranja.

Rdeča črta na grafikonu opustitve in napovedanih površin (slika 5) kaže delež napovedanih površin v odvisnosti od izbranega kumulativnega praga. Pri kumulativnem pragu 0 % so na voljo vse površine (vrednost 1), pri pragu 100 % pa ni površin, ki bi bile na voljo. Drugi del grafikona predstavlja meri opustitve za učne in testne točke. Učne točke predstavljajo delež točk prisotnosti, ki jih programsko orodje uporabi za prepoznavanje vrednosti neodvisnih spremenljivk, ki so primerne za prisotnost vrste. Testne točke predstavljajo delež točk prisotnosti, ki jih programsko orodje uporabi za vrednotenje uspešnosti modeliranja. Opustitev je definirana kot delež točk prisotnosti vrste, ki v rezultatu modeliranja ležijo v celicah, ki jih metoda ni določila kot primerne za prisotnost proučevane vrste (Phillips, Anderson, Schapire, 2006). Pri kumulativnem pragu 0 tako ni točk, ki se ne bi nahajale na območju napovedanih površin. Pri kumulativnem pragu 100 % velja ravno obratno. Črti obeh mer opustitve morata čim bolje slediti predpostavljeni meri opustitve (Phillips, 2017). Iz grafikona 4 je razvidno, de rezultati temu pogoju ustrezajo, kar nakazuje na uspešnost modeliranja in kvalitetne rezultate.

Slika 6 je najpomembnejša in prikazuje krivulji ROC. Gre za funkcijo med deležem napovedanih površin (1 – specifičnost) in občutljivostjo. Specifičnost (angl. *specificity*) predstavlja površine, ki jih določeni prag ne zaobjema, občutljivost pa predstavlja delež točk prisotnosti vrste, ki ležijo v rastrskih celicah, ki jih je metoda prepoznala kot primerne za prisotnost vrste (Phillips, 2017; Phillips in sod., 2017). Pri pragu 0 % ni točk, ki bi se nahajale znotraj napovedanih površin, ker teh ni. Pri pragu 100 % so znotraj napovedanih površin vse točke, saj prag zaobjema celotno proučevano območje. Z grafa je razvidno, da se poteka obeh črt zadovoljivo ujemata in da vrednost AUC za testne podatke znaša 0,86. Kot omenjeno, to rezultate modela ocenjuje z dobro mero statistične uspešnosti (Araujo in sod., 2005). Hipotetična črna črta ROC predstavlja AUC vrednost 0,5. Gre za situacijo, v primeru katere bi bila napoved kljub vsem omejitvam (uporabljenim neodvisnim spremenljivkam) povsem naključna, rezultati pa povsem neuporabni.

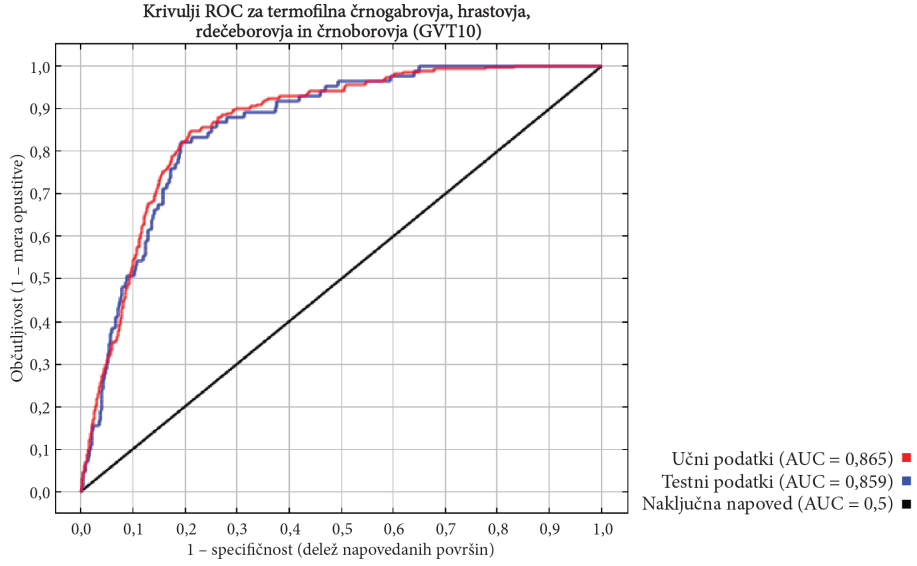
Slika 7 predstavlja končne prostorske rezultate modeliranja. Pri njih so upoštevane vse ostale verjetnosti prisotnosti ostalih GVT in so bili generalizirani za potrebe kartografskega prikaza.

Slika 5: Opustitev in napovedane površine za GVT10.



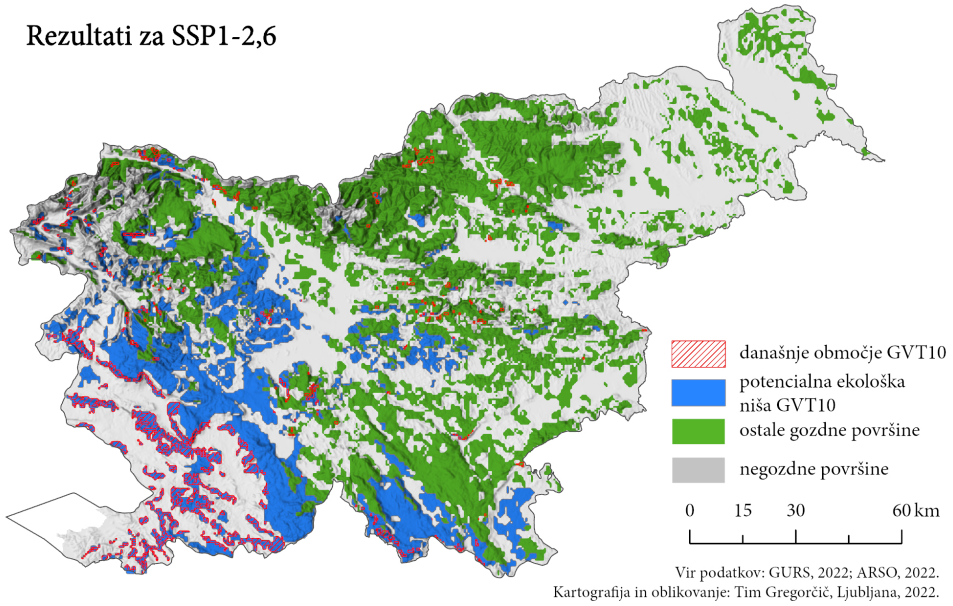
Avtor: Tim Gregorčič, 2022.

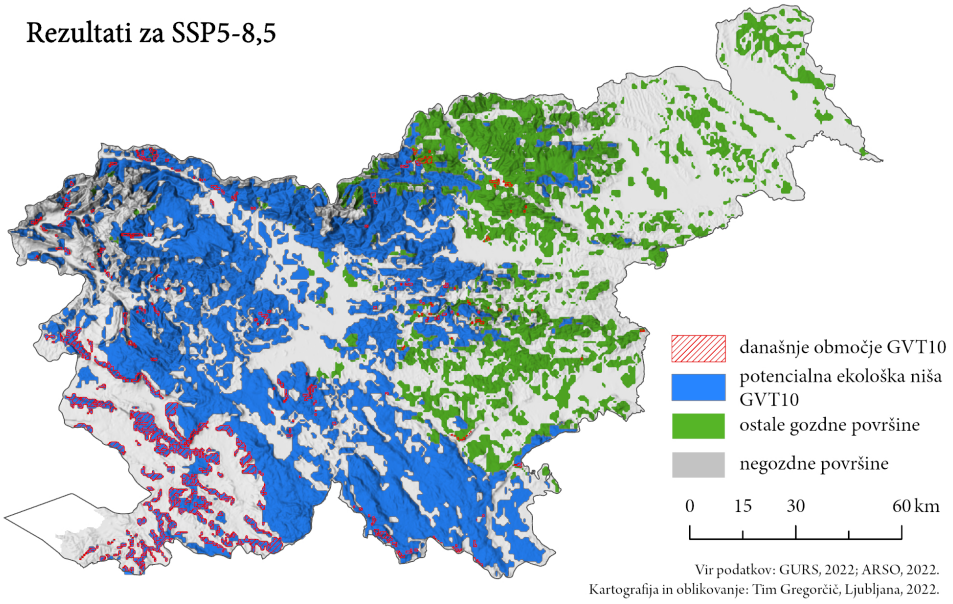
Slika 6: Krivulji ROC za GVT10.



Avtor: Tim Gregorčič, 2022.

Slika 7: Prostorski rezultati modeliranja potencialne ekološke niše za GVT10.





5 RAZPRAVA IN ZAKLJUČEK

Metoda maksimalne entropije in programsko orodje Maxent sta do sedaj že bila nekajkrat uporabljena za proučevanje različnih pojavov na območju Slovenije. Kuralt (2016) je modeliral potencialno razširjenost pajka črne vdove (*Latrodectus tredecimguttatus)* glede na različne podnebne scenarije RCP. Kalan in sod. (2017) so Maxent uporabili za modeliranje potencialnih arealov invazivnih tigrastih komarjev *(Aedes albopictus)* in invazivnih japonskih komarjev *(Aedes japonicus japonicus)*. To je sicer metodološko lahko sporno, saj vrsti zaradi svoje invazivnosti še nista v dinamičnem ravnovesju, kar je ena od predpostavk modeliranja razširjenosti vrst oz. ekoloških niš. Šet (2019) je metodo uporabil za modeliranje razširjenosti kriptičnih vrst rodu *Niphargus* v današnjih podnebnih pogojih. Enako tudi Knez (2020), ki je modelirala potencialne habitate za naselitev evropskega bizona (*Bison bonasus*) v Sloveniji.

V našem primeru se uporaba maksimalne entropije in Maxenta razlikuje od pristopov omenjenih avtorjev po namenu in metodologiji. Modeliranje s programskim orodjem Maxent smo prvič uporabili za proučevanje potencialnih vplivov podnebnih sprememb na slovenske gozdove. Prvič smo uporabili tudi podnebne scenarije imenovane »smeri skupnega družbenogospodarskega razvoja«. Z metodološkega vidika se naša raziskava od omenjenih študij bistveno razlikuje v tem, da nismo modelirali potencialnih vplivov na en GVT, kot so ostali avtorji to počeli zgolj za eno živalsko vrsto. Metodo smo uporabili za modeliranje trinajstih GVT, s čimer se je porodila potreba po drugačnem pristopu določevanja končnih ekoloških niš glede na verjetnost prisotnosti. Pri modeliranju ene vrste je treba namreč zgolj določiti prag sprejemljive verjetnosti prisotnosti glede na določene predpostavke.

Glede na statistične rezultate modeliranja ocenjujemo, da je metoda maksimalne entropije za proučevanje vpliva podnebnih sprememb primerna in učinkovita. Kljub rezultatom, ki to potrjujejo, moramo opozoriti, da je njihova dejanska kakovost odvisna od kakovosti vhodnih podatkov. Tudi s pomanjkljivimi vhodnimi podatki lahko metoda doseže dobre rezultate, ki pa so do neke mere vprašljivi. Med razvojem metodologije smo veliko pozornosti namenili kakovostni pripravi vhodnih podatkov, a smo kljub temu naleteli na nekaj omejitvenih dejavnikov, ki so preprečevali še kakovostnejšo pripravo. Prvi se nanaša na mrežo temperaturnih merilnih mest, ki je bila mnogo redkejša od mreže merilnih mest količine padavin. Ob večjem številu merilnih mest bi lahko izvedli natančnejše interpolacije, ki bi imele manj napak, čeprav se jim nikoli ne bi mogli popolnoma izogniti. Poleg tega smo za ustvarjanje podnebnih slojev izbrali metodo, ki velja za relativno preprosto. Z izborom kompleksnejših metod bi prišli tudi do točnejših rezultatov (Di Piazza in sod., 2011; Viggiano in sod., 2019).

Zavedamo se tudi, da v modeliranje niso bili vključeni vsi vplivi, ki bodo (lahko) vplivali na slovenske gozdove v prihodnosti. Nekatere pomembne neodvisne spremenljivke smo izpustili načrtno, saj smo njihov vpliv primerno metodološko nadomestili. To velja za ekspozicijo in naklon površja, ki sta pomembna rastiščna dejavnika. Teh dveh neodvisnih spremenljivk v modeliranje nismo vključili, ker izračun

insolacije, katerega rezultati so bili uporabljeni za izdelavo temperaturnih slojev, že vključuje naklon in ekspozicijo površja. Nekateri podatkovni sloji, ki bi jih sicer morali nujno vključiti v modeliranje (npr. spremembe vlažnosti prsti glede na podnebne scenarije, globina prsti, vsebnost organske snovi v prsteh, vpliv prihodnjih podnebnih razmer na stopnjo razkroja in kroženja organske snovi, vodna kapaciteta prsti itd.), ne obstajajo ali pa niso dostopni. Poleg tega obstajajo tudi vplivi, ki bodo ob intenzifikaciji podnebnih sprememb nedvomno vplivali na slovenske gozdove, a jih metoda ne more vključiti. To so ekstremni vremenski pojavi, pojav novih škodljivcev in razširjanje obstoječih itd. Zavedamo se tudi, da človek tako kompleksnih naravnih sistemov najverjetneje nikoli ne bo docela razumel in povsem verodostojno modeliral, zato je v metodologijo nemogoče vključiti vse dejavnike, ki vplivajo na razširjanje slovenskih gozdov danes ali v prihodnosti.

Dodatna pomanjkljivost se nanaša tudi na vhodne podatke o prisotnosti GVT. Podatkov o gozdni vegetaciji v nekajdesetkilometrskem pasu zunaj državne meje nismo imeli na voljo, zato smo v modeliranje naravnih procesov umestili mejo, ki v resnici ne obstaja. Za predele ob severni meji Slovenija to sicer ne velja, saj karavanški gorski grebeni dejansko predstavljajo tudi očitno vegetacijsko pregrado in ločnico.

Priložnosti nadaljnjega razvoja metodologije za proučevanje potencialnih vplivov podnebnih sprememb na slovenske gozdove tako vidimo v izboljšanju prostorske natančnosti in točnosti vhodnih podatkov, dodatni identifikaciji in vključitvi relevantnih neodvisnih spremenljivk in v testiranju drugih orodij za modeliranje ekoloških niš, ki bi lahko privedla do novih spoznanj o potencialnih smereh razvoja ekoloških niš GVT v prihodnosti.

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PREDICTING POTENTIAL CLIMATE CHANGE IMPACTS ON SLOVENIAN FORESTS USING THE MAXIMUM ENTROPY METHOD

Summary

The earth's climate has changed in the course of the earth's history through the transitions into ice ages and interglacial periods until today (Ogrin, 2005). Today, the climate is also changing (Bertalanič et al., 2018), but there is scientific consensus that humans are responsible for these changes for the first time in Earth's history due to the massive greenhouse gas (GHG) emissions they cause. The two most problematic GHGs are CO_2 and CH_4 respectively, which in combination with other GHGs contribute to the Earth's positive effective radiative forcing, leading to higher global temperatures, altered precipitation characteristics, more extreme weather events, etc. (Lee et al., 2021). From the perspective of climate change mitigation and adaptation, many scientific disciplines are trying to figure out how climate change might affect different environmental and social systems on Earth (Daddi et al., 2020). In this scientific field, phytogeography plays an important role, as we can already consider climate change as a non-negligible ecological stressor for the biosphere, and Slovenia is no exception.

Slovenia is a densely forested country with relatively high forest vegetation diversity (Bončina et al., 2021; Kutnar, Kobler, Bergant, 2009). This should not be taken for granted, as climate change is also expected to alter the site conditions of Slovenian forests. These potential changes can be assessed through ecological niche modelling. The main objective of this study was to develop a methodology to investigate the potential impacts of climate change on Slovenian forests in the period between 2081 and 2100 using Maxent software based on maximum entropy principles (Phillips, Dudik, Schapire, 2004).

Following the latest IPCC report from 2021, we used 2 of 5 climate scenarios called Shared Socioeconomic Pathways (SSP), which are the successors to the RCP climate scenarios (Lee et al., 2021). They are named after the estimated effective radiative forcing at the end of the 21st century (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5) and predict the increase in global average temperatures between 1.5 and 4.8° C compared to the period 1850–1900. The first scenario we chose SSP was SSP1-2.6. If realised, it is expected to increase global average temperature by 2.0° C (1.3–2.8° C) compared to the period 1850–1900 (Lee et al., 2021). This scenario is the most optimistic and at the same time the most realistic. It was chosen because we believe that society can achieve this goal by responding responsibly and collectively to this challenge, while SSP1-1.9, which is a goal of the Paris Agreement to limit the mean global temperature increase to 1.5° C, is no longer realistic (Forster et al., 2021). The second

SSP scenario chosen was SSP5-8.5, which, if realised, is expected to increase global mean temperature by 4.8° C (3.6–6.5° C) compared to the 1850-1900 period (Lee et al., 2021). Although today's trends indicate that we are unlikely to follow this destructive fossil fuel-based path of future development, we chose this scenario to find out how total climate deterioration could affect Slovenian forests.

We have obtained future climate data based on selected scenarios for 3 different Earth System Models (ESM). They were developed during the recent CMIP6 phase of climate model development. The first ESM, named CNRM-ESM2-1, was developed by CNRM – CERFACS, one of the European working groups (Séférian et al., 2019). The second ESM, named BCC-CSM2- MR, was developed by one of the Chinese groups (Wu et al., 2019). The results of this model have already proven useful for Maxent modelling in southern Europe, including Slovenia (Jamal et al., 2021). Kuralt (2016) also used the previous version of this model (BCC-CSM1-1 from CMIP5) for Maxent modelling of the potential distribution of the Mediterranean black widow (*Latrodectus tredecimguttatus*) in Slovenia. The third model we have chosen is called MIROC6. It was developed by the Japanese working group and is said to be one of the models that are well suited for predicting climate extremes in Europe (Fernandez-Granja in sod., 2021).

The Maxent software was introduced in 2004 (Phillips, Dudik, Schapire, 2004). It is freely available on the internet and is widely used for modelling ecological niches (Web of Science, 2022). The software requires 3 basic data sets for ecological niche modelling: species sample data, raster environmental layers (covariates) and future data for the same environmental layers. It is also advisable to include the bias file in the modelling process. For the species sample data, we divided the Slovenian forest areas into 13 forest vegetation types (Kutnar, Kobler, Bergant, 2009) and created random points. We used the following environmental criteria for the raster environmental layers and future data for the same environmental layers: soil pH, topographic wetness index (TWI), Euclidean distance to water bodies and 19 bioclimatic variables. We created all layers using GIS. The bioclimatic variables were downloaded from the WorldClim portal (Fick, Hijmans, 2017). We could not use these variables directly as they were available at a resolution of 2.5 arcmin, which was not suitable for our case as a more detailed data resolution was required. Therefore, we used several methodological approaches to improve the raster cell resolution to 500 m. We had adopted a combination of methods from Ninyerola, Ponsa in Roura (2000; 2007), Poggio, Simonetti and Gimona (2018) and then adapted them to Slovenian conditions. We also included bias files in our methodology. We created them using the Python-based SDMtoolbox library within ArcGIS Pro 2.9.0 (Brown, 2014). The methodology used is called Sample by Buffered MCP.

The basic output data can be divided into a statistical and a spatial part. In the statistical part, the two main output diagrams are "omission and predicted area" and "sensitivity vs. 1-specificity". The second diagram shows ROC curves and AUC values.

AUC values Quality of results. After testing the methodology for all 13 forest vegetation types, we obtained excellent results for 4 of them (AUC > 0.90), good results for 6 of them (0.90 > AUC > 0.80) and satisfactory results for 3 of them (0.80 > AUC > 0.70). This shows that our methodology was developed appropriately. The separate spatial output results had to be additionally merged into one data set and generalised for visualisation.

(Translated by the authors)

Matjaž Uršič*

PREDNOSTI IN SLABOSTI AVTOMOBILIZMA KOT TEMELJA TURISTIČNEGA RAZVOJA SLOVENIJE

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Izvleček

V članku so analizirane prednosti in slabosti, ki izhajajo iz uporabe avtomobilskega prevoza v turizmu. Pri tem je posebna pozornost namenjena analizi problemov odvisnosti turizma od avtomobilskega prometa. Predstavljeni so dejavniki, ki potencialno zavirajo razvoj novih oblik turistične ponudbe, ki bi temeljila na bolj trajnostni rabi potencialov Slovenije kot zelene destinacije. Analiza temelji na uporabi vrste podatkov iz uradnih statistik (SURS, Eurostat, Direkcija RS za infrastrukturo), ki jih dopolnjujejo podatki in ugotovitve iz drugih raziskav s področja prometa in turizma. Pomemben del analize predstavlja tudi analiza vrednotnih orientacij prebivalstva Slovenije v odnosu na percepcijo vloge turizma in prometa.

Ključne besede: turizem, avtomobilija, utemeljevalna teorija, strategija razvoja turizma, zelena destinacija, vrednotni sistemi

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THE ADVANTAGES AND DISADVANTAGES OF AUTOMOBILE TRANSPORT AS THE FOUNDATION OF TOURISM DEVELOPMENT IN SLOVENIA

Abstract

The article analyzes the advantages and disadvantages arising from the use of car transport in tourism. Special attention is paid to the analysis of problematic interdependence between tourism and automobile traffic. Presented are factors that potentially obstruct the development of new forms of tourism offer that would be based on a more sustainable use of Slovenia's potentials as a green destination. The article is based on the use of a range of data from official statistics (SURS, Eurostat, Directorate of Infrastructure of the Republic of Slovenia), supplemented by data and findings from other research in the field of transport and tourism. An important part of the article also represents the analysis of value orientations of the population of Slovenia in relation to the perception of the role of tourism and transport.

Keywords: tourism, automobility, grounded theory, tourism development strategy, green destination, value systems

1 UVOD

Po hitrem naraščanju števila turistov v predkovidnem obdobju in po sprostitvi večine epidemioloških ukrepov v Sloveniji se ponovno odpira vrsta vprašanj glede nadaljnjih strategij turističnega razvoja Slovenije. Pri tem se poleg tipičnih razvojno-strateških vprašanj, ki se tičejo promocije destinacij, oblikovanja ponudbe nastanitvenih kapacitet, servisov, podpore različnim vrstam turizma in hotelske infrastrukture, vse bolj odpirajo tudi problematike, povezane s trajnostnim razvojem turizma (glej npr. Cigale, 2009; Jurinčič, 2009; 2014; Vodeb, 2014). Promocija Slovenije kot zelene destinacije, ki naj bi vključevala pestro ponudbo naravnih površin, parkov in drugih naravnih danosti, namreč odpira vrsto problematik, povezanih prav z degradacijo zelenega sistema kot posledico množičnega turizma. V tem kontekstu se pogosto pojavljajo tematike, povezane z onesnaževanjem, predelavo odpadkov, porabo vode, rabo prostora in drugimi okoljskimi problemi, vezanimi na turistične destinacije (glej npr. Butler, 1991; Brancelj, 1999; Cigale, 2007; Holden, 2016; Repe, Mrak, 2009; Theobald, 2012). V precej manjši meri se v navezavi na trajnostni razvoj pojavljajo tematike in problematike, povezane s turistično mobilnostjo oziroma načini, na katere turisti dostopajo do zelenih destinacij v Sloveniji (glej npr. Cigale in sod., 2009).

Turistična mobilnost v Sloveniji temelji na avtomobilskem prevozu, kar prinaša določene prednosti in slabosti v turistični razvoj. Če omenimo samo nekatere, potem velja poudariti, da po eni strani avtomobilski razvoj omogoča 24-urno dostopnost destinacij in visoko omreženost težko dostopnih turističnih lokacij v Sloveniji, po drugi strani pa pretirana raba avtomobilskega prevoza sproža preobremenjenost posameznih lokacij, zastoje in probleme s parkirnimi površinami. V članku bomo analizirali vrsto prednosti in slabosti, ki so vezane na uporabo avtomobilskega prevoza v turizmu, in jih poskušali postaviti v vzročna razmerja. Pri tem bomo še posebno pozornost namenili analizi odvisnosti turizma od avtomobilskega prometa, ki morebiti zavira razvoj novih oblik turizma in ponudbe, ki bi temeljila na bolj trajnostni rabi potencialov Slovenije kot zelene destinacije. V ta namen bo analizirana vrsta podatkov iz uradnih statistik (SURS, Eurostat, Direkcija RS za infrastrukturo), ki jih bomo kombinirali s podatki iz različnih raziskav (Cigale in sod., 2009; Vodeb, 2014). V pojasnjevalno strukturo članka so vključene tudi analize vrednotnih orientacij prebivalstva Slovenije (Hočevar in sod., 2018; Uršič, Hočevar, 2007), prek katerih bomo skušali prikazati kompleksnost in večplastnost problematike, ki se veže na turistično mobilnost in turistični razvoj Slovenije.

2 AVTOMOBILIJA IN RAZVOJ TURIZMA

V strategijah turističnega razvoja Slovenije (MGRT, 2017; MGRT, PKF, 2022) je promet pogosto predstavljen kot pomemben del načrtov turističnega razvoja. Tako je na primer v Strategiji slovenskega turizma 2022–2028 (MGRT, PKF, 2022) pod politiko 5 »Dostopnost in trajnostna mobilnost« identificirana vrsta problematik, ki se vežejo na pretirano rabo avtomobilskega prometa. Med drugim so omenjene: emisije, ki izvirajo iz uporabe fosilnih goriv, mirujoči promet, tranzitnost turistov, zamude pri razvoju kolektivnih javnih prevoznih sredstev in prometnih strategij ipd. V tem sklopu je predvidena tudi vrsta ukrepov, ki naj bi pripomogli k zmanjševanju odvisnosti turizma od avtomobilskega prevoza. Predlagani ukrepi na primer vključujejo »pilotno uvajanje turističnih destinacij brez avtomobilov«, »spodbude razvoja kolesarske in pohodniške čezmejne infrastrukture«, »zasnovo modela maksimiranja pozitivnih učinkov '*pit stop*' turistov«, »sofinanciranje izdelave celostnih prometnih strategij v vodilnih turističnih destinacijah in mobilnostnih načrtov turističnih podjetij«, »spodbujanje razvoja sistemov t. i. '*P+Feel*' za dostop do najbolj obremenjenih turističnih točk – destinacij in na območju naravnih vrednot«, »vzpostavljanje novih oblik mobilnosti v turističnih destinacijah«, »integrirani JPP za potrebe turizma«, »pospeševanje e-mobilnosti« ipd. (MGRT, PKF, 2022, str. 193–200). Obsežno navajanje ukrepov obsega tudi relativno definirano finančno shemo, ki naj bi bila namenjena tovrstnim aktivnostim (skupno približno 60 mio EUR) (glej MGRT, PKF, 2022, str. 286–287). Kljub identifikaciji problematike odvisnosti turizma od uporabe

avtomobilskega prevoza in predlagani vrsti ukrepov, se zdi da je način implementacije tovrstnih strategij relativno nedodelan in nerazdelan, saj je uporaba avtomobilskega prevoza v Sloveniji bistveno bolj zakoreninjena v mobilnostne sheme prebivalcev in temelji na kompleksnih vrednotnih orientacijah, ki posredno usmerjajo tudi razvoj turistične panoge in jih bo težko preseči v kratkem obdobju brez odločnejših in korenitih posegov v obstoječe življenjske stile uporabnikov avtomobilov.

Urry (1999, str. 1) s tega vidika razlikuje med »avtomobilizacijo« in »avtomobilijo«. Prva se nanaša na delež naraščanja avtomobilov glede na število prebivalstva, medtem ko druga označuje nastanek družbenih vzorcev vedenja, ki so utemeljeni na povečani rabi avtomobilskega prevoza. Urry (ibid.) navaja, da je avtomobilija popolnoma preoblikovala civilno družbo z vključevanjem novih oblik premikanja, bivanja, socializacije in novimi prostorsko-časovnimi dimenzijami avtomobilske dostopnosti. Urry (ibid.) tiste civilne družbe, ki so odvisne od uporabe avtomobilskega prevoza, poimenuje »družbe avtomobilije«. Med le-te z enim višjih števil avtomobilov na prebivalca v EU (0,566) in nizko uporabo javnih prevoznih sredstev (5–7 % v obdobju 2017–2021) nedvomno spada tudi Slovenija (glej Eurostat, 2020; SURS, 2020). Avtomobilija spreminja način gibanja in pomembnost posameznih lokacij ter sproža nastanek novih družbenih prostorov, ki zgoščujejo tokove ljudi ob ključnih prometnih infrastrukturah, tj. cestah in avtocestah. Urry (ibid.) ugotavlja, da večina tistega, kar ljudje poznajo pod pojmom »družbenega življenja«, niti ne bi mogla obstajati brez fleksibilnosti avtomobila in njegove 24-urne dostopnosti. Uporaba avtomobila posamezniku omogoča večje možnosti pri gibanju v prostoru in mu prepusti samostojno odločanje o potovalnem času. Avtomobilija posameznikom predstavlja hkrati izvor svobode in povezanosti s širšo skupnostjo (Featherstone, 2004). Fleksibilnost avtomobila omogoča vozniku hitro potovanje ob katerem koli času in v katerokoli smer ali lokacijo, ki leži na prepletenih sistemih cestnih in avtocestnih povezav, ki povezujejo dom, delovni prostor in turistične oziroma kulturne, zabavne, prostočasne lokacije (Lucas, 2009).

Povečevano uporabo avtomobila torej po eni strani lahko razumemo kot »povečevanje stopnje svobode gibanja« za posameznika (Urry, 1999, str. 12–14), ki mu je s tem omogočena večja fleksibilnost v vsakdanjem življenju. Vendar Urry ob tem simptomatično opozarja, da gre v primeru avtomobilije pravzaprav za lažno fleksibilnost oziroma »prisiljeno fleksibilnost« (ibid.), in sicer v smislu, da avtu prilagojeni deli prostorskega sistema, ki jih avtomobilija generira, povzročajo tudi fragmentacijo prostora oziroma naraščanje ločene rabe površin v prostorskem sistemu. V tem kontekstu ni nujno, da množična (avto)mobilnost povzroča tudi enakomeren razvoj vseh prostorov in krajev. Avtomobil namreč spada med tehnologije, ki spodbujajo t. i. »časovno-prostorsko distanciacijo« (Giddens, 1984, str. 171; Hočevar, 2017, str. 831) oziroma omogočajo ločevanje socialnih interakcij od materialne, fizične navzočnosti, kar hkrati povečuje razdalje med posameznimi, za uporabnika pomembnimi točkami v prostorskem sistemu. Z drugimi besedami, pogosta uporaba ali velika odvisnost od avtomobilskega prevoza uporabnika spodbuja k uporabi selektivnih (rutiniziranih)

mobilnostnih vzorcev in k selektivni rabi posameznih lokacij za določene storitve, pri čemer se lahko povečujejo neenakosti v prostoru. Pri tem lahko izginja multifunkcionalen značaj posameznih prostorov in krajev, kar pomeni da se turistična ponudba specializira za specifične oblike ponudbe dejavnosti in storitev. Kombinacija slabo razvitega javnega prevoza in slabe izrabe dostopnih kolektivnih prevoznih sredstev ob povečani uporabi avtomobilskega prevoza torej povzroča oblikovanje zelo specifičnih rab prostora in homogenih časovno-prostorskih poti ter rutin. Z navedenim fenomenom se povezuje tudi koncept »kapsularnosti« (Cauter, 2004, str. 10), ki opozarja, kako lahko prevozno sredstvo prek spodbujanja določenih vzorcev socializacije vpliva na način rabe posameznih prostorov.

Koncepta dostopnosti in mobilnosti sta ključnega pomena za razumevanje vplivov, ki jih ima avtomobilija na razvoj prostorskega sistema Slovenije in posledično tudi turizma. Dostopnost se nanaša na »število priložnosti ali prizorišč dejavnosti, ki so dostopna v določeni razdalji ali času potovanja« (Handy, Niemeier, 1997, str. 1175–1194), mobilnost pa se nanaša na »zmožnost premikanja med različnimi prizorišči, kjer se odvijajo dejavnosti« (ibid.). Prostorski sistem z razvito avtomobilsko prometno infrastrukturo omogoča večjo stopnjo mobilnosti prebivalstva, vendar ima lahko zaradi ustaljenih, rutiniziranih, udobnih, a funkcionalno rigidnih načinov uporabe teh omrežij tudi manj prožno časovno-prostorsko omrežje, ki posamezniku zmanjšuje dostopnost in uporabnost posameznih prizorišč in dejavnosti po principu »povečana dostopnost prostorov – povečane motnje v prostoru«. Z drugimi besedami, če skladno s povečevanjem avtomobilske dostopnosti ne rešujemo tudi problemov, ki jih tovrstna povečana dostopnost prinaša, se problemi akumulirajo in povzročajo motnje v prostoru, ki se zrcalijo v gneči, zastojih, mirujočem prometu, onesnaževanju ipd.

Ko je v Sloveniji dostopnost do storitev postala bolj odvisna od uporabe avtomobila, so se temu prilagodili tudi uporabniki, ki iščejo storitve z najlažjim, najbolj udobnim načinom dostopa. Pri tem velja poudariti, da gre v razmerju med uporabo avtomobila in naraščanjem specifične rabe površin v prostorskem sistemu za dvostranski vzajemni proces. Potreba po uporabi avtomobila ni le posledica naraščanja specifične (na avtu utemeljene) rabe prostorov v prostorskem sistemu, temveč je obenem tudi vzrok naraščanja specifične rabe površin in izginjanja določene ponudbe storitev na posameznih mikrolokacijah, ki niso dostopne z avtomobilom.

Popolna prilagoditev oziroma soodvisnost uporabe cestnega omrežja in ekonomsko-turistične ponudbe ustvarja določene eksternalije oziroma dodatne stroške, ki niso vidni takoj, ampak šele skozi daljša, večletna obdobja. Kako sistemi, ki imajo enostransko razvito prometno infrastrukturo, ustvarjajo eksternalije, podrobneje pojasnjujejo Pucher, Lefèvre (1996), Newman, Kenworthy (1989; 1999) in Jacobs (1994). Omenjeni avtorji opozarjajo, da večina analiz v izračun koristi in stroškov uporabe infrastrukture ne vključuje latentnih stroškov oziroma eksternalij, ki se ne odražajo v ekonomski ceni dobrine ali storitve, vendar dolgoročno lahko bistveno vplivajo na blagostanje celotne skupnosti. Eksternalije nastajajo postopno in jih je mogoče opaziti

šele takrat, ko so njihovi vplivi tako močni, da prihaja do poslabšanja kakovosti življenja na določenih območjih. V primeru Slovenije že lahko razpoznamo nekatere stranske učinke, ki jih povzročata pretirana avtomobilizacija in nerazvitost javnih prevoznih sistemov. Te učinke je zaenkrat možno identificirati na lokalni ravni prek avtomobilske preobremenjenosti nekaterih turističnih območij (npr. Bled, Bohinj, slovenska Istra ipd.), ki generirajo probleme, povezane s pomanjkanjem parkirišč, zastoji, gnečo in onesnaževanjem, medtem ko so problemi, povezani s potencialno dolgoročno neenakomernim ekonomskim razvojem celotnega prostorskega sistema Slovenije, še težje razpoznavni in jim je v analizah namenjene manj pozornosti.

V nadaljevanju bomo na primeru podrobne analize učinkov, ki jih je imela izgradnja avtomobilske infrastrukture na razvoj turizma v Sloveniji, prikazali kako lahko dominantnost razvoja avtomobilske prometne infrastrukture sicer zadovolji osnovne potrebe turistov in prebivalcev po mobilnosti, vendar ob tem lahko povzroča tudi določene škodljive učinke za družbeno-prostorski razvoj posameznih območij. Razvoj in povezovanje prostorskega sistema prek prometnih infrastrukturnih omrežij je socio-tehnični postopek, ki združuje »mehke« (družbene, psihološke, kvalitativne) in »trde« (fizične, kvantitativne) dejavnike in pri katerem se je treba vprašati, kako uvajanje novih prometnih infrastruktur spreminja potrebe in navade uporabnikov.

3 ANALIZA UČINKOV VPETOSTI TURISTIČNE PANOGE V UPORABO AVTOMOBILSKEGA PREVOZA

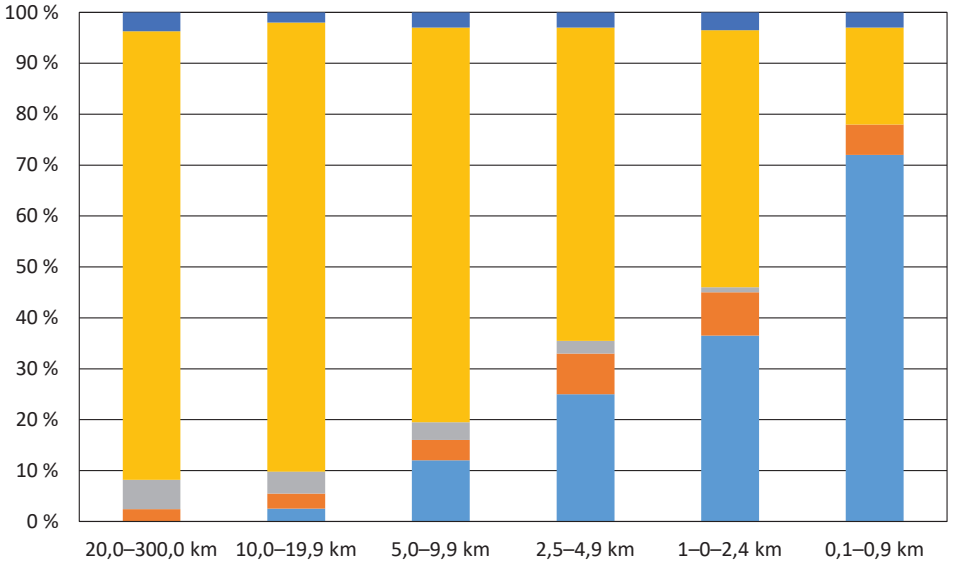
Analiza prednosti in slabosti odvisnosti turistične panoge od avtomobilskega prevoza v Sloveniji temelji na t. i. utemeljevalni teoriji (Strauss, Corbin, 1998; Thomas, James, 2006), kjer se različne podatke iz kvantitativnih in kvalitativnih raziskav združuje z namenom dokazovanja oziroma pojasnjevanja specifičnih družbenih trendov. Utemeljevalna teorija (v ang. *grounded theory approach*) je primerna metoda za analizo, kjer je na voljo veliko število zelo razpršenih in izvorno različnih raziskovalnih podatkov, ki pokrivajo posamezne fragmente analizirane problematike. Iz analize bodisi primarnih ali sekundarnih podatkov pridobiva fragmente novega znanja, pri čemer raziskava ne poteka po načinu preverjanja neke vnaprej postavljene, točno določene hipoteze (ki bi jo lahko preverjali), temveč na način postopne izdelave teorije, prek katere se pojasnjuje družbene in prostorske spremembe v kontekstu turističnega razvoja Slovenije. Gre torej za strategijo razločanja raziskovalnih podatkov, kjer se po induktivni poti, od spodaj navzgor, prek nabora pomembnih faktorjev oziroma indikatorjev prostorskega razvoja in analize posameznih dejavnikov, značilnosti prostorskega razvoja, prehaja k splošnejši sliki trenutnih trendov, ki vplivajo na prostorski razvoj turizma v Sloveniji. Na podlagi utemeljevalne teorije je potekal tudi izbor podatkov, ki so zajeti skozi daljše časovno obdobje med leti 2009 in 2022. Prav akumulacija podatkov skozi daljše časovno obdobje je omogočila postopno identifikacijo posameznih

trendov, povezanih z rabo prometa in razvojem turizma, ki so v Sloveniji prisotni že več desetletij in kažejo na njihovo sistemsko ukoreninjenost. Pri tem so bili uporabljeni sekundarni podatki iz že obstoječih raziskav (npr. Okoljski učinki turizma in prometa v Sloveniji, Prostorske in okoljske vrednote 2004–2018, Trajnostni razvoj turističnih destinacij alpsko-jadranskega prostora, Nosilna zmogljivost Slovenske Istre za turizem, Socialno prostorski vplivi avtocest v Sloveniji – Slovensko javno mnenje o avtocestah) in uradnih statistik (npr. SURS, Direkcija RS za infrastrukturo, Eurostat).

3.1 Ključni dejavniki spodbujanja uporabe avtomobilskega prevoza v turizmu

V Sloveniji ne moremo govoriti o tipičnem »avtomobilskem turizmu«, kot ga omenjajo posamezni avtorji s tega področja (glej npr. Conlin, Jolliffe, 2022; Cudny, 2018; Cudny, Jolliffe, 2019), kjer prihaja do državno podprte načrtne oziroma strateško-razvojne gradnje infrastrukture, s katero se skuša povečevati delež turizma, ki temelji na uporabi avtomobilskega prevoza (npr. avtomobilski hoteli, karavaning, avtomobilska izkustvena industrija v smislu tematskih poti, avtomobilskih dirk, specializiranih avtomobilskih muzejev in razstav ipd.). V kontekstu Slovenije prihaja do spontanega razvoja avtomobilskega turizma, kjer posamezni segmenti turistov opažajo, da uporaba avtomobila predstavlja najudobnejši, najlažji in včasih tudi edini način obiskovanja slovenskih turističnih destinacij. Temu spontanemu razvoju avtomobilskega turizma se potem prilagajajo ne le posamezni ponudniki turističnih storitev na lokalni ravni, temveč tudi lokalne oblasti, ki sicer poskušajo v manjših obsegih uveljavljati bolj trajnostne oblike mobilnosti (npr. izposoja e-koles, *hop-on hop-off* avtobusi, pešpoti), vendar z nadgradnjo obstoječe cestne infrastrukture spontano spodbujajo nadaljnjo uporabo avtomobila in ohranjajo obstoječe trende avtomobilije. Kako prevladujoča je uporaba avtomobilskega prevoza, je razvidno iz podatkov o prometni obremenjenosti slovenskih cest, kjer avtomobilski promet zavzema največji delež motoriziranega prometa (glej npr. Direkcija RS za infrastrukturo, 2020) in podatkov, ki pojasnjujejo uporabo posameznih vrst prevoza glede na dolžino potovanj (slika 1).

Slika 1: Potovanja glede na način prevoza in dolžino potovanj v Sloveniji.



Vir: SURS, 2021.

Obremenjenost slovenskih cest je glede na število prebivalstva velika in na posameznih odsekih presega 50.000 vozil na dan (npr. ljubljanski avtocestni obroč). Ob tem ostaja delež cestnega blagovnega prevoza v skupnem kopenskem blagovnem prevozu v zadnjem desetletju relativno nespremenjen in v letu 2018 dosega že več kot 81 % vsega blagovnega prevoza po Sloveniji (SURS, 2022). Iz podatkov na sliki 1 je razvidno, da prebivalci Slovenije na razdaljah nad 10 km več kot 90 % poti opravijo z avtomobilskim prevozom, sorazmerno veliki pa so tudi deleži pri krajših razdaljah, saj na razdaljah med 1 in 2,4 km več kot 50 % posameznikov še vedno preferira avtomobilski prevoz, v kategoriji med 5 in 9,9 km pa je ta odstotek še precej višji (več kot 75 %). Po deležu opravljenih poti z osebnimi vozili smo bili s 93,1 % leta 2006 prvi med vsemi evropskimi državami, medtem ko je povprečje EU27 znašalo 82,3 % (Lampič, Ogrin, 2009, str. 23). V letu 2020 je ta delež znašal 91,2 %, pri čemer smo med 27 državami EU zasedali tretje mesto (EC, 2022, str. 49). Prevladujočim shemam mobilnosti v državi se prilagajajo tudi turisti iz drugih držav, kar potrjujejo podatki o uporabi prevoznih sredstev glede na državo izvora v letu 2019 (preglednica 1).

Preglednica 1: Tuji turisti po državah prebivališča in glavnih prevoznih sredstvih po izbranih dvomesečjih anketiranja v letu 2019.

Izbrano dvomesečno obdobje	Vrsta prevoznega sredstva	Izbrane države				
		Avstrija	Italija	Nemčija	Druge evropske države	Neevropske države
April, maj	Avto, kombi	41.668	57.022	17.657	81.801	–
	Avtodom	–	N	N	N	–
	Avtobus	5.353	3.921	8.858	16.431	–
	Motorno kolo	1.169	2.995	N	N	–
	Kolo	–	N	N	N	–
	Letalo	3.282	1.391	6.224	58.278	122.883
	Vlak	N	N	N	2.274	–
Julij, avgust	Avto, kombi	46.792	79.084	86.885	318.441	N
	Avtodom	4.931	6.363	33.108	35.752	–
	Avtobus	2.863	5.326	3.560	10.682	–
	Motorno kolo	2.219	4.567	3.997	6.765	–
	Kolo	N	N	N	6.700	–
	Letalo	N	1.037	8.148	77.437	120.722
	Vlak	993	N	5.775	4.198	–
	Ladja	–	N	–	–	–
	Drugo	–	–	N	N	–
September, oktober	Avto, kombi	42.186	46.582	30.108	95.273	–
	Avtodom	N	N	N	–	–
	Avtobus	4.821	1.283	9.811	20.539	–
	Motorno kolo	2.906	1.332	3.165	2.800	–
	Kolo	N	–	N	–	–
	Letalo	–	1.279	3.908	50.473	134.222
	Vlak	–	N	814	1.367	–
December, januar	Avto, kombi	29.264	63.941	6.746	88.014	–
	Avtodom	N	N	–	666	–
	Avtobus	4.321	3.788	2.147	5.347	–
	Motorno kolo	–	–	N	N	–
	Kolo	–	–	–	–	–
	Letalo	N	2.349	1.630	25.067	33.020
	Vlak	N	1.296	N	N	–

Opomba: N – za objavo premalo zanesljiva ocena.
Vir: SURS, 2021.

Avto je prevladujoča oblika prevoza v vseh dvomesečjih, pri čemer še posebej izstopata dvomesečji julij–avgust (čas poletnih dopustov in počitnic) ter september–oktober (vremensko in časovno še vedno ugodna obdobja za potencialna turistična potovanja), kjer je delež avtomobila v odnosu na ostala prevozna sredstva še večji. Na primer 78 % turistov iz Italije je v tem obdobju uporabilo avtomobilski prevoz, če k temu prištejemo še približno 6 % uporabljenih avtodomov, je ta delež prek 84 %. Podobna razmerja se pokažejo tudi v primeru Nemčije in Avstrije. Avto torej močno izstopa kot primarno prevozno sredstvo pri tujih turistih in predstavlja osnovno obliko mobilnosti po državi. Podobne rezultate prikaže analiza rezultatov turističnih potovanj domačih turistov po prevoznih sredstvih, ki kaže, da prebivalci Slovenije tako za turistično pot v tujino kot po Sloveniji izrazito preferirajo avtomobilski prevoz (preglednica 2).

Preglednica 2: Turistična potovanja (v 1000) po destinaciji potovanja in po glavnem prevoznem sredstvu v obdobju 2018–2020, domači turisti.

Izbrano območje	Vrsta prevoznega sredstva	Izbrano obdobje		
		2018	2019	2020
Slovenija	**Osebno cestno motorno vozilo**	1.907	1.657	1.219
	Avtobus	72 M	71 M	N
	Vlak	N	N	N
	Letalo	–	–	–
	Drugo	N	N	N
Tujina	**Osebno cestno motorno vozilo**	2.486	2.363	1.000
	Avtobus	216	234	N
	Vlak	42 M	N	N
	Letalo	427	528	78 M
	Drugo	N	N	N

Opomba: M – manj zanesljiva ocena – previdna uporaba; N – za objavo premalo zanesljiva ocena.
Vir: SURS, 2021.

Ko gre za turistična potovanja po Sloveniji, je bil v predkovidnem letu 2018 pri državljanih avto približno 26-krat pogostejši način prevoza od katerihkoli drugih oblik prevoza. V primeru, da so se odpravili iz Slovenije na turistično potovanje v tujino, pa je bil avto v letu 2018 približno 11-krat pogostejša oblika prevoza v primerjavi z drugimi oblikami mobilnosti. Navedeni podatki odslikavajo globino trendov avtomobilije, v katero je zakoreninjen slovenski sistem mobilnosti. Pri tem je treba izpostaviti, da je slovenski sistem mobilnosti za razliko od nekaterih drugih držav v bistveno večji

meri odvisen od avtomobilskega prevoza kot pa drugih oblik mobilnosti (glej npr. deleže opravljenih poti z osebnimi vozili v 2020; EC, 2022). Odvisnost od uporabe avtomobilskega prevoza se jasno izrisuje tudi pri analizi vrednotnih sistemov, ki so povezani z razvojem turizma in mobilnostjo. V raziskavi Vrednote prostora in okolja (Hočevar in sod., 2018) je ob primerjavi podatkov med leti 2004 in 2018 opazno, da se je v Sloveniji delež posameznikov, ki jih obstoječi sistem mobilnosti zelo moti, zmanjšal (preglednica 3).

Preglednica 3: Odgovori anketirancev na vprašanje: »Ocenite, v kolikšni meri vas v vašem bivalnem okolju moti gost promet?«

	Sploh me ne moti	**Deloma me moti**	**Moti me**	**Zelo me moti**	**Ne vem, brez odgovora**
2004	31,24 %	21,59 %	27,66 %	18,51 %	1,00 %
2018	23,30 %	40,78 %	26,55 %	8,98 %	0,38 %

Vir: Hočevar in sod., 2018.

Kljub povečanju deleža v kategoriji »deloma me moti« je opazen premik posameznikov od bolj ekstremne odklonilne pozicije k manj odklonilni poziciji oziroma omilitvi negativnega odnosa do gostote prometa in povečanje stopnje tolerantnosti do le-tega. Odgovori na vprašanje »za katere namene bi bilo po vašem mnenju potrebno nameniti več prostora v Sloveniji nasploh in posebej v vašem kraju« pa kažejo, da kategoriji 'turizem' in 'ceste' za anketirance predstavljata pomembna bodoča razvojna dejavnika Slovenije (preglednica 4).

Iz preglednice 4 je razvidno, da turizem predstavlja pomembno razvojno dimenzijo za prebivalce Slovenije tako na državni kot lokalni ravni. Kategorija turizem v letu 2018 (ibid.) z deležem približno 45 % anketirancev zaseda zelo visoko tretje mesto med 13 kategorijami, na ravni kraja z 42 % anketirancev pa celo drugo mesto (takoj za kategorijo rekreacija, šport). Kategorija ceste na ravni Slovenije z deležem 29 % zaseda sedmo mesto, na ravni kraja pa visoko tretje mesto z deležem 38 %. Velik pomen turizma in cestne infrastrukture v smislu percepcije razvojnih potencialov s strani vprašanih ne preseneča. Percepcija povezanosti med razvojem turizma in razvojem cestne infrastrukture se še bolj nazorno kaže pri nadaljnji analizi, kjer smo podatke o pomembnosti kategorij križali z nekaterimi trditvami v vprašalniku. Izkazalo se je, da 54 % vprašanih, ki podpirajo trditev »stara mestna jedra bi morali zapreti za avtomobilski promet«, hkrati tudi meni, da bi cestam morali nameniti več prostora v Sloveniji, na ravni kraja pa ta številka znaša kar 69 %. Delež tistih, ki podpirajo gradnjo lokalnih cest in hkrati menijo, da bi bilo treba zapirati stara mestna jedra za avtomobilski promet, je torej na lokalni ravni izrazito velik.

Preglednica 4: Odgovori anketirancev na vprašanje: »Za katere namene bi bilo po vašem mnenju potrebno nameniti več prostora v Sloveniji nasploh in posebej v vašem kraju?«

Rang	Kategorije za območje Slovenije	Delež
1	Rekreacija, šport	47,76 %
2	Kmetijske površine	46,90 %
3	**Turizem**	**45,27 %**
4	Industrija	42,98 %
5	Stanovanja	42,79 %
6	Zaščitena naravna območja	38,78 %
7	Visoko-tehnološki in razvojni parki	29,80 %
8	**Ceste**	**29,42 %**
9	**Parkirišča**	**24,16 %**
10	Obrtniške cone	21,20 %
11	Prostori umetnosti in kulture	15,19 %
12	Lokalne trgovine	16,14 %
13	Veliki nakupovalni centri	3,25 %

Rang	Kategorije za območje kraja (lokalno območje)	Delež
1	Rekreacija, šport	51,58 %
2	**Turizem**	**42,22 %**
3	**Ceste**	**38,11 %**
4	Stanovanja	33,91 %
5	Kmetijske površine	32,28 %
6	Zaščitena naravna območja	31,81 %
7	Lokalne trgovine	27,22 %
8	**Parkirišča**	**21,59 %**
9	Industrija	21,01 %
10	Prostori umetnosti in kulture	16,71 %
11	Obrtniške cone	16,62 %
12	Visoko-tehnološki in razvojni parki	15,19 %
13	Veliki nakupovalni centri	3,92 %

Vir: Hočevar in sod., 2018.

Podatki potrjujejo domneve, da sta v Sloveniji turizem in avtomobilski promet močno povezana. Visoko stopnjo tolerance do uporabe avtomobila in gostote prometa ob hkratnem zaznavanju pomena turizma lahko povezujemo z analizo koristi in stroškov (glej Uršič, 2012). Pri ocenjevanju najprimernejšega prevoznega sredstva v lokalnem okolju posamezniki napravijo lastno lestvico prednostnih nalog, ki jo uveljavljajo med postopkom odločanja. Opirajo se na individualizirano analizo koristi in stroškov in se odločijo za nasprotovanje spremembam mobilnostnih vzorcev takrat, ko se jim zazdi, da bi jim brezkompromisno sprejemanje novosti prineslo trenutno prevelike ali pa nepotrebne stroške. Analiza koristi in stroškov temelji na izločanju (v ang. *tappering*) manj primerne prometne infrastrukture (ponudbe prevoznih storitev), ki je na voljo za turistične poti ali vsakodnevne poti na delo, v šolo, trgovino ipd. Uporabniki pri tem strogo ocenjujejo vse mogoče značilnosti infrastruktur, ki jim lahko prinašajo bodisi koristi ali izgubo, merjene tako v denarju kot porabljenem času, udobju, psihološkem naporu ipd. Zasnova individualne analize koristi in stroškov je pomemben mehanizem,

ki pojasnjuje posameznikovo na videz nesmotrno ali nerazumno delovanje. Učinki, ki jih sproža avtomobilija (npr. onesnaževanje zraka, problematika uporabe površin za parkiranje, gradnja dodatnih cest v mestnem središču, prometni zastoji ipd.), so za posameznika, ki aktivno zagovarja vidike trajnostnega razvoja prometa, dolgoročno morda nerazumno delovanje. Kljub temu pa so z vidika vrednotno zasnovane, kratkoročne subjektivne analize koristi in stroškov povprečnega udeleženca v prometu učinki avtomobilije lahko popolnoma razumno in upravičeno dejanje, saj uporaba avtomobila prinaša manjše stroške (v času, denarju in naporu) glede na druga prevozna sredstva in za posameznika predstavlja najugodnejše prevozno sredstvo.

Negativnih učinkov turizma, ki temelji na avtomobilskem prevozu, ne občutijo vsi enako, kar omogoča prerazporejanje oziroma razpršitev odgovornosti na veliko število ljudi in na videz manj opazne škodljive učinke, ki se ne akumulirajo enako pri vseh skupinah uporabnikov prostora (preglednica 5).

Preglednica 5: Mnenje domačinov in turistov o intenziteti vplivov turizma v izbranih turističnih krajih v letu 2006.

Intenzivnost vpliva (v %)	**Majhni**		**Srednji**		**Velik**	
Deležniki	Domačini	Turisti	Domačini	Turisti	Domačini	Turisti
Večja gneča zaradi številnih obiskovalcev	33,0	30,3	35,1	43,7	31,9	26,1
Boljša urejenost kraja	21,7	18,3	39,9	39,3	38,5	42,4
Izguba tradicionalne arhitekturne podobe kraja	50,7	46,9	31,7	35,6	17,6	17,5
Povečanje količin trdnih odpadkov	29,5	25,4	39,3	42,6	31,2	31,9
Vpliv na vodne vire (odplake ...)	38,8	33,9	35,6	38,6	25,5	27,4
Povečana hrupna obremenjenost kraja	31,1	29,3	37,4	39,2	31,5	31,5
Prometna gneča, problem parkiranja	19,1	23,4	23,7	30,3	57,1	46,2

Vir: Cigale, 2009.

Preglednica 5 kaže, da posamezniki, ki na določeni lokaciji preživijo manj časa (turisti), v primerjavi z domačini v drugačni meri občutijo obremenitve turizma (npr. prometna gneča, problem parkiranja). V kontekstu Slovenije, ki ima izrazito razpršen poselitveni sistem z manjšim številom večjih urbanih središč, to pomeni izrazito lokalno zaznavanje in posledično tudi necelostno (lokalno) reševanje tovrstnih turistično-prometnih obremenitev z dopolnjevanjem obstoječih cestnih omrežij. Necelostno reševanje

problema mobilnosti se izraža tudi prek nepreglednosti vlaganj v lokalno prometno infrastrukturo[1], pri čemer izdatkov občin (lokalna raven) za tovrstne namene državne statistike ne seštevajo (Tavčar, Drevenšek, 2019). V operativnem »Načrtu vlaganj v promet in prometno infrastrukturo v Republiki Sloveniji za obdobje 2020–2025« so v okviru posodobitve cestne infrastrukture zajeti le izdatki DARS-a (glej MZI, 2020). Kljub temu lahko prek množice manjših vlaganj v lokalno prometno infrastrukturo (npr. urejanje lokalnih cest, izgradnja, dopolnjevanje lokalne prometne infrastrukture) domnevamo o ekstenzivnih vlaganjih v te namene. K temu lahko dodamo še podatek, da od leta 1994 nismo dobili nobene nove železniške proge, pri čemer je od 1207 kilometrov prog 874 kilometrov enotirnih in le 333,5 kilometra dvotirnih. Za nameček je elektrificiranih le polovica prog (Tavčar, Drevenšek, 2019). Lokalistično usmerjene prometno-razvojne cestne politike se skladajo z razpršitvijo odgovornosti med veliko število uporabnikov avtomobilskih prevoznih sredstev in v primeru Slovenije predstavljajo pomemben dejavnik ohranjanja obstoječih trendov avtomobilije, pri čemer prihaja do zelo počasnega spreminjanja obstoječega vrednotnega sistema.

3.2 Pregled prednosti in slabosti odvisnosti turistične panoge od uporabe avtomobilskega prevoza

Vpetost Slovenije v avtomobilski prevoz prinaša tako pozitivne kot negativne učinke pri razvoju turizma in družbeno-ekonomskem razvoju države. V obdobju po osamosvojitvi Slovenije je avtomobilski prevoz s pripadajočo infrastrukturo nedvomno pripomogel k razvoju turizma, ohranjanju visokega življenjskega standarda v urbanem sistemu in predstavljal podstat celotnega ekonomskega razvoja Slovenije. Odvisnost Slovenije od avtomobilskega prevoza seveda prinaša tudi vrsto škodljivih učinkov, ki smo jih skušali podrobneje analizirati. V preglednici 6 so zajete tako prednosti kot slabosti odvisnosti turizma od uporabe avtomobilskega prometa, saj je treba različne vidike postaviti v kontekst oziroma uravnotežiti glede na koristi in škodo, ki jo ustvarjajo glede na časovne (kratkoročne/dolgoročne) okvire.

1 Dostopni podaki navajajo, da je država leta 2017 v železnice vložila 277 milijonov evrov, v ceste pa 217 milijonov. V letu 2018 je bilo vložkov v železnice za 323 milijone evrov, v ceste pa za 226 milijonov. Vložku za ceste je treba dodati še vložke Darsa, ki je leta 2018 v avtoceste in navezovalne ceste vložil skoraj 153 milijonov evrov (glej Tavčar, Drevenšek, 2019). Podatki o izdatkih občin za dopolnjevanje, nadgrajevanje, vlagajanje v prometne infrastrukture so na ravni državnih statistik zaradi prevelikih razlik v beleženju in množici različnih identifikacij stroškov nepregledni in nedosegljivi.

Preglednica 6: Prednosti in slabosti odvisnosti turistične panoge od uporabe avtomobilskega prometa.

Prednosti (+) uporabe avtomobilskega prevoza za razvoj turizma	**Slabosti (–) uporabe avtomobilskega prevoza za razvoj turizma**
visoka avtomobilska mobilnost turistov	gneča v določenih časovnih obdobjih, problem parkirnih površin in posledično omejena mobilnost, upočasnjeni promet
zmožnosti prilaganja potrebam in zmogljivostim lokacij s pomočjo ustvarjanja določenih omejitev (kvot)	problemi z onesnaževanjem (emisije izpušnih plinov), hrup, vpliv množičnega avtomobilskega turizma na okolje
nastanek novih delovnih mest (dodatno zaposlovanje), souporaba cest za potrebe vzdrževanja gozdnih poti in širjenje gozdnega gospodarstva	veliki pritiski na naravno okolje zaradi potreb gradnje (poraba prostora) avtomobilske infrastrukture (ceste, parkirišča), pretrganost naravnih habitatov, motenje migracijskih poti živali, vzdrževanje cest (izpiranje s cestišča; olja, goriva, sol), degradacija obcestnih površin
ekonomski razvoj podeželja, privabljanje novih podjetij (podlaga za nadaljevanje politik policentričnega razvoja), nove gospodarske aktivnosti (diverzifikacija turističnih storitev v prostoru), novi viri prihodkov	fragmentacija in specializacija turistične ponudbe glede na posamezne storitve, lokacije, kraje (odvisnost ekonomskih funkcij, socialnih, prostočasnih dejavnosti od avtomobilskega prevoza), tveganje nastanka eksternalij (stroškov), ki so posledica prilaganja družbenih vzorcev vedenja avtomobilskemu prevozu
gosta mreža (avto)cestnih povezav omogoča hiter in udoben dostop do večine turističnih destinacij in storitev	neučinkovit javni prevoz in odvisnost turizma od avtomobilskega prevoza onemogoča hitrejši razvoj, vzpostavljanje alternativnih, bolj trajnostno naravnanih mobilnostnih infrastruktur
dober dostop do naravnih danosti in rekreacijskih površin (možnosti nadaljnjega razvoja turizma v naravnih parkih in na podeželskih območjih)	močan, utrjen vrednotni sistem avtomobilije, ki temelji na udobni, hitri uporabi avtomobila in preprečuje večjo podporo razvoju manj udobnih, a bolj trajnostno naravnanih oblik mobilnosti
Revitalizacija prek avtomobilske dostopnosti, ponovno oživljanje zanemarjenih prostorov – urejanje javnih prostorov	nezmožnost nadzora turističnih tokov in obremenitev v določenih okoljih, povečana dostopnost prostora – povečane motnje v prostoru
vzdrževanje lokalnih avtonomij – razvoj turizma na odročnih lokacijah	konflikti med lokalnim prebivalstvom in obiskovalci in posledično izguba občutka lokalne skupnosti
obstoječa dobra mreža cestnih povezav predstavlja potencial za morebitne nove oblike kombiniranega, multimodalnega (integriranega) prevoza	nadgradnja avtomobilske infrastrukture kot podpora lokalnim partikularizmom in destruktivni (neproduktivni) tekmovalnosti med posameznimi urbanimi območji, naselji, občinami v urbanem sistemu in državo
dvigovanje (ekonomskih) vrednosti posameznih lokacij in s tem izboljševanje ekonomske podlage območij	eksponencialno naraščanje cen nepremičnin (procesi gentrifikacije) na posameznih lokacijah, ki so dobro prometno omrežene

Vir: Cigale in sod., 2009; Lampič, 2009; Uršič, Hočevar, 2007.

Posamezne značilnosti obstoječega sistema avtomobilske mobilnosti bi bilo treba upoštevati pri razvoju Slovenije v naslednjih razvojnih obdobjih. Dobro razvejano cestno omrežje nedvomno predstavlja podlago za razvoj multimodalnosti in integriranih oblik prevoza, pri čemer se javni prevoz kombinira z individualnimi oblikami prevoznih sredstev (Plevnik in sod., 2019). Glede na vse prednosti in slabosti se je treba zlasti vprašati, do katere mere so določeni trendi kratkoročno ali dolgoročno koristni ali škodljivi glede na družbeno-ekonomske razmere, v katerih se je znašla Slovenija? Z drugimi besedami, kje stroški pretirane uporabe avtomobila presegajo nosilne zmogljivosti okolja in tolerančne meje prebivalcev Slovenije in generirajo pretirano škodljive učinke za kakovost življenja? S tega vidika se glede na analizirane podatke zdi, da smo v Sloveniji na začetku procesov identifikacije škodljivih eksternalij, ki jih povzroča prekomerna odvisnost od avtomobilskega prevoza. Pretirana raba določenih vrst mobilnosti za namene turizma povzroča negativne okoljske učinke, ki so zabeleženi v raziskovalnih študijah (Cigale, 2009; Jurinčič, 2014; Kralj, 2019), vendar še »niso dovolj intenzivni, da bi zaradi njih prihajalo do na splošno negativnega vrednotenja turizma oziroma turističnega razvoja« (Cigale, 2009, str. 183). Kljub temu se v lokalnih skupnostih vse bolj pojavljajo civilne iniciative in NIMBY sindromi (v angl. *not in my backyard*), kjer vpleteni deležniki niso pripravljeni tolerirati eksternalij oziroma raznovrstnih stroškov (v denarju, porabljenem času, kvaliteti življenja), ki nastajajo ob pretirani uporabi avtomobilskega prevoza in z njim povezanega turizma. Obremenitve, ki izvirajo iz avtomobilskega prometa na lokalni ravni, so zabeležene v vrsti raziskav (glej npr. Cigale, Lampič, 2005; Kos in sod., 2002; Ogrin, 2009; Vintar Mally, 2009) in opažene v turističnih strategijah (npr. MGRT, 2022), a ostajajo v diskurzu državno-razvojnih politik izven prioritetnih okvirov. Kljub temu da se pojavljajo manjši lokalni posegi v reševanje avtomobilske odvisnosti (npr. platforme e-koles ipd.) pa na sistemski ravni ne prihaja do obsežnejših sprememb. Zdi se, da tovrstne relativno lokalno in časovno-periodično (glede na letni čas) zamejene prometne problematike še niso akumulirale dovolj aktivističnega potenciala na državni ravni, pri čemer še vedno nismo blizu potencialne točke preloma, kjer bi s strani večine populacije prišlo do zahtev po celostnem preoblikovanju in implementaciji drugačnih lokalnih in državnih mobilnostnih politik. Šele ko bodo stroški pretirane uporabe avtomobilskega prevoza generirali takšno akumulacijo škodljivih učinkov, da se bo javno mnenje začelo usmerjati k implementaciji alternativnih, bolj trajnostnih oblik mobilnosti, se bo začela postopna in dolgoročna implementacija alternativnih mobilnostnih sistemov, ki zmanjšujejo avtomobilsko odvisnost.

4 SKLEP – SLOVENIJA KOT ZELENA DESTINACIJA, DOSEGLJIVA PREK AVTOMOBILSKEGA PREVOZA?

V Sloveniji je izgradnja avtocestnega omrežja poleg spodbujanja ekonomskega razvoja pomenila tudi spodbudo za naraščanje avtomobilije, propadanje javnega prevoza in procese spontane avtomobilistične odvisnosti turistične ponudbe in storitev na privlačnih lokacijah. Pri tem prihaja na turistično privlačnih lokacijah v Sloveniji do še toliko večje koncentracije obiskovalcev (glej Paliska in sod., 2022). Kljub temu, da se strategije turističnega razvoja Slovenije vse bolj naslanjajo na oblikovanje in promoviranje zelenih destinacij, le-te paradoksalno slonijo na popolni odvisnosti od avtomobilskega prevoza. Odvisnost turizma od avtomobilskega prevoza bi utegnila v prihodnosti vplivati na razvrednotenje nekaterih naravnih območij, omejevati turistično-razvojne potenciale Slovenije in postopno vplivati na poslabšanje kakovosti bivanja na turistično privlačnih območjih.

Analiza podatkov iz različnih raziskav je najprej prikazala stanje avtomobilije v Sloveniji, nato so bili prikazani nekateri ključni dejavniki, povezani z vrednotnimi sistemi prebivalcev, ki podpirajo oziroma vzdržujejo tovrstna mobilnostna razmerja v ravnotežju ter upočasnjujejo razvoj alternativne, bolj trajnostno naravnane prometne infrastrukture. Podatki kažejo, da se v kontekstu Slovenije na lokalni ravni sicer identificirajo prometne problematike, povezane z ukoreninjenostjo v avtomobilskem prevozu, vendar so na državni ravni tovrstni problemi precej manj razpoznavni. Zaradi izrazito lokalistično naravnanih razvojnih politik prihaja pri tovrstnih problematikah do distribucije oziroma razpršitve odgovornosti na množico posameznikov, kar tudi zaustavlja poskuse bolj celostne (sistemske, državne) rešitve razvoja alternativnih prometnih infrastruktur. Reševanje problematike avtomobilskega prometa je tako prepuščeno lokalnim akterjem in usmerjeno pretežno v množico hitrih, preprostih rešitev prek dopolnjevanja lokalne cestne infrastrukture.

Izgradnja avtocestnega sistema in izboljšanje pogojev mobilnosti po cestnem omrežju ne pomeni nujno tudi optimalnega dolgoročnega razvoja vseh območij v prostorskem sistemu Slovenije. Obstoječa, (avto)cestno izboljšana prometna infrastruktura nedvomno prispeva k boljši fizični povezanosti Slovenije, vendar jo je treba umestiti v širši družbeni kontekst, da lahko razumemo, kakšne učinke v prostorskem sistemu povzroča v dolgoročni perspektivi. Če hočemo, da obstoječa prometna infrastruktura povezuje prostorski sistem v učinkovito celoto, ji je treba dodati primerno programsko opremo oziroma drugačno vsebino, ki določa njeno dolgoročno vlogo v prostorskem sistemu (Ausubel, Herman, 1998). Če je vloga infrastrukture slabo določena, lahko spodbuja destruktivno tekmovalnost, ki jo opredelimo kot obliko boja za turistično kapitalizacijo med naselji v prostorskem sistemu. Ob tem pogosto prihaja do spontane centralizacije turističnih tokov in kopičenja dejavnosti, pojavljajo se večinoma enosmerni prostorski tokovi (turistov, blaga, kapitala, informacij) proti lokacijam, ki imajo dominantno vlogo v takem prostorskem sistemu. Ko sistem deluje

v okvirih destruktivne tekmovalnosti, poteka spontano tekmovanje po načelu 'izkoriščanja trenutnih razmer', pri čemer izrazito prosperirajo lokacije, ki imajo v danem trenutku primerjalne prednosti v odnosu do ostalih lokacij (glej npr. Hawley, 1951; Neenan, 1973). Pri tem je problematično dejstvo, da gre zgolj za začasne situacije, ki imajo omejen rok trajanja. Ko se razmere spremenijo (npr. zaradi onesnaženja, spremembe cen, globalnih vplivov), ostanejo prej favorizirane lokacije brez primerjalne prednosti in tok izčrpavanja se obrne v drugo smer in išče se nova območja priložnosti za kapitalizacijo turističnih potencialov. Prostorski sistem, v katerem se kljub dobri razvitosti posameznih prometnih infrastruktur ohranja destruktivna tekmovalnost med naselji, ne izkorišča optimalno svojih možnosti in potencialov ter začne postopoma izčrpavati kvaliteto svojih turističnih potencialov in zaostajati v ekonomskem ter družbenem razvoju. Ob prevladi destruktivne tekmovalnosti prihaja zgolj do fizične povezanosti posameznih enot v prostorskem sistemu, medtem ko je bolj usklajenemu, tj. komplementarno raznovrstnemu razvoju vseh naselij v prostorskem sistemu namenjena premajhna pozornost.

Pomanjkljiv razvoj prometne infrastrukture tako vzdržuje sistem »marginalne koristnosti« (Broadhurst, 2001, str. 122), pri čemer se v dolgoročni perspektivi ne povečuje donosnost oziroma koristnost vloženega kapitala za vse vpletene deležnike. Strategija nadaljnjega enosmernega izpopolnjevanja cestne infrastrukture brez izrazitih poskusov izgradnje alternativnih in dopolnjujočih sistemov mobilnosti bo sprožala vse hujše konflikte na lokalni ravni. To se že kaže v številnih konfliktih na lokacijah, kjer se koncentrirajo avtomobilski turistični tokovi in skušajo lokalne oblasti z gradnjo dodatnih parkirišč, cest in krajevnih obvoznic na inkrementalni ravni reševati mobilnostno problematiko (npr. Bled, Tolmin, Bohinj, slovenska Istra ipd.). S tega vidika je pomembno, da prometna omrežja niso organizirana le na podlagi začasnih, kratkoročnih rešitev, temveč tudi na podlagi dolgoročnega, strateškega razvoja prostorskega sistema kot celote. Če ne bo v bližnji prihodnosti prišlo do prehoda na prometno bolj integriran prostorski sistem, ki združuje različne oblike javnega in individualnega prevoza, potem utegne v dolgoročni perspektivi prostorski in turistično-produkcijski sistem Slovenije postopoma nazadovati. Razvoj prostorskega sistema, v katerem so sile usmerjene v integracijo prometnega sistema in postopno izboljševanje mobilnosti in dostopnosti za vse skupine deležnikov oziroma v razvoj trenutno mobilnostno deprivilegiranih območij, se v kratkoročni perspektivi morda zdi nesmiseln in prepotraten, vendar utegnejo kumulativni učinki novih mobilnostnih shem v dolgoročnem izračunu prinesti več koristi v smislu ohranjanja zelenega sistema in kakovosti življenja v Sloveniji.

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THE ADVANTAGES AND DISADVANTAGES OF AUTOMOBILE TRANSPORT AS THE FOUNDATION OF TOURISM DEVELOPMENT IN SLOVENIA

Summary

The rapid increase in the number of tourists after the relaxation of Covid-19 measures in Slovenia raises a series of questions regarding the future strategies of Slovenia's tourism development. Besides typical development-strategic questions that address the promotion of destinations, the creation of accommodation capacities, services, support for various types of tourism and hotel infrastructure, also new topics related to the sustainable development of tourism are gaining increased interest. The promotion of Slovenia as a green destination, which should include a wide range of natural areas, parks and other natural features, opens up a series of problems related to the degradation of the green system as a result of mass tourism. In this context, it is necessary to mention the issues related to tourist mobility, or the ways in which tourists access tourist destinations in Slovenia.

The basic transport network on which tourist mobility in Slovenia is based is car transport, which brings certain advantages and disadvantages to tourism development. If we mention only a few advantages, then it should be emphasized that, on the one hand, automobile development enables 24-hour accessibility of destinations and quick access of hard-to-reach tourist locations in Slovenia. On the other hand, the excessive use of automobile transport causes overloading of individual locations,

traffic jams and problems with parking areas. The article analyses the advantages and disadvantages arising from the use of car transport in tourism. Special attention is paid to the analysis of problematic interdependence between tourism and automobile traffic. Presented are factors that potentially obstruct the development of new forms of tourism offer that would be based on a more sustainable use of Slovenia's potentials as a green destination. The article is based on the use of a range of data from official statistics (SURS, Eurostat, Directorate of Infrastructure of the Republic of Slovenia), supplemented by data and findings from other research in the field of transport and tourism. An important part of the article also represents the analysis of value orientations of the population of Slovenia in relation to the perception of the role of tourism and transport.

Despite the identification of the problematic dependence of Slovenian tourism upon the use of car transport, the proposed strategies and series of measures at the national level seem inappropriate and insufficient. The use of car transport in Slovenia reached a level that is significantly more intensely rooted in the mobility schemes of the inhabitants than the currently prepared strategies can address. The use of car transport in Slovenia is based on complex value orientations, which also indirectly direct the development of the tourism industry and will be difficult to overcome in a short period of time without more decisive and radical interventions in the existing lifestyles of car users.

In the detailed analysis of the dependence of tourism industry upon the use of automobile transport is first analysed the intensity of automobility in Slovenia. Automobility is in this regard identified as a set of social practices based upon car transport. Then are analysed some key factors related to the value systems of the inhabitants, which support or maintain such mobility relationships in balance and slow down the development of alternative, more sustainable transport infrastructure. The data show that, in the context of Slovenia, traffic problems related to the rootedness in automobile transport, are more clearly identified at the local level that at the national level, where such problems are much less recognizable. Due to strongly locally based development policies, problems of this type lead to distribution or dispersion of responsibilities among a multitude of small, local actors, which also stops more ambitious attempts at formulating a more integrated (systemic, national) solution to the development of alternative transport infrastructures. Solving the problem of car traffic is thus left to local actors and is mainly aimed at a multitude of quick, simple solutions through the addition of local road infrastructure.

In the period after Slovenia's independence, the rapid development of the highway network and the upgrading of road networks coincided with the affordability of automobile ownership. In this regard, road transport with the associated infrastructure undoubtedly contributed to the development of tourism, helped to maintain a high standard of living and represented the basis of the entire economic development of Slovenia. Under current circumstances, the situation changed and Slovenia's

dependence on automobile transport needs to be placed in a different socio-development context. From this perspective high dependence upon car transport also brings a series of harmful effects, which the article tries to analyse in more detail. The analysis of the data shows how the dominance of automobile transport satisfies basic mobility needs of tourists and residents, but at the same time also causes certain harmful effects for the socio-spatial development of individual areas. The development and integration of a spatial system through transport infrastructure networks is a socio-technical process that combines 'soft' (social, psychological, qualitative) and 'hard' (physical, quantitative) factors that consequently change user needs and habits. Despite the fact that Slovenia's tourism development strategies increasingly rely on the design and promotion of green destinations, they are paradoxically based on complete dependence upon automobile transport. In the future, the dependence of tourism upon automobile transport could affect the devaluation of some natural areas, limit Slovenia's tourism and development potential and gradually affect the quality of life in tourist-attractive areas.

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ARE TOURISM STRATEGIES RESPONSIVE TO CRITICAL EVENTS? COPING WITH THE COVID-19 PANDEMIC IN SLOVENIAN URBAN DESTINATIONS LJUBLJANA AND MARIBOR

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Abstract

In 2020, the COVID-19 pandemic brought tourism to an abrupt halt. Supply-side stakeholders suddenly found themselves in a lockdown with unusable assets, unprofitable investments and jobs in jeopardy. Using qualitative research, we take a closer look at how they dealt with this unprecedented crisis in the Slovenian urban destinations of Ljubljana and Maribor. Our results show that existing policy and strategy mechanisms did not equip the supply-side stakeholders to tackle the pandemic challenges. However, both institutional ad hoc responses were quick and to some extent adequate.

Keywords: COVID-19 pandemic, crisis management, governance, qualitative research, policy making, middle-sized European cities, strategic planning, urban tourism

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SO TURISTIČNE STRATEGIJE ODZIVNE NA KRITIČNE DOGODKE? ODZIV NA PANDEMIJO COVIDA-19 V SLOVENSKIH MESTNIH DESTINACIJAH LJUBLJANA IN MARIBOR

Izvleček

V letu 2020 je pandemija covida-19 nenadoma zaustavila turizem. Turistični ponudniki so se znašli sredi zaprtja z neuporabnimi sredstvi, nedonosnimi naložbami in ogroženimi delovnimi mesti. S kvalitativno raziskavo smo podrobneje proučili, kako so se s to krizo brez primere spopadli v slovenskih mestnih destinacijah Ljubljana in Maribor. Naši rezultati kažejo, da obstoječe politike in strateški mehanizmi deležnikov niso opremili za uspešno spopadanje z izzivi pandemije, vendar so bili tako institucionalni kot ad hoc odzivi hitri in do neke mere ustrezni.

Ključne besede: pandemija covida-19, krizni management, upravljanje, kvalitativne raziskave, priprava politik, srednje velika evropska mesta, strateško načrtovanje, mestni turizem

1 INTRODUCTION

The last twenty years were crucial for development of the urban tourism both in research (Ashworth, Page, 2010; 2011; Edwards, Griffin, Hayllar, 2008; Shoval, 2018) and in practice. The focus of urban tourists moved from classical motivation of cultural tourists to niche tourists interested in the urban lifestyle, open spaces, architecture and vibrant atmospheres of urban destinations (Boivin, Tanguay, 2019; Füller, Michel, 2014; Marot, Stubičar, 2022); from the primary European urban destinations such as London, Berlin or Paris, to second-tier ones, like Bologna, Ljubljana, and Turin. For better understanding of this phenomenon, Šauer et al. (2021) inspected Central European tourist flows. Enablers like low-cost airlines, shared economy accommodation and others have made cities accessible to tourists as never before. In consequence, many urban destinations became overcrowded and overtouristed. Tourists have brought with them conflicts with, and provoked opposition from the residents (Klepej, Stubičar, Marot, 2022; Martín Martín, Guaita Martinez, Salinas Fernandez, 2018; Milano, Novelli, Cheer, 2019; Novy, Colomb, 2019). Similar development path also occurred in the capital city of Slovenia, Ljubljana (Horvat, 2019; Kuščer, Mihalič, 2019; Stubičar, 2022), which has found itself on the global tourist map with one of the fastest increase of arrivals in Central Europe (+10% per year) and heavily promoted diversification of the tourists' origin

markets. Our second showcase, the city of Maribor, on the other hand, faced a modest (low in absolute numbers) increase (Horvat, Stubičar, 2021; Horvat, 2022).

Amidst this maturing phase of the two destinations according to the Butler's cycle (Getz, 1992), the COVID-19 pandemic happened. Tourism, which was in Ljubljana strongly integrated into the local economy and social environment, and in Maribor moderately so, has practically disappeared over night, and empty city centres have suddenly become proof of the vast spatial and social effects of this economic sector. In Koh's words (2020): "the pandemic has turned the state of tourism in many cities from 'over-tourism' to 'no tourism'".

So far, researchers focused on different impacts COVID-19 caused in the cities. Liang et al. (2021) analysed impact and changes in vacations rentals, Frago (2021) on retail industry, Pasquinelli et al. (2021) on social media city branding and Kunzmann (2020) on smart cities. Anguera-Torrell et al. (2021) have calculated the urban tourism performance index to evaluate an overall performance of the cities in the challenging period. Further to that, Seraphin and Dosquet (2020) illustrated that pandemic caused the urban population exodus as was the case in Paris where 10% of population have left the city and fled to their second homes in rural and mountainous areas of France. The same patterns of behaviour were discovered in Sweden. The increased time people spent in their secondary homes put pressure on existing infrastructure and services (Åberg, Tondelli, 2021).

In Slovenia, the last recorded crisis of similar proportions began in 1991. The decrease in the number of foreign tourist arrivals which started with the declaration of national independence, lasted for over ten years. The current crisis, which started only a few months before the main tourist season of 2020, has forced tourism providers into adjusting their offer and governments into stronger intervening in this otherwise predominantly market-oriented economic sector (Fong, Law, Ye, 2021; Koh, 2020). Various authors (e.g. Jones, Comfort, 2020; Yeoman, 2020) claim that crisis represents a great opportunity for rebranding the sector and, especially, a push for implementation of alternative, more sustainable and mostly more resilient governance practices as well in this sector. Discussions on both sustainable development and risk management for tourism in Ljubljana have started a decade ago (Dwyer et al., 2012). How well a city or destination can act in this regard, depends also on its responsiveness. By responsiveness we understand the ability of (public) actors and policies to sense and adjust to both foreseen and unforeseen changes (Degner, Leuffen, 2020; Rauws, 2017; Salet, 2006; Salet, Woltjer, 2009). Improved responsiveness of public governance on all levels is seen as one of the priorities and a facilitator of future tourism development also by the OECD (2018), especially considering quick technological development both in the tourism sector and in general.

In this paper, we examine the urban tourism strategies and supply-side stakeholders' response to the COVID-19 pandemic in the Slovenian urban destinations Ljubljana and

Figure 1: Ljubljana in April 2020, during the lockdown (Photos: D. Klepej).

Figure 2: Maribor in April 2020, during the lockdown (Photos: D. Klepej).

Maribor. We apply the Sigala (2020) categorisation when addressing the tourism management issues such as existing strategies for crisis management, responses to pandemic in this manner, impact of public interventions on functioning of the sector, and professional perception of the crisis by the supply-side tourist services providers. In order to do this, we start with a short overview of the COVID-19 effects on urban tourism in Slovenia and the existing tourism strategies at the time when the pandemic hit. We then present both the qualitative methodology we used (based on the semi-structured interviews) and the results of the interviews. The aim of our discussion in the final part of this paper is to evaluate how responsive the current strategies are to critical events and how much, if at all, pandemic contributed to improving their responsiveness.

2 EFFECTS OF THE COVID-19 PANDEMIC ON URBAN TOURISM AND POLICY RESPONSE IN SLOVENIA

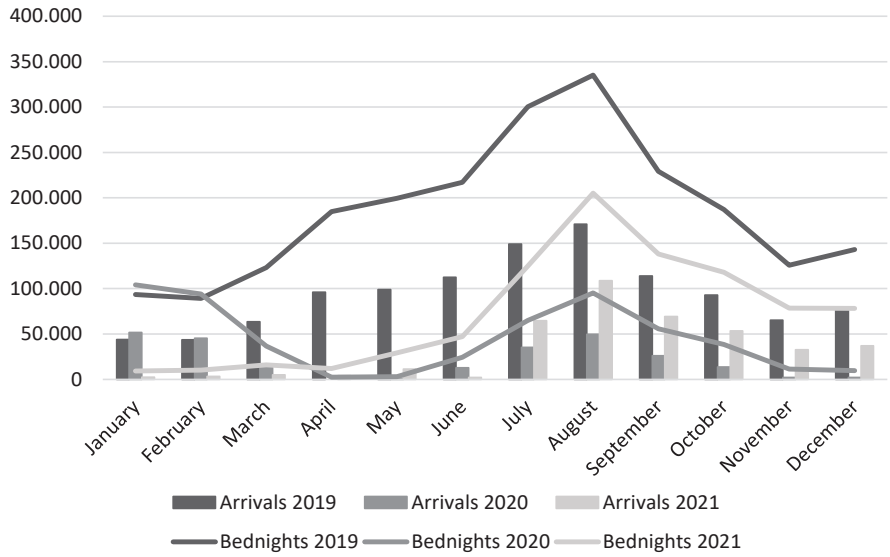
Similar to other EU countries, the COVID-19 pandemic was declared in Slovenia on March 12th, 2020. On April 24th, 2020 the Slovenian Tourist Board (STB) and the Ministry of Economic Development and Technology (MEDT) established a consultative Council for Tourism consisting of the major national tourism stakeholders and associations (MEDT, 2020a). The Council discussed important tourism issues and offers proposals, formulated legal measures, opinions and positions regarding strategic guidelines, financial incentives and proposals for changes in the development and promotion of tourism, especially in the light of mitigating the effects of the coronavirus epidemic on Slovenian tourism, all this in cooperation with the health care professionals (MEDT, 2020a). The measures were announced in several steps, always as part of the COVID-19 measures packages prepared by the government. The analysis of the then-existing national policy (Strategija trajnostne rasti slovenskega turizma 2017–2021; Strategy of sustainable growth of Slovenian tourism 2017–2021) showed lack of any measures prepared to be put in place in case of a crisis. And this despite the fact that the same document recognises the huge impacts that the economic crisis of 2009–2012 had on the Slovenian tourism sector (also due to lack of its preparedness and lacklustre response) as well as possible impacts the potential other economic, political or safety (terrorist) crises in Slovenia or wider region might have on Slovenian tourism. Other than general goals (such as pursuing good financial structure of companies or maintain a high level of safety in the country) there are no specific measures prepared to tackle these foreseen discrepancies. As such, in 2020, the response to the new reality needed to be prepared *ad hoc*.

Two major measures marked the year 2020: the first one is launching the campaign *"Now is the time for you, my Slovenia"* on May 14th, with intention to give the domestic tourism a major push, and the second one the introduction of the so-called tourist vouchers on May 29th. Every permanent resident of Slovenia over the age of

18 received 200 EUR, while those under the age of 18 received 50 EUR. In 2020, the vouchers were to be spent on accommodation in registered Slovenian tourism facilities; in 2021 it was also possible to use the money for cultural activities, e.g. buying books. The total value of this measure was estimated at 345 million EUR. It was expected that tourists would spend an additional 172 million EUR in selected destinations (RTV SLO, 2020). By the end of September 2020, 833 thousand vouchers were used. Of these 114 million EUR, only 1.2% were spent in the city of Ljubljana and 0.7% in the city of Maribor (FORS, 2020); a total of only 2.15 million EUR "subsidies" to help urban tourism in these two cities survive the pandemic. In addition, STB, MEDT, the Tourism and Hospitality Chamber of Slovenia, and the National Institute of Public Health published Responsible Travel Standards of Slovenian Tourism (STB, 2020). These contain a collection of hygienic recommendations for tourism and hospitality activities, identify tourism business opportunities in the post-corona period and provide guidelines for communication between hosts and guests. Furthermore, the government financed the payment of furlough for the employees in the sector.

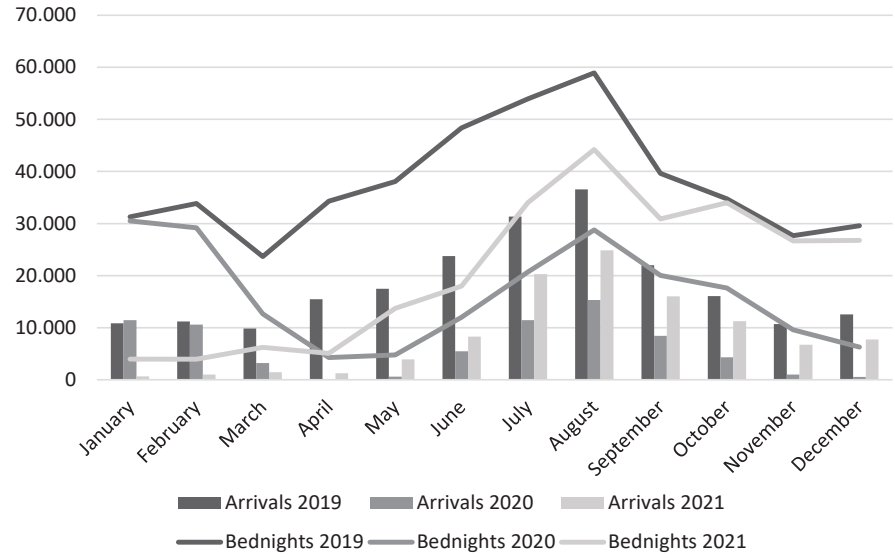
In the second half of 2022, we were better equipped to assess the effects of the pandemic on the tourism sector. Compared to the pre-pandemic year 2019, 71% less registered overnight stays by foreign tourists were recorded in Slovenia in 2020. In 2022, this number was still down by 58% (SURS, 2022a). The total decrease was smaller as the number of overnight stays by domestic tourists, largely due to tourist vouchers, increased. Compared to 2019, the decrease in overnight stays of foreign tourists in Ljubljana was significant: –79% in 2020 and –65% in 2021. The same goes for Maribor, –62% in 2020 and –52% in 2021. In 2019, the overnight stays in Ljubljana accounted for 10.5% of the Slovenian total. Of this total, only 2.2% were attributed to domestic and 97.8% to the foreign tourists' overnight stays. Taking into account (1) the average tourist spending of 160 EUR daily in Ljubljana and 122 EUR daily in other Slovenian urban municipalities (SURS, 2020b), and (2) the 2.2 million overnight stays recorded in Ljubljana and a little over a million in other city municipalities in 2019; in the last 'normal' year the daily urban tourist expenditures represented almost 500 million EUR of tourism revenues in Slovenia. With the recorded pandemic-related decline in overnight stays, the loss of the Slovenian tourism sector in 2020 amounted to approximately 270 million EUR in Ljubljana and 30 million EUR in Maribor.

Figure 3: Tourist arrivals and bednights in Ljubljana from 2019 to 2021.



(Source: SURS, 2022a).

Figure 4: Tourist arrivals and bednights in Maribor from 2019 to 2021.



(Source: SURS, 2022a, c).

3 METHODOLOGY AND DATA COLLECTION PROCESS

Our empirical data were collected in the framework of the national research project *MESTUR – Analysis of Territorial and Social Impacts on the Urban Tourism and Its Territorial Governance: The Cases of Ljubljana, and Maribor*. The project started in 2019 with the purpose to evaluate the (at that point in time more and more prevailingly negative) impacts of urban tourism in a comprehensive manner. However, in the wake of the COVID-19 pandemic, we partially adjusted our research design in 2020.

As a consequence, we decided to apply qualitative methodology based on a sample that can be characterized both as convenience and expert sampling: we conducted a series of semi-structured interviews with supply-side stakeholders who have already participated or expressed their willingness to participate in workshops and other activities of the MESTUR project (see Table 1). This is in line with the approach of Paraskevas et al. (2013) who explore crisis knowledge in tourism and van der Zee et al. (2017) who explore governance networks in tourism. We attempted to obtain an assessment of the institutional readiness to respond to the COVID-19 pandemic and the current strategies in place to address the issue (see Marot et al., 2020, for more details). The interview guide contained seven open-ended questions. These were dedicated to the evaluation of the current pandemic situation, the institutional approach towards adaptation of activities planned before the pandemic, institutional and personal strategies on tackling the crises, relationships between the state and the tourism sector, and the expected duration of the pandemic impact on their institution as well as the tourism sector as a whole.

Table 1: Interviewed tourism and planning stakeholders in Ljubljana and Maribor according to their role.

Administrative level	**Ljubljana**	**Maribor**
National level	• Tourism and Hospitality Chamber of Slovenia (TGZS) • Faculty of Tourism Studies, Turistica, University of Primorska (FTŠ) • Sava Tourism (national hotel chain)	
Regional level	/	• Maribor Development Agency (MRA)
Local level (management)	• Tourism Ljubljana • City Municipality of Ljubljana (MOL), planning department	• City Municipality of Maribor (MOM), planning department • Maribor Tourist Board
Local level (suppliers)	• Ljubljana Castle • Musems and Galleries of the City of Ljubljana (MGML) • Poligon Creative centre	• Hotel City Maribor • Sava hotel

The interviews were carried out in May and June 2020. This needs to be taken into account when interpreting the results. Thus, some of the stakeholders were approached before the major government measures for tourism were introduced, and some of them later on when the summer season, although significantly modified, has already started. Altogether, we interviewed four representatives of tourism providers, two representatives of local and one of national tourism organizations, two representatives of municipalities, one representative of a regional development agency, one representative of the research sphere and one representative of the creative sector. This makes a total of 13 interviewees. Due to lockdown in progress at the time, the interviews were conducted either by telephone or via video call. The key findings are reported in the next section.

4 OVERVIEW OF KEY FINDINGS

The key findings from our interviews are organized by topics. Selected verbatim quotes are provided where relevant. Firstly, the stakeholders' view of the tourism sector vulnerability and their forecast of what would happen in the pandemic are given. Secondly, relevance of existing strategic documents and contingency measures is assessed and commented upon. Thirdly, the responsibility for policy-making and action-taking is evaluated. Finally, possible positive effects of COVID-19 on urban tourism are discussed.

4.1 Vulnerability of the sector

At the beginning of the interview, each interviewee was asked about his or her personal opinion on the early 2020 UNWTO forecasts of a 30% reduction in international arrivals at the global level in 2020. Only two interviewees agreed with this UNWTO's forecast, while the rest predict a much larger decline in international arrivals with numbers going up to 80%. The decline was expected to vary greatly across different markets depending on the origin (domestic to foreign ratio) of guests and the period of validity of measures banning international travel. The representative of Ljubljana Castle thus estimated that Slovenia, as a destination with a large share of foreign guests, would have a larger decline than predicted in these forecasts, and two other interviewees saw domestic guests as saviours of the 2020 summer season. More of them mentioned that it would be necessary to change the functioning of the sector since it is very sensitive to crisis events and consequently needs to react quickly when facing a crisis situation.

Three months into the pandemic and just before the start of the tourist season, only one of the stakeholders (TGZS) actually performed a comprehensive destination assessment of losses due to the coronavirus crisis. With their larger members, they conducted an analysis of loss estimates in 2020, based on which they estimated

a 50 to 70% decrease in turnover compared to 2019. The estimates differ by destination: a larger loss was expected in internationally well-known Slovenian destinations (Bled, Ljubljana), and a smaller one in spas, where traditionally there is a larger share of domestic guests and which need to stay operational because of the health services they provide. In Maribor, the decrease was estimated at 30%. The Ljubljana tourism mostly predicted losses due to the lower demand of guided tours, excursions, lower sale of the tourist card and souvenirs. The rest of the stakeholders had at that point in time yet to evaluate their potential losses; this was mostly due to their lack of relevant knowledge, human and/or financial resources.

While the individual numeric forecasts about pandemic impacts were not unified accross the interviewees, they did agree that tourist attraction and event organizers will take the most direct and profound hit. The interviewees further agreed that catering industry will get over the crisis the easiest since they could operate even in the lock down (take-away and delivery options). Hotel businesses and other accommodation providers would need longer than catering, however, they could valorise the vouchers incentive. What might represent a challenge is the new regulation and standards concerning the hygiene and disinfection. On the one hand, the hotels should have an easier job to recover than shared economy providers because of their existing standard operating procedures; on the other, tourists might prefer apartments as accommodation type due to better distancing and isolation possibilities. The impacts on the hotel business would also differ according to the ownership status and investment power of the accommodation owner. When comparing the private and public sectors, both would feel the consequences, however to a different extent. The public sector would suffer less (and for a shorter period of time) because of the public funding. The impact would be more visible in cultural institutions and tourism attractions closed for visitors because of the pandemic.

A spokeswoman for Tourism Ljubljana pointed out that the prices for (service) offer in the city have not decreased. Instead, there was concern they might go up, which would certainly not be good for local inhabitants. The COVID-19 situation has, however, not affected investments in the sector, as investment projects in the tourist infrastructure (e.g. hotel construction) in Ljubljana to this day continue as planned.

Table 2: Overview of negative pandemic effects along with mitigation measures by stakeholder groups.

Stakeholders	Negative effects of pandemic	Mitigation measures	Impact size
Tourist agencies, services providers	• Less turnover, less consumers	• Change in the products on the market	The largest
Event organisers	• Event cancellations	• Events moved to 2021 • Vouchers in the summs of selled tickets • Business models with on-line offer	
Congress tourism	• Event cancellations	• Organisation of on-lline events	
Tourist attractions	• Closed, no visitors	• New offer, new type of tickets, discounts	Large
Cultural institutions	• Closed, no visitors	• Design of new offer (web)	
Air line companies	• No flights operation	• Changed protocols • Some connections permanently closed down	
Hotels	• Closed • Problem of travel to the destination, cleaning, deinfection, airing and serving the food and drinks *Size matters.	• Longer closure • Acting according to the higiene standards • Benefiting from the vouchers	Large/medium
Accommodation via shared economy options	• Lower trust in cleaning protocols • Illiquidity does not allow for paying of the loans	• Acting according to the higiene standards • Transfer of the offer from tourism to the real-estate market	Medium
Catering (restaurants, …)	• Closed • Smaller capacities due to the required distance	• Delivery service • New services (Wolt, eHrana) • Different tables setting	Smaller
Souvenir sellers	• Closed	• Closed permanently.	

4.2 Relevance of strategic documents and contingency measures

In 2020, none of the institutions included into the study could rely on strategic documents or any other measures helping them to deal with occurrence of a major crisis like pandemic. Potential safety threats such as terrorist attack were given a very low priority due to the fact that Slovenia, compared to other European countries, has always prided itself as a safe and secure destination. The possibility of an epidemic was not viewed as a potential safety issue at all. During the outbreaks of Zika, Ebola, bird flu, or SARS, Slovenia had never been directly at larger risk.

The only measures already in place were those for an event of economic and/or financial crisis similar to that in the period 2009–2012. The City Municipality of Maribor (MOM), which had faced its share of economic crises before, had a regulation of procedures for the adoption of measures should one segment of the economy be affected; in this framework, intervention measures and transfers of funds are possible. Thus, in May 2020, MOM adopted some such measures, for example city parking fee exemptions and restaurant rental deferrals.

Tourism Ljubljana postponed the adoption of the Sustainable Development and Marketing Strategy of the Tourist Destination Ljubljana and the Ljubljana Urban Region 2020–2025 due to the coronavirus to the autumn 2021. While they did not add additional measures to the document, they adjusted the indicators and reduced the growth forecasts, as financially they largely depend on tourist tax and concession fees. During the crisis, several offers for domestic tourists and special tourist programmes (the so-called Ljubljana experience) were designed for different target groups. Tourism Ljubljana also further intensified cooperation with tourist providers, e.g. Ljubljana hotels, and prepared special packages that include the benefits of various tourist services. A City Municipality of Ljubljana (MOL) spokesman reported that they actually have instructions for providers based on response scenarios in the event of a critical events such as earthquakes or terrorist attacks.

The Tourism and Hospitality Chamber of Slovenia, shorter TGZS, too, had no measures in place to deal with the pandemic, but since March 2020, in cooperation with its members and with 12 tourism associations, they co-drafted proposals for crisis mitigation measures to be forwarded to the government and responsible ministries. Most of the proposals for measures are of economic, financial and legal nature, and address specific segments of tourism, e.g. spas, gambling. The TGZS was also involved in the adoption of the third set of State aid in the event of a crisis targeting tourism. Several stakeholders (FTŠ, TGZS, Ljubljana Castle, MOL) pointed out that current tourism development strategies with orientations towards sustainable and green tourism are also appropriate in light of the pandemic. All that is needed is further and accelerated work on their proper implementation.

4.3 Responsibility for taking action in the field of urban tourism

Key issue here is the question whether tourism can be viewed exclusively as a commercial activity or not. An interviewee from FTŠ certainly did not agree with the view that tourism is exclusively a commercial activity. Although it has economic effects and needs to be promoted, it also has a socio-cultural function, in addition to environmental, which concerns the local population and the local community. According to the FTŠ interviewee, the state should first understand the complexity of tourism and the whole system of its management, which is based on different (non)formal structures and several management levels. Local and regional level are relevant at first, then national and transnational level follow. A state should understand this complexity and properly promote integration, co-operation and networking mechanisms between tourism stakeholders.

Her view was strongly opposed by a representative of the Maribor Development Agency who had a completely different opinion on state interventions in tourism:

> *"Tourism is an economic activity which has been closed down temporarily by the state's commanded measures, which is why the state must act responsibly after the end of these measures."*

The government's systemic approach to assisting tourism was also cited as the most important measure by representatives of MGML, MOM, Poligon Creative Centre and the Maribor Tourist Board. Several interviewees have described the measures so far as "clumsy" or "incontinual" because they did not target everyone involved in the tourism industry. Many tourism workers did not qualify at all to receive a subsidy – e.g. tour guides without income outside of the tourist season. In particular, these interviewees highlighted the urgent need for understanding of seasonality and other specifics of work in tourism and the need for overarching cooperation and communication of stakeholders in the tourism industry.

Among the criticisms of the implemented measures, stakeholders such as Poligon Creative Centre, MOL, or Maribor Tourist Board highlighted their short-term impact and their focus on primarily saving large hotel services providers. They also pointed out other governmental misunderstandings of the tourism sector, including the full nationwide lockdown instead of implementation of less stricter rules for areas with lower numbers of COVID-19 infections.

4.4 Possible positive effects of COVID-19 on urban tourism

All stakeholders agreed that the coronavirus crisis will also have positive effects. Most of them pointed out that the crisis is an opportunity to reflect on the direction of tourism towards greater sustainability as well as environmental and social responsibility of the

sector which is also related to policy-making. Stakeholders already highlighted existing green initiatives such as the green scheme of the Slovenian tourism (TGZS) and direction of the promotion of Slovenia as a green and sustainable destination. Due to the pandemic, the lower number of incoming tourists would reverse the negative effects of tourism on the environment and society; the experience of visitors would also improve due to the lower quantities of tourists altogether. In order to change the values of local population and their attitude towards fellow city inhabitants and tourists, one of the interviewees pointed out that orientation towards the niche tourism is the right choice:

> *"While it is necessary to develop the exclusive boutique tourism, this does not mean we go in the direction of elitist tourism. Tourism must be accessible to all people, like all other goods and services. There is much we can do in the future to develop tourism in a better direction."*
>
> (Representative of the Faculty of Tourism Studies Turistica)

Maribor Tourist Board saw the pandemic as an opportunity for less developed and less recognizable destinations and tourist providers. They expected the domestic tourists to cash in tourist vouchers in less known regions like Podravje instead of traditional summer holiday destinations such as Croatia, the Greek islands and alike. Tourism Ljubljana expressed a will to refocus research efforts into studies calculating the carrying capacity of the environment or investigate tourist flows management practices. Generally, our interviewees believed the pandemic would result in closer cooperation of tourism providers in both the development and the promotion of tourism with the goal of better preparing themselves for possible future critical events. The expectations seemed to be that after the normalisation of the situation, tourism will eventually return to its pre-crisis scale and form. This is best illustrated in the following statement:

> *"Tourism has picked up after every crisis. The only difference is that, after previous crises, it has picked up faster than estimates of this crisis predict. But I am sure the sector will return to the previous level."*
>
> (Representative of the Tourist Hospitality Chamber of Slovenia)

And the effects of the pandemic on policy-making? Firstly, one stakeholder stated that COVID-19 is not the only transformational factor for tourism, but that tourism is also more strongly influenced by other global changes, such as global population growth, ageing, internet-based solutions and digitalisation which should be taken into account in the transformation process. Secondly, a caution was advised with regard to adopting the most severe measures like mandatory quarantine, border closures and restrictions on border crossings and travel bans in the face of further waves of

coronavirus infections. Thirdly, promotional campaigns were recognised as one way of managing the tourist flows also in the times of pandemic.

Besides the overall sector adaptations, individual adjustment were also made by the stakeholders in question, although not necessarily supported or initiated by the policies or government. The inconclusive list included:

- maintenance work done on the accommodation buildings;
- promotional activities via different channels (on-line meetings, e-news for business partners and tourist agencies);
- preparation of new tourist products or adaptation of the old ones that they are more financially accessible to the domestic visitor;
- digitalisation of the cultural offer and cultural events;
- documentation of the pandemic period by the citizens as an art project;
- on-line meetings, events and seminars for tourism providers;
- adapted communication strategies of the tourism sector and its economic and social importance.

Many supply-side stakeholders also used the pandemic-induced lockdowns for team-building activities and employee skills enhancement.

5 DISCUSSION

From the 2022 perspective, what we have learnt so far about the pandemic is that the most pessimistic forecasts about the large decrease of international arrivals were correct. Some of the origin markets like Asia will need a much longer time to bounce back to normality and in terms of tourism travels to Europe (and in this framework also to Ljubljana). The optimistic forecast of the Tourism Economics from 2020 that urban tourism will recover in 2021 has not materialised, however, in 2022 the prospects looked, and got empirically confirmed, as good. Most likely the forecast of the OECD from 2020 that urban destinations will fully recover by 2024 will actually become reality in two years time.

As far as our target Slovenian urban destinations are concerned, the data presented in the second section of this paper shows that Ljubljana and Maribor were hit in a different way. Before the pandemic, 95% of overnight stays in Ljubljana were generated by the foreign tourists (SURS, 2022a). Hence, Ljubljana lost big time. On the other hand, Maribor profited both by increased number of overnight stays due to the domestic tourists and voucher spending due to its tourism offer characterized by largely outdoor activities.

This is in line with the DuBois (2020) prediction that non-urban destinations and those city destinations with a higher share of domestic tourists, which applies to cities both in the USA as well as in Europe, will recover faster.

Our analysis of mid-2020 interview data shows that the tourism sector stakeholders did not have capacity, both in knowledge as well as human and financial resources, to adequately address the challenge of a pandemic. Furthermore, the cities and the sector were not digitally prepared to move the services, including tourism on-line, and offer digitally supported solutions, although the smart city concept has been rapidly entering the urban management in 21st century (Kunzmann, 2022). In this way, the pandemic has sped up innovation, both in the urban tourism and urban planning sectors. Citizens and tourists are now more inclined and skilled to use digitalised services.

At the institutional level, the situation is different. The pandemic has forced tourism suppliers to think out of the box and develop both products and campaigns that dive in greener directions and require less travel: for example travelling shorter distances, capitalising on the virtual tourism offer, develop hidden destinations and improve the management of the number and behaviour of tourists. While the crisis exposed the role of individual stakeholders and the lack of their co-operation in tourism management, it also revitalized the relationship between the government and tourism, or in other words, between the public and private sector. Although some of our interviewees recognised tourism as a strictly commercial activity, many highlighted the wider positive impacts of tourism on society and the environment and, consequently, greater responsibility the state should take in the management of the industry. Ambiguity in relationships and responsibilities is also reflected at local level, where on one side, local tourism organisations primarily act as promoters of the destination, but on the other, they are asked by the cities to manage tourism in a comprehensive manner for which they have no allocated resources. Cristiano and Gonella (2020) who discuss resilience and sustainable tourism development in Venice after the pandemic, also talk about systemic thinking. More precisely, only addressing the overtourism and tourism decrease issues in urban destinations is not enough. The quality of life in the city should be primarily secured for its inhabitants, and only secondarily for tourists. Therefore, an effective use of available urban resources should be considered in this framework

Governmental intervention analysis also indicates that national, regional and local authorities need to act in a more integrative manner and develop realistic measures in cooperation with supply-side tourism stakeholders (Marot et al., 2022). This is important because there are companies of different size on the supply side: from self-employed entrepreneurs (e.g. tourist guides) to global tour operators. These individuals and organizations have completely different styles of operation – and of possibilities to survive a long-term pandemic-related dry patch. The pandemic has also confirmed that human capacities and governance approaches of the cities are only partially adapted to today's needs of urban management, including concepts such as resilience, smart cities etc., and that the cities vary great deal in regard to that.

6 CONCLUSION

In view of our research findings, we can conclude that while the need for comprehensive strategic management of tourism and application of newer urban management concepts such as smart city and sustainability has been recognised, this is not followed up with targeted actions in practice. The same goes for the concept of resilience, which calls for better risk management and targeted crisis response based on predeveloped scenarios. In second-tier European urban destinations, concepts such as these should be seriously discussed by the stakeholders, and a better system of co-operation between stakeholders, including the ones from urban planning, should be put in place.

Furthermore, crisis management should acquire better recognition both in the urban and tourism management, and together with the measures find a place in urban and tourism strategies, instead of, as so far noted going back to "business as usual", except for some exceptions or good practice tourist products and promotional campaigns. As for stimulation and promotion recovery, both top-down and bottom-up approaches are necessary, though the authorities at all levels (national, regional, and local) should understand the heterogeneity of supply-side tourism stakeholders and implement stimulating measures that target as many as possible and not just selected few which might be too large to fail. When preparing for tomorrow, the best way forward for the tourism sector is to be proactive. Barandiaran et al. (2019) argue that Spanish tourism recovery after the economic crisis in 2008 was successful because the tourism sector took a leadership role in the economic recovery and applied a collaborative governance approach.

According to what we have learnt so far, the best preparation for tomorrow seems to be to develop strategic plans and responses for critical events like the pandemic and also to reconcile the tourism offer with the needs and expectations of local inhabitants. As pointed out by one of our interviewees, the tourism always manages to rejuvenate itself. The question that needs to be answered rather quickly is just to what extent do we want it rejuvenated (we certainly should not want to fall back into overtourism) and in what manner.

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SO TURISTIČNE STRATEGIJE ODZIVNE NA KRITIČNE DOGODKE? ODZIV NA PANDEMIJO COVID-19 V SLOVENSKIH MESTNIH DESTINACIJAH LJUBLJANA IN MARIBOR

Povzetek

Zadnjih dvajset let je bilo ključnih za razvoj mestnega turizma tako v raziskovalni sferi (Ashworth, Page, 2011; Edwards, Griffin, Hayllar, 2008; Shoval, 2018) kot tudi v praksi. Fokus urbanih turistov se je premaknil od klasičnega, s kulturno ponudbo motiviranega turista k takšnim, ki jih zanimajo urbani življenjski slog, javni prostori, arhitektura in destinacijska atmosfera (Boivin, Tanguay, 2019; Füller, Michel, 2014; Marot, Stubičar, 2022); zaznaven je tudi premik od primarnih evropskih mestnih destinacij, kot so London, Berlin ali Pariz, k sekundarnim, kot so Bologna, Ljubljana in Graz. Za boljše razumevanje tega fenomena so Šauer in sod. (2021) raziskovali srednjeevropske turistične tokove. Le-te spodbujajo različni dejavniki, od nizkocenovnih letalskih prevoznikov do delitvene ekonomije in skupnostnih namestitev, ki so napravili mesta dosegljiva turistom kot nikoli poprej, kar je imelo za posledico tudi prenapolnjene in s turističnimi obiskovalci prenasičene mestne destinacije. Takšen razvoj je povzročil precej nejevolje in odpora med lokalnim prebivalstvom (Klepej, Stubičar, Marot, 2022; Martín Martín, Guaita Martinez, Salinas Fernandez, 2018; Milano, Novelli, Cheer, 2019; Novy, Colomb, 2019). Podoben razvoj je doživelo tudi glavno mesto Slovenije, Ljubljana (Horvat, 2019; Kuščer, Mihalič, 2019; Stubičar, 2022), ki se je ob intenzivni promociji diverzifikacije izvornih turističnih trgov znašlo na svetovnem turističnem zemljevidu z eno najbolj hitro rastočih stopenj rasti števila prihodov turistov v Srednji Evropi (+ 10 % in več letno). Drugo mesto, katerega odziv na pandemijo analiziramo v tem članku, tj. Maribor, je pred pandemijo uživalo relativno visoko, v absolutnih številkah pa nizko rast števila prihodov (Horvat, Stubičar, 2021; Horvat, 2022).

V času, ko je faza dozorevanja po Butlerjevem ciklu (Getz, 1992) še trajala, se je zgodila pandemija covida-19. Tako v Ljubljani (kjer je bil turizem močno integriran v lokalno gospodarsko in družbeno okolje) kot tudi v Mariboru (kjer je bila raven integracije nižja) je turizem praktično čez noč izginil; prazne mestne ulice so bile najboljši dokaz velikih prostorskih in družbenih učinkov tega sektorja gospodarstva.

Številni raziskovalci so se ukvarjali z različnimi vidiki in učinki pandemije v okviru urbanih turističnih destinacij: Liang in sod. (2021) so analizirali učinke in spremembe v počitniških najemih; Frago (2021) učinke in spremembe v trgovini na drobno; Pasquinelli in sod. (2021) znamčenje mest v socialnih omrežjih in Kunzmann (2020) pametna mesta. Anguera-Torrell in sod. (2021) so izračunali poseben indeks poslovanja na področju urbanega turizma. Seraphin in Dosquet (2020) sta se ukvarjala s

problematiko urbanega eksodusa zaradi pandemije (število pariškega prebivalstva se je zmanjšajo za 10 %, saj so cele družine iz mesta zbežale v ruralne in gorske predele Francije, na svoje sekundarne domove). Enak vzorec so zaznali tudi švedski raziskovalci, kjer je zaradi eksodusa urbanega prebivalstva celo prišlo do motenj v kritični infrastrukturi in oskrbi (Åberg, Tondelli, 2021).

Zadnje kritično krizno obdobje podobnih razsežnosti je Slovenija na področju turizma doživela ob svoji osamosvojitvi v letu 1991. Upad števila prihodov tujih turistov je takrat beležila celo desetletje. Kriza zaradi pandemije, ki se je pričela le nekaj mesecev pred glavno turistično sezono v koledarskem letu 2020, je turistične ponudnike prisilila v velike in hitre modifikacije njihove ponudbe, vlade in odločevalce pa k intenzivnejšemu interveniranju v tem sicer predominantno tržno orientiranem sektorju gospodarstva (Fong in sod., 2021; Koh, 2020).

Ob tem je treba poudariti, da so različni avtorji (npr. Jones, Comfort, 2020; Yeoman, 2020) takoj pričeli opozarjati na dejstvo, da je mogoče krizne razmere prepoznati tudi kot priložnost za repozicioniranje turističnega sektorja; za obrat v smeri trajnostnega razvoja ob upoštevanju ukrepov kriznega managementa; za izboljšanje odpornosti mest na krizne šoke (to diskusijo so Dwyer in sod. v Ljubljani načeli že leta 2012). O tem, kako naj bi se odzivali mesto, urbana destinacija oziroma pristojni odločevalci, je bilo že veliko napisanega (glej npr. Degner, Leuffen, 2020; Rauws, 2017; Salet, 2006; Salet, Woltjer, 2009). Že pred pandemijo je izboljšanje odzivanja javnih akterjev in politik OECD (2018) izpostavil kot prioriteto v prihodnjem razvoju turizma, ne nazadnje tudi zaradi hitrega tehnološkega razvoja, ki je že pred pandemijo povzročal tektonske premike tako v splošnem kot še posebej v turističnem sektorju.

V tem prispevku naslavljamo vprašanje primernosti strategij mestnega turizma in odzivanja deležnikov na strani turistične ponudbe na epidemijo covida-19 v dveh slovenskih mestih: Ljubljani in Mariboru. Pri diskusiji upravljalskih izzivov, vezanih na pandemijo, izhod iz nje ter sistematično pripravo na čas po njej, se opiramo na kategorizacijo, ki jo je razvila Sigala (2020).

V prispevku najprej na kratko prikažemo učinke pandemije na mestni turizem v Sloveniji, nato predstavimo uporabljeno kvalitativno raziskovalno metodologijo, rezultate delno strukturiranih intervjujev s ključnimi deležniki v obeh preučevanih mestih ter na njihovi osnovi pridobljena ključna spoznanja.

Kot je pokazalo dogajanje zadnjih dveh let, je med vsemi vrstami turizma mestni turizem na kratek in srednji rok najobčutljivejši na krizna dogajanja. Pandemija je v Sloveniji najbolj prizadela skupino mestnih občin, saj se je v njih turistični obisk najbolj zmanjšal. Med letoma 2019 in 2021 je število turistov v skupini mestnih občin upadlo za 59,7 % in število nočitev za 55,6 %, kar je bilo največje zmanjšanje med vsemi skupinami turističnih občin. Še večje zmanjšanje je zaznala Ljubljana, v kateri se je število turistov zmanjšalo za 63,2 %, število nočitev pa za 61,1 %. Glavni razlog za tolikšno zmanjšanje je velik izpad obiska tujih turistov.

Pred pandemijo je bila glavna značilnost mestnega turizma v najbolj obiskanih destinacijah njegova masovnost, ki je v diametralnem nasprotju z različnimi vidiki trajnosti. Med pandemijo se je izkazalo, da je večina obstoječih poslovnih modelov mestnega turizma (v tem kontekstu še posebej kongresnega in sejemskega turizma) netrajnostna in neprožna in da so kot takšni na dolgi rok (sploh v slovenskem kontekstu z zelo majhnim številom stalnih letalskih povezav s svetom) skoraj gotovo obsojeni na neuspeh. Za netrajnostne so se izkazali tudi ukrepi ekonomske politike, implementirani s ciljem dviga povpraševanja po turističnih proizvodih in storitvah – uspešni so bili v okviru morskih in zdraviliških destinacij, ne pa mestnih. Prav tako je analiza obstoječih strategij pokazala, da mesta niso pripravljena na krizne situacije in nimajo strategij, ki bi omogočile prilagodljivost na nenadne spremembe. Tako smo bili med pandemijo priča izgubi šolanega kadra, posameznikov s posebnimi spretnostmi, ponudnikov posebnih turističnih proizvodov in storitev. Kot so nam razkrili intervjuji s ponudniki, je kriza prinesla tudi nekatere pozitivne rešitve, med katerimi velja poudariti prenovo hotelskih zmogljivosti in infrastrukture, digitalizacijo (kulturne) ponudbe, razmislek o prihodnji smeri razvoja turizma in povezanih dejavnosti.

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SEASONALITY AND SUSTAINABILITY OF TOURISM – CASE STUDY: PROTECTED MOUNTAIN AREAS IN SERBIA

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Abstract

The role of seasonality in the sustainability of tourism is multiple and complex. The connection between seasonality and sustainability is even more complex when it comes to protected areas. This connection was investigated on the examples of selected protected mountain areas in Serbia – Kopaonik and Tara National Parks, and Stara planina and Zlatibor Nature Parks. The Gini index was used to measure seasonality, and to show the imbalance in the monthly distribution of the number of tourist overnight stays in the mentioned destinations, in the period 2013–2021. The research results show that the analyzed protected mountain areas in Serbia have different values of the Gini index, which is conditioned by their natural predispositions for tourism development (e.g. altitude and duration of snow cover), and at the same time the levels of tourist development of the area. In order to reduce the effects of seasonality, in each of the destinations that are the subject of this paper, alternative types of tourism and activities are implemented.

Keywords: tourism, seasonality, sustainability, protected areas, Serbia

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SEZONSKOST IN TRAJNOSTNOST TURIZMA – ŠTUDIJA PRIMERA: ZAVAROVANA OBMOČJA V SRBIJI

Izvleček

Vloga sezonskosti v trajnostnem razvoju turizma je večplastna in kompleksna. Povezava med sezonskostjo in trajnostnostjo je še bolj zapletena, ko gre za zavarovana območja. To povezavo smo proučili na primerih izbranih zavarovanih gorskih območij v Srbiji – narodnih parkov Kopaonik in Tara ter naravnih parkov Stara planina in Zlatibor. Za merjenje sezonskosti in prikaz neuravnoteženosti mesečne porazdelitve števila turističnih prenočitev v omenjenih destinacijah v obdobju 2013–2021 smo uporabili Ginijev indeks. Rezultati raziskave kažejo, da imajo analizirana zavarovana gorska območja v Srbiji različne vrednosti Ginijevega indeksa, kar je pogojeno z njihovimi naravnimi predispozicijami za razvoj turizma (npr. nadmorska višina in trajanje snežne odeje), hkrati pa tudi stopnje turistične razvitosti območja. Da bi zmanjšali vplive sezonskosti, v vsaki izmed obravnavanih destinacij izvajajo alternativne oblike turizma in aktivnosti.

Ključne besede: turizem, sezonskost, trajnostnost, zavarovana območja, Srbija

1 PREVIOUS RESEARCH

The definition of tourism seasonality depends on whether it refers to supply or demand. The definition given by Butler (1994) is significant in the context of demand. He believes that seasonality is a temporal imbalance in tourism and can be expressed in terms of visitor numbers, the amount of money tourists spend, employment, and the like. Taking into account the supply, tourism seasonality is defined as a temporary imbalance in which the marketing of tourism products is concentrated in one or more periods (Lopez, Lopez, 2006).

As an inherent characteristic and market phenomenon, seasonality is of great importance in the sustainability of the tourism business (Su et al., 2019). From an economic perspective, the World Tourism Organization identifies seven dimensions of sustainability, one of which is seasonality. The basic issues and indicators of tourist destinations include tourism seasonality, defined by the arrival of tourists by months or quarters, the percentage of occupancy of accommodation by months, the percentage of business facilities opened during the year, the number and percentage of jobs in tourism that are permanent (compared to temporary jobs) (United Nations World Tourism Organization, 2004).

The seasonality of tourism is regarded as a problem for many world destinations, especially from the point of view of sustainability (Duro, Turrión-Prats, 2019). To

understand the effects of seasonality on the sustainability of a destination, it is necessary to identify three aspects that are accepted in sustainable development planning (Ayuso, 2003). These are: environmental sustainability (development compatible with the maintenance of ecological processes, biological diversity, and natural resources); social and cultural sustainability (it is compatible with culture, maintains and strengthens community identity); and economic sustainability (economically efficient development and management of resources to preserve them for future generations). Blancas et al. (2011) and Lozano-Oyola et al. (2012) consider the seasonality of tourism activities, such as accommodation supply, demand, or employment, in the economic indicators of the sustainability of tourism. Sustainable tourism requires stable activity to reduce the negative effects of high season and intense activity related to employment, use of resources, and excessive use of tourist areas. A short high season means underutilization of investments in the low season, and thus a limited return on capital (Sæþórsdóttir, Hall, Stefánsson, 2019).

Seasonality in tourism has negative effects on all three mentioned aspects. Seasonality affects the environment as the high concentration of visitors leads to overexploitation of resources and often inadequate disposal of large amounts of waste. In a socio-cultural sense, destinations lose their identity due to overcrowding during certain periods of the year, which leads to a lower quality of residents' life and a lower level of satisfaction among tourists. Regarding the economic dimension, the more realistic the long-term use of the location and the continuity in the use of the destination capacity, the higher the level of sustainability will be (Martín Martín, de Dios Jimenez Aguilera, Molina Moreno, 2014).

Numerous studies have shown the negative effects of seasonality on the sustainability of tourist destinations. One of them refers to the region of Andalusia, where it was determined that the coastal areas have the highest seasonality and the highest influx of tourists, which threaten sustainability. Martín Martín et al. (2020) conclude that seasonality in rural tourism should not be evaluated in general, because each destination has specific conditions that determine stability or seasonality. High seasonal concentration threatens protected areas in Croatia. The daily number of visitors is limited in Krka National Park (Ćorluka, Vukušić, 2017). Although tourism is a permitted activity in national parks, it requires the application of sustainable development principles and strategies that encourage the positive impacts of tourism and mitigate or eliminate the negative ones. Gee et al. (1999) include the following in these strategies: policy and planning, resource management, facility construction and layout, visitor management, environmental adaptation, marketing and promotion, education and training, research and monitoring. In addition to negative perceptions of seasonality, there are also positive ones. On the example of the Mediterranean islands as typical summer season destinations we could observe also positive impacts during low winter season (Selänniemi, 2001), and complementarity with other activities, such as agriculture (Shaw, Williams, 1994).

2 METHODOLOGY

From the point of view of supply or demand, the double approach of defining tourism seasonality affects its measurement. The variable used to measure the intensity of seasonality determines the ranking of the analyzed destinations (Martín Martín, de Dios Jimenez Aguilera, Molina Moreno, 2014), in this case, protected mountain areas, which are also established tourist centers. The fluctuations in the number of overnight stays by tourists were taken into account as an expression of seasonality.

One of the broadest ways of analysis focuses on the concentration index assessment, which is used to quantify the seasonal intensity of a destination. Concentration index values are the result of measuring the degree of concentration of tourist activity throughout the year (Fernandez-Morales, 2003; Lundtorp, 2001; Rossello et al., 2004; Wanhill, 1980). The Gini index is often used to measure seasonal intensity (Fernandes et al., 2020; Fernandez-Morales, Cisneros-Martinez, McCabe, 2016; Fernandez-Morales, Mayorga-Toledano, 2008; Kožić, Krešić, Boranić-Živoder, 2013; Lau, Koo, Dwyer, 2017; Lau, Koo, 2022; Nastassios, Sitouras, 2004; Papakonstantinidis, 2012). It has also been used in measuring the seasonal concentration of tourism in protected natural areas (Kostopoulou, Kyritsis, 2006; Prachvuthy, 2006; Sims, 2010; Xu, Pan, 2019; Rahman, 2022).

The Gini index is a measure of the intensity of tourism seasonality for each of the analyzed years. It shows the imbalance in the monthly distribution and the variable is related to the number of visits or overnight stays (Grainger, Judge, 1996). In this paper, the Gini index, obtained using data on the number of overnight stays, was analyzed.

The Gini index is easy to interpret, and useful in comparing data and analyzing their distribution (dispersion). Lundtorp (2001) considers the Gini index to be the most stable indicator of seasonality. This methodology has limitations that must be considered. The most significant limitation is the lack of data. Not all tourist destinations have readily available monthly data on the variables that the Gini index implies. Therefore, it is only possible to carry out certain case studies and define certain models of seasonality that differ not only between different destinations (e.g. mountain, coastal, protected natural areas, spa, urban, rural...), but also between similar destinations that usually do not represent a homogeneous category in terms of seasonality. Other limitations refer to the non-inclusion of the ecological, social, and economic characteristics of the area, the people who inhabit it, and the tourists who visit it.

The Gini index is obtained using the following formula:

$$G = \frac{2}{n} \sum_{i=1}^{n} \left(x_i - y_i \right)$$

Where n represents the total number of proportions, which in the case of calculating the degree of inequality of tourist overnight stays in months in one year is 12, x_i is the rank of the proportion (ordinal number of the element), from 1/12 to 12/12,

while y_i is the cumulative relative frequency of tourist overnight stays and refers to the cumulative element of the Lorenz curve.

The cumulative element of the Lorenz curve for the i month is determined by the formula

$$f_i = \frac{v_i}{v_0}$$

where v_i is the cumulative number of overnight stays starting from January to December, while v_0 is the total number of overnight stays during the year.

The Gini index has values in the interval between 0 and 1. The value 0 is for the lowest degree of seasonal concentration of tourists, and 1 is for the highest degree of seasonality concentration. The closer the Gini index is to zero, the more evenly distributed the series values are, and the closer the value is to 1, the more unevenly distributed.

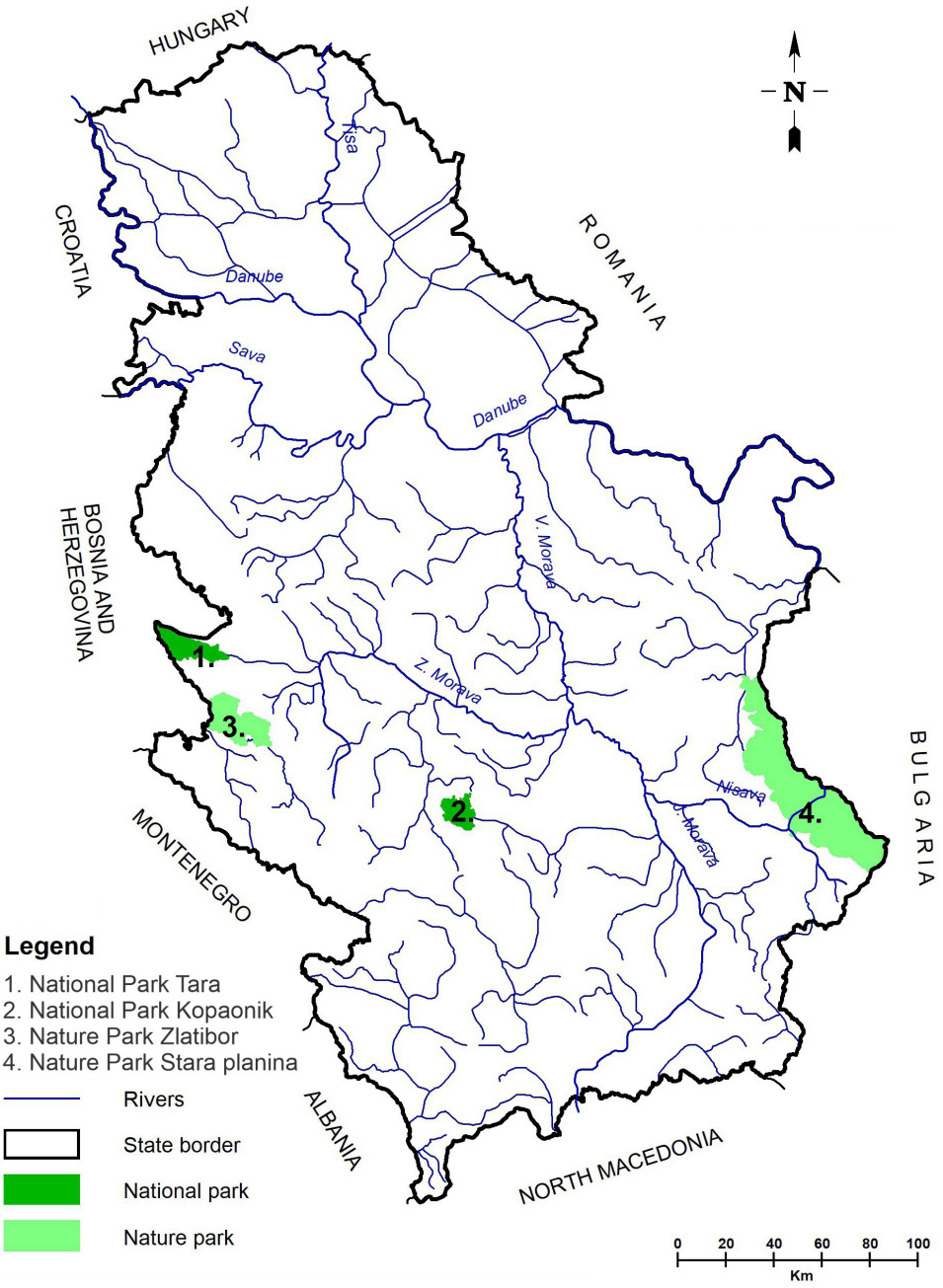
The first research hypothesis is that the seasonality of tourism in the protected mountain tourist centers of Zlatibor, Kopaonik, Tara, and Stara planina is not equal, but rather different depending on the destination. Another hypothesis is that each of these mountain destinations has similar Gini index values during the observed period.

3 RESULTS AND DISCUSSION

The Gini index values were determined in four mountain tourist centers in Serbia, parts of which are protected areas: Zlatibor, Kopaonik, Tara, and Stara planina (Figure 1). The tourist centers studied are characterized by the tradition of tourism development, recognition in the tourist market, visitation, tourist services and activities, and area protection.

The basic natural values of protected mountain areas are based on the richness, originality, and rarity of biodiversity, geodiversity, and variety of landscapes. On the territory of Kopaonik National Park, the habitat has more than 1,600 species of plants, more than half of which are high mountain flora with 91 species of endemic and 82 species of sub-endemic character. Kopaonik is habitat to 170 species of birds, 90% of which are nesting birds. Tara National Park is characterized by distinct forested areas with 35 forest and 9 meadow communities with more than 1,000 plant species, the most famous of which is the Balkan endemic and Tertiary relict of Pančić's spruce (*Picea omorika*). There are also 130 species of birds and 24 species of mammals, the most famous of which are the brown bear (*Ursus arctos*) and chamois (*Rupicapra rupicapra*). Zlatibor Nature Park is a habitat for as many as 960 species of plants, more than 150 species of birds, and also 54 species of mammals. Regarding the area, the largest protected area in Serbia is Stara planina Nature Park, which is in the process of being declared a national park. About 1,190 plant species inhabit this mountain

Figure 1: Geographical position of the studied protected mountain areas in Serbia.



massif. Stara planina is habitat to more than 110 species of diurnal butterflies, 18 species of amphibians and reptiles, 200 species of birds, and 30 species of mammals (Amidžić et al., 2011). To protect complex natural values, the development of tourism following the principles of sustainable development can be planned and implemented in zones that are under the protection regime III (Table 1).

Table 1: Overview of areas under the protection regimes I, II and III of Kopaonik and Tara National Parks and Zlatibor and Stara planina Nature Parks.

Protected area	Total area (ha)	Protection regime (%)		
		I	II	III
Kopaonik NP	11,969.04	12.38%	29.94%	57.68%
NP Tara NP	24,991.82	13.35%	34.07%	52.58%
Zlatibor Nature Park	41,923	4.69%	45.93%	49.38%
Stara planina Nature Park	114,332	3.22%	17.63%	79.15%

Source of data: www.zzps.rs

The ecological consequences of the tourist attractiveness of the researched areas are also manifested by the transformation of the primary vegetation cover. Based on the research results by a group of authors (Djurdjić, Jakovljević, Stojković, 2022), it was determined that in a time interval shorter than 20 years, the autochthonous vegetation was transformed, even in the zone that is under the protection regime I (examples Kopaonik National Park and Stara planina Nature Park), while the most intensive changes were observed on the territory of Zlatibor Nature Park in zones under the protection regimes II and III. In addition to the transformation or disappearance of habitats, changes have been observed in the form of intensification of erosive processes, increased sediment transport in watercourses, more frequent occurrence of landslides and torrential flows. The networks of ravines, gullies, and rills reduce the quality of the terrain intended for winter sports.

Among the researched mountain tourist centers, the most visited is Zlatibor, which in the period 2013–2021 had the largest number of overnight stays – 777,057 in 2019. The second destination by overnight stays is Kopaonik, with 565,980 overnight stays in 2019, the third is Tara with 281,002 overnight stays also in 2019, and Stara planina had the highest number of overnight stays in 2020 – 88,395 (Announcement, Statistical Office of the Republic of Serbia, 2022).

In connection with the analysis of seasonality attributes, the most visited months on Zlatibor are from May to August, on Kopaonik from December to March, on Tara from May to August, and on Stara planina in January and February. It is evident that Kopaonik, as a ski tourist center, has a dominant winter season, as does Stara planina, but with much smaller infrastructural and suprastructural capacities. The highest

peaks of Kopaonik and Stara planina are higher than 2000 m. The tourist destination of Kopaonik has a clearly expressed seasonality in the visitation, due to the strongest factor of attractiveness, the height of the snow cover, which allows the practice of winter sports. On Kopaonik, the height of the snow cover is greatest in February and March (about 100 cm). The mountains of Zlatibor and Tara are not intended for winter sports, due to the insufficient slopes of the mountain sides for practicing winter sports, and for this reason, the summer season is more dominant.

Table 2: Gini index in selected mountain tourist centers/protected areas in Serbia for the period 2013–2021.

Year	Zlatibor	Kopaonik	Tara	Stara planina
2013	0.15	0.43	0.26	0.37
2014	0.17	0.46	0.27	0.40
2015	0.15	0.41	0.34	0.42
2016	0.16	0.40	0.28	0.47
2017	0.13	0.37	0.22	0.34
2018	0.14	0.38	0.27	0.33
2019	0.12	0.39	0.22	0.34
2020	0.35	0.56	0.46	0.49
2021	0.22	0.44	0.40	0.37

Source of data: Authors' findings based on monthly data on tourist overnight stays, accessed on the website of the Statistical Office of the Republic of Serbia.

The data in Table 2 show that Kopaonik and Stara planina have higher Gini index values compared to Zlatibor and Tara. On Kopaonik, the values of the Gini index vary from 0.37 to 0.56, and on Stara planina from 0.33 to 0.47, which shows that the first hypothesis is confirmed and the second rejected. Among the investigated natural assets, Zlatibor has the lowest value of the Gini index (0.12 in 2019), but also with a value of 0.35, calculated for the 2020 data, which was conditioned by the COVID-19 pandemic. The increase in the Gini index value in 2021 is also a consequence of increased seasonality, as in the previous year.

The Gini index represents the area enclosed on the graph by the Lorenz curve and the direction of the area distribution. The cumulative order of the data, i.e. the frequency of the data from the smallest to the largest, gives a graphical representation of the Lorenz curve. In one year, the percentage proportions of the months in the year from 1/12% to 12/12% of the months are located cumulatively on the abscissa. The ordinate shows the total number of overnight stays that belong to certain proportions of the months of the year. If the number of overnight stays was the same in all months,

then the Lorenz curve would have the shape of a line of equal distribution. The form closer to the curve of unequal distribution is when there is inequality in the distribution of tourist overnight stays by months of the year.

A Lorenz curve is shown for each of the four protected mountain areas (Figures 2–5). Years with the highest and lowest value of the Gini index were taken into account.

Figure 2: Lorenz curve of tourist overnight stays on Zlatibor.

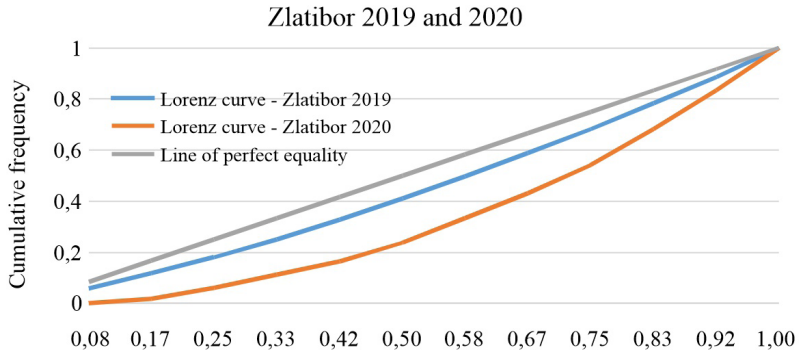


Figure 3: Lorenz curve of tourist overnight stays on Kopaonik.

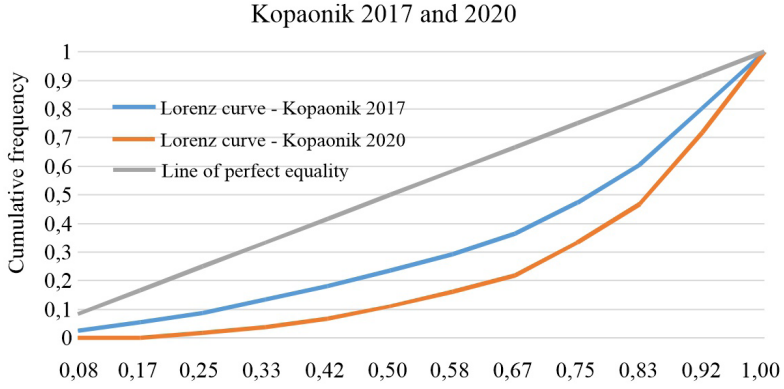


Figure 4: Lorenz curve of tourist overnight stays on Tara.

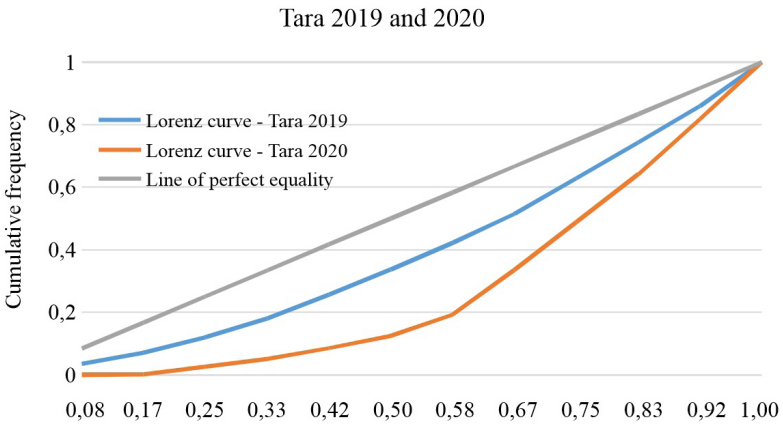
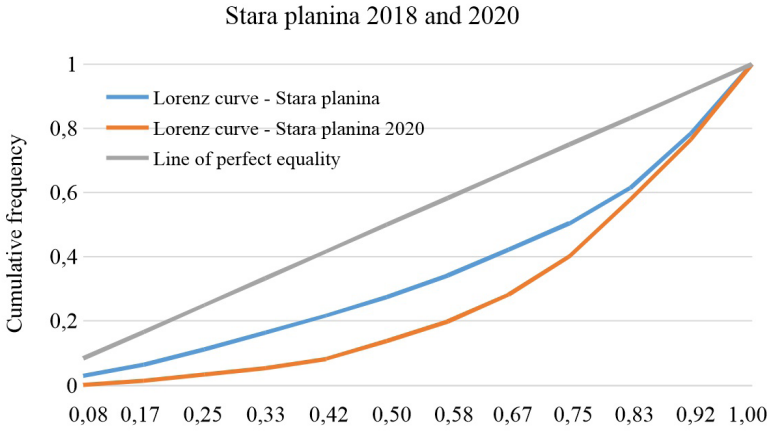


Figure 5: Lorenz curve of tourist overnight stays on Stara planina.



A comparison of Figures 2–5 shows that Zlatibor has the most even number of overnight stays throughout the year, with the lowest value of the Gini index in 2019 in the nine-year period studied. The inequality in the distribution of tourist overnight stays is most pronounced in 2020, which was affected by the COVID-19 pandemic.

One of the measures for the seasonally balanced development of tourism refers to the promotion of different alternative types of tourism. In this way, seasonality would be reduced, with an increase in economic effects (Dimoska, Petrevska, 2012). Financing projects that allow the use of accommodations throughout the year and

developing new tourism products to attract visitors in the off-season should be the task of many destinations.

The effects of seasonality could be mitigated by adapting the offer of products and services to diverse target markets. For example, although Kopaonik has a marked seasonality in its offer – in winter the target segment is skiers, in summer it could be tourists who prefer geotourism, ecotourism, adventure tourism, etc., in spring and fall the companies (seminars and team buildings). The Kopaonik ski center has over 50 km of groomed alpine slopes and a system of 24 cable cars with a total capacity of about 30,000 skiers per hour. In addition to the well-developed winter season, outdoor facilities also contribute to the development of the summer season: sports fields, zip lines, bobsled riding on rails, tubing, trim tracks for recreationalists, adventure parks, mountain biking, and cable car rides. In addition to sports and recreation, congress tourism is possible, because there are accommodation facilities that have halls for organizing various business meetings. To promote the summer season, events are organized: off-road driving on the Serbian Trophy Trails, orienteering competition Orienting Kopaonik Open, Blueberry Days, the Three Sides of Kopaonik Bicycle Race, and local events (Đorđević et al., 2018).

Zlatibor does not have the typical natural predispositions for the construction of ski slopes and cable cars, and therefore for the development of winter sports and recreational tourism, but it has for other types of tourism, which are conditioned by various tourist attractions (national geoheritage objects – Stopića pećina, waterfall in the village of Gostilje, lakes, ethno complex in Sirogojno). Zlatibor mountain favors health tourism. It is a therapeutic area for diseases of the respiratory organs, thyroid gland, anemia, and metabolic diseases. The events are mostly recreational and cultural and entertaining. One of the most interesting is the night race of Nordic skiers and in the summer season the Zlatibor Cultural Summer, with numerous events. The image of Zlatibor is recognizable in the domestic tourist market, but in the last decade, it has been characterized by high urbanization and crowds, especially in the summer season.

Tara mountain is a destination that offers active vacation, recreation, health, business tourism, rural tourism, and forms of nature-related tourism. A network of forest roads suitable for mountain biking and hiking has been developed, and additional facilities are available, such as rafting and cruises on the Drina River. In the locality of Mitrovac, there is a children's resort, and in the locality of Predov krst, there are ski areas (the length of the slope is from 3 to 5 km). The Perućac zone offers various activities on the water (fishing is especially popular), summer and winter holidays, but also shorter stays, as well as the use of the benefits of rural tourism (Đorđević et al., 2018).

The climate of Stara planina is favorable because the mountain is covered with snow for almost five months, which is a good basis for winter sports. The average duration of a snow cover thicker than 50 cm is about 70 days, and the average maximum height of the snow cover is 110–150 cm (Manojlović et al., 2015).

In addition to the climate, a significant factor in Stara planina's competitiveness is its rich biodiversity and geodiversity. However, investments in this destination are still insufficient, which is the main competitive threat compared to other tourist destinations. This situation has its advantages, which are related to lower degradation of the area. In addition to the conditions for winter tourism, which is given priority, there are conditions for ecotourism, because Stara planina is a natural asset of national importance of the protection category I. Ecotourism can influence the extension of the tourist season, to justify potential economic investments and realize the ecological and social components of sustainable development (Manojlović et al., 2015).

A comparison of this paper's results was made with the results of a study in the Republic of Korea, which highlighted the necessity of monitoring 133 protected areas on Jeju Island, identified as hotspots of tourist visits, which showed a value of the Gini index greater than 0.5. Protected areas such as SeongsanIlchulbong and Cheonjeieon Waterfall had high seasonal dynamics and were some of the most frequently visited natural resources (Kim et al., 2020). Protected natural assets in Serbia, which are the subject of this paper, do not have such an accentuated seasonality.

Most Mediterranean countries have a seasonal nature of tourist visits. Tourist activities are increasing, resulting in a seasonal business. An example of this is Croatia, which has the value of the Gini index of 0.64 when it comes to overnight stays by tourists (higher values compared to arrivals) (Ćorluka, Vukušić, 2017). The seasonality of tourism in Croatia is constantly present due to the structure of accommodation facilities as well as the greater increase in the number of overnight stays in the summer season compared to the rest of the year (Suštar, Laškarin Ažić, 2018). This example also proves that the values of the Gini index depend on the types of destinations, i.e. dominant forms of tourism and tourist demand.

4 CONCLUSION

Case studies show that tourism in destinations in protected mountain areas of Serbia and their surroundings has heterogeneous impacts, taking into account demand, tourism resources, and the markets they attract. In perspective, research and recommendations could go in the direction of further identifying geographic areas and environmental conditions that allow for greater annual stability. The advantage of the methodology used is that it enables the comparison of the intensity of seasonality not only in one destination over time but also in several destinations. Further and more advanced studies could be conducted in areas with different characteristics, e.g. protected mountain areas in neighboring countries, with different management policies. Subsequent research could investigate the impact of seasonality on the local population, how seasonality is affected by proximity to emission centers, and trends in the international tourism market. All these and similar research would contribute to the definition of a model for reducing seasonality.

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SEZONSKOST IN TRAJNOSTNOST TURIZMA – ŠTUDIJA PRIMERA: ZAVAROVANA OBMOČJA V SRBIJI

Povzetek

Povezava med sezonskostjo in trajnostnim turizmom je v znanstveni literaturi obravnavana tako z ekonomskega kot ekološkega in socialnega vidika. Sezonskost v turizmu ima negativne, a tudi pozitivne učinke na vse tri omenjene vidike. Analizirana je na podlagi prihodov in prenočitev turistov po mesecih, zasedenosti nastanitvenih zmogljivosti, obratovanja zmogljivosti na letni ravni ter začasnih zaposlitev v turizmu.

V metodološkem smislu se za kvantificiranje sezonskosti destinacije pogosto uporablja indeks koncentracije. Merjenje sezonske koncentracije turizma v izbranih zavarovanih gorskih območjih Srbije je bilo izvedeno z uporabo Ginijevega indeksa in kaže neenakost prenočitev turistov po mesecih v letu. Vrednosti Ginijevega indeksa so bile izračunane za štiri gorska turistična središča v Srbiji: narodna parka Kopaonik in Tara ter naravna parka Stara planina in Zlatibor, in sicer za obdobje 2013–2021. Ključne vrednosti obravnavanih gorskih turističnih destinacij temeljijo na biodiverziteti in geodiverziteti, tradiciji turističnega razvoja, obiskanosti in turističnih vsebinah.

Najbolj obiskani meseci na Zlatiboru so od maja do avgusta, na Kopaoniku od decembra do marca, na Tari od maja do avgusta, na Stari planini pa januarja in februarja. Kopaonik kot smučarsko turistično središče ima prevladujočo zimsko sezono, prav tako Stara planina, medtem ko Zlatibor in Tara nimata dovolj pobočij, primernih za zimske športe. Zaradi tega je na Zlatiboru in Tari glavna poletna sezona. Na izrazito sezonskost obiskanosti Kopaonika vpliva predvsem višina snežne odeje, ki je februarja in marca okoli 100 cm.

Izrazitejša sezonskost turističnega obiska Kopaonika in Stare planine se kaže v višjih vrednostih Ginijevega indeksa v primerjavi z Zlatiborom in Taro. Vrednosti Ginijevega

indeksa na Kopaoniku so od 0,37 do 0,56, na Stari planini pa od 0,33 do 0,47. Zlatibor ima najnižje vrednosti Ginijevega indeksa (0,12 v letu 2019), Tara pa je do leta 2020 imela najvišjo vrednost tega kazalnika 0,34 (l. 2015). Pandemija covida-19 v letih 2020 in 2021 je na Kopaoniku povzročila povišanje vrednosti Ginijevega indeksa na 0,56.

Spodbujanje in izvajanje alternativnih oblik turizma in dejavnosti prispeva k zmanjševanju sezonskosti. Zelo pomembno je prilagajanje turistične ponudbe različnim ciljnim skupinam. V tem smislu gre za različne turistične produkte in dejavnosti, kot so geoturizem, ekoturizem, doživljajski turizem ter prireditveni in poslovni turizem.

Na značilnosti turizma v izbranih gorskih turističnih destinacijah na zavarovanih območjih Srbije vplivajo različni dejavniki, med katerimi so naravne predispozicije, turistični trg in promocijske aktivnosti. Z uporabo Ginijevega indeksa smo intenzivnost sezonskosti obravnavali v kronološko-prostorskem kontekstu, kar bi s podrobnejšimi analizami in vključevanjem drugih dejavnikov v turistični razvoj destinacij lahko prispevalo k opredelitvi drugačnih modelov blaženja sezonskosti.

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THE MAIN PECULIARITIES OF LABOUR MIGRANTS' INTEGRATION IN GEORGIA (CASE OF TBILISI AND BATUMI)

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Abstract

Following the dissolution of the Soviet Union, Georgia became a country of intensive emigration. However, the last decade has marked a notable change in the country's migration profile due to the inflow of immigrants. This is a new challenge for contemporary Georgia, especially in terms of immigrant integration. The purpose of this paper is to identify the main features of labour migrants' integration into Georgian society. The research findings are mostly based on the results of a qualitative sociological research, employing in-depth interviews with migrant workers residing in Georgia, and experts of the field. Lack of complete legislation and sound policies is the main characteristic feature of labour immigration management in Georgia; therefore, the migrant integration process goes spontaneously: one group of migrants, namely English- and Russian-speakers, as well as skilled workers still feel comfortable, and they keep intense communication with the local population. Another part of migrants who is denied state support in studying Georgian remains isolated from the host society.

Keywords: labour immigration, integration, Georgia, Tbilisi, Batumi

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POSEBNOSTI INTEGRACIJE DELOVNIH MIGRANTOV V GRUZIJI (PRIMER TBILISIJA IN BATUMIJA)

Izvleček

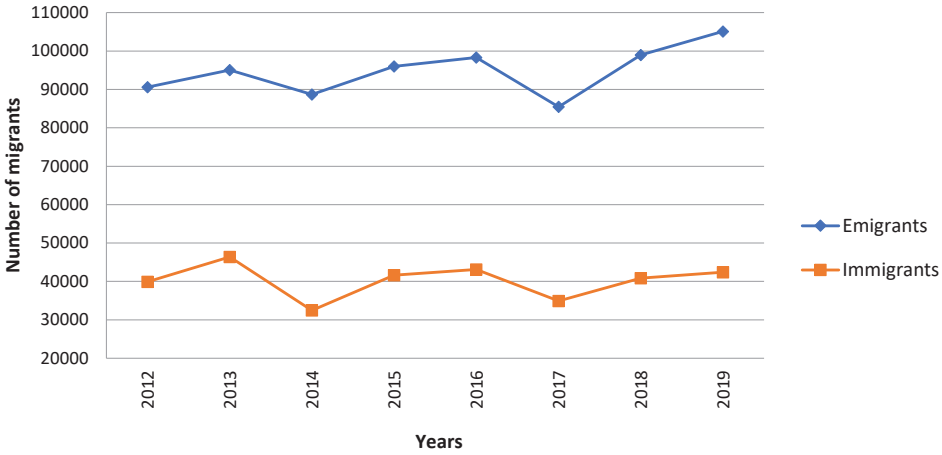
Po razpadu Sovjetske zveze je Gruzija postala država intenzivnega izseljevanja. V zadnjem desetletju pa so se migracijski procesi v državi zaradi intenzivnejšega priseljevanja spremenili. To je nov izziv za sodobno Gruzijo, zlasti z vidika integracije priseljencev. Namen prispevka je opredeliti glavne značilnosti integracije delovnih migrantov v gruzijsko družbo. Raziskovalne ugotovitve temeljijo predvsem na rezultatih kvalitativne sociološke raziskave, pri kateri smo uporabili poglobljene intervjuje z delavci migranti, ki prebivajo v Gruziji, in strokovnjaki s tega področja. Glavna značilnost politike priseljevanja delovne sile v Gruziji je pomanjkanje popolne zakonodaje in trdnih migracijskih politik, zato proces integracije priseljencev poteka spontano: ena skupina migrantov, in sicer angleško in rusko govoreči ter kvalificirani delavci, se v gruzijski družbi dobro počuti (zaradi uspešne integracije) in ohranja intenzivno komunikacijo z lokalnim gruzijskim prebivalstvom. Druga skupina migrantov, ki jim država ne nudi podpore pri učenju gruzijščine, pa ostaja izolirana od gruzijske družbe.

Ključne besede: delovna migracija, integracija, Gruzija, Tbilisi, Batumi

1 INTRODUCTION

Georgia has been a country of immigration for centuries, including the Soviet period. In the 1990s, due to worsened socio-economic conditions and ethnic conflicts, large-scale emigration flows started. During the period of independence, about 1.5 million people have left the country. In the last decade emigration significantly decreased and net migration came to balance. Moreover, in 2020 immigration even exceeded emigration. Immigration statistics is misleading because of the approach of the National Statistics Office of Georgia, which includes in immigration statistics any person who stayed on the territory of Georgia for at least 183 days and at the same time Georgia was not his/her permanent residence country for the last six months regardless of his/her citizenship (National Statistics Office of Georgia, 2020). Article 3.1 of law of Georgia on immigration states: "*An immigrant is an alien who has acquired the right of permanent residence in Georgia under Georgian legislation*" (Law of Georgia on Immigration, 1997). Therefore, for further analysis, it would be relevant to exclude a number of Georgian citizens from the official immigration statistics. Nevertheless, during the last decade, immigration to Georgia grew significantly (Figure 1).

Figure 1: Dynamics of number of immigrants and emigrants in Georgia (2012–2019).



Source: National Statistics Office of Georgia, https://www.geostat.ge/en/modules/categories/322/migration.

As obvious from Table 1 Russian nationals constitute a big part of immigration flow to Georgia. It should be also mentioned that significant part of Russian immigrants is represented by ethnic Georgians.

Table 1: Number of immigrants in Georgia by countries of their citizenship (2012–2019).

Immigrants by country of citizenship	Year							
	2012	2013	2014	2015	2016	2017	2018	2019
Russia	7.475	10.427	9.692	10.552	11.185	9.723	10.323	11.515
Turkey	6.959	10.007	4.672	5.810	6.294	4.365	3.934	3.419
Iran	675	1.080	825	1.766	418	1.335	3.798	5.664
Azerbaijan	1.883	3.211	2.163	2.839	3.420	3.501	3.761	3.669
India	1.215	1.212	679	800	1.435	2.686	3.015	2.846
Ukraine	1.853	1.610	1.552	2.886	2.922	2.275	2.175	2.303
Armenia	10.724	7.043	3.856	4.143	6.241	2.042	2.174	2.274
USA	1.102	1.536	883	1.081	1.101	1.075	1.159	1.349
China	626	1.143	584	1.267	873	904	974	944
Others	7.103	8.942	7.434	10.344	9.036	6.909	8.861	8.334
Stateless persons	250	168	115	145	217	81	94	69
Not specified	25	0	0	0	0	0	1	0
Total number	39.890	46.379	32.455	41.633	43.142	34.896	40.269	42.386

Source: National Statistics Office of Georgia, https://www.geostat.ge/en/modules/categories/322/migration.

To respond to growing immigration, the Georgian government, on the one hand, speeded up developing respective legislation in the last decade while on the other hand it accelerated the building up institutions to manage immigration.

Managing labour migration requires sound policies, qualified staff, and institutional knowledge. In Georgia's case, there is an additional challenge: Georgian scholars keep focusing on emigration issues, thus leaving labour migrants' integration out of their interest. The given work, in fact, is the first attempt to fill this gap by undertaking an academic study of the topic.

The paper reveals the main features of labour migrants' integration into Georgian society.

The research aims to answer the following questions:

- Are Georgia's legislation and governmental policies on migrant integration comprehensive and effective?
- What are the main challenges revealed by the sociological survey?
- What are the specific aspects of integration processes in Tbilisi and Batumi?

2 DATA AND METHODS

The research is mainly based on qualitative sociological research methods. It includes in-depth interviews with labour migrants, as well as with experts in Tbilisi and Batumi. Within the research framework, 56 in-depth interviews were conducted with migrant workers (Table 2) employed in various economic sectors of the above-mentioned cities, using the qualitative sociological method with semi-structured questionnaires in the English, Georgian, Russian and Turkish languages. As part of the qualitative sociological research, the authors interviewed 13 specifically selected experts using the in-depth interview method. The majority of them were pundits of the respective area, while others – public servants involved in migration management. The research was conducted between July and November 2021.

Table 2: Main characteristics of interviewed labour migrants.

Labour migrants	**Tbilisi**	**Batumi**
Gender	Female 50%; Male 50%	Female 46%; Male 54%
Medium age	37 years	38 years
Marital status	39% married; 61% single	64% married; 36% single
Country of citizenship (by alphabetic order)	Azerbaijan, Belarus, China, Egypt, India, Iran, New Zealand, Romania, Russia, Serbia, South Africa, United Kingdom, Turkey, Ukraine, USA, Uzbekistan	Belarus, Jordan, Kazakhstan, Lithuania, Nigeria, Russia, Serbia, Turkey, Turkmenistan, Ukraine

Labour migrants	Tbilisi	Batumi
Visa type / residence permit / citizenship (Number)	Residence permit – 14 Working visa – 2 Visa free regime – 10 Dual citizenship – 2	Residence permit – 8 Working visa – 0 Visa free regime –19 Dual citizenship – 0 Tourist visa – 1
Type of employment	Employer – 3 Self-employed and freelancer – 6 Employed – 19	Employer – 10 Self-employed and freelancer – 13 Employed – 5
Branch of Employment	Education – 35% Tourism – 11% Real estate – 7% Other services – 40% NGO – 7%	Tourism – 11% Restaurant business – 7% Real estate -14% Other services – 47% Construction –14% Industry – 7%
Position (Number)	Head of company – 3 Manager – 5 Other positions – 20	Head of company – 10 Manager – 1 Other positions – 17
Total number of respondents	28	28

Due to several reasons, the sociological research was conducted in two cities: Tbilisi and Batumi. Tbilisi is the capital and the biggest economic and cultural centre of Georgia with a population of about 1.2 million. Batumi – the administrative centre of Ajara Autonomous Republic, is the second biggest city (150,000 inhabitants) of the country, situated near the Turkish border. Batumi, especially since the 19th century, became a very important port of the Caucasus region. Both Tbilisi and Batumi always have been multicultural cities, tolerant to different religions and cultures. Not surprisingly, in Georgia, the overwhelming majority of immigrants are concentered in those cities.

For the selection of the respondents, we used a two-stage sample design. From the beginning, the respondents were chosen based on purposive sampling, considering the following characteristics – country of origin and occupation. Thus, at that stage, we purposely chose 10 respondents. In the second stage, we used snowball sampling. Under this method, the respondents propose other people who fit into the selected category. Accordingly, one respondent connected the researcher with another one and so on, until the needed number of people in the target audience were interviewed. Based on the snowball sample 46 migrants were interviewed. Overall, the research covered 56 migrants living and working in two Georgian cities.

We may conditionally divide all 56 respondents into three categories based on countries of their origin: economically highly developed countries, post-Soviet countries, and other countries. Migrants from economically highly developed countries mostly included native English speakers from the United Kingdom, the USA, New Zealand,

South Africa and the EU countries. Respondents from the post-communist states were citizens of Russia, Belarus, Serbia, Ukraine, Kazakhstan, Turkmenistan, Azerbaijan, and Lithuania. Other countries included migrants mostly from the Middle East (Turkey, Iran, Jordan, Egypt), as well as from Asia (China, India) and Africa (Nigeria).

One of the methods of the research is collection-processing-analyzing official data on international mobility. A big part of statistics was obtained from the official site of the National Statistics Office of Georgia. Some statistics were also provided by the Ministry of Economy and Sustainable Development of Georgia. Covid-19 pandemic and related restrictions significantly altered immigration dynamics. With this in mind, we did not include 2020 and 2021 immigration statistics in the paper.

In order to review and assess socio-economic and legal variables of immigration in general, and immigrants' integration, in particular, we reviewed reports and researches of the Georgian governmental agencies, international organizations and local NGOs, including the State Commission on Migration Issues, International Organization for Migration (IOM), Institute for Development for Freedom of Information (IDFI), Tolerance and Diversity Institute (TDI).

A significant part of the paper is dedicated to the description and assessment of the Georgian legislation on migration. All laws and legal acts on migration are available on the official website of the Parliament of Georgia.

The authors critically reviewed and analyzed various academic literature on the subject, and applied a comparative method when disclosing similarities and differences between the migrant integration processes in Tbilisi and Batumi.

3 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Human mobility is an ancient socio-geographic phenomenon. Ernst Georg Ravenstein pioneered the theorization of migration in the 1870–1880s (Rees, Lomax, 2019, p. 352). Since then, a wide variety of works have been dedicated to migration studies.

Among the international migration theories, the *neoclassical* is the best-known one. The theory argues that the main motivation for human mobility is economic: a difference in wages between sending and receiving countries is the decisive factor for migration. In other words, people move to areas where they expect to earn more money. According to this theory, migration decisions are made by individuals. Migrants have to bear material and non-material costs before and after reaching the country of destination, which include travel expenses, housing prior to finding employment, learning a foreign language and cultural peculiarities of the host society, getting used to the new labour market, establishing new contacts and suspending old ones. Accordingly, a potential migrant chooses the country, where profit seems higher after consideration of the above costs (Massey et al., 1993). The main hindrance of neoclassical theory is that it very much focuses on the economic component of migration

and underestimates its socio-cultural and political dimensions. The theory also ignores the role of historic ties between sending and receiving countries.

The theory of mobility (*intervening opportunities*) represents a modification of the gravity model. This theory tries to describe the likelihood of migration. The central point of the theory is that there is no necessary connection between mobility and distance. Considering intervening opportunities, a migrant may change his/her mind and settles in a place different from the originally planned destination (Stouffer, 1940).

The New economics of labour migration (NELM), also known as the *theory of household economics*, is one of the most influential migration theories since the 1980s. NELM focuses on two main aspects of migration: a decision on migration is made at the group (mostly family) and not individual level, and the main task of migration is rather diversification of revenues within a family than maximization of income. By combining these aspects, we conclude that a family or household duly controls its own material well-being by diversifying its labour resources. In the best scenario, one part of a family members is engaged in household work, the second part in internal migration, and the third part in international migration. Notably, unlike a neoclassical theory, NELM does not consider international migration as a one-way process. Moreover, NELM is making emphasis on return migration (King, 2012). We believe that this theory has two main shortcomings: it is less or even not applicable to socio-economically developed societies and independent individuals, as well as to the situation when an entire family migrates.

Alternative models known as historical-structural theories review international migrations through the lens of Marxism. Michael Piore (1979), based on a fact that industrialized societies have permanent demand for a labour force, believes that international migration is rather caused by *pull* than *push* factors (Wickramasinghe, Wimalaratana, 2016). Some scholars (e.g., Arango, 2000) criticize *the dual labour market theory* as it does not provide a comprehensive analysis of migration causes, especially the push factors.

One of the most influential social theories of post-modernity is Immanuel Wallerstein's w*orld-systems theory*. It gives a good historical analysis of the emergence of the Capitalist World Economy, as well as modern characteristics of economic ties between the highly developed North and developing South. Wallerstein (1974) also provides a geographic structure of the world economy: core – semi-periphery – periphery. However, this theory is very much focused on highlighting the negative sides of international economic relations, ignoring the benefits that it brings to developing countries and to the part of their population.

Wilbur Zelinsky (1971) uses geographic, in particular time-space approach for migration process analysis. He gives a five-stage mobility pattern of Europe, arguing that there is a clear correlation between intensity, as well as the character of migration and historic type of society. He singled out five types of European societies from pre-modern traditional up to future super-advanced. Although this concept looks quite attractive, it

still lacks the geographic scope. It covers historical specificities of advanced countries but is less applicable for the developing part of the world (King, 2012).

Migration network theory arose on a basis of the *social capital concept*. The social networks help to distribute information about job opportunities, accommodation possibilities, and the main features of the cultural and religious life of receiving countries. In general, those networks have a positive effect on the migration decision-making process and reduce the costs and social risks for newcomers (Massey et al., 1993; Arango, 2004).

The migration process does not end with mobility, i.e., with a person transferring from one place to another, as it is followed by a complex and difficult process of integration.

The term "Integration" still does not have a legal definition and is being interpreted differently. We share the definition formulated by Rinus Penninx: "*Integration is a process by which immigrants become accepted into society, both as individuals and as groups*." This process at the group level takes quite a time and its results could be revealed no earlier than at the second generation of immigrants (Penninx, 2003).

In general, the integration process is measured by legal-political, socio-economic, and cultural-religious dimensions (Penninx, Garcés-Mascareñas, 2016). Entzinger and Biezeveld (2003) argue that besides the mentioned three domains of migrant integration there is one more: attitudes of recipient societies. However, we believe that the latter does not function independently, as it is a part of all other three domains.

Russel King and Aija Lulle (2016), based on the frameworks of Ager and Strang (2004), and Heckmann (2005) offered a simplified approach, more precisely, a list of spheres of migrants' integration. This includes: economic, social and cultural, educational, political and citizenship integration(s), as well as spatial dimensions of integration. The latter one, which is distinct from the previously known dimensions, creates a good opportunity in finding out territorial (regional) peculiarities of migrants' integration.

One of the important topics which touched the interest of geographers is the sense of belonging of immigrants to the host society. According to Yuval-Davis (2016), belonging is constructed by three interrelated analytical facets, such as social locations, emotional attachments to different communities and groups, and ethical and political value systems of immigrants and locals. On the other hand, a whole set of factors (cultural, including language, social interaction, economic, legal, safety, and comfort) determines a sense of belonging. Some researchers argued that a sense of belonging is shaped by the combination of contextual aspects (Cichocka, 2021, p.1953). In this paper, we outline those factors that in our understanding play a rather important role in developing a sense of belonging in the cases of Tbilisi and Batumi.

In 2005, the EU Commission of the European Communities adopted *A Common Agenda for Integration* including 11 common basic principles of the immigrant integration policy (CEC, 2005). The very first principle states that integration is a two-way

process. The rest 10 principles conditionally could be divided into two sets: the first set of principles is addressed to host countries and the second one – is to immigrant communities. The authorities of EU member states are recommended to ensure the rights and freedoms of immigrants to employment, education, participation in the democratic process, access to institutions, practice their own religion and culture, as well as to enhance frequent interaction between immigrants and member state citizens. Simultaneously, the governments of the member states should mainstream the integration policies and develop indicators and evaluation mechanisms of the policy implementation. On the other hand, immigrants are suggested to pay respect to the basic values of the European Union; to get basic knowledge of the host society's language, history, and institutions.

4 LABOUR IMMIGRATION TO GEORGIA: LEGAL ISSUES AND GOVERNMENTAL POLICIES

Labour migration in Georgia is regulated by national laws and procedures, as well as international instruments to which Georgia is a signatory. Among the laws regulating labour migration, the Constitution of Georgia, the Law on Labor Migration, and the Law of Georgia on the Legal Status of Aliens and Stateless Persons are of primary importance.

According to Georgian legislation, the term "labour immigrant" refers to a foreigner with a work residence permit. This status allows an immigrant (including freelancers) to carry out entrepreneurial or labour activities (Parliament of Georgia, 2015). A person coming to Georgia for employment should get an immigration visa (D1 category) in the first place. Persons who come to Georgia for family reunion purposes are eligible for a D4 category visa (Guidebook on Legal Immigration, 2015).

Since 2015, the number of immigration visas issued in Georgia has reduced. This can be explained by the legislative changes, more specifically: nationals of 98 countries are allowed to enter Georgia without a visa; from this, citizens of 28 countries apart from visa-free entry are eligible to one year stay (Immigrant Integration Policy and Practice in Georgia, 2021). Therefore, an immigrant visa is no longer a mandatory requirement for the nationals of the above countries. Under international agreements and national legislation, Georgia allows visa-free entry to citizens of the USA, the EU countries, Turkey, Ukraine, most members of the Commonwealth of Independent States (CIS), as well as part of the Persian Gulf countries.

The work residence permit is issued to individuals coming to Georgia for labour or entrepreneurial activities, as well as to freelancers. In 2015–2018, Residence permits were mostly issued to men (66%) who belonged to the 18–65 age group. As for work residence permits, they were mostly granted to people aged 26–40 (Migration Profile of Georgia, 2019).

It is remarkable that many foreigners participated in the governmental project "Remotely from Georgia" launched during the Covid-19 pandemic. Among them were freelancers, full-time employees, or investors, who could stay in Georgia for at least 360 days without a visa and whose monthly income exceeded 2.000 USD. Between August and October 2021, about 1.100 foreign citizens were involved in the "Remotely from Georgia" program (Agenda.ge, 2020).

The institutionalization of migration management in Georgia began in 2010 with the establishment of the State Commission on Migration Issues – the consultative unit of the government of Georgia. Nine national agencies, as well as 10 local NGOs and international organizations with consultative status, take part in its work (Table 3).

Table 3: Structure of the State Commission on Migration Issues of Georgia.

The State Commission on Migration Issues				
Agencies-members of the commission				
Ministry of Economy and Sustainable Development	Ministry of Justice (Chair)	Ministry of Education and Science	Ministry of Foreign Affairs	Ministry of Internal Affairs (Co-chair)
State Security Service	Ministry of Finance	Ministry of Internally Displaced Persons from the Occupied Territories, Labour, Health and Social Affairs		National Statistics Office
Organizations with the Consultative Status				
Civil Development Agency	Migration Centre	Delegation of the European Union to Georgia	International Organization for Migration	UN High Commissioner for Refugees (UNHCR)
Public Defender's Office	International Centre for Migration Policy Development	Georgian Young Lawyer's Association	German International Cooperation Society (Giz)	Innovations and Reforms Centre
Thematic Working Groups				
Working Group on Statelessness	Working Group on Unified Migration Data Analytical System	Migration Laboratory	Working Group on Migration Risk Analysis	Working Group on Integration Issues

Source: State Commission on Migration Issues, https://migration.commission.ge/index.php?article_id=5&clang=1.

Since 2013 the commission has been developing the migration strategy of Georgia. Taking into consideration the dynamic character of migratory and political processes (e.g., Georgia's Association Agreement with the EU and the Visa Liberalization Action Plan of 2015), migration strategy has been subjected to frequent modifications. Apart from Georgian citizens living inside or outside the country, the target groups of the latest strategy (2021–2030) include immigrants (regardless of status), returned migrants, stateless refugees and asylum seekers (Migration Strategy of Georgia, 2020).

The 2021–2030 migration action plan aims at solving the problems in the field of migrant integration. The following objectives are singled out in this direction:

- Designing unified approaches towards immigrants' integration;
- Raising public awareness on immigrants' potential;
- Providing immigrants with wider opportunities for learning the state language.

The Georgian legislation (The Parliament of Georgia, 2014a) ensures all basic rights and freedoms for integration to foreigners residing in Georgia, which includes: education, employment, entrepreneurship, healthcare, social protection, residence, acquisition of citizenship, family reunification, own and inherit property, religion, cultural traditions, use of mother tongue etc.). However, there still is a need for developing a consolidated and complex program targeted at labour migrants and members of their families.

Citizenship is the highest stage of civic integration. The basic principles of Georgian citizenship and the grounds for its obtaining are regulated by the Organic Law of Georgia on Georgian Citizenship (The Parliament of Georgia, 2014b). In 2018, new amendments to the law defined the conditions of dual citizenship. A foreign national may retain his/her citizenship and acquire Georgian citizenship (i.e., becomes dual national) based on the decision made by the President of Georgia. In 2005–2013 there were 53,067 cases of granting Georgian citizenship to foreign nationals, and in 2014–2017, 16,463 individuals were granted Georgian citizenship by means of exception, including citizens of Russia (61%), USA (7%), Armenia (6%), Greece (4%), Israel (4%), Ukraine (4%), Turkey (2%) and Iran (1%) (IDFI 2018).

5 RESULTS AND DISCUSSION

The review of Georgia's migration statistics confirms that people mostly prefer to move to those destinations which are closer to their country of origin (Ravenstein, 1889). A large part of migrant workers arriving in Georgia is from neighbourhood areas (Armenia, Azerbaijan, Russia, Turkey, Iran, Ukraine). In 2019, about 2/3 of all labour migrants residing in Georgia were from the above-mentioned countries.

A qualitative study does not provide enough ground for measuring the main reasons for the mobility of migrants to Georgia, however, we may still draw some general

conclusions. The sociological research showed that economic considerations still prevail over other factors, especially for people from the economically developing world. The interviewed migrant workers underline that the business environment in Georgia is favourable. The country ranked seventh in the world for ease of doing business and second – for ease of starting a business (Doing Business, 2020). Therefore, many migrants have good perspectives for successful business activities in Georgia. It is also an important fact to note that part of immigrants is wealthier and more skilled than locals. A 33-year-old Russian immigrant woman noted: "*– I arrived in Georgia as a tourist but finding this country attractive, decided to stay here and start my business. I would not have rushed with such decision in Russia, compared to which Georgia has many favourable conditions for doing business.*"

According to the research results, the majority of the job-seekers had heard about Georgia through social networks and found a workplace before arrival. In the case of migrants from the post-Soviet space and Asian countries, the importance of network connections is crucial. This is especially true in the case of Iranians and Ukrainians, who arrived in Georgia with the help of other migrant networks residing in Georgia. One of the main principles of NELM theory states that a decision on migration is made at the family level. The research shows that it is applicable mostly in the case of labour migrants, who arrived from economically developing countries.

The research revealed that the lack of legislation and procedures on labour migrants' integration is among acute problems for Georgia. The interviewed governmental official noted: "Improvement of the legislative framework is critical from a migration perspective. The law on Labor Migration deals only with emigration, while immigration is regulated by the governmental ordinance. The country does not have integration programs and there is no plan for elaborating one in a near future."

Almost all respondents noted that they like the natural environment (landscape, climate, and biodiversity) of the host country. They spend their free time with friends (mostly migrants) or family. Research showed that the majority of immigrants residing in Georgia feel safe and emotionally calm. Accordingly, when listing the reasons for choosing to stay in the country, they ranked psychological well-being higher than economic considerations. *"Although I don't speak Georgian and I don't have a stable income at the moment, I am still satisfied with my arrival, because here my priority is my mental comfort and for me, this is the most important thing today*" – a 41-year-old migrant woman from Lithuania commented.

The size of a city does not necessarily determine to which extent the local community is open or tolerant to migrant integrations. It could go either way (e.g. Cichoka, 2021; Gauci, 2020). Our study revealed that Batumi is a very migrant-friendly city. This can be conditioned by the cultural diversity and historical past of the city: at different times this region was under the Ottoman and Russian Empires, and therefore until now Batumi has remained a home of both Muslims and Christians. In the Soviet days, it was an important tourist destination. All these factors have bred a particularly

tolerant attitude of its residents towards foreigners. Most of the migrants in Batumi are Turks and former Soviets who already own real estate and other property. For immigrants from post-Soviet countries, it is easier to interact with locals. This is because of shared cultural values from the Soviet past, and the absence of language barriers between them. A 33-year-old Russian man noted: *"You know even though Batumi's population is over 100.000, everyone knows each other and crime is rare; here, if you do something wrong, everyone will know about it. You will be forced to leave the city. That's why everyone here helps each other; if someone finds a phone on the bench or something else, it is immediately returned to the owner."*

In 2019, only 31 per cent of real estate buyers in Batumi were Georgian citizens, while 69 per cent came on the account of foreigners, with Russians and Ukrainians having the higher share. Foreigners buy the property for investment purposes. It is notable, that 69 per cent of bank loans in Batumi were also taken by foreigners (Kordzaia, Chiligashvili, 2019). An increasing number of short- and medium-term residents, and second-home owners, including freelancers, shows that residential tourism is a developing phenomenon in Batumi, which eventually leads to what Benson and O'Reilly labelled as "lifestyle migration" (2009: 621).

The research reveals that the political situation in sending countries serves as an important push factor. Part of the respondents from Russia and Belarus noted that their mobility was caused by political reasons. "*Now more Belarusians and Russians are arriving. I sell and rent flats in Batumi and there are a lot of Russians, in Particular Jehovah's Witnesses, and Belarusians, who do not want to live under Lukashenko's rule*" – a 33-year-old Belarus migrant man commented. *"My spouse is a media journalist; I worked for the Russian TV channel NTV. We decided to leave Russia because of our professional and political considerations. We realized that it was difficult to work under the existing regime in our country. We are not very outspoken liberals but when politics strongly affects your professional activities, it is very depressing," –a* 43-year-old migrant woman from Russia said. The immigration of part of Iranian nationals is affected by the harsh political conditions in their country. As they have very limited possibilities in terms of moving to European countries or the USA, they choose Georgia as a final destination. For some Ukrainians a reason was a forced migration conditioned by the occupation of Crimea and part of Donbas by Russia in 2014–2015.

Education is one of the most important factors of integration. In Tbilisi and Batumi secondary and high school education is available in Russian, as well as in English languages. In both cities Russian secondary schools are public. Since there are no Turkish, Arabic, Chinese or Iranian schools, the children of migrants from these countries attend Georgian public or English private schools.

The language barrier is an acute problem for immigrants. The sociological survey showed that for foreigners the main obstacle on the way of integration is the lack of knowledge of the Georgian language. On the one hand, part of immigrants lacks motivation for learning the state language, while on the other hand, the host government

does not provide them with special programs on language study. The mentioned program in Georgia is available for asylum seekers and internationally protected individuals through various state-funded activities. The only official free online resource for learning Georgian is the web portal – »Georgian as a Foreign Language«, which is adapted only for English speakers and cannot meet the demand of all segments of foreigners living in Georgia (Georgian as a Foreign Language, 2014).

Many migrants from Asia (mostly from Iran and China) do not speak Georgian, Russian or English. This creates additional difficulty for them in the process of integration. Such migrants have less contact with the local population and live rather isolated. In such situations, residents also show little or no interest in their integration. *"Consequently, there is not a big integration desire from the Georgians and probably less from the part of immigrants"* – noted the expert of migration field.

A certain part of migrants learns the Georgian language, especially those who wish to stay or have a long-term job in Georgia: *"I'm learning the Georgian language, though, in fact, I don't need it…"*– said a 24-year-old American man. For most of the respondents, such efforts are not necessary, because most of the population in Georgia speaks English and Russian (English is rather spoken by young people, while Russian – by elders). The additional discouraging factor is the difficulty of the Georgian language. *"I don't learn Georgian. For communication I use mostly Russian language when I speak with the elder generation and English when I communicate with youth"* – a 30-year-old freelancer man from Russia commented.

From a religious point of view, both cities are favourable due to the abundance of churches (Orthodox, Catholic and Armenian Apostolic), mosques, and synagogues, and the tolerant attitude of the local population towards other confessions. None of the respondents noted having problems because of their religious beliefs or rituals. "*I've never got any problem because of performing religious rituals*"– a 42-year-old Iranian migrant woman residing in Tbilisi said. 29-year-old Turk migrant worker residing in Batumi noted that "*Muslim Turks in Batumi freely exercise all religious practices*". However, according to the survey conducted by the IOM Georgia, for the Georgian population difference in religion is the most important problem in terms of integration (IOM Georgia, 2021).

Almost all migrants have bank accounts in Georgia and enjoy various banking services. As for a standard health insurance package, it is available only for those immigrants who work for big companies. Other migrants prefer to pay for certain health services (when needed). They also do not have enough information about the health care sector and health insurance in Georgia. „*It would have been helpful if insurance companies familiarized migrants with their terms. I don't know what they offer. I should find them on my own and I don't have time for it. If they had come and suggested their products, I would probably have agreed,*" – 40 years old Azerbaijani national said. "*We don't have health insurance. We have a doctor and pay for an appointment or medical services*" – a 33-year-old Ukrainian national woman commented.

Compared to other groups, immigrants from Asia (including the Middle East) and Africa, find it more difficult to integrate into Georgian society. This can be explained by different factors and, first of all, by procedural difficulties in obtaining a legal status of a resident. This creates a serious problem, as they sell houses in their homeland and buy real estate in Georgia, but still, cannot get the status of permanent resident (Khatiashvili et al, 2021). Some respondents claim this is an unfair approach because they are legally employed, pay taxes and cannot get the residence permit, and often appeal to the court. *"It's like gambling, you don't know if you may stay here or not… I have a job and pay taxes… all my documentations are valid, so I prefer to get a legal status… but the government office refused to accept my labour contract and I have turned to the court ..."* – a 36-year-old Iranian migrant man complained.

Safety, stability and comfort of a place matter. It is noteworthy that most of the migrants surveyed in Batumi are married and arrived in Georgia with their families. The majority of the migrants working in Tbilisi are single. This can be explained by the fact that Batumi is a city with a quiet environment which is more attractive for families and couples with small children. The sociological survey showed that Batumi is mainly chosen by migrants from Moscow, Kyiv and other overcrowded megacities: *„Situation here is more relaxed compared to Moscow. I wish to live in a calm environment. The sea, beautiful nature, mountains and, basically, just a comfortable life"* – a 33-year-old Russian migrant woman noted.

In general, it should be noted that for Russian and English-speaking immigrants it is much easier to integrate into Georgian society. They feel themselves more comfortable in Georgia, as they do not need to learn the Georgian language and can freely communicate in English with a significant part of the population. It is remarkable that English and Russian speakers learn the Georgian language if they intend to stay for a long time. English speakers also find themselves in a better legal position compared to Asian migrants. A 35-year-old Iranian migrant woman noted that because of being Iranian, her documents are checked more thoroughly at the border crossing point, which is not the case with westerners.

The research revealed that the lack of comprehensive legislation and procedures on labour migrants' integration is among the acute problems for Georgia. The interviewed governmental official noted: "Improvement of the legislative framework is critical from a migration perspective. The law on Labour Migration deals only with emigration, while immigration is regulated by the governmental ordinance. The country does not have integration programs and there is no plan for elaborating one in a near future."

6 KEY FINDINGS

The research identified the main opportunities and challenges of the process of labour migrants' integration into Georgian society.

Georgia's liberal emigration legislation, easiness of starting and doing business, good climate, hospitable people, and general safe environment make Georgia an attractive place for migrants. In Georgia, people representing different confessions do not face problems in exercising their religious or cultural rituals.

It is noteworthy that the vast majority of respondents emphasized that Georgian society is friendly and tolerant towards foreigners, which creates fertile ground for the successful integration of immigrants. The Georgian government has also taken important steps as well, in particular, by adopting important legal acts that initiated the institutionalization of migration management.

A significant part of labour migrants come to Georgia with the purpose to start their own businesses. Immigrants being wealthier than the local population – is a specificity of Georgia's labour migration. Labour migrants who arrive from the economically developed world or the post-Soviet countries often have higher qualifications than locals. Labour migration in general, positively affects Georgia's economy, as part of migrants bring their investments thus contributing to economic development. Highly-qualified migrants, such as freelancers, entrepreneurs and skilled specialists are important for Georgia's economy, as they bring new business practices. Almost all migrants have bank accounts and use different kinds of bank services.

Batumi has rather favourable conditions for integration than Tbilisi, accordingly, communication between locals and migrants is more intensive in this city. Batumi is an especially comfortable place for migrants from post-Soviet countries.

The general observation is that the integration of migrant workers in Georgia goes spontaneously. At the same time, it does not proceed similarly in different groups of migrants and depends on their education level, material wealth, country of origin, and cultural-religious belonging. Migrant Integration from economically developed countries goes more smoothly than that from developing ones. Newcomers with higher incomes get more opportunities to integrate into Georgian society.

It is more difficult for migrants from Asian countries to integrate compared to other migrant groups, which is conditioned by legal, cultural, linguistic and other factors. The migrants who speak Russian or English languages rather smoothly undergo integration even if they do not speak Georgian. Those who do not speak Georgian or above languages face bigger problems.

Although Georgia's migration policy is liberal, there are shortcomings in its enforcement. Uneven execution of procedures, including unjustified denials in granting residence permits, hinders the integration of migrants from developing countries.

Immigrants, in most cases, are not covered by state or private healthcare programs (Immigration Policy and Practice in Georgia, 2021). Exceptions are those migrants who work in big companies or corporations.

Investors (e.g. Turks, Chinese) often bring labour force from their respective countries. Such cases run into contrary expectations of creating new jobs for locals.

There is a differentiated approach from the state's side towards the migrants from different countries. The law is applied more strictly to immigrants from Asia and Africa, which is also reflected in the visa policy (citizens of developed countries do not need a visa).

The targeted groups of the governmental integration policies include ethnic minorities and persons under international protection, but not labour migrants. Due to the absence of special governmental programs, both migrants and the local population are not fully aware of the advantages that immigration and the integration of migrants might bring to the host country.

Elaboration and implementation of the consolidated policy of integration is a formidable task not only for the counties like Georgia, which have a weak economy but also for some new member states of the EU (e.g., Zogata-Kusz, 2020; Okólski, Wach, 2020).

Lack of resources, respective experience and knowledge are the reasons for conditioning the absence of complete migration legislation and policy, as well as effective state institutions in Georgia. In general, it can be concluded that in terms of immigration management, including labour immigration, Georgia lags behind the highly developed EU countries; however, certain achievements made in this area create a ground for further progress.

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POSEBNOSTI INTEGRACIJE DELOVNIH MIGRANTOV V GRUZIJI (PRIMER TBILISIJA IN BATUMIJA)

Povzetek

Prispevek oriše priložnosti in izzive procesa vključevanja delovnih migrantov v gruzijsko družbo na primeru dveh gruzijskih mest – Tbilisija in Batumija. Avtorji predstavijo glavne poudarke raziskave, ki so jo izpeljali v omenjenih dveh gruzijskih mestih med junijem in novembrom 2021 s pomočjo poglobljenih intervjujev. V raziskavo je bilo vključenih 56 delovnih migrantov, polovica iz Tbilisija in polovica iz Batumija.

Gruzija je zaradi liberalne migracijske zakonodaje, enostavnega postopka ustanavljanja podjetij in poslovanja, ugodnega podnebja, varnega okolja in odprtosti družbe različnim verskim skupinam privlačna za priseljevanje.

Večina anketirancev je v raziskavi poudarila, da je gruzijska družba prijazna in strpna do tujcev, kar po njihovem mnenju ustvarja dobre pogoje za uspešno vključevanje migrantov. K temu je pripomogla tudi gruzijska vlada, saj je v preteklosti sprejela nekaj pomembnih pravnih aktov na področju urejanja migracij.

Raziskava je pokazala nekaj značilnosti priseljevanja in priseljencev v Gruziji:

- Veliko priseljencev se priseli v Gruzijo zaradi podjetniških priložnosti, saj v Gruziji lažje kot v izvornem okolju, ustanovijo svoje podjetje.
- Priseljenci so v Gruziji navadno premožnejši od lokalnega prebivalstva.
- Delovni migranti, ki se v Gruzijo priselijo iz gospodarsko razvitejših držav ali držav nekdanje Sovjetske zveze, so navadno bolje kvalificirani kot domače gruzijsko prebivalstvo.
- Delovna migracija pozitivno vpliva na gruzijsko gospodarstvo, saj delovni migranti s seboj prinesejo svoje prihranke in tako prispevajo h gospodarskemu razvoju Gruzije.
- Visoko kvalificirani migranti, kot so samostojni podjetniki, podjetniki in usposobljeni strokovnjaki, so pomembni za gruzijsko gospodarstvo, saj prinašajo s seboj nove poslovne priložnosti.
- Mesto Batumi ima boljše pogoje za integracijo priseljencev, saj je komunikacija med priseljenci in domačini po ocenah iz raziskave boljša in intenzivnejša. Prav

tako je raziskava pokazala, da je Batumi priljubljen zlasti za priseljevanje tistih, ki prihajajo iz držav nekdanje Sovjetske zveze.

- Integracija priseljencev je odvisna od stopnje izobrazbe priseljencev, njihovega finančnega položaja, države izvora in kulturno-verskih značilnosti. Integracija priseljencev iz gospodarsko razvitejših držav je lažja kot pri tistih, ki prihajajo iz držav v gospodarskem razvoju. Prav tako je lažje vključevanje v gruzijsko družbo za tiste priseljence, ki so v boljšem finančnem položaju.
- V primerjavi z ostalimi priseljenci, se v gruzijsko družbo težje vključijo priseljenci iz azijskih držav, kar je posledica predvsem pravnih, kulturnih, jezikovnih značilnosti.
- V gruzijsko družbo se lažje vključijo tisti priseljenci, ki govorijo rusko ali angleško, tudi če ne govorijo gruzijsko. Ostali se pri vključevanju v gruzijsko družbo soočajo z večjimi izzivi.
- V večini primerov priseljenci niso vključeni v državne ali zasebne programe zdravstvenega varstva. Izjema so tisti priseljenci, ki delajo v velikih podjetjih (korporacijah).
- Investitorji (npr. Kitajci, Turki) pogosto s seboj pripeljejo svojo delovno silo, kar pomeni, da novih ustvarjenih delovnih mest ne zasedejo domačini, temveč priseljenci iz držav investorja.

Čeprav je gruzijska migracijska politika liberalna, se pri izvajanju te politike kažejo določene pomanjkljivosti, kot so neenakomerno izvajanje postopkov, neupravičene zavrnitve pri izdajanju dovoljenj za prebivanje, oviranje priseljevanja tistih, ki prihajajo iz držav v gospodarskem razvoju ipd. Migracijski zakoni so strožji do priseljencev iz azijskih in afriških držav, kar se posledično kaže tudi v izdajanju vizumov (priseljenci iz gospodarsko razvitih držav pa vizumov sploh ne potrebujejo).

Trenutno Gruzija na področju upravljanja priseljevanja, vključno s področjem priseljevanja delovne sile, zaostaja za gospodarsko razvitimi državami EU.

NAVODILA AVTORJEM ZA PRIPRAVO PRISPEVKOV V ZNANSTVENI REVIJI DELA

1. Znanstvena revija DELA je periodična publikacija Oddelka za geografijo Filozofske fakultete Univerze v Ljubljani. Izhaja od leta 1985. Namenjena je predstavitvi znanstvenih in strokovnih dosežkov z vseh področij geografije in sorodnih strok. Od leta 2000 izhaja dvakrat letno v tiskani in elektronski obliki (http://revije.ff.uni-lj.si/Dela). Revija je uvrščena v mednarodne baze (Scopus, CGP – Current Geographical Publicaons, DOAJ, ERIH PLUS, GEOBASE, Central and Eastern European Academic Source, GeoRef) in ima mednarodni uredniški odbor.

2. V prvem delu so objavljeni znanstveni članki (1.01 in 1.02 po kategorizaciji COBISS). V drugem delu se objavljajo informativni prispevki v rubriki POROČILA, in sicer biografski prispevki (obletnice, nekrologi), predstavitve geografskih monografij in revij, pomembnejše geografske prireditve in drugi dogodki idr.

3. Znanstveni in strokovni članki so lahko objavljeni v treh jezikovnih različicah: dvojezično slovensko-angleško, samo v slovenskem jeziku, samo v angleškem jeziku. Prispevki morajo imeti naslednje sestavine:

- naslov članka;
- ime in priimek avtorja/avtorjev;
- avtorjev poštni naslov (npr. Oddelek za geografijo Filozofske fakultete Univerze v Ljubljani, Aškerčeva cesta 2, SI-1000 Ljubljana);
- avtorjev elektronski naslov;
- ORCID (če ga avtor ima);
- izvleček (skupaj s presledki do 500 znakov);
- ključne besede (do 8 besed);
- besedilo članka (skupaj s presledki do 30.000 znakov; v primeru daljših prispevkov naj se avtor predhodno posvetuje z urednikom);
- v primeru enojezičnih člankov tudi povzetek/summary v drugem jeziku (skupaj s presledki od 5000 do 8000 znakov) ter prevod izvlečka in ključnih besed v drugi jezik;
- ime prevajalca.

4. Članek naj ima naslove poglavij in naslove podpoglavij, označene z arabskimi številkami v obliki desetiške klasifikacije (npr. 1 Uvod, 2 Metode, 3 Rezultati in razprava, 4 Sklep, Literatura in viri ipd.). Razdelitev članka na poglavja je obvezna, podpoglavja naj avtor uporabi le izjemoma.

5. Avtorji naj prispevke pošljejo v digitalni obliki v formatih *.doc, *.docx ali *.odt. Digitalni zapis besedila naj bo povsem enostaven, brez slogov in drugega zapletenega oblikovanja, brez deljenja besed, podčrtavanja in podobnega. Avtorji naj označijo le krepki in ležeči tisk. Besedilo naj bo v celoti izpisano z malimi tiskanimi črkami (velja tudi za naslove in podnaslove, razen velikih začetnic), brez nepotrebnih krajšav, okrajšav in kratic.

6. Zemljevidi, grafične priloge in fotografije morajo upoštevati največjo velikost v objavljenem delu, to je 125 x 180 mm. Rastrski formati (*.tiff ali *.jpg) morajo biti oddani v digitalni obliki z ločljivostjo najmanj 300 pik na palec (dpi). Zemljevidi in druge grafične priloge v vektorski obliki (*.ai, *.pdf, *.cdr) morajo vsebovati fonte, večje od 6 pt. Grafikoni morajo biti izdelani s programom Excel ali sorodnim programom (avtorji jih oddajo skupaj s podatki v izvorni datoteki, npr. Excelovi preglednici). Če avtorji ne morejo oddati prispevkov in grafičnih prilog v navedenih oblikah, naj se predhodno posvetujejo z urednikom. Za grafične priloge, za katere avtorji nimajo avtorskih pravic, morajo priložiti fotokopijo dovoljenja za objavo, ki so ga pridobili od lastnika avtorskih pravic.

7. Avtorji so dolžni upoštevati način citiranja v članku ter oblikovanje seznama virov in literature, preglednic in ostalega grafičnega gradiva, kot je to navedeno v podrobnejših navodilih za pripravo člankov na povezavi http://revije.ff.uni-lj.si/Dela/about/submissions#authorGuidelines. Za dela, ki jih je avtor uporabil v elektronski obliki, naj poleg bibliografskih podatkov navede še elektronski naslov, na katerem je delo dostopno bralcem, in datum citiranja. Za znanstvene članke s številko DOI avtorji navedejo DOI številko.

8. Znanstveni članki bodo recenzirani. Recenzentski postopek je praviloma anonimen, opravita ga dva kompetentna recenzenta. Recenzenta prejmeta članek brez navedbe avtorja članka, avtor članka pa prejme recenzentove pripombe brez navedbe recenzentovega imena. Če recenziji ne zahtevata popravka ali dopolnitve članka, se avtorju članka recenzij ne pošlje. Uredniški odbor lahko na predlog recenzentov zavrne objavo prispevka.

9. Avtorji, ki želijo, da se njihov članek objavi v reviji, se strinjajo z naslednjimi pogoji:
- Pisci besedila z imenom in priimkom avtorstva potrjujejo, da so avtorji oddanega članka, ki bo predvidoma izšel v reviji DELA v okviru Znanstvene založbe Filozofske fakultete Univerze v Ljubljani (Univerza v Ljubljani, Filozofska fakulteta, Aškerčeva 2, 1000 Ljubljana). O likovno-grafični in tehnični opremi dela ter o pogojih njegovega trženja odloča založnik.
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12. Avtorji naj prispevke pošljejo na elektronski naslov *dela_geo@ff.uni-lj.si* ali pa oddajo na spletni strani revije (https://journals.uni-lj.si/Dela/login).

INSTRUCTIONS FOR AUTHORS PREPARING ARTICLES FOR THE SCIENTIFIC JOURNAL – DELA

1. The scientific journal DELA is a periodical publication of the Department of Geography, Faculty of Arts, University of Ljubljana. It has been published since 1985. It is dedicated to presenting scientific and technical achievements in all fields of geography and related disciplines. Since 2000 it has been published twice yearly in print and electronic form (http://revije.ff.uni-lj.si/Dela). The magazine is included in the international databases (Scopus, CGP – Current Geographical Publicaons, DOAJ, ERIH PLUS, GEOBASE, Central and Eastern European Academic Source, GeoRef) and has an international Editorial Board.

2. Published in the first part are scientific articles (1.01 and 1.02 by COBISS categorisation). Published in the second part are informative articles categorised as REPORTS as well as biographical contributions (anniversaries, obituaries), reviews of geographical monographs and journals, major events in the field of geography and other events, etc.

3. Scientific articles may be published in one of three language configurations: bilingual Slovene-English, entirely in Slovene or entirely in English

Articles must have the following components:

- Article title;
- Name and surname of author/authors;
- Author's address (eg. Department of Geography, Faculty of Arts, University of Ljubljana, Aškerčeva cesta 2, 1000 Ljubljana, Slovenia);
- Author's email;
- Author's ORCID (if available);
- Abstract (up to 500 characters with spaces);
- Keywords (up to eight);
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- In cases of articles written in one language, these must also include a summary in the other language (between 5,000 and 8,000 characters with spaces) and translations of the abstract and keywords;
- Name of translator.

4. The article should have chapter headings and subheadings identified with Arabic numerals in the form of decimal classification (e.g. 1 Introduction, 2 Methods, 3 Results and discussion, 4 Conclusion, References etc.). Structuring the article in chapters is mandatory, authors may use sub-chapters only in exceptional cases.

5. Authors should submit their articles as digital copies – format may be *.doc, *.docx or or *.odt. The digital version of the text should be completely clean, without styles and other sophisticated design, without line break hyphenation nor underlining, and so forth. Authors may mark using only bold and italic text. The text should be written entirely in lowercase (including in the title and subtitle, with the exception of capitalised words) without unnecessary contractions, acronyms and abbreviations.

6. Maps and other graphic materials must conform to the format of the journal. Fullpage figures need to be sized 125 x 170 mm, while smaller figures are restricted to a maximum width of 125 mm. Font size must be at least 6pt. All graphic materials must be submitted as individual files (i.e. not as part of the file with the text). Graphics (maps, etc.) should be in AI, CDR, PDF, TIFF or JPG file formats. Those in raster formats (e.g. *.tiff or *.jpg) must have a resolution of at least 300 dots per inch (dpi). Charts must be prepared in Excel or a similar programme (authors should submit them together with the data in the source file, e.g. Excel spreadsheet). If authors are unable to submit articles and graphic materials in the mentioned forms, they should consult with the editor. If an author is not the copyright holder of graphic materials then they must attach a photocopy of the approval for publication, which they have obtained from the copyright owner.

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11. The publisher shall ensure that all articles that are positively reviewed are published, provided it has funds available for printing. The sequence of articles is decided by the Editorial Board. Each author is entitled to one free copy of the printed publication.

12. Authors should send their articles to e-mail address *dela_geo@ff.uni-lj.si* or upload them to the journal's website (https://journals.uni-lj.si/Dela/login).

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Ljubljana je bila v letu 2019 slovenska občina z največjim številom prihodov in prenočitev turistov, v času pandemije covida-19 pa je doživela drastičen upad turističnega obiska. Na sliki je središče Ljubljane aprila 2020 (foto: D. Klepej).

In 2019, Ljubljana was the Slovenian municipality with the most tourist arrivals and overnight stays. During the covid-19 pandemic, the number of tourist visits dropped drastically. The photo shows the centre of Ljubljana in April 2020 (photo: D. Klepej).