UNIVERZA V LJUBLJANI
FF
Filozofska fakulteta

Dela
61

Oddelek za geografijo,
Filozofska fakulteta Univerze v Ljubljani

Department of Geography,
Faculty of Arts, University of Ljubljana

LJUBLJANA 2024

ISSN 0354-0596
DELA
61
2024

Elektronska izdaja — Electronic edition
ISSN 1854-1089

Založnik — Published by
Založba Univerze v Ljubljani

Izdajatelj — Issued by
Znanstvena založba Filozofske fakultete Univerze v Ljubljani;
Oddelek za geografijo, Filozofska fakulteta Univerze v Ljubljani

Za založbo — For the Publisher
Gregor Majdič, rektor Univerze v Ljubljani

Za izdajatelja - For the Issuer
Mojca Schlamberger Brezar, dekanja Filozofske fakultete

Urednika — Editors
Dejan Cigale, Boštjan Rogelj

Upravnik — Editorial Secretary
Nejc Bobovnik

Oblikovna zasnova — Design
Žiga Valetič

Prelom — Layout
Eva Gašperič

Tisk — Printed by
Birografika Bori, d. o. o.

Naklada — Edition
320 izvodov

Naslov uredništva — Publisher's address
Oddelek za geografijo, Filozofska fakulteta Univerze v Ljubljani, Aškerčeva 2, SI-1000 Ljubljana

Elektronski dostop — On-line access: https://journals.uni-lj.si/Dela

DELA so vključena v — DELA is included in
Scopus, CGP – Current Geographical Publications, DOAJ, ERIH PLUS, GEOBASE, Central and Eastern European Academic Source, GeoRef, Russian Academy of Sciences Bibliographies, TOC Premier, International Bibliography of the Social Sciences

Izdano s finančno pomočjo Javne agencije za znanstvenoraziskovalno in inovacijsko dejavnost Republike Slovenije in Oddelka za geografijo FF Univerze v Ljubljani.

VSEBINA CONTENTS

RAZPRAVE PAPERS

Dejan Rebernik*

URBANA KULTURNA POLITIKA IN URBANA REGENERACIJA NA PRIMERU MARIBORA, NOVE GORICE IN LJUBLJANE

COBISS 1.01
DOI: 10.4312/STZO8532

Izvleček

Avtor v članku predstavi pomen in vlogo urbane kulturne politike ter investicij v kulturno infrastrukturo za urbano regeneracijo in revitalizacijo. V prvem delu prispevka je naveden teoretski okvir urbane regeneracije na osnovi kulture (ang. *culture led urban regeneration*). Še posebno je poudarjen pomen koncepta »ustvarjalno mesto« kot orodja za ekonomsko prestrukturiranje mest. V osrednjem delu članka avtor poda pregled, analizo in vrednotenje ciljev ter ukrepov urbane kulturne politike kot načina za urbano regeneracijo v izbranih slovenskih mestih Maribor, Nova Gorica in Ljubljana. Na osnovi pregleda in analize razvojnih dokumentov in politik ter izvedenih investicij v kulturno infrastrukturo avtor ovrednoti pričakovane učinke na urbano regeneracijo, ekonomsko prestrukturiranje in urbano revitalizacijo določenih urbanih območij. V vseh treh izbranih mestih je kultura prepoznana kot ključni dejavnik in način za urbano regeneracijo. Poglavitni pričakovani učinki investicij v kulturo in kulturno infrastrukturo so revitalizacija degradiranih urbanih območij, razvoj kulturnega turizma, izboljšana podoba mesta in višja kvaliteta bivanja za lokalno prebivalstvo.

Ključne besede: urbana kulturna politika, kulturna infrastruktura, urbana regeneracija, urbana revitalizacija, Maribor, Nova Gorica, Ljubljana

*Oddelek za geografijo, Filozofska fakulteta Univerze v Ljubljani, Aškerčeva 2, SI-1000 Ljubljana, Slovenija
e-pošta: dejan.rebernik@ff.uni-lj.si
ORCID: 0000-0001-5037-1115

URBAN CULTURAL POLICY AND URBAN REGENERATION: CASE STUDY OF MARIBOR, NOVA GORICA AND LJUBLJANA

Abstract

The importance of urban cultural policy and investments in cultural infrastructure for urban regeneration and revitalization is presented in the paper. In the first part of the paper the theoretical framework of culture led urban regeneration is presented. The importance of concept of creative city for economic urban regeneration is highlighted. In the central part of the paper the author presents the general overview, analysis and evaluation of the goals and measures of urban cultural policy as a mean for urban regeneration in selected Slovene cities Maribor, Nova Gorica and Ljubljana. Based on analysis of strategic development documents and policies and finished investments in cultural infrastructure an impact on urban regeneration and revitalization of selected urban areas is evaluated. In all selected cities culture is recognized as an essential tool for urban regeneration. Main anticipated effects of investments in cultural infrastructure are revitalization of derelict urban areas, development of cultural tourism, better image of the city and improved quality of life for residents.

Keywords: urban cultural policy, cultural infrastructure, urban regeneration, urban revitalization, Maribor, Nova Gorica, Ljubljana

1 UVOD

Urbana kulturna politika in investicije v kulturno infrastrukturo ter kulturno produkcijo v mestih so že več desetletij prepoznane kot eden izmed najbolj učinkovitih načinov za urbano regeneracijo. Kultura v povezavi s kulturno oziroma kreativno industrijo je od osemdesetih let 20. stoletja dalje postala eden izmed temeljev ekonomskega prestrukturiranja mest v času deindustializacije. V povezavi s tem se na področju urbanih študij in urbane politike uveljavi paradigma ustvarjalno mesto, ki poudarja pomen ustvarjalnih oziroma inovativnih dejavnosti za ekonomski razvoj in prestrukturiranja mest. Urbana regeneracija na osnovi kulture in umetnosti (ang. *culture led urban regeneration*) tako postane poglavitna oblika urbanih razvojnih politik in katalizator ekonomskega prestrukturiranja mest v ZDA in Evropi, postopoma pa tudi drugod. Urbano regeneracijo razumemo kot nabor ukrepov za celovito ekonomsko, socialno in okoljsko preobrazbo mesta v smeri doseganja ciljev trajnostnega urbanega razvoja. Cilji urbane regeneracije so tako spodbujanje ekonomskega razvoja mesta, izboljšana kvaliteta bivanja za lokalno prebivalstvo, socialna pravičnost in vključevanje, revitalizacija degradiranih urbanih območij ter zmanjševanje onesnaževanja okolja. Urbana revitalizacija pa je fizična, ekonomska in socialna prenova določenih urbanih območij. Hočevar (2000), poudarja da je revitalizacija mestnih središč proces, ki naj nujno poteka na treh ravneh: socialna, fizična in simbolično ambientalna prenova. Pomemben vidik pa je tudi ekonomska prenova, pri kateri gre za poskus, da se v mestnem jedru z raznimi ukrepi spodbuja nastajanje novih, ohranjanje starih ter oživljanje tradicionalnih ekonomskih dejavnosti, ki so že propadle (Rebernik, 2008). Pri fizičnem vidiku revitalizacije govorimo o prenovi grajenih struktur, na primer zgradbe, odprti javni prostori in infrastruktura (Hočevar, 2000). Pri socialnem vidiku revitalizacije je v ospredju vključevanje lokalnega prebivalstva in njegovih potreb v programe prenove. Ob tem pogosto pride do konflikta med interesi kapitala, ki spodbuja gentrifikacijo, in interesi lokalnega prebivalstva. Simbolično ambientalna raven revitalizacije postavlja lokalno kulturo pred globalno. Na ta način se ob prenovi poskrbi za ohranjanje lokalne kulturne identitete ter za simbolno in vizualno estetiko. Ohranjanje lokalne kulturne identitete je v procesu prenove s procesi kulturne globalizacije, gentrifikacije in turistifikacije sicer pogosto ogroženo (Hočevar, 2000).

Tudi slovenska mesta so urbano kulturno politiko prepoznala kot način za urbano regeneracijo in doseganje ciljev trajnostnega urbanega razvoja. To je razvidno iz temeljnih strateških razvojnih dokumentov ter tudi iz dejanskih investicij v kulturno infrastrukturo in kulturno produkcijo v slovenskih mestih. Ob tem je seveda treba poudariti, da je kultura le eden izmed dejavnikov oziroma načinov za urbano regeneracijo in revitalizacijo. Mesta poskušajo urbano regeneracijo spodbujati tudi z razvojem turizma oziroma turistifikacijo, razvojem trajnostne urbane mobilnosti, s posebnim poudarkom na omejevanju dostopa osebnega avtomobilskega prometa v mestna središča ter celovitim urejanjem javnih površin oziroma prostorov. Ob tem je treba poudariti velik pomen javnega prostora kot dejavnika mestne vitalnosti. Ravno v starih mestnih središčih ima javni prostor pomembno vlogo. Mestni trgi, ulice, nabrežja ob rekah in podobno so prostori druženja in naključnega dogajanja, ki daje mestu utrip in privlačnost. Uršič (2008) tako pravi, da javni prostor definira urbanost, le-ta pa se najbolje kaže s prizoriščnostjo in naključnimi dogodki, ki se zgodijo v mestu. A prizoriščnosti je z upadanjem števila dejavnosti in obiskovalcev v mestnih središčih čedalje manj, tako da se pogosto govori o zamiranju mestnega utripa.

Osnovni namen prispevka je pregled, analiza in vrednotenje ciljev ter ukrepov urbane kulturne politike kot načina za urbano regeneracijo in doseganje ciljev trajnostnega urbanega razvoja v izbranih slovenskih mestih. V prispevku so tako na osnovi analize strateških razvojnih dokumentov ter dejanskih investicij v kulturno infrastrukturo ovrednoteni učinki urbane kulturne politike na urbano regeneracijo na primeru treh slovenskih mest: Maribora, Nove Gorice in Ljubljane. V drugem poglavju so predstavljena teoretska izhodišča in izbrani primeri urbane regeneracije na osnovi kulture v svetu, zlasti v ZDA in Zahodni Evropi, v tretjem poglavju pa metodologija dela. V četrtem, osrednjem poglavju članka sta podana analiza in vrednotenje urbane regeneracije na osnovi kulture na primeru prej omenjenih mest. Za navedena mesta smo se odločili iz različnih razlogov. Nova Gorica je bila izbrana zato, ker se mesto pripravlja na investicije ter organizacijo dogodkov v sklopu naziva Evropska kulturna prestolnica. V sklopu raziskave smo želeli predstaviti in ovrednotiti predvidene učinke naziva Evropska kulturna prestolnica na urbano regeneracijo. Maribor smo izbrali zato, ker je med vsemi slovenskimi mesti doživel najbolj intenzivno deindustrializacijo ter je ravno v kulturi mesto prepoznalo način za urbano regeneracijo. Poleg tega smo želeli tudi v primeru Maribora predstaviti in kritično ovrednotiti učinke naziva Evropska kulturna prestolnica iz leta 2012. Ljubljana je bila izbrana kot mesto, ki je v zadnjih letih v razvoj kulturne infrastrukture investiralo daleč največ sredstev med vsemi slovenskimi mesti, ter mesto z najbolj razvitim kulturnim turizmom ter kulturno industrijo v Sloveniji. V sklepu so navedene ključne ugotovitve in primerjava med proučevanimi mesti.

2 TEORETSKA IZHODIŠČA: URBANA KULTURNA POLITIKA IN URBANA REGENERACIJA

Urbana kulturna politika je v ZDA že v sedemdesetih in osemdesetih letih 20. stoletja postala način za urbano revitalizacijo in ekonomsko prestrukturiranje mest. Ob postopnem zatonu industrije v mestih in prehodu v postindustrijsko družbo sta ravno kultura in kulturna industrija postali eden izmed temeljev nove urbane ekonomije in poglavitni vzvod urbane regeneracije. Kultura, ki je bila do tedaj videna kot strošek in prepuščena zlasti javnemu financiranju, je postopoma postala percipirana kot dejavnik in katalizator ekonomskega razvoja in preobrazbe mest (Grodach, 2017). Od investicij v kulturno infrastrukturo in spodbujanja kulturne produkcije v mestu se je pričakovalo ugodne ekonomske učinke: razvoj kulturnega turizma, razvoj kulturne industrije, izboljšana podoba mesta, privabljanje ustvarjalnih podjetij in posameznikov, izboljšana kvaliteta bivanja za lokalno prebivalstvo, rast cen nepremičnin, revitalizacija degradiranih urbanih območij in gentrifikacija. Govorimo lahko o konceptu regeneracije na osnovi umetnosti (ang. *arts-led regeneration*) oziroma o kulturnem planiranju (ang. *cultural planning*). Koncept kulturnega planiranja zavrača pojmovanje kulture kot proračunskega porabnika javnih sredstev in urbano kulturno politiko, kulturno industrijo, kulturno dediščino, umetniško ustvarjanje in domačo obrt razume kot katalizator ekonomskega razvoja (Grodach, 2017).

V urbanih študijah se oblikuje koncept oziroma paradigma ustvarjalno mesto (ang. *creative city*). Gre za politiko urbanega razvoja, ki poudarja pomen ustvarjalnih oziroma inovativnih dejavnosti in poklicev, ki naj postanejo poglavitno gonilo ekonomskega razvoja in prestrukturiranja mest. Med ustvarjalne dejavnosti se na eni strani uvršča področje znanstvenih in tehnoloških inovacij in na drugi strani umetniško ustvarjanje in kulturno produkcijo. Koncept ustvarjalnega mesta je v svoji biti neoliberalističen: umetnost in kulturo obravnava kot katalizator ekonomskega razvoja mest, urbana kulturna politika in investicije v kulturo so torej način doseganja ekonomskih ciljev. Ustvarjalno mesto je generator urbanega ekonomskega razvoja in revitalizacije, po mnenju kritikov pa ima tudi številne negativne učinke: povečevanje socialne in ekonomske neenakosti in izključevanja, kulturni elitizem ter pretirana turistifikacija in gentrifikacija posameznih delov mest (Landry, 2008). Ob tem lahko navedemo prispevek slovenskih avtorjev, ki opozarjajo na »pozabljene« vrednote industrijskega mesta, kot so socialna kohezivnost in solidarnost, ki lahko dopolnijo koncept ustvarjalnega mesta (Kozina, Bole, Tiran, 2021).

Koncept ustvarjalnega mesta sta v urbano teorijo uvedla Bianchini in Landry (1995) na primeru urbane regeneracije britanskih mest na osnovi kulture in kulturne industrije. Eden glavnih teoretikov koncepta ustvarjalno mesto Richard Florida (2002a) kot glavni dejavnik razvoja postindustrijskih mest vidi ustvarjalni razred (ang. *creative class*). V ustvarjalni razred uvršča »ustvarjalne poklice« s področja znanosti, raziskovanja, inovacij, kulture, umetnosti, oblikovanja in medijev. »Ustvarjalni razred sestavljajo znanstveniki in inženirji, profesorji, pesniki in arhitekti, in tudi zaposleni v oblikovanju, izobraževanju, umetnosti, glasbi in zabavni industriji, katerih ekonomska funkcija je ustvarjanje novih idej, inovacij in kreativnih vsebin« (Florida, 2002b, str. 34). Florida trdi, da mesta, ki uspejo pritegniti in zadržati ustvarjalni razred, napredujejo, ostala nazadujejo. Za mesta, ki privlačijo ustvarjalni razred, so značilni trije T: talent (visoko izobraženi in talentirani posamezniki), toleranca (liberalne in raznolike skupnosti) in tehnologija (tehnološka infrastruktura, ki je potrebna, da se razvije ustvarjalni potencial) (Florida, 2002b). Teorija ustvarjalnega razreda je doživela številne kritike, med drugim iz ekonomske (povezava med ustvarjalnim razredom in ekonomskim razvojem mest ni bila dokazana) in socialne perspektive (povečevanje socialne neenakosti v ustvarjalnih mestih) (Comunian, 2011). Pratt (2010) na primeru analize britanskih mest ugotavlja, da imajo urbane politike, ki temeljijo na konceptu ustvarjalnega mesta, tako pozitivne kot tudi negativne prostorske, ekonomske ter socialne učinke.

Urbana regeneracija, povezana s kulturo, je tako postala ena izmed najbolj uveljavljenih in uporabljenih oblik urbanih politik. Urbana regeneracija, povezana s kulturo, je iz zanimive alternative najprej zrasla v politiko urbanega razvoja, nato pa v osrednjo strategijo v vse večjem številu mest in regij po svetu (Garcia, 2004, str. 315). Pri tem je ključen odnos med kulturo in gospodarstvom, ki se postopoma vse bolj zbližujeta. Bianchini (1999, cit. po Garcia, 2004) pri tem loči tri obdobja: (1) petdeseta in šestdeseta leta označuje kot »obdobje obnove«, ko je kultura nasprotna sfera materialni produkciji in gospodarstvu, (2) sedemdeseta in osemdeseta leta poimenuje »obdobje participacije«, ko je kultura dejavnik politične in socialne participacije, (3) od sredine osemdesetih let dalje se v »obdobju trženja« uveljavi razumevanje kulture kot orodja za ekonomsko urbano regeneracijo. Povezovanje urbane kulturne politike, urbane revitalizacije in ekonomskega razvoja lahko torej označimo kot obdobje mestnega trženja (»city marketing«). Osnovni namen takšnega mestnega trženja je kreiranje prepoznavne blagovne znamke in turistične destinacije (Garcia, 2004).

V Evropi se je pojmovanje urbane kulturne politike kot dejavnika ekonomskega razvoja mest začelo uveljavljati v sredini osemdesetih let (Garcia, 2004). Kong (2000) definira štiri značilnosti tako imenovane »kulturne ekonomske politike«: investicije v infrastrukturo za kulturno produkcijo, investicije v paradne in ikonične kulturne projekte in dogodke (ang. *flagship cultural projects*), urejanje in oživljanje urbanih javnih prostorov in javno-zasebno partnerstvo na področju kulturne infrastrukture. Evans (2005) pri tem loči tri oblike oziroma modele urbane regeneracije, povezane s kulturo. V prvem primeru lahko govorimo o regeneraciji, ki jo vodi kultura (ang. *culture-led regeneration*). Kultura je razumljena kot poglavitni, ključni in edinstveni katalizator urbane regeneracije. Najbolj očiten primer so investicije v paradne kulturne inštitucije. Drugi model Evans poimenuje kulturna regeneracija (ang. *cultural regeneration*), pri kateri je kultura sestavni del ekonomskih, socialnih ali okoljskih razvojnih strategij. Ta model je tesno povezan s konceptom urbane politike »ustvarjalno mesto«. V tretjem modelu, imenovanem kultura in regeneracija (ang. *culture and regeneration*), kultura ni vključena v začetni fazi oblikovanja strategije urbanega razvoja in se pojavi pozneje ter v samo določenih delih ali fazah projekta. Gre za manjše kulturne projekte, pri katerih je kultura naknadno dodana v razvojno strategijo mesta. Primeri politik urbanega razvoja na osnovi kulture (ang. *culture led urban development*) in ustvarjalnih dejavnosti v Evropi so številni. Med najbolj odmevne prav gotovo sodi francoski program »Veliki kulturni projekti« (fra. *Grands Projets Culturels*) za investicije v kulturno infrastrukturo (kulturni center Georges Pompidou, piramida muzeja Louvre, Opera Bastille in drugi projekti) (Garcia, 2004). Bayliss (2007) navaja primer Köbenhavna, ki koncept ustvarjalnega mesta uporablja kot temeljno paradigmo urbanega razvoja. Byrne (2012) ugotavlja, da je urbana kulturna politika na Škotskem, vse od naslova Evropske kulturne prestolnice Glasgowa v letu 1990, postala orodje za spodbujanje ekonomskega razvoja mest in privabljanje ustvarjalnih ljudi in podjetij. Škotska mesta se promovira kot »najbolj privlačna za poslovanje«, ob tem se pogosto poudarja posebnosti in edinstvenost škotske kulture. Urbana regeneracija na osnovi kulture v postsocialističnih mestih Srednje in Vzhodne Evrope precej zaostaja v primerjavi s preostalo Evropo (Pavel, Jucu, 2020). Toda primer revitalizacije ulice v starem mestnem jedru Novega Sada dokazuje, da postaja kultura pomemben dejavnik urbanega razvoja tudi v postsocialističnih mestih (Nedučina, Krklješa, Gajić, 2019). Primeri urbane regeneracije na osnovi kulture so številni tudi drugod po svetu. Chiu, Lee in Wang (2019) podajo primer strategije za urbano regeneracijo na osnovi kulture mesta Tajpej, ki temelji predvsem na revitalizaciji javnih prostorov in skupnosti.

Ob tem pa ostaja odprto vprašanje merjenja dejanskih učinkov investicij v kulturno infrastrukturo in paradne kulturne inštitucije na urbano regeneracijo. Evans (2005) tako ugotavlja, da so dokazi za urbano regeneracijo na osnovi velikih kulturnih projektov omejeni ter da bi bila potrebna izdelava splošnega modela za evalvacijo učinkov urbane regeneracije na osnovi kulture. Primer za empirično merjenje pomena kulture v izbranih evropskih mestih je monitoring kulturnih in kreativnih mest (ang. *the cultural and creative city monitor*), ki ga je izdelala skupina raziskovalcev Skupnega raziskovalnega središča Evropske komisije Ispra (Italija) (ang. *Joint Research Center Ispra*). Gre za podatkovno bazo, ki na osnovi 29 kazalnikov poskuša meriti prisotnost in privlačnost kulturnih dogodkov (kulturna živahnost), sposobnost kulture za generiranje delovnih mest in inovacij (kreativna ekonomija) ter pogoje za razvoj kulture in ustvarjalnih dejavnosti (podporno okolje) (Montalto in sod., 2019).

Eno izmed najbolj direktnih orodij urbane regeneracije na osnovi kulture v Evropi je program Evropske Unije »Evropska prestolnica kulture«. Program je zasnovala Melina Mercouri, tedanja grška zunanja ministrica, v letu 1983. Namen projekta je bil okrepiti kulturno dimenzijo Evropske unije in poudariti pomen evropske kulture za evropsko povezovanje in krepitev skupne evropske identitete. Prve evropske kulturne prestolnice so bile uveljavljena evropska kulturna in umetniška središča: Atene (1985), Firence (1986), Amsterdam (1987), Zahodni Berlin (1988) in Pariz (1989). Za leto 1990 je Velika Britanija izbrala Glasgow, kar predstavlja radikalno spremembo v konceptu in namenu programa evropska kulturna prestolnica (Garcia, 2004). Glasgow je kot tipično postindustrijsko mesto iskal nove načine in priložnosti za ekonomski razvoj. Glasgow je bil prvo mesto, ki je naziv evropska prestolnica kulture izrabilo kot način za urbano regeneracijo in ekonomsko prestrukturiranje mesta, kar je spodbudilo številne javne in zasebne investicije (Garcia, 2004). Poglavitni elementi urbane kulturne politike mesta Glasgow v okviru programa Evropska prestolnica kulture, ki so jih kasneje posnemala druga mesta, so bili: (1) širše razumevanje pojma »kultura«, ki je vključevalo tudi druge elemente, ki so odražali identiteto Glasgowa, kot na primer oblikovanje, arhitektura, ladjedelništvo, religija in šport, (2) razporeditev aktivnosti po celotnem mestu in ne samo v mestnem središču, še zlasti v degradiranih urbanih območjih, (3) povezovanje vodilnih domačih in tujih kulturnih inštitucij ter lokalnih umetnikov in kulturnih dejavnosti, (4) hkratno financiranje tekoče kulturne produkcije in dogodkov ter kulturne infrastrukture (Garcia, 2004). V naslednjih letih so tudi druga evropska mesta bolj ali manj uspešno izrabila naziv Evropska prestolnica kulture za urbano regeneracijo, ekonomsko prestrukturiranje in mestni marketing. Evropska unija tako navaja, da so poglavitni cilji programa zlasti krepitev skupne evropske kulturne identitete, poudarjanje evropske kulturne raznolikosti, urbana regeneracija, izboljšana podoba mest, krepitev lokalne kulture, razvoj kulturnega turizma in krepitev mednarodnega ugleda mesta. Avtorja študije o evropskih prestolnicah kulture (Garcia, Cox, 2013) ugotavljata, da ima program različne kulturne, ekonomske, prostorske, socialne in politične dolgoročne učinke. Med kulturnimi učinki izpostavljata krepitev obstoječega kulturnega sistema mesta in izboljšano podoba mesta, tako v očeh prebivalcev kot mednarodne javnosti. Richards in Wilson (2004) na primeru Rotterdama ugotavljata, da je učinek naziva Evropska prestolnica kulture na podobo mesta sicer precej omejen. Pri ekonomskih učinkih je najbolj opazen porast kulturnega turizma, v prostorskem razvoju pa investicije v kulturno infrastrukturo v mestu, ki so bolj ali manj uspešne. Neuspešnost takšnih investicij se odraža zlasti v slabem načrtovanju rabe infrastrukture po koncu naziva prestolnica kulture. Socialne učinke je težko objektivno izmeriti, avtorja navajata povečan obisk kulturnih dogodkov in krepitev občutka ponosa in identifikacije z mestom. Pri političnih učinkih se omenja, da naziv prestolnica kulture deluje kot katalizator sprememb. Pogost dolgoročni učinek je sprememba mestne kulturne politike, kar se odraža v večji finančni podpori kulturnemu sektorju (Garcia, Cox, 2013).

Eden od najbolj uspešnih primerov urbane regeneracije na osnovi investicije v paradno in ikonično kulturno inštitucijo je prav gotovo mesto Bilbao v Španiji, kjer je bila izgradnja Guggenheimovega muzeja Bilbao dejavnik ekonomske preobrazbe mesta in celotne regije. V strokovni literaturi se zato uveljavi termin »učinek Bilbao« (ang. *Bilbao effect*) za poimenovanje urbane regeneracije na osnovi investicije v ikonično kulturno inštitucijo (Franklin, 2016). Guggenheimov muzej Bilbao so odprli leta 1997 na območju opuščene ladjedelnice z namenom, da bi razvoj mesta preusmerili od propadajoče industrije v smeri kulture, storitev in turizma. Načrtovano je bilo 400.000 obiskovalcev letno, že v prvem letu je obisk muzeja presegel 1 milijon, kar se je ohranilo tudi v nadaljnjih letih. Z muzejem sodobne umetnosti, ki ga odlikuje tudi izjemno atraktivna arhitektura, je Bilbao postal pomembno središče mednarodnega kulturnega turizma. Guggenheimov muzej Bilbao je spodbudil investicije v turizem, kulturno industrijo in storitve ter tako pomenil ključni dejavnik ekonomske preobrazbe mesta. »Učinek Bilbao« je tako postal primer uspešne urbane regeneracije, ki so ga v naslednjih desetletjih posnemala številna, zlasti industrijska mesta, ki so se znašla v recesiji (Franklin, 2016). Le redka mesta pa so doživela tako uspešno ekonomsko preobrazbo kot Bilbao. Še več, večina podobnih investicij v prestižne in zelo drage kulturne projekte, kot na primer muzeji v mestih Sheffield, Seattle, Helsinki in Milwaukee, se je izkazala za zelo neuspešne. Številni avtorji so ob tem opozarjali, da je »učinek Bilbao« rezultat prepleta številnih dejavnikov in ne le investicije v prestižno kulturno inštitucijo (Plaza, 2000). V literaturi so le redke empirične analize učinka paradne kulturne inštitucije na urbano regeneracijo. Kot primer lahko navedemo analizo pričakovane urbane preobrazbe mesta Arles ob odprtju prestižnega muzeja (Raevskikh, 2018). Avtor ugotavlja, da je že sama napoved izgradnje prestižnega muzeja Fundacije Luma v starem mestnem središču povzročila dvig cen nepremičnin ter posledično odseljevanje revnejšega prebivalstva ter zapiranje malih lokalnih podjetij. Na osnovi analize urbanih kulturnih politik v Veliki Britaniji pa Comunian in Mould (2014) ugotavljata, da je vpliv paradnih javnih kulturnih inštitucij na razvoj lokalnega ustvarjalnega sektorja pogosto šibek. Barcelona je naslednji primer uspešne urbane regeneracije na osnovi razvoja kulture. Govorimo lahko o »modelu Barcelona«, za katerega je značilna kombinacija pomembnih dogodkov, velikih infrastrukturnih projektov in krepitve lokalne kulturne identitete kot katalizatorja urbanega razvoja. Ob tem različni avtorji opozarjajo na omejitve in negativne učinke tako zasnovanih urbanih kulturnih politik. Investicije v prestižne kulturne institucije spodbujajo razvoj elitne kulture, kar sicer krepi mednarodno prepoznavnost mest in kulturni turizem, po drugi strani pa krepi gentrifikacijo in socialno neenakost (Garcia, 2004).

3 METODOLOGIJA

Osnovni cilj prispevka je ovrednotenje učinkov urbane kulturne politike na urbano regeneracijo na primeru izbranih slovenskih mest. V ta namen smo analizirali razvojne in strateške dokumente (trajnostne urbane strategije, strategije razvoja kulture, strategije razvoja kulturnega turizma) ter izvedene investicije v kulturno infrastrukturo v treh slovenskih mestih. Temeljni metodološki postopek raziskave je torej primerjalna analiza strateških razvojnih dokumentov s področja urbane kulturne politike in trajnostnega urbanega razvoja ter vrednotenje učinkov že izvedenih investicij v kulturno infrastrukturo. Ob tem smo ovrednotili pričakovane ali dejanske učinke na urbano regeneracijo, ekonomsko prestrukturiranje in urbano revitalizacijo določenih urbanih območij. Vrednotenje pričakovanih učinkov urbane kulturne politike na urbano regeneracijo je temeljilo na primerjalni analizi strateških razvojnih dokumentov, vrednotenje dejanskih učinkov pa na analizi urbane regeneracije in ekonomskega razvoja mest ter urbane revitalizacije posameznih četrti oziroma urbanih območij v izbranih mestih. Ob tem je treba poudariti, da je bila večina obravnavanih investicij v kulturno infrastrukturo zaključena pred kratkim, tako da je njihov učinek na urbano regeneracijo še težko ovrednotiti.

V četrtem, osrednjem poglavju članka sta torej podana analiza in vrednotenje urbane regeneracije na osnovi kulture na primeru treh slovenskih mest: Maribora, Nove Gorice in Ljubljane. Maribor je edino slovensko mesto, ki je do sedaj prejelo naziv Evropska prestolnica kulture. Čeprav velja splošna ocena, da Maribor naziva Evropska prestolnica kulture ni najbolje izkoristil za investicije v kulturno infrastrukturo in urbano regeneracijo, pa je mesto v zadnjem desetletju vlagalo veliko naporov v razvoj kulture in kulturne infrastrukture, zlasti s ciljem revitalizacije starega mestnega središča. Nova Gorica bo skupaj z Gorico Evropska prestolnica kulture v letu 2025. V prispevku so predstavljeni koncept, temeljni cilji in pričakovani učinki Evropske prestolnice kulture Nova Gorica-Gorica 2025 na urbano regeneracijo. Ljubljana se opredeljuje kot »mesto kulturne, umetniške in znanstvene ustvarjalnosti, prostorske kulture in dediščine«. Kulturo in ustvarjalne dejavnosti razume kot enega ključnih dejavnikov urbanega razvoja, kar potrjujejo tudi velike investicije v kulturno infrastrukturo. Mesto še posebno poudarja pomen razvoja kulturnega turizma in ustvarjalnih dejavnosti.

Od leta 2016 dalje je temeljni strateški dokument za usmerjenje urbanega razvoja trajnostna urbana strategija. Področje kulture je močno zastopano v trajnostnih urbanih strategijah, ki so jih pripravile slovenske mestne občine. Trajnostna urbana strategija je dokument, v katerem mesto oblikuje celovito vizijo in projekte trajnostnega urbanega razvoja. Izdelana trajnostna urbana strategija za urbano območje je eden od pogojev za pridobitev evropskih kohezijskih sredstev, ki so namenjena mestom za njihove celovite ukrepe trajnostnega urbanega razvoja. Do sredstev za trajnostni urbani razvoj je v Sloveniji upravičenih 12 mestnih občin: Celje, Koper, Kranj, Ljubljana, Maribor, Murska Sobota, Nova Gorica, Novo mesto, Ptuj, Slovenj Gradec, Velenje in Krško. Da bi občine pravočasno in čim bolj učinkovito pripravile takšno strategijo, je Ministrstvo za okolje in prostor leta 2014 vzpostavilo neposredni dvosmerni dialog z mesti. Tako so vse mestne občine do leta 2016 pripravile in sprejele trajnostne urbane strategije na podlagi smernic Ministrstva za okolje in prostor. V strategijah so občine opredelile svojo razvojno vizijo, cilje, ukrepe in način izvajanja strategije. Vsebine so oblikovali z vključevanjem javnosti in drugih pomembnih deležnikov. Proces priprave strategije je povezal delovanje in sodelovanje deležnikov znotraj mestne uprave ter spodbudil tudi sodelovanje in povezovanje med mesti. V izvedbenih načrtih trajnostnih urbanih strategij so mestne občine pozneje opredelile konkretne ukrepe ter ključne projekte in njihovo financiranje. S tem so izpolnile glavni pogoj za dostop do evropskih kohezijskih sredstev za urbani razvoj (Ministrstvo za okolje in prostor, 2015). V vseh slovenskih mestnih občinah je bil razvoj kulture in investicije v kulturno infrastrukturo prepoznan kot eden od ključnih načinov za doseganje ciljev trajnostnega razvoja in kot pomemben strateški razvojni cilj. Ljubljana se tako med drugim opredeli kot »Ljubljana – mesto kulture, prostorske kulture in dediščine«. Maribor v okvir prednostne usmeritve »mestni Maribor« uvršča ukrep »kultura za urbano prenovo«, Celje se opredeli kot »ustvarjalno in vključujoče mesto« ter Kranj kot »živahno mesto – središče kulturne ustvarjalnosti in umetniških dosežkov«. Tudi vse ostale mestne občine so kulturo uvrstile med prednostne razvojne cilje ali ukrepe.

4 REZULTATI IN RAZPRAVA

4.1 Maribor

Z vstopom Slovenije v Evropsko unijo so se tudi slovenska mesta vključila v program Evropska prestolnica kulture (v nadaljevanju EPK). Edino slovensko mesto, ki je do sedaj nosilo naziv Evropska prestolnica kulture, je bil Maribor. Maribor je bil izbran, skupaj z mestom Guimares, za Evropsko prestolnico kulture v letu 2012. V letu 2025 bo naziv nosila Nova Gorica, ki pa bo dogajanje v okviru Evropske prestolnice kulture pripravila skupaj z italijansko Gorico. Maribor je bil za evropsko prestolnico kulture izbran na razpisu na osnovi odločitve mednarodne strokovne komisije v letu 2007. Na razpis so se prijavila še mesta Celje, Koper in Ljubljana. Osrednji poudarek mariborske kandidature je bilo sodelovanje z drugimi mesti v kohezijski regiji Vzhodna Slovenija, pri prijavi so tako sodelovala še mesta Murska Sobota, Ptuj, Novo mesto, Slovenj Gradec in Velenje (Očekrl, 2016). Dogovorjena vsota za izvedbo projekta je bila 200 milijonov evrov, od tega 50 milijonov evrov za program in 150 milijonov evrov za investicije. Projekt evropske prestolnice kulture je vodil javni zavod Maribor 2012 – Evropska prestolnica kulture, ki pa je bil ustanovljen pozno, šele leta 2010, kar je močno negativno vplivalo na izvedbo. Program je predvideval štiri osnovne programske sklope (Ključi mesta, Urbane brazde, Terminal 12 in Življenje na dotik) ter še tri programske entitete (Kulturne ambasade, Priložnost za vse, RAZ:UM) (Javni zavod Maribor, 2013). Maribor je poleg številnih kulturnih dogodkov načrtoval tudi pomembne prostorske učinke, ki jih je povzel v prostorski viziji mesta in scenariju prostorskega razvoja EPK 2012. Prostorska vizija izpostavlja zlasti nadaljevanje revitalizacije starega mestnega središča in prostorski razvoj občine kot regijskega središča (Očekrl, 2016). Umeščanje prizorišč EPK in razvoj kulturne infrastrukture je bilo vezano predvsem na prostor ob Dravi, zlasti v območju četrti Lent in Studenci. Predvidene so bile številne investicije v kulturno infrastrukturo (galerije, muzeji, kulturni centri …) in celostna ureditev posameznih delov mesta (urejanje odprtih in javnih prostorov ter prometne infrastrukture). Od načrtovanih projektov je bilo zaradi pomanjkanja finančnih sredstev izvedenih le malo, na primer prenova Trga Leona Štuklja, Rotovškega trga, Vetrinjskega dvora in kulturnega centra Pekarna. Večina ostalih projektov ni bila izvedena, ravno tako ni bila izkoriščena možnost prenove in uporabe degradiranih urbanih, zlasti industrijskih območij v mestu. Kljub vsem obljubam in velikim načrtom je ostal vtis, da projekt Maribor 2012 za seboj ni pustil ničesar (Kordiš, 2020). Prebivalci Maribora so ocenili, da projekt ni bistveno vplival na izboljšano kvaliteto bivanja, mestno infrastrukturo, krepitev identitete skupnosti in možnosti za zaposlovanje (Dragićević in sod., 2012). V nasprotju s tem pa Horvat (2013) ugotavlja, da je imel projekt Evropske prestolnice kulture pomemben pozitiven učinek na razvoj turizma v Mariboru, saj so v letu 2012 zabeležili kar 18,8 % več turistov in 16,8 % več nočitev kot v letu 2011. Med njimi so prevladovali tuji turisti (82,4 %). Zelo se je povečalo zlasti število dnevnih obiskovalcev (za 47 %), število vodenih ogledov mesta pa kar za 164 % (Horvat, 2013). Toda »čeprav Maribor 2012 marsikdo dojema kot enega od manj uspešnih projektov EPK, pa je ta neuspeh, paradoksalno, spodbudil vznik kar nekaj živahnih samoniklih prizorišč kulturne in ustvarjalne produkcije na neodvisni sceni in na področju socialnega podjetništva« (Kordiš, 2020, str. 140).

Maribor je tudi po zaključku projekta Evropska prestolnica kulture ostal zavezan razvoju kulture kot generatorja razvoja in preobrazbe mesta. Mesto tako želi postati sodobni urbani in kulturni center. Med ukrepi se v Izvedbenem načrtu trajnostne urbane strategije navaja »kultura za urbano prenovo« (Mestna občina Maribor, 2017). Mogoče je ravno razočaranje nad prostorskimi in gospodarskimi učinki projekta EPK spodbudilo mesto v bolj aktivno urbano kulturno politiko in investicije v kulturno infrastrukturo. Najbolj pomemben projekt je vsekakor nova kulturna četrt Minoriti, ki je bila uradno odprta v letu 2022. Obnova Lenta v Mariboru se je začela v osemdesetih letih 20. stoletja, po letu 2000 pa se je začelo s prenovo območja med Lentom, Dravo in mariborsko tržnico. Najprej je bil prenovljen minoritski samostan, v katerem deluje

Lutkovno gledališče Maribor. Obnova je potekala med letoma 2007 in 2010 in je bila sofinancirana s sredstvi Evropskega sklada za regionalni razvoj. Sledila je izgradnja zunanjega avditorija (2014) in obnova minoritske cerkve (2015), ki zdaj služi kot glasbeno in razstavno prizorišče. V nadaljevanju je bil obnovljen še Vojašniški trg z delno rekonstrukcijo srednjeveškega zidu, objekt Tri babe, v katerem deluje Lutkovni muzej, ter Muzej najstarejše trte. Vsi našteti projekti so bili v vrednosti 80 % sofinancirani iz Evropskega sklada za regionalni razvoj v okviru mehanizma celostnih teritorialnih naložb. Skupna vrednost vseh investicij je bila blizu 25 milijonov evrov. Kulturna četrt Minoriti tako predstavlja dober primer obnove degradiranega urbanega območja in urbane regeneracije na osnovi investicij v kulturno infrastrukturo. Drug velik kulturni projekt v mestu Maribor je Center Rotovž, inovativni center, usmerjen k promociji knjige, izobraževanja, kulture in digitalizacije. V centru bodo delovali Mariborska knjižnica, Umetnostna galerija Maribor in Artkino. Projekt je pomemben tudi za urbano prenovo širšega območja Rotovškega trga in povezovanje Glavnega in Slomškovega trga. Gradnja se je pričela v letu 2022, zaključek je predviden v letu 2024. Stroški izgradnje so ocenjeni na 25 milijonov evrov, od tega polovico sofinancira državni proračun.

4.2 Nova Gorica

Leta 2025 bo naslov EPK ponovno podeljen enemu mestu v Sloveniji (Nova Gorica z Gorico) in enemu mestu v Nemčiji (Chemnitz). Poleg Nove Gorice z Gorico so bile v drugi krog razpisa v letu 2019 izbrane še kandidature Ljubljane, Pirana in Ptuja. V drugem krogu v letu 2020 je mednarodna komisija za Evropsko prestolnico kulture v letu 2025 izbrala Novo Gorico z Gorico. Od samega začetka priprave kandidature se v območje EPK vključuje območje, ki zajema dolino Soče, Goriška brda, Vipavsko dolino, Trnovsko-Banjško planoto in del Krasa ter Gorico kot partnersko mesto in ozemlje Goriške pokrajine. V projekt je tako vključenih še dodatnih 13 občin v Sloveniji (Bovec, Kobarid, Tolmin, Kanal, Cerkno, Brda, Idrija, Šempeter - Vrtojba, Renče - Vogrsko, Ajdovščina, Vipava, Miren - Kostanjevica in Komen) ter 27 občin v regiji Furlanija - Julijska krajina, ki projekt podpirajo (Humar in sod., 2020). Rdeča nit programa EPK Nove Gorice z Gorico je brezmejnost, ki jo ponazarja slogan »GO Borderless« oziroma sobivanje in sodelovanje med obema mestoma. Osrednji cilj EPK 2025 je »torej s pomočjo prebivalcev dveh mest, njihovim čezmejnim gibanjem in bivanjem, ustvariti čezmejno mesto, ne da bi se pri tem odpovedali kulturni, zgodovinski, arhitekturni, upravni in še marsikateri različnosti dveh mest« (Veselinovič, Kozorog, 2022, str. 83). Program povzemajo cilji čezmejne kulturne strategije: pomembno kulturno in ustvarjalno središče, revitalizacija kulturne dediščine, močan kulturni turistični model za regijo, Nova Gorica – inovativno mesto in Nova Gorica – evropsko mesto (Čok, 2021). Kot je zapisano v Kandidaturi za Evropsko prestolnico kulture, je dolgoročni cilj projekta »oblikovanje čezmejnega somestja, zelenega, trajnostnega mesta, odprtega v Evropo in svet, dinamičnega in podjetniško naravnanega« (Humar in sod., 2020, str. 5). Prvi in poglavitni namen pa je predvsem izboljšana kakovost življenja prebivalcev mesta in njegove širše okolice. V okviru tega so določeni 3 cilji: (1) oblikovanje enega čezmejnega evropskega mesta Nova Gorica - Gorica, (2) zeleno, živahno mesto z visoko kakovostjo življenja, (3) inovativno mesto s podjetniško miselnostjo (Humar in sod., 2020). Poudarek na oblikovanju evropskega čezmejnega mesta je vsekakor edinstven med dosedanjimi projekti Evropska prestolnica kulture. V okviru tega cilja želijo organizatorji zlasti vzpostaviti čezmejni kulturni prostor in večkulturno okolje. Središče dogajanja in kulturnega ter umetniškega programa bo skupni trg med obema mestoma. Poglavitni prostorski oziroma infrastrukturni projekt je zato celovita prenova Trga Evropa/ Piazza della Transalpina ter izgradnja kulturnega središča ter razstavnega prostora EPICenter. Po prvotnem načrtu bi moral biti EPICenter zgrajen pod Trgom Evropa, za kar je bil tudi izbran zmagovalni projekt italijanskega arhitekturnega studia Baviglio Negrini. Na ta način bi stavba z lokacijo v obeh državah simbolno poudarila temeljno poslanstvo projekta. Kot so zapisali organizatorji, »bo EPIC brez dvoma najbolj priljubljena evropska stavba leta 2025. To bo edini kraj v Evropi, v katerem boste lahko doživeli zgodbo evropskega 20. stoletja v stavbi, ki jo dobesedno prečka meja. Ne samo meja med dvema državama članicama EU, ampak tudi meja med dvema velikima evropskima skupinama (romansko in slovansko) in meja med nekdanjim Vzhodom in Zahodom. Med kapitalizmom in socializmom. To mora biti prostor, ki ga vsi želijo videti.« (Humar in sod., 2020, str. 68). Zaradi birokratskih ovir na obeh straneh meje, v Sloveniji zaradi poplavne ogroženosti območja Trga Evropa in v Italiji zaradi zaščite kulturne dediščine, je bil projekt kasneje zavrnjen. To ponovno dokazuje, da smo še daleč od pravega skupnega »brezmejnega« mesta. Po novem projektu se bo na mejni črti zgradil manjši pritlični objekt kot vstopna informacijska točka in EPICenter severno od Trga Evrope na območju skladišč Slovenskih železnic. Predvidena je izgradnja nadhoda nad železniškimi tiri ter ureditev zelenega koridorja in posameznih kulturnih in športnih objektov. Poleg trga bo prenova zajela širše degradirano urbano območje ob meji, ki ga domačini imenujejo »nikogaršna zemlja«. Revitalizacija Trga Evrope, železniške postaje in mestnega obmejnega pasu je torej temeljni pričakovani učinek projekta EPK 2025 na urbano regeneracijo (Mestna občina Nova Gorica, 2019). Revitalizacija urbanih območij na osnovi investicij v kulturno infrastrukturo je eden izmed ukrepov, ki jih predvideva tudi Trajnostna urbana strategija – Nova Gorica do leta 2030 (Mestna občina Nova Gorica, 2022).

4.3 Ljubljana

Mestna občina Ljubljana je med svoje strateške razvojne cilje zelo visoko postavila kulturo in kulturno infrastrukturo. To je razvidno iz več strateških dokumentov

(Trajnostna urbana strategija Mestne občine Ljubljana za obdobje 2014–2030, Strategija razvoja kulture v Mestni občini Ljubljana 2020–2023 z usmeritvami do 2027, Strateške smernice kulturnega turizma v Ljubljani 2017–2020), še zlasti pa iz dejansko izvedenih investicij v kulturno infrastrukturo. V pripravah na kandidaturo za EPK je Mestna občina Ljubljana definirala glavne infrastrukturne in programske projekte in temeljit premislek, kako lahko kultura prispeva h gospodarskemu in družbenemu razvoju mesta. Kultura in umetniško ustvarjanje pomembno prispevajo k »mednarodni prepoznavnosti Ljubljane kot odprtega, multikulturnega in svetovljanskega mesta« (Mestna občina Ljubljana, 2020, str. 4). Mestna občina Ljubljana pri svoji kulturni strategiji izhaja iz koncepta »urbanega razvoja na osnovi kulture« (ang. *culture based urban development*) na osnovi »prepoznanega pomena kulture za trajnostni razvoj MOL, in sicer kot ključnega dejavnika za kakovost življenja njegovih prebivalk in prebivalcev« (Mestna občina Ljubljana, 2020, str. 4). Med vsemi izvedenimi investicijami v kulturno infrastrukturo na osnovi trajnostne urbane strategije izstopata zlasti Galerija Cukrarna in Center Rog.

Slika 1: Galerija Cukrarna, največja investicija v kulturno infrastrukturo v Ljubljani (foto: D. Rebernik).

Obnova Cukrarne, nekdanje tovarne sladkorja, se je pričela v letu 2018 in je bila zaključena v letu 2021. Galerija Cukrarna je največji dokončan projekt na področju kulture, sofinanciran je bil s strani Evropskega sklada za regionalni razvoj in državnega proračuna. Projekt je bil izveden v okviru celostnih teritorialnih naložb, ki so namenjene odpravi degradacije in revitalizaciji urbanega prostora. Mestna občina Ljubljana je s projektom Cukrarna uresničila več ciljev. Po eni strani je mesto pridobilo največji razstavni prostor v Sloveniji, primeren tudi za velike in zahtevne razstave in kulturne dogodke. Ljubljana na ta način želi okrepiti svoj položaj mednarodno prepoznavnega kulturnega središča in izboljšati dostopnost do kulture za vse prebivalce. Ljubljana je z mednarodnim grafičnim bienalom in bienalom oblikovanja (BIO Ljubljana) že uveljavljeno središče za vizualne umetnosti in oblikovanje, z Galerijo Cukrarna želi ta položaj še okrepiti (Mestna občina Ljubljana, 2023b). Po drugi strani gre za primer urbane revitalizacije, saj so z obnovo izboljšali urbano okolje in revitalizirali degradirano urbano območje na vzhodnem robu mestnega središča. Odpravljena je bila tudi fizična ovira za boljšo prometno povezavo vzhodnega dela mesta z mestnim središčem. Stavba je tudi arhitekturno zelo prepoznavna, s čimer bi jo lahko uvrstili med tako imenovane paradne oziroma ikonične projekte. Poleg Galerije Cukrarna bo do leta 2024 obnovljena tudi sosednja Palača Cukrarna, v kateri bo deloval osrednji mladinski center (Mestna občina Ljubljana, 2017).

Drugi velik projekt na področju kulture je Center Rog. Industrijski objekt je bil zgrajen v letu 1922. V njem je prvotno delovala usnjarna, med letoma 1953 in 1994 pa tovarna koles Rog. Gre za primer zelo kvalitetne industrijske kulturne dediščine, stavba je bila v register nepremične kulturne dediščine vpisana v letu 2001 (Roglab, 2023). Po letu 2006 so v prazni stavbi tovarne Rog začeli delovati posamezni umetniki, aktivisti in društva, ki so se povezali v skupnost »Avtonomna tovarna Rog«. Skvot Rog je deloval do leta 2021, ko je Mestna občina Ljubljana objekt izpraznila. Po mnenju uporabnikov Roga je bila izpraznitev nelegalna in nasilna in je v delu javnosti sprožila veliko ogorčenja in nasprotovanja. Rog je torej deloval kot urbani skvot, kot neformalni kulturni, socialni in družabni prostor, po mnenju dela javnosti je mesto z njegovo ukinitvijo veliko izgubilo (Inštitut za politike prostora, 2023). Mestna občina Ljubljana je z obnovo začela v letu 2001, Center Rog je bil uradno odprt oktobra leta 2023. Kreativno središče »Center Rog« bo delovalo kot javni proizvodni prostor 21. stoletja, namenjen kulturnemu in kreativnemu sektorju, s poudarkom na izdelovalništvu, uporabnih umetnostih in oblikovanju. Ustvarjalcem in meščanom bo ponujal skoraj 9.000 m^2 novega ustvarjalnega prostora in vsebin, poleg tega pa tudi nov, 8.000 m^2 velik park, namenjen dnevni rabi meščanov in javnim prireditvam (Mestna občina Ljubljana, 2023a). Center Rog je torej zasnovan kot sodobni proizvodni prostor, namenjen delovanju kreativnega sektorja. Kot je zapisano v brošuri Center Rog – Razvoj javnega kreativnega stičišča v središču Ljubljane »želimo vzpostaviti nov model produkcijskega prostora, ki bo omogočal infrastrukturno in programsko podporo malim in srednjim podjetjem, nevladnim organizacijam in samostojnim ustvarjalcem iz kreativnega sektorja. Center Rog bo namenjen podpori družbeno koristnih projektov, sledil bo načelom varovanja okolja, krožne ekonomije in družbene pravičnosti« (Roglab, 2023, str. 3). V Centru Rog bodo tako umeščeni zlasti individualni delovni in projektni prostori, namenjeni izdelovalcem, urbanim rokodelcem in obrtnikom, oblikovalcem, arhitektom in inženirjem ter skupni proizvodni laboratoriji (lesarski, kovinski, tekstilni, multimedijski, kuharski). Zastopani bodo zlasti naslednji sektorji: oblikovanje in arhitektura, umetnost, rokodelstvo, kulturna dediščina in izobraževanje (Roglab, 2023).

Vizija Mestne občine Ljubljana »je postati globalno mesto kulture, to je mesto, prepoznavno po vsem svetu po svoji bogati kulturni dediščini, sodobni kulturni infrastrukturi, ki omogoča vrhunsko umetniško ustvarjanje, po živahnem kulturnem utripu ter odličnosti celotne kulturne ponudbe«. (Turizem Ljubljana, 2022, str. 7). V okviru tega želi mesto razpršiti turistično ponudbo in povpraševanje zunaj strogega mestnega centra. Za dosego tega cilja mesto razvija kulturne četrti. »V kulturnih četrtih, ki so glavni povezovalec lokalnih skupnosti, lahko obiskovalci doživijo mesto na drugačen način. Četrti so privlačne za obiskovalce, ki ne želijo doživeti mesta kot turisti, ampak začutiti utrip lokalnega življenja« (Turizem Ljubljana, 2022, str. 74). Poleg že uveljavljenih kulturnih četrti v ožjem mestnem središču želi mesto okrepiti kulturne četrti Metelkova in Tabor, Rog in Cukrarna ter Šiška, Bežigrad in Moste.

5 SKLEP

Iz pregleda strateških in razvojnih dokumentov na področju urbane kulturne politike in trajnostnega urbanega razvoja je razvidno, da tudi slovenska mesta veliko pričakujejo od razvoja kulture ter kulturne infrastrukture. Mesta vidijo kulturo kot katalizator ekonomskega razvoja, še zlasti kulturnega turizma in ustvarjalnih dejavnosti, kot način za izboljšanje kvalitete bivanja za lokalno prebivalstvo ter kot način za izboljšano podobo mesta. Na ta način mesta z urbano kulturno politiko zasledujejo tudi cilje trajnostnega urbanega razvoja, še zlasti ekonomski in socialni vidik trajnosti. V vseh izbranih mestih je področje kulture in ustvarjalnih dejavnosti prisotno med temeljnimi cilji in ukrepi v trajnostnih urbanih strategijah. V strategijah razvoja kulture pa je kultura prepoznana kot način za spodbujanje ekonomskega razvoja in revitalizacijo degradiranih urbanih območij. Strateška usmeritev v koncept urbane regeneracije na osnovi kulture (ang. *culture led urban regeneration*) je podkrepljena tudi z dejanskimi velikimi investicijami v kulturno infrastrukturo, še zlasti v Ljubljani in Mariboru. Obe mesti sta pri investicijah v kulturno infrastrukturo zelo uspešno črpali sredstva iz skladov regionalne politike Evropske unije. Eden najbolj prepoznavnih učinkov investicij v kulturno infrastrukturo je nedvomno revitalizacija degradiranih urbanih območij, na primer v Mariboru območje med Lentom, Dravo in mariborsko tržnico ter v Ljubljani prenova industrijske kulturne dediščine (Cukrarna, Rog). V Novi Gorici so pričakovanja od naziva Evropska prestolnica kulture 2025 velika, za vrednotenje učinkov bo treba počakati vsaj do konca leta 2025. Vrednotenje učinka investicij v kulturo na razvoj kulturnega turizma je bolj kompleksno, toda izjemno hiter razvoj turizma v Ljubljani in v manjši meri tudi v Mariboru je nedvomno tudi posledica boljše kulturne ponudbe in izboljšane podobe mesta.

Ob tem je treba opozoriti na konflikt med alternativno kulturo oziroma subkulturo na eni strani ter tako imenovano kulturo glavnega toka (ang. *mainstream culture*) na drugi strani. Ta konflikt je še posebno izrazit v Ljubljani (Metelkova, Rog, Plac – Partipacitivna ljubljanska avtonomna cona) in deloma tudi v Mariboru (Kulturni center Pekarna) in ga je seveda treba razumeti v okviru širšega družbenega konflikta med ekonomskim neoliberalizmom in konceptom socialne pravičnosti. Kritiki koncepta ustvarjalno mesto (ang. *creative city*), ki med drugim temelji na razvoju kulture glavnega toka, tako poudarjajo, da gre v osnovi za neoliberalen ekonomski koncept, ki umetnost in kulturo obravnava kot katalizator ekonomskega razvoja mest ter na ta način spodbuja naraščanje socialnega razslojevanja, pretirano turistifikacijo in gentrifikacijo, elitizacijo in izrivanje nevladnih/nekomercialnih/avtonomnih organizacij s področja kulture. Dominantna kulturna politika na ta način ščiti interese kapitala, nepremičninskih investitorjev in višjega sloja. V tem kontekstu se lahko problematizira enega glavnih učinkov urbane regeneracije na osnovi kulture – revitalizacijo degradiranih urbanih območij. Območja, ki so definirana kot degradirana urbana območja, na primer nekdanja avtonomna cona Rog, avtonomna kulturna cona Metelkova mesto ali Kulturni center Pekarna, so po mnenju nekaterih (bila) najbolj umetniško-kulturno dejavna in vitalna.

Med mesti, ki smo jih vključili v raziskavo, lahko torej najdemo precej podobnosti, toda tudi razlik. Ljubljana vsekakor odstopa po obsegu investicij v kulturno infrastrukturo ter po intenzivnosti novejših procesov ekonomske in socialne preobrazbe, še zlasti mestnega središča. V mestu potekata intenzivna turistifikacija in gentrifikacija, z vsemi pozitivnimi in negativnimi posledicami. Investicije v kulturno infrastrukturo ter posledičen razvoj kulturne produkcije, kulturne industrije ter kulturnega turizma so tesno medsebojno povezani z omenjenimi procesi urbane preobrazbe. Tudi Maribor v zadnjih letih učinkovito črpa evropska sredstva za investicije v kulturno infrastrukturo, pri čemer je v ospredju revitalizacija degradiranih urbanih območij v historičnem mestnem središču in na osnovi razvoja kulture iskanje nove identitete »postindustrijskega mesta«. Odločitev mesta za zelo aktivno kulturno politiko in investicije v kulturno infrastrukturo v zadnjem desetletju je deloma tudi posledica razočaranja nad slabo izrabo in majhnimi učinki naziva Evropska kulturna prestolnica iz leta 2012. Nova Gorica se kot manjše regionalno središče po obsegu investicij v kulturno infrastrukturo ter intenzivnosti procesov urbane preobrazbe ne more primerjati z Ljubljano in Mariborom. Mesto pa ima seveda enkratno priložnost, da se z nazivom Evropska kulturna prestolnica uveljavi kot pomembno kulturno središče, revitalizira obmejno urbano območje in okrepi povezanost z italijansko Gorico v enotno urbano regijo.

Zahvala

Avtor se zahvaljuje poročevalcem na znanstvenem srečanju Mesec prostora 2021 na Oddelku za geografijo na Filozofski fakulteti v Ljubljani z naslovom »Kulturna infrastruktura v mestih in trajnostni urbani razvoj«, ki so bili s svojimi referati pomemben navdih pri pisanju prispevka.

Literatura in viri

Bayliss, D., 2007. The rise of the creative city: Culture and creativity in Copenhagen. European Planning Studies, 15, 7, str. 889–890. DOI:10.1080/09654310701356183.

Bianchini, F., 1999. Cultural planning for urban sustainability. V: Nystrom, L., Fudge, C. (ur.). Culture and cities. Cultural processes and urban sustainability. Stockholm: The Swedish Urban Development Council, str. 34–51.

Bianchini, F., Landry, C., 1995. The creative city. London: Demos.

Byrne, T., 2012. The creative city and cultural policy: opportunity or challenge? V: Feldman, Z. (ur.). Cultural policy, criticism and manegament research. London: City University London, str. 52–78.

Chiu, Y. H., Lee, M. S., Wang, J. W., 2019. Culture-led urban regeneration strategy: An evaluation of the management strategies and performance of urban regeneration stations in Taipei City. Habitat International, 86, 2, str. 1–9. DOI: 10.1016/j.habitatint.2019.01.003.

Comunian, R., 2011. Rethinking the creative city: The role of complexity, networks and interections in urban creative economy. Urban Studies, 48, 6, str. 1157–1179. DOI: 10.1177/0042098010370626.

Comunian, R., Mould, O., 2014. The weakest link: Creative industries, flagship cultural projects and regeneration. City, Culture and Society, 5,2, str. 65–74. DOI: 10.1016/j.ccs.2014.05.004.

Čok, L., 2021. Go! Borderless! Nova Gorica and Gorizia European Capital of Culture 2025. The Bulletin of the European Association of Professors Emeriti, 2, 1, str. 12–14. URL: https://europemeriti.org/bulletin/EAPE_BULLETIN_ISSUE_2021-2-1_1-22.pdf (citirano 28. 9. 2023).

Dragićević, V., Bole, D., Bučić, A., Prodanović, A., 2012. Evropska prestolnica kulture: Mnenje prebivalcev o družbenih koristih in stroških dogodka – Primer Maribora 2012. Acta geographica Slovenica, 55, 2, str. 283–302. DOI: 10.3986/AGS.747.

Evans, G., 2005. Measure for measure: Evaluating the evidence of culture's contribution to regeneration. Urban Studies, 42, 5/6, str. 959–983. DOI:10.1080=00420980500107102.

Florida, R., 2002a. Bohemia and economic geography. Journal of Economic Geography, 2, 1, str. 55–71. DOI: 0.1093/jeg/2.1.55.

Florida, R., 2002b. The rise of the creative class, and how it is transforming work, leisure, community and everyday life. New York: Basic Books.

Franklin, A., 2016. Journeys to the Guggenheim Museum Bilbao. Towards a revised Bilbao Effect. Annals of tourism research, 59, 2, str. 79–92. DOI: 10.1016/j.annals.2016.04.001.

Garcia, B., 2004. Cultural policy and urban regeneration in Western European cities: Lessons from experience, prospects for the future. Local Economy, 19, 4, str. 312–326. DOI: 10.1080/0269094042000286828.

Garcia, B., Cox, T., 2013. European Capitals of Culture: Succes strategies and long term effects. European Parliament: Study. European Parliament, Directorat General for Internal Policies. URL: https://www.europarl.europa.eu/RegData/etudes/etudes/join/2013/513985/IPOL-CULT_ET(2013)513985_EN.pdf (citirano 10. 9. 2023).

Grodach, C., 2017. Urban cultural policy and creative city making. Cities, 68, 1, str. 82–91. DOI: 10.1016/j.cities.2017.05.015.

Hočevar, M., 2000. Novi urbani trendi. Prizorišča v mestih – omrežja med mesti. Ljubljana: Fakulteta za družbene vede.

Horvat, U., 2013. Vpliv projekta Evropska prestolnica kulture na turistični obisk v Mariboru. Revija za geografijo, 8, 1, str. 113–128.

Humar, V., Rusjan Bric, N., De Sabbata L., Del Biancho, D., Mokorel, S., 2020. GO BORDERLESS – Kandidatura za evropsko prestolnico kulture. Nova Gorica: Mestna občina Nova Gorica in Občina Gorica.

Inštitut za politike prostora, 2023. Ali vemo kaj smo izgubili z Rogom? URL: https://www.ljubljana.si/assets/Uploads/Brosura-Center-Rog-2024.pdf (citirano 21. 9. 2023).

Javni zavod Maribor, 2013. Maribor 2012 – Evropska prestolnica kulture. Maribor. URL: http://www.maribor2012.info/wp-content/uploads/2014/01/Od_izzivov_do_rezultatov.pdf (citirano 6. 9. 2023).

Kong, L., 2000. Culture, economy, policy: Trends and developments. Geoforum, 31, 4, str. 385–390. DOI: 10.1016/S0016-7185(00)00004-X.

Kordiš, M., 2020. Maribor je prihodnost. (Proti) učinek Evropske prestolnice kulture Maribor 2012 v polju nevladnega sektorja kulturne produkcije. Etnolog, 30, str. 139–156.

Kozina, J., Bole, D., Tiran, J., 2021. Forgotten values of industrial city still alive: What can the creative city learn from its industrial counterpart? City, Culture and Society, 25, 100395. DOI: 10.1016/j.ccs.2021.100395.

Landry, C., 2008. The Creative City – A Toolkit for Urban Innovators. London: Earthscan.

Mestna občina Ljubljana, 2015. Trajnostna urbana strategija Mestne občine Ljubljana za obdobje 2014–2030. Ljubljana.

Mestna občina Ljubljana, 2017. Trajnostna urbana strategija Mestne občine Ljubljana 2014–2030. Izvedbeni načrt. URL: https://www.ljubljana.si/assets/Uploads/Izvedbeni-nacrt-Trajnostne-urbane-strategije-Mestne-obcine-Ljubljana-2014-2030-kor.pdf (citirano: 21. 9. 2023).

Mestna občina Ljubljana, 2020. Strategija razvoja kulture v Mestni občini Ljubljana 2020–2023 z usmeritvami do leta 2027. URL: https://www.ljubljana.si/assets/Uploads/Strategija-razvoja-kulture-v-Mestni-obcini-Ljubljana-2020-2023-z-usmeritvami-do-leta-2027.pdf (citirano: 21. 9. 2023).
Mestna občina Ljubljana, 2023a. Projekt Center Rog. URL: https://www.ljubljana.si/sl/moja-ljubljana/kultura-v-ljubljani/projekt-center-rog/ (citirano 14. 10. 2023).
Mestna občina Ljubljana, 2023b. Projekt ureditve Galerije Cukrarna. URL: https://www.ljubljana.si/sl/moja-ljubljana/kultura-v-ljubljani/projekt-ureditve-galerije-cukrarna/ (citirano 14. 10. 2023).
Mestna občina Maribor, 2017. Izvedbeni načrt trajnostne urbane strategije Mestne občine Maribor. Maribor.
Mestna občina Maribor, 2022. Strategija razvoja kulture v Mestni občini Maribor v obdobju 2022–2026. Maribor.
Mestna občina Nova Gorica, 2019. Lokalni program za kulturo v Mestni občini Nova Gorica 2019–2023. Nova Gorica.
Mestna občina Nova Gorica, 2022. Trajnostna urbana strategija. Nova Gorica do leta 2030. Nova Gorica.
Ministrstvo za okolje in prostor, 2015. Smernice za pripravo trajnostnih urbanih strategij – TUS URL: https://www.gov.si/assets/ministrstva/MOP/Dokumenti/Urbani--razvoj/7ab5def04d/Smernice_za_pripravo_TUS.pdf (citirano 7. 9. 2023).
Montalto, V., Tacao Moura, J. C., Langedijk, S., Saisana, M., 2019. Culture counts: An empirical approach to measure the cultural and creative vitality of European cities. Cities, 89, str. 167–185. DOI: 10.1016/j.cities.2019.01.014.
Nedučina, D., Krklješa, M., Gajić, Z., 2019. Post-socialist context of culture-led urban regeneration – Case study of a street in Novi Sad, Serbia. Cities, 85, str. 72–82. DOI: 10.1016/j.cities.2018.11.024.
Očekrl, P., 2016. Družbeno-prostorski vplivi Evropske prestolnice kulture na Maribor. Magistrsko delo. Ljubljana: Fakulteta za družbene vede.
Pavel, S., Jucu, I. S., 2020. Urban transformation and cultural evolution of post-socialist European citiest. The case of Timisoara (Romania): From »Little Vienna« urban icon to European Capital of culture (ECoC 2012). City, Culture and Society, 20, 2. DOI: 10.1016/j.ccs.2019.100296.
Plaza, B., 2000. Guggenheim museum's effectiveness to attract tourism. Annals of Tourism Research, 27, 4, str. 1055–1058. DOI: 10.1016/S0160-7383(99)00131-0.
Pratt, A. C., 2010. Creative cities: Tensions within and between social, cultural and economic development. A critical reading of the UK experience. City, Culture and Society, 1, 1, str. 13–20. DOI: 10.1016/j.ccs.2010.04.001.
Raevskikh, E., 2018. Anticipating »Bilbao effect«: Transformations of the city of Arles before the opening of the Luma Foundation. Cities, 83, str. 92–107. DOI: 10.1016/j.cities.2018.06.012.

Richards, G., Wilson J., 2004. The impact of cultural events on city image: Rotterdam, Cultural Capital of Europe 2001. Urban Studies, 41, 10, str. 1931–1951. DOI: 10.1080/0042098042000256323.

Roglab, 2023. Center Rog – Razvoj javnega kreativnega stičišča v središču Ljubljane. URL: https://www.ljubljana.si/assets/Uploads/Brosura-Center-Rog-2024.pdf (citirano 21. 9. 2023).

Turizem Ljubljana, 2022. Strateške smernice kulturnega turizma in prireditev v Ljubljani 2022–2027. Ljubljana.

Uršič, M., 2008. Ali mestni zrak še osvobaja? Vpliv prometa in potrošnje na spreminjanje vloge odprtih javnih prostorov. V: Simoneti, M., Marinček, P. (ur.). Odprt javni prostor. Zbornik predavanj in prispevkov ob mednarodni konferenci. Ljubljana: Društvo krajinskih arhitektov Slovenije, Oddelek za krajinsko arhitekturo, Biotehniška fakulteta, str. 83–87.

Veselinovič, J., Kozorog, M., 2022. European Capital of Culture 2025: A Multidirectional engine of a common city development in Nova Gorica and Gorizia. Traditiones, 51, 3, str. 75–97. DOI: 10.3986/Traditio2022510304.

URBAN CULTURAL POLICY AND URBAN REGENERATION: CASE STUDY OF MARIBOR, NOVA GORICA AND LJUBLJANA

Summary

From the 1980s onward urban cultural policy and investments in cultural infrastructure and production are being recognized as one of the most effective ways to promote urban regeneration and urban economic restructuring. Culture led urban regeneration became one of the most important tools in urban regeneration policies, especially in post-industrial cities which were experiencing intense deindustrialization and economic recession. Culture which was for a long time considered as public expenditure became a catalysator of economic development of cities. Culture led urban regeneration was based on development of cultural tourism and creative industry, improved image of the city and quality of life for local population, revitalization of derelict urban areas and gentrification. The concept of creative city became one of the main urban policy instruments. Slovene cities began to use culture as a tool for urban regeneration and revitalization as well. This became very pronounced especially after the implementation of sustainable urban strategies in the framework of Urban Agenda of European Union. Culture, cultural infrastructure, and creative sector are well represented in Sustainable Urban Strategies of Slovene urban municipalities.

The main objective of the paper is to analyze and evaluate the main goals and measures of urban cultural policy as a tool for promoting urban regeneration and sustainable urban development in three selected Slovene cities: Maribor, Nova Gorica and Ljubljana. Based on the analysis of strategic development documents and investments in cultural infrastructure we evaluated the role of culture in urban regeneration and revitalization. The basic method of the research is a comparative analysis of strategic development documents (sustainable urban strategies, strategies of cultural development) and completed investments in cultural infrastructure and their impact on urban regeneration in selected cities. In all studied cities culture has a very important role in urban regeneration and revitalization. Maribor was assigned a title of European capital of Culture in 2012. Despite big expectations, the city didn`t succeed to use the status of European Capital of Culture for urban regeneration. But in the last decade the Municipality of Maribor is very active in culture led urban regeneration. The best example is revitalization of western part of old city center (Lent) with investments in cultural infrastructure (cultural quarter Minoriti). Nova Gorica will be together with Italian Gorizia European Capital of Culture in 2025. The city has very ambitious plans to promote urban revitalization of the area around Trg Evrope (Piazza Transalpina) on the border between Slovenia and Italy. The other goal is creation of a single cross-border and multicultural urban area including Nova Gorica and Gorizia. Ljubljana defines itself as a city of culture and cultural heritage. In the last ten years the city carried out very ambitious investments in cultural infrastructure, for example Art Gallery Cukrarna and Creative Center Rog. In this way Ljubljana succeeded to revitalize derelict urban areas in the eastern part of the city center (Tabor, Poljane) and promote the development of cultural tourism and creative industries. We can conclude that all three cities successfully use culture as a catalysator of urban regeneration, mostly in the form of revitalization of derelict urban areas, development of cultural tourism and improved image of the city.

Andrej Rigler*, Goran Turk**

VPLIV GOSTOTE PROMETA IN NAČINA VOŽNJE NA PROMETNI TOK TER IZPUSTE CO_2

COBISS 1.01
DOI: 10.4312/DZOB1160

Izvleček

Namen prispevka je na primeru 1500 m dolge ceste z enim pasom proučiti značilnosti prometa in ugotoviti, kako na pretok in izpuste ogljikovega dioksida (CO_2) vplivajo gostota vozil, omejitev hitrosti in način vožnje. V raziskavi je uporabljen mikroskopski prometni model celični avtomat (v nadaljevanju CA), imenovan razširjeni model LAI, ki vsebuje nove funkcije in je nadgrajen za izračun izpustov. Glede na rezultate prometnih simulacij so z modelom, ki so ga predstavili Panis, Broekx in Liu (2006), izračunani izpusti CO_2 na prevožen kilometer. Rezultati kažejo, da je pri največji dovoljeni hitrosti 70 km/h največji pretok 2122 vozil/uro dosežen pri gostoti 0,25 vozila/celico. Med gostotama 0,22 in 0,28 vozila/celico je prometni tok v sinhronizirani fazi, v kateri zaradi medsebojnega delovanja vozil povprečna hitrost pade. Pri višjih gostotah nastajajo zastoji, povprečna hitrost še naprej pada, povečuje se količina izpustov. Najvišja dovoljena hitrost vpliva na izpuste CO_2 le pri nižjih gostotah, pri višjih pa nanje precej bolj vpliva stopnja pospeška. Menimo, da bi bilo v času prometnih zgostitev koristno zmanjšati gostoto prometa, da bi dosegli čim bolj optimalen pretok in zmanjšali negativne vplive na okolje, na primer s spodbujanjem občasnega dela od doma, uporabe javnega prevoza in potovanj pred ali po predvidenih prometnih konicah.

Ključne besede: prometni tok, izpusti CO_2, mikroskopski modeli prometnega toka, emisijski modeli, celični avtomat, razširjeni model LAI

*Oddelek za geografijo, Filozofska fakulteta Univerze v Ljubljani, Aškerčeva cesta 2, SI-1000 Ljubljana, Slovenija (Na jami 16, SI-1000 Ljubljana, Slovenija)
**Katedra za mehaniko, Fakulteta za gradbeništvo in geodezijo Univerze v Ljubljani, Jamova 508, SI-1000 Ljubljana, Slovenija
e-pošta: ar7918@student.uni-lj.si (andrej.rigler1@gmail.com), goran.turk@fgg.uni-lj.si
ORCID: 0000-0002-4596-3594 (G. Turk)

1 UVOD

Avtomobilski promet je vir različnih težav, kot so prometne nesreče in onesnaževanje zraka. Leta 2016 je prometni sektor prispeval približno 25 % svetovnih izpustov CO_2, kar je 71 % več kot leta 1990. Onesnaženost zraka z drobnimi delci lahko tudi poveča tveganje pljučnega raka in smrtnost zaradi zapletov s srcem ter pljuči (Escap, 2019; Hoek in sod., 2002; Marzoug in sod., 2022). Vpliv prometa na onesnaženost zraka je še posebej velik tik ob prometnicah. Onesnaženost zaradi prometa namreč hitro upada z oddaljenostjo od cest (Ogrin, 2007; Strle in sod., 2020). Na onesnaženost močno vplivajo lega in vremenske razmere (Glojek in sod., 2019). Promet je tudi porabnik prostora. V mestih, kjer je vse večji problem tudi hrup, predstavlja veliko obremenitev mirujoči promet (Ogrin, 2018).

De Vlieger, Keukeleere in Kretzschmar (2000) so pokazali, da lahko zmernejši način vožnje zmanjša izpuste v prometu in obratno. Ježek in sod. so ugotovili, da četrtina osebnih vozil na dizelski pogon, ki najbolj onesnažujejo okolje, prispeva 63 % in 47 % izpustov črnega ogljika oziroma NO_X (Ježek in sod., 2015).

Pred začetkom uvajanja ukrepov za zmanjšanje izpustov je nujno najprej oceniti izpuste. Obstajata dva glavna pristopa za ocenjevanje izpustov: makroskopski in mikroskopski. Prvi se nanaša na oceno izpustov v širšem merilu, drugi pa na oceno izpustov vsakega vozila posebej (Ntziachristos in sod., 2009; Panis, Broekx, Liu, 2006; Rakha in sod., 2000). Mikroskopski modeli računajo izpuste iz prometa s pomočjo podatkov o emisijskih faktorjih (EF) vozil in njihovi aktivnosti. Gre za pristop »od spodaj navzgor«. Poznamo še drug način računanja izpustov iz prometa, in sicer »od zgoraj navzdol«, pri čemer so prispevki virov določeni na podlagi *in-situ* meritev koncentracij različnih sledil v zunanjem zraku. Ježek (2015) je z zasledovalno metodo merila emisijske faktorje črnega ogljika in NO_X za vozila različnih kategorij.

Čeprav so mikroskopski modeli zelo natančni, niso primerni za uporabo na velikih območjih, ker za oceno izpustov potrebujejo podatke o vsaki sekundi vožnje vozila, kar je računsko zahteven postopek. Zato so za velika omrežja računsko bolj učinkoviti makroskopski modeli, ki pa so običajno manj natančni v primerjavi z mikroskopskimi metodami. Podatke za makroskopsko modeliranje, kot sta povprečna hitrost in gostota omrežja, je relativno enostavno zbrati s pomočjo prometnih števcev in detektorjev (Halakoo, Yang, Abdulsattar, 2023). Mikroskopske prometne modele je treba uporabljati v kombinaciji z mikroskopskimi simulacijami prometa, ki modelirajo premikanje posameznih vozil in s tem realistično predstavijo gibanje prometnega toka. Med temi je dobra možnost za modeliranje prometa tip modelov celični avtomat (CA) (Guzman in sod., 2018).

Z uporabo modelov CA lahko opišemo številne fizikalne sisteme in procese. Izkazali so se za uporabne ne samo pri modeliranju prometnih tokov, ampak tudi v številnih različnih aplikacijah, na primer pri modeliranju širjenja gozdnih požarov, rasti prebivalstva, vedenja pešcev itd. V geografiji se uporabljajo za simulacije spremememb rabe tal, saj zmorejo povezati interakcije različnih dejavnikov v prostoru (Pinto, Antunes, Roca, 2021; Xu, Xing Zhu, Liu, 2023). Ker modeli CA računajo količino pojava v prostoru, lahko s prometnimi modeli CA merimo vpliv križišč, zožitev cest, omejitev hitrosti ali drugih značilnosti in dejavnikov prometa kjerkoli na proučevanem območju.

Model CA je sestavljen iz n-dimenzionalne mreže ali niza celic, pri čemer se različne vrednosti vseh celic hkrati posodabljajo v posameznih časovnih korakih glede na vrednosti sosednjih celic v predhodnem časovnem koraku (Karafyllidis, Thanailakis, 1998; Maerivoet, De Moor, 2005). V primeru nadgrajenega razširjenega modela LAI se v vsakem časovnem koraku posodabljajo hitrost, pospešek in prevožena pot vseh vozil naenkrat.

V primeru prometnih modelov CA je cesta razdeljena v celice določene velikosti. Pri enoceličnih modelih je vsaka celica lahko prazna ali vsebuje vozilo. Čas predstavljajo diskretni časovni koraki (v smislu, da čas ni zvezna spremenljivka). Glede na različna pravila se stanje celic v sistemu spreminja v času oziroma v časovnih korakih, tako da se posnema gibanje vozil (Maerivoet, De Moor, 2005).

Prometni modeli CA so postali priljubljeni pri modeliranju prometnih tokov, ker učinkovito in hitro delujejo v računalniških simulacijah, kjer lahko s pomočjo preprostega nabora pravil in nizkih računskih zahtev izvajajo obsežne simulacije. Prav tako lahko posnemajo realno vožnjo in upoštevajo psihološke lastnosti voznikov (Benjamin, Johnson, 1996).

Prvi deterministični CA model prometnega toka je znan kot Wolframovo pravilo 184, ki predstavlja spreminjanje osrednje celice v času glede na lastnosti obeh sosednjih celic. V fizikalnem smislu rezultat pravila 184 predstavlja gibanje vozila, ki se premakne za en korak v desno, če je prostor prazen, oziroma ostane na mestu, če je prostor zaseden (Wolfram, 1983).

Leta 1992 sta Nagel in Schreckenberg (NaSch) izdelala prvi stohastični prometni model CA, pri katerem je eno od pravil stohastično. Z uporabo naključnega zaviranja lahko model simulira nastajanje prometnih zastojev. V modelu NaSch, v katerem je najvišja dovoljena hitrost 5, lahko vozila pospešijo le za eno stopnjo, če imajo prostor (Nagel, Schreckenberg, 1992).

Prometni modeli CA so se razvijali skozi čas, ko so avtorji uvajali nova pravila za pospeševanje, vzdrževanje razdalje in postopek posodabljanja (Barlovic in sod., 1998; Benjamin, Johnson, 1996; Knospe in sod., 2000; Takayasu, Takayasu, 1993). K pomembnemu napredku so prispevali Kerner, Klenov in Wolf (2005), ki so v svoj model KKW CA vključili sinhronizacijsko razdaljo. Ko vozilo pripelje v območje interakcije vozila spredaj (tj. sinhronizacijske razdalje), poskuša svojo hitrost prilagoditi hitrosti tega vozila (Kerner, Klenov, Wolf, 2002).

Leta 2010 sta Larraga in Alvarez-Icaza nadgradila pristop CA z modelom LAI (gre za krajšavo imen avtorjev, Larraga in Alvarez-Icaza), ki simulira prost pretok, zgoščen promet, sinhroniziran tok in druge kompleksne prostorsko-časovne vzorce. Hkrati se model izogiba kompleksnim pravilom, značilnim za modele, ki temeljijo na modelu KKW. Pri modelu LAI vozila prilagajajo hitrost glede na razdaljo do vozil pred njimi. Odziv voznika temelji na analizi varnosti, ki je sestavljena iz njegovega reakcijskega časa, hitrosti vozila, hitrosti vozila spredaj in razdalje med njima (Larraga, Alvarez-Icaza, 2010). Model LAI je bil pozneje izboljšan in razširjen (Guzman in sod., 2015; Li in sod., 2016).

Poznamo tudi različne mikroskopske modele za računanje izpustov. Za uporabo modela, ki so ga leta 2018 razvili Panis, Broekx in Liu (model PBL) za izračun izpustov PM, VOC, CO_2 in NO_X za mestni promet, potrebujemo zgolj podatke o hitrosti in stopnji pospeška v vsakem trenutku. Koeficienti v funkciji so pridobljeni iz empiričnih opazovanj. Pri nekaterih modelih potrebujemo za računanje izpustov še druge podatke, na primer moč motorja, naklon ceste ali obremenitev vozila (Quaassdorff in sod., 2022).

Številni avtorji so uporabili kombinacijo modelov CA in mikroskopskih modelov izpustov. Pan in sod. (2018) so proučevali povezavo med pretokom prometa, porabljeno količino goriva, izpusti in razpršitvijo delcev na enem pasu. Za prometne simulacije so uporabili model NaSch CA, za izračun izpustov delcev pa model PBL.

Marzoug in sod. (2018) so proučevali prometne izpuste na semaforiziranih križiščih. Za gibanje vozil so uporabili model NaSch CA in model menjave voznih pasov. Za opis prometa v križiščih so uporabili algoritme delovanja semaforjev, za izračun izpustov CO_2, PM, VOC in NO_X pa model PBL.

Xue in sod. (2020) so za simulacijo prometnega toka na enosmernem pasu pri odprtih mejnih pogojih uporabili trifazni model KKW CA. Porabo goriva vozil so proučevali z metodo, ki so jo razvili Treiber, Kesting in Thiemann (2007) in pri kateri se uporablja Newtonovo formulo za izračun mehanske moči kot funkcije pospeška in hitrosti.

Rezultati študij so pokazali, da je vpliv omejitve hitrosti na različne izpuste in porabo goriva pri manj zgoščenem prometu drugačen kot pri prometnih konicah. Podobno velja za trajanje zelene luči na semaforjih. Z zgostitvijo prometa se povečujeta količina izpustov in poraba goriva.

Namen članka je na primeru 1500 m dolge ceste z enim pasom proučiti značilnosti prometa in ugotoviti, kako na pretok ter izpuste CO_2 vplivajo gostota vozil, omejitev hitrosti ter način vožnje. Cesta je namišljena in ne predstavlja dejanskega odseka ceste. Z razumevanjem dinamike prometnega toka lažje sprejmemo ukrepe na obremenjenih cestnih odsekih (na primer omejitev hitrosti, širitev ali zožitev cest, preusmeritev prometa), ki pripomorejo k zmanjšanju pretoka in obremenitev prometa v okolju. V slovenski geografski literaturi in nasploh slovenski znanstveni literaturi nismo zasledili uporabe modelov CA. Prav tako v slovenski literaturi nismo zasledili izdelave prometnega simulatorja, ne da bi za to uporabili že izdelana orodja. Model CA je primeren za raziskavo, ker je z njim mogoče številsko ovrednotiti določen pojav v času in prostoru. Na področju prometa je uporaben za izračun hitrosti, pospeškov in lokacij vozil v časovni enoti. V kombinaciji z emisijskim modelom je primeren za računanje izpustov. Hkrati je razmeroma preprost za izdelavo lastnega simulatorja. Z modelom CA je mogoče izvesti prometne simulacije na razmeroma velikih območjih. Razširjeni model CA LAI zaradi uporabe teorije kinematike in realnih stopenj pospeškov ter pojemkov posnema dejansko stanje prometa (Guzman in sod., 2018).

2 METODOLOGIJA

2.1 Prometni model

V raziskavi smo uporabili razširjeni model LAI, ki smo ga nadgradili za izračun izpustov. Model vrste CA izvira iz modela LAI in njegovih pravil izogibanja trkom. Pri obeh modelih v vsakem časovnem koraku izračunamo varnostno razdaljo zasledovanega vozila oziroma vozila zadaj glede na hitrost zasledovanega vozila, hitrost vozila spredaj, sposobnost zasilnega zaviranja obeh vozil in razdaljo med obema voziloma. Glede na izračunano medsebojno razdaljo se zasledovano vozilo odloči, ali bo pospešilo, ohranilo svojo hitrost, upočasnilo ali zavrlo v sili.

Avtorji so v novi različici dodali dve novosti:

1. različne vrednosti pospeševanja in zaviranja za različna vozila,
2. pospeševanje vozil temelji na enakomernem pospešenem gibanju namesto na impulzivnem pospešenem gibanju, značilnem za večino modelov CA.

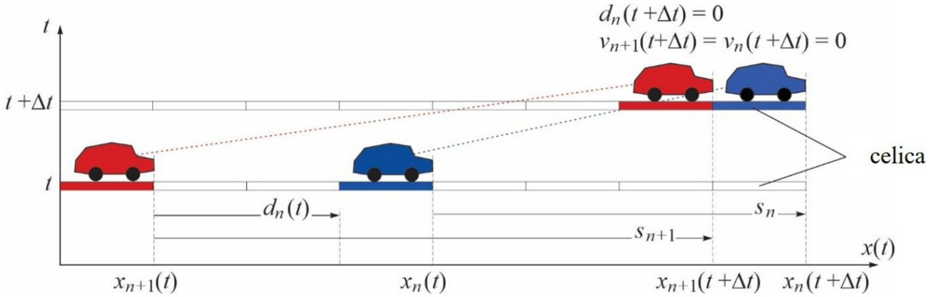
Razširjeni model LAI prav tako omogoča izračun treh varnostnih razdalj med vozilom zadaj in vozilom spredaj, ki imata lahko različne ali enake vozne lastnosti. Glede na izračunane razdalje nato vozilo zadaj sprejme odločitev za pospešek (ali pojemek oziroma zaviranje) glede na najslabši možni scenarij, pri katerem vozilo spredaj zavre v sili. Razširjeni model je bolj v skladu z realnim prometom, saj uporablja realne stopnje pospeševanja/pojemanja. Pri tem se vozila gladko približujejo počasnejšim vozilom ali stoječim vozilom. Model temelji na preprostih pravilih kinematike in njenih parametrov, določenih glede na položaje in hitrosti sosednjih vozil. Izhaja iz enakomerno pospešenega gibanja, kjer je stanje vozila v času opisano na naslednji način:

$$x_n(\mathrm{t}) = x_{n_0} + v_{n_0}t + \frac{1}{2}a_n t^2 \quad (1)$$

$$v_n(\mathrm{t}) = v_{n_0} + a_n t \quad (2)$$

Pri tem x_n in v_n označujeta položaj in hitrost vozila n, t je čas, x_{n_0} in v_{n_0} sta začetni položaj in hitrost vozila, a_n pa je pospešek. Vrednosti parametrov za pospešek, pojemek in človeški reakcijski čas izhajajo iz opazovanj prometa (Guzman in sod., 2018). Model zato reši pojav nenadnih pojemkov in kompleksnosti, kar je značilno za modele CA. Rezultati simulacij kažejo, da lahko razširjeni model LAI posnema empirične ugotovitve (Guzman in sod., 2018).

Slika 1: Shematični diagram za računanje varne razdalje.



Razširjeni model LAI je verjetnostni model CA, sestavljen iz N vozil, ki se premikajo v eno smer na enodimenzionalni mreži L celic. Vsaka celica je bodisi prazna bodisi jo zaseda eno samo vozilo. Njihove hitrosti so vrednosti, ki se spreminjajo od 0 do $v_{\max}$, kar označuje največjo hitrost vozila. Na tem mestu omenimo razlike med razširjenim modelom LAI in različico, uporabljeno v tej raziskavi. V prvem modelu lahko vozilo zasede več kot eno celico, v drugem pa eno samo celico. Dolžina celice v novem modelu je 7,5 m, kar je velikost mesta, ki ga zasede posamezen avtomobil v zastoju (Nagel, Schreckenberg, 1992). Pri razširjenem modelu LAI znaša dolžina celice 1 m. Za razliko od razširjenega modela LAI v novi različici vrednosti hitrosti niso cele vrednosti, ampak realna števila. Položaj vozila v novem modelu predstavljata dve vrednosti, ki označujeta položaj sprednjega odbijača vozila. Prva vrednost je njegov natančen položaj na cestišču, druga pa položaj, ki sovpada z zaporedno številko celice. Druga vrednost se uporablja za izračun izpustov. Vozilo zasede eno samo celico v celoti le na začetku, ko zapelje na cestišče. Pozneje ni več v eni sami celici, temveč v dveh celicah. Zato vrednost celice predstavlja celico, v katero je vstopilo vozilo v celoti. Število tako sovpada z večkratnikom velikosti celice. Na primer, če ima vozilo položaj 7,5 m, to pomeni, da se je ravnokar pojavilo na mreži celic in zasedlo prvo celico. Na položaju 14 m še vedno zaseda prvo celico, pri čemer je ostanek 6,5 m. Na položaju 15 m je zasedlo drugo celico. Ni možnosti, da bi se dve vozili pojavili v isti celici, ker mora biti med njima minimalna razdalja velikosti celice. Nadgrajeni model vključuje dve časovni spremenljivki. Spremenljivka t_r, ki predstavlja reakcijski čas voznika, se uporablja za izračun varnostnih razdalj za določitev novega pospeška vozila in je enaka 1 s, kar ustreza človeški reakciji (Guzman in sod., 2018).

Na podlagi tega pospeška druga časovna spremenljivka ustreza časovnemu koraku Δt, ki se uporablja za izračun nove hitrosti in položaja vozila. Za razliko od t_r spremenljivka Δt ni odvisna od načina vožnje. To je druga razlika glede na razširjeni model LAI, ki ne vključuje časovnih spremenljivk, saj sta časovni korak in reakcijski čas vedno 1.

2.2 Pravila za posodabljanje

Korak 1:
Izračun varnostne razdalje. V prvem koraku se določi najmanjša varnostna razdalja za vozila $d_{\mathrm{acc}n}$, $d_{\mathrm{keep}n}$ ali $d_{\mathrm{dec}n}$, pri čemer spremenljivke predstavljajo potrebne razdalje med vozilom spredaj n in vozilom zadaj $n+1$ v primeru, da želi slednje pospešiti, obdržati hitrost ali zavreti (Guzman in sod., 2018).

Korak 2:
Počasno pospeševanje. Glede na hitrost vozila v_{n+1} je določen parameter stohastičnega šuma R_a.

$$R_{\mathrm{a}} = \min\left(R_{\mathrm{d}}, R_0 + v_{n+1}\frac{R_{\mathrm{d}}-R_0}{v_{\mathrm{s}}}\right) \quad (3)$$

Pri tem parameter stohastičnega šuma R_a označuje verjetnost, da bo vozilo pospešilo, kar je odvisno od njegove hitrosti. Predpostavlja se, da bo vozilo, katerega hitrost je manjša od v_s v prejšnjem časovnem koraku, pospešilo z manjšo verjetnostjo kot preostala vozila v gibanju $v_{n+1}>v_s$, kar pomeni, da morajo počasna vozila čakati dlje, preden lahko nadaljujejo z vožnjo. Vrednost parametra $R_a(<1)$ linearno interpolira med R_0 in R_d ($R_0 < R_d$), če je hitrost v_{n+1} manjša od hitrosti v_s, ki v našem primeru znaša 8 m/s (Larraga, Alvarez-Icaza, 2010). Vrednosti vseh parametrov so definirane v poglavju 3.1.

Korak 3:
Odločitev.

Glede na medsebojno razdaljo $d_n(t)$ zasledujočega vozila in vozila spredaj, ki se primerja z izračunanimi varnostnimi razdaljami v koraku 1, je izračunan pospešek zasledovanega vozila. Upoštevane so tudi verjetnosti pospeševanja (korak 2).

Korak 3a:
Pospeševanje.

če $d_{\mathrm{acc}_n} \leq d_n(t)$ potem

$$a_{n+1}(t) = \begin{cases} a & \text{če randf()} \leq R_{\mathrm{a}}, \\ 0 & \text{sicer} \end{cases}$$

pri čemer $a_{n+1}(t)$ označuje stopnjo pospeška, ki ga uporabi zasledovano vozilo v naslednjem časovnem koraku Δt.

Korak 3b:
Naključno ustavljanje.

če $d_{\mathrm{keep}_n} \leq d_n(t) < d_{\mathrm{acc}_n}$ potem

$$a_{n+1}(t) = \begin{cases} -a & \text{če randf()} \leq R_s, \\ 0 & \text{potem} \end{cases}$$

pri čemer R_s predstavlja verjetnost, da bo vozilo zavrlo kljub temu, da ima dovolj prostora, da ohranja hitrost.

Korak 3c:
Zaviranje.

če $d_{\mathrm{dec}_n} \leq d_n(t) < d_{\mathrm{keep}_n}$ potem

$$a_{n+1}(t) = -a$$

Korak 3d:
Zaviranje v sili.

če $d_n(t) < d_{\mathrm{dec}_n}$ potem

$$a_{n+1}(t) = -a_{\max}$$

pri čemer $a_{\max}$ predstavlja stopnjo najvišjega pospeška, ki ga uporabi vozilo, ko zavira v sili.

Korak 4:
Akcija.

$$v_{n+1}(t + \Delta t) = \min(\max(0, v_{n+1}(t) + a_{n+1}(t)\Delta t), v_{\max})$$

pri čemer $v_{n+1}(t)$ predstavlja hitrost zasledovanega vozila v časovnem koraku t, $v_{n+1}(t+\Delta t)$ pa hitrost zasledovanega vozila v naslednjem časovnem koraku $t+\Delta t$

Korak 5:
Premik vozila.

če $(a_{n+1}(t) \geq 0)$ potem

$$x_{n+1}(t + \Delta t) = x_{n+1}(t) + v_{n+1}(t)\Delta t + \frac{a_{n+1}(t)\Delta t^2}{2}$$

pri čemer $x_{n+1}(t+\Delta t)$ označuje položaj zasledovanega vozila v naslednjem časovnem koraku $t+\Delta t$

če $(a_{n+1}(t+\Delta t) < 0)$ potem

$$x_{n+1}(t+\Delta t) = x_{n+1}(t) + v_{n+1}(t)\Delta t_s + \frac{a_{n+1}(t)\Delta t_s{}^2}{2}$$

pri čemer Δt_s označuje časovno razliko med t in časom, ko se vozilo ustavi. Če je ta vrednost manjša kot Δt, potem se mora uporabiti Δt_s. Pravilo je sledeče:

$$\Delta t_s = \min\left(\Delta t, \text{abs}\left(\frac{v_{n+1}(t)}{a_{n+1}(t)}\right)\right)$$

(Guzman in sod., 2018).

2.3 Emisijski model

V raziskavi uporabljamo emisijski model PBL (Panis, Broekx, Liu, 2006), ki omogoča izračun izpustov CO_2 vsakega vozila v vsakem časovnem koraku glede na njegov pospešek in trenutno hitrost. Panis, Broekx in Liu (2006) so s 95-odstotno zanesljivostjo dokazali, da je model primeren za izračun prometnih izpustov v mestih. Na podlagi empiričnih meritev in z uporabo tehnike nelinearne multiple regresije so razvili naslednjo splošno emisijsko funkcijo:

$$E_n(t) = \max(E_0, f_1 + f_2 v_n(t) + f_3 v_n(t)^2 + f_4 a_n(t) + f_5 a_n(t)^2 + f_6 v_n(t) a_n(t)) \quad (4)$$

Pri tem je $E_n(t)$ trenutna količina izpustov (g/s) vozila. Spremenljivki $v_n(t)$ in $a_n(t)$ predstavljata trenutno hitrost in pospešek vozila n v času t. E_0 je spodnja meja izpustov (g/s), določena za vsako vrsto vozila in vrsto onesnaževala, f_1 do f_6 pa so emisijske konstante, specifične za vsako vrsto vozila in onesnaževala. Model lahko oceni količino izpustov CO_2, NO_X, VOC in PM (Panis, Broekx, Liu, 2006). Model PBL se uporablja v številnih študijah in je tudi privzeti emisijski model v simulatorju prometa Aimsun (Halakoo, Yang, Abdulsattar, 2023). Emisijske konstante modela PBL za izpuste CO_2 za bencinska in dizelska osebna vozila so navedene v preglednici 1.

Preglednica 1: Parametri za enačbo 4.

Onesnaževalo	Tip vozila	E_0	f_1	f_2	f_3	f_4	f_5	f_6
CO_2	Bencinski avto	0	$5{,}53 \cdot 10^{-1}$	$1{,}61 \cdot 10^{-1}$	$-2{,}89 \cdot 10^{-3}$	$2{,}66 \cdot 10^{-1}$	$5{,}11 \cdot 10^{-1}$	$1{,}83 \cdot 10^{-1}$
CO_2	Dizelski avto	0	$3{,}24 \cdot 10^{-1}$	$8{,}59 \cdot 10^{-1}$	$4{,}96 \cdot 10^{-3}$	$-5{,}86 \cdot 10^{-1}$	$4{,}48 \cdot 10^{-1}$	$2{,}3 \cdot 10^{-1}$

2.4 Uporaba metod CA in PLB v geografiji

Metoda prometnega modela CA v kombinaciji z mikroskopskim emisijskim modelom, kot je model PBL, je uporabna v geografski znanosti v prvi vrsti zato, ker lahko meri različne pojave kjerkoli v prostoru proučevanja. Z ugotovitvami je potem mogoče razumeti pojave v prometu in sprejeti ukrepe, ki bi na primer pripomogli k zmanjšanju njegovih negativnih vplivov na okolje. V primeru raziskave, ki smo jo izvedli, metoda proučuje pretok, povprečno hitrost in izpuste CO_2 na 1500 m dolgi enosmerni cesti v odvisnosti od različnih parametrov, gostote, najvišje dovoljene hitrosti in agresivnosti vožnje. Metoda omogoča tudi merjenje drugih izpustov na specifičnih lokacijah, na primer v križiščih, ob semaforjih, v conah za pešce ali večjih sistemih cest oziroma ulic. Z ugotavljanjem pretoka na različnih lokacijah lahko ocenjujemo tudi druge učinke prometa na okolje in se lažje odločamo za sprejetje določenih ukrepov, koristnih za izboljšanje učinkovitosti prometa.

2.5 Nastavitve modela in parametrov

Simulacije so bile narejene v programskem okolju Mathematica, različica 13.2. Model simulira promet na enopasovni krožni cesti s periodičnimi robnimi pogoji. Vsaka celica predstavlja 7,5 m, pri čemer je ena celica zasedena z največ enim avtomobilom. Določitev velikosti celice izhaja iz velikosti območja, ki ga zasede avto v zastoju (Nagel, Schreckenberg, 1992).

Vsak časovni korak znaša $\Delta t = 1$ s. Dolžina ceste $L = 200$ sovpada z dolžino ceste 1500 m. V začetnem stanju model naključno razporedi vozila po cestišču z začetno hitrostjo, ki je prav tako naključno izbrana med vrednostma 0 in najvišjo možno hitrostjo glede na prostor, ki ga ima vozilo pred seboj. Za izračun izpustov CO_2 so bile določene različne vrednosti za v_{max}. Glede na oceno varnostne razdalje, odvisno od sosednjih vozil, se določi najvišja hitrost za vsako vozilo z uporabo kvadratne enačbe glede na predpogoj, da v začetnem stanju vozila ne pospešujejo. Na ta način so hitrosti vozil določene na način, da v naslednjem časovnem koraku ne bo prišlo do nesreče. Gostota vozil na cestišču znaša ρ=vozilo⁄celica. Njihove hitrosti in položaji se posodabljajo po pravilih, opisanih v poglavju o metodologiji. Parametri modela za stohastični del so nastavljeni na enake vrednosti kot v razširjenem modelu LAI, $R_d = 1$, $R_0 = 1$, v_s=8 m/s in R_s=0,01. Parameter v_s določa, da lahko samo vozila s hitrostjo, manjšo od 8 m/s, pospešujejo z zamikom (Guzman in sod., 2018).

Določitev stopnje pospeševanja in pojemanja je bila bolj kompleksna naloga. Na podlagi empiričnih opazovanj so Guzman in sod. (2018) uporabili vrednost 8 m/s^2 za največji pojemek in 4 m/s^2 za pospešek. V drugem delu študije, v katerem so simulirali heterogeni tok, so uporabili te vrednosti za navadna, drugačne pa za tovorna vozila. Največji pojemek slednjih znaša 4 m/s^2, pospešek pa 2 m/s^2.

Zeng in sod. (2023) so za stopnjo pospeška uporabili vrednost 3 m/s^2. Feng, Liu in Liang (2023) so v svoji raziskavi upoštevali različne načine vožnje. Po zbranih podatkih na odseku ceste, kjer je največja hitrost znašala 73,21 km/h, so ugotovili, da je 20 % voznikov agresivnih s stopnjo pospeševanja in zaviranja 4 m/s^2, 20 % voznikov je umirjenih s stopnjo pospeševanja in zaviranja 1 m/s^2, 60 % voznikov pa ima zmeren način vožnje s stopnjo pospeševanja in zaviranja 2 m/s^2.

Glede na zbrane podatke smo določili stopnjo pospeševanja za voznike, pri čemer smo tako kot Feng in sod. (2023) sklepali, da je 20 % voznikov agresivnih, 60 % voznikov zmernih, 20 % voznikov pa umirjenih. Agresivni vozniki pospešujejo s stopnjo pospeška 4 m/s^2, umirjeni z 2 m/s^2, zmerni vozniki pa s 3 m/s^2. Stopnja največjega pojemka agresivnih in zmernih voznikov je 8 m/s^2, stopnja največjega pojemka umirjenih voznikov pa 4 m/s^2 (preglednica 2).

V nasprotju z Guzman in sod. (2018) in Feng, Liu in Liang (2023) model v tej raziskavi omogoča agresivnim voznikom, da pospešijo z nižjo stopnjo, če nimajo dovolj prostora za pospeševanje z najvišjo stopnjo. Po drugi strani pa enako kot v primeru Guzman in sod. (2018) vozila zavirajo le z eno stopnjo poleg stopnje zaviranja v sili. To agresivnim voznikom omogoča, da vozijo dlje časa z višjo hitrostjo in začnejo zavirati pozneje, ko so bližje vozilu spredaj. Rezultati, s katerimi sta bila narejena diagrama pretok-gostota in hitrost-gostota, so bili pridobljeni s simulacijami dolgimi 400 sekund oziroma časovnih korakov. Za vsako gostoto od 0 do 1 smo izvedli 10 simulacij in določili srednjo vrednost. Za izračun izpustov CO_2 so bile določene različne kombinacije stopenj pospeškov in pojemkov.

Preglednica 2: Parametri načinov vožnje.

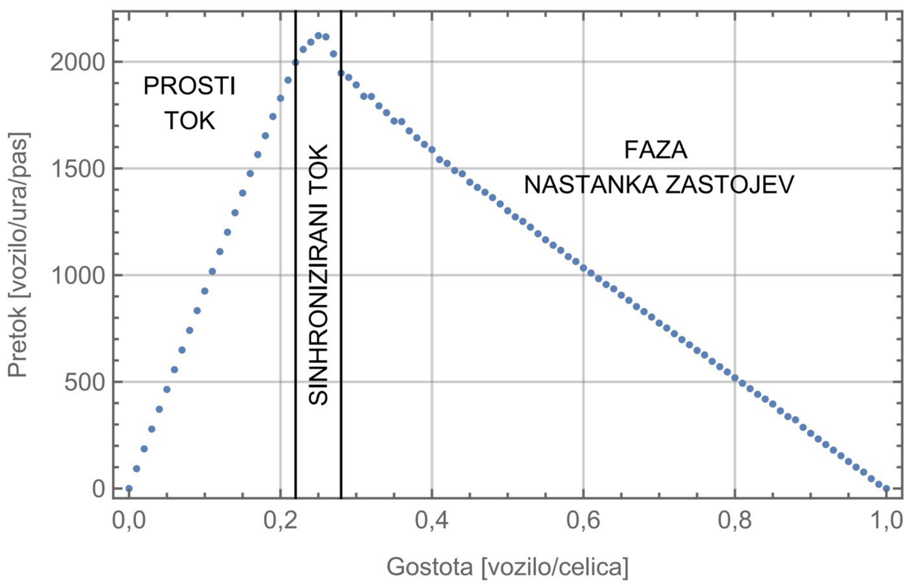
Način vožnje	Delež vozil	Največji pospešek	Pojemek	Pojemek v sili
Agresivni način	20 %	4 m/s^2	4 m/s^2	8 m/s^2
Zmerni način	60 %	3 m/s^2	3 m/s^2	8 m/s^2
Umirjeni način	20 %	2 m/s^2	2 m/s^2	4 m/s^2

3 REZULTATI SIMULACIJ IN DISKUSIJA

3.1 Analiza temeljnih diagramov

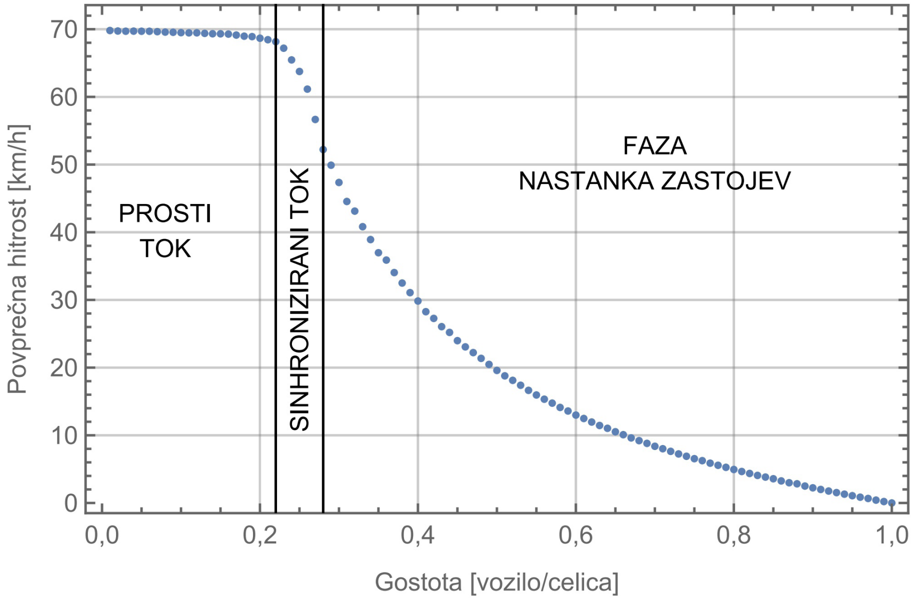
Na sliki 2 je predstavljeno razmerje pretok-gostota nadgrajenega razširjenega modela LAI, ki predstavlja enega izmed temeljnih diagramov analize prometa. Kot je razvidno, pretok doseže največjo vrednost 2122 vozil/uro pri optimalni gostoti 0,25 vozila/celico, nad katero začne upadati. Pri gostoti 0,28 pride do nenadnega padca prometnega toka, ko se ta spremeni v fazo nastanka zastojev. Sprememba iz faze prostega toka v fazo sinhroniziranega toka se zgodi pri gostoti 0,22, ko začne tudi hitrost padati zaradi več medsebojnih interakcij med vozili, a še ne pride do zastojev.

Slika 2: Diagram pretok-gostota je pridobljen iz simulacij, ki so bile izvedene v nadgrajenem razširjenem modelu LAI, pri čemer je bila določena najvišja dovoljena hitrost 70 km/h.



Sinhronizirani tok pri najvišji dovoljeni hitrosti 70 km/h nastane med gostotama $0{,}22<\rho<0{,}28$ vozila/celico. Na sliki 3 je predstavljeno razmerje med hitrostjo in gostoto nadgrajenega razširjenega modela LAI. Kot je razvidno, na območju sinhroniziranega toka povprečna hitrost vozil pade, in sicer za 16 km/h glede na najvišjo dovoljeno hitrost. Hkrati je njihova hitrost še vedno stabilna (slika 4b), vozila pa vzdržujejo enako medsebojno razdaljo na celotnem cestnem odseku.

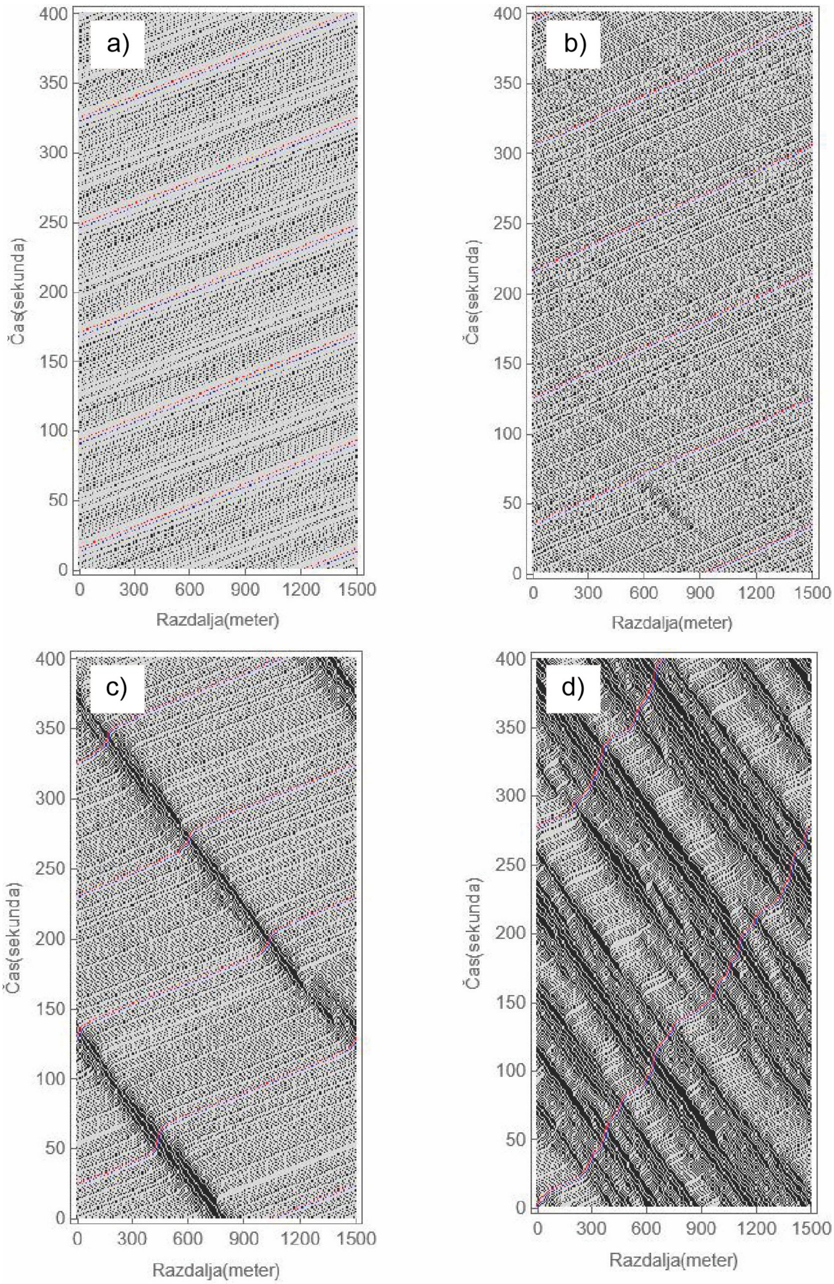
Slika 3: Diagram hitrost-gostota je pridobljen iz simulacij, ki so bile izvedene v nadgrajenem razširjenem modelu LAI, pri čemer je bila določena najvišja dovoljena hitrost 70 km/h.



Ko gostota preseže 0,27 vozila/celico, pride s povečanjem gostote le za 0,01 do točke preloma. Faza sinhroniziranega toka preide v fazo nastanka zastojev (slika 4c). Pri gostoti 0,28 vozila/celico hitrost vozil ni več enakomerna po celotnem cestnem odseku, saj se začnejo pojavljati zastoji. Zato, da vozila pri gostoti 0,28 vozila/celico ohranjajo varnostno razdaljo, njihova povprečna hitrost spet znatno pade (slika 3).

Pri nadgrajenem razširjenem modelu LAI je pretok prometa pri najvišji dovoljeni hitrosti 115 km/h največji pri nižji gostoti 0,21 vozila/celico, kar je logično, saj vožnja z višjo hitrostjo zahteva ohranjanje večje varnostne razdalje med vozili. Zato imajo pri višjih hitrostih vozila dovolj prostora med seboj le pri nižjih gostotah. Vendar pa nadgrajeni razširjeni model LAI doseže največji pretok prometa pri višjih gostotah, kot to velja za originalni razširjeni model LAI (Guzman in sod., 2017). Menimo, da je to posledica prilagojenega pospeševanja, ki jo omogoča nadgrajeni razširjeni model LAI in ki agresivnim voznikom, za katere je značilno, da močneje pospešujejo, omogoča pospeševanje z manjšim pospeškom, če nimajo dovolj prostora za uporabo največjega pospeška. Originalni model LAI te možnosti nima.

Slika 4 prikazuje različne vrste prometnih razmer, prosti tok, sinhronizirani tok in fazo nastanka zastojev. Pike v vodoravnih vrsticah predstavljajo položaje vozil, ki se v času premikajo proti desni, medtem ko posamezen stolpec pik predstavlja prisotnost



Slika 4: Prostorsko-časovni diagram različnih faz prometa, prostega toka (4a), sinhroniziranega toka (4b) in nastanka zastojev (4c in 4d) pri najvišji dovoljeni hitrosti 70 km/h.

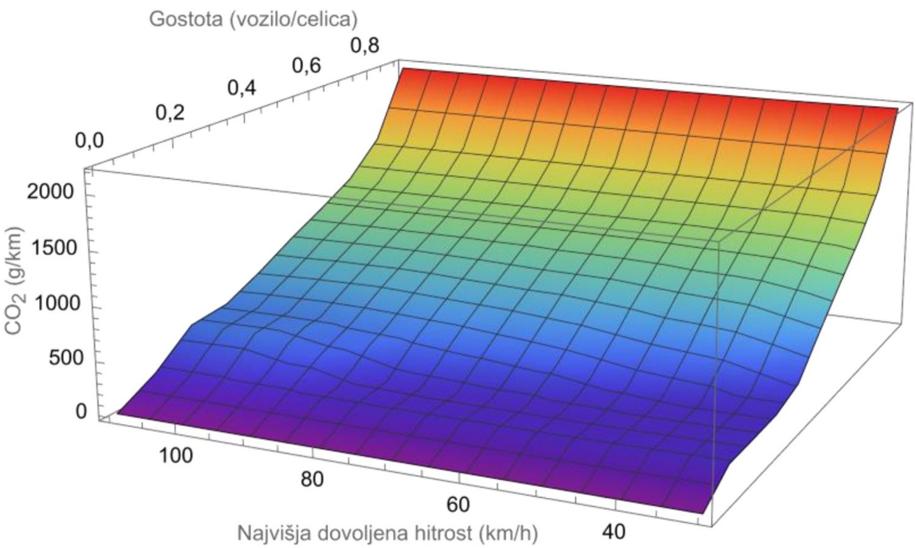
vozila na posamezni celici v času. Celica je lahko zasedena z vozilom ali prazna. Rdeče in modre pike predstavljajo položaj dveh primerov vozil v času (glej tudi sliko 1).

Na sliki 4a so prikazana vozila z višjimi hitrostmi, ko na cesti ni zastojev in lahko doseżejo najvišjo hitrost. Ko je na cesti gneča, hitrost vozila pade na nič. Na slikah 4c in 4d so prikazana vozila v fazi zastojev. Do sinhroniziranega prometnega toka pride, ko hitrosti nekoliko padejo, vendar v prometnem toku še ne nastajajo zastoji (slika 4b). Do pomembnega in zanimivega pojava pride pri gostotah 0,27 in 0,28 vozila/celico. Pri 0,27 vozila/celico je pretok namreč v sinhronizirani fazi, že pri 0,28 vozila/celico pa preide v fazo nastanka zastojev. Očitno je pri gostoti 0,27 vozila/celico pretok nestabilen, saj le rahla motnja spremeni značilnost toka, kot je prikazano na dnu slike 4b.

3.2 Vpliv najvišje dovoljene hitrosti na izpuste CO_2 in pretok

Na sliki 5 je prikazan tridimenzionalni diagram izpustov CO_2 (v g/km) pri različnih gostotah (med 0 in 0,9 vozila/celico) vozil in različnih najvišjih hitrostih (med 30 in 110 km/h). Tu računamo količino izpustov na prevožen kilometer. Rezultati kažejo, da se vrednosti izpustov povečujejo z večanjem gostote. Ko gostota prometa znaša 0,7 ali več, so vrednosti izpustov enake pri vseh najvišjih dovoljenih hitrostih (1200 g/km), saj pri teh gostotah hitrosti ne presegajo niti najnižje vrednosti najvišje dovoljene hitrosti, ki znaša 30 km/h. Sklenemo lahko, da ne glede na najvišjo dovoljeno hitrost pri visokih gostotah prometa hitrosti ostajajo enake (slika 5).

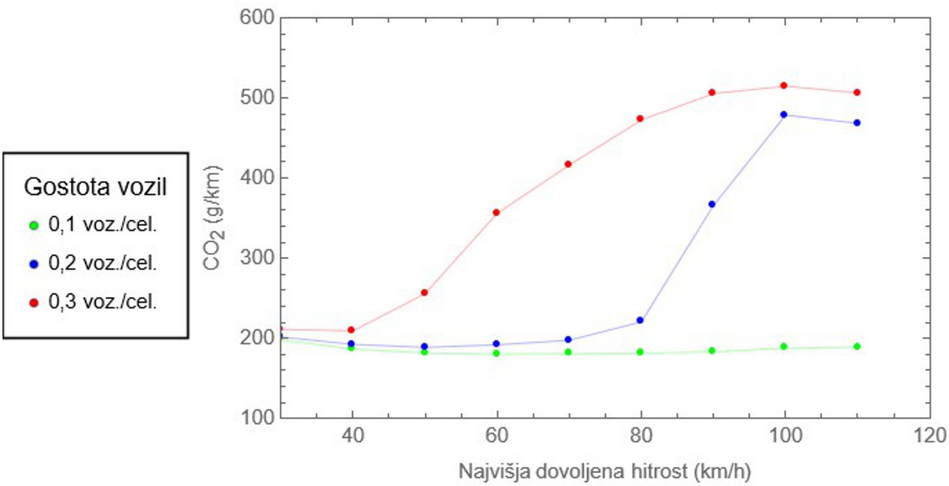
Slika 5: Izpusti CO_2 kot funkcija najvišje dovoljene hitrosti in gostote prometa.



Hkrati pa je pri nižjih vrednostih gostote, med 0,2 in 0,4, količina izpustov pri največji dovoljeni hitrosti 110 km/h več kot dvakrat višja kot pri hitrosti 30 km/h (slika 6). Razlog za ta pojav je pojav zastojev, ki pri teh gostotah nastanejo le pri višjih hitrostih. Pri gostoti 0,2 vozila/celico in hitrosti 110 km/h znaša količina izpustov 470 g/km, pri 30 km/h pa približno 200 g/km. Pri gostoti 0,4 vrednosti pri enakih hitrostih znašata približno 665 in 295 g/km.

Krivulje na sliki 6 prikazujejo različne vrednosti izpustov pri vseh proučevanih najvišjih dovoljenih hitrostih pri gostotah 0,1, 0,2 in 0,3 vozila/celico.

Slika 6: Izpusti CO_2 kot funkcija najvišje dovoljene hitrosti pri gostotah 0,1, 0,2 in 0,3 vozila/celico.

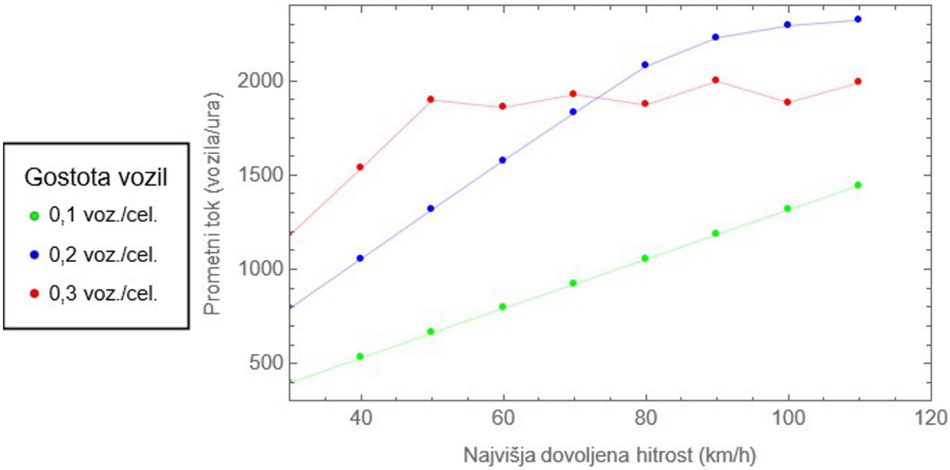


Pri gostoti 0,1 ne nastanejo zastoji pri nobeni najvišji dovoljeni hitrosti. Izpusti CO_2 dosežejo najnižjo vrednost pri hitrosti 60 km/h, kar ustreza najnižji emisijski stopnji porabe goriva pri nekaterih mikroskopskih emisijskih modelih za mestna območja (Quaassdorff in sod., 2022).

Pri gostoti 0,2 in največji hitrosti 80 km/h (kot je razvidno iz slike 6) je vrednost izpustov podobna vrednosti izpustov pri nižjih največjih dovoljenih hitrostih (220 g/km). Pri največji hitrosti 90 km/h vrednost izpustov hitro naraste (365 g/km), zato sklepamo, da se na tej točki začnejo pojavljati zastoji. Pri gostoti 0,3 se to zgodi že pri nižjih omejitvah hitrosti.

Na izpuste najbolj vpliva sprememba vrste prometnega toka, kar je razvidno iz slike 7.

Slika 7: Pretok kot funkcija najvišje dovoljene hitrosti pri gostotah 0,1, 0,2 in 0,3 vozila/celico.



Pri vrednosti gostote 0,2 in največjih dovoljenih hitrostih med 80 km/h in 100 km/h se vrednosti izpustov CO_2 več kot podvojijo, vendar pretok še vedno raste z naraščajočo največjo dovoljeno hitrostjo pri enakih preostalih parametrih.

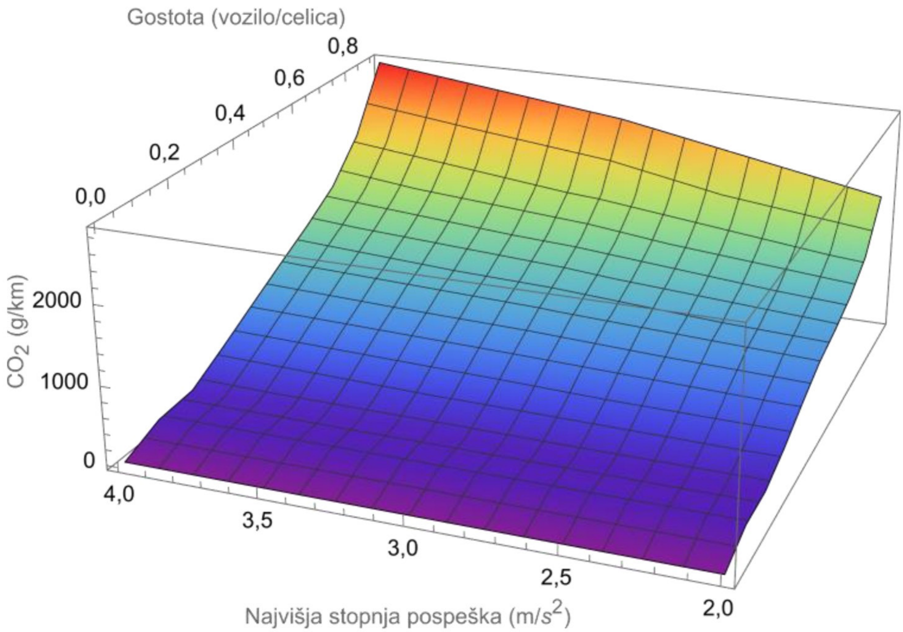
Pri gostoti 0,1 pretok raste sorazmerno z največjo dovoljeno hitrostjo (slika 7), pri čemer ostaja količina izpustov skoraj konstantna (slika 5), med 185 in 190 g/km pri hitrostih med 40 in 110 km/h. To pomeni, da promet ostaja v fazi prostega toka pri vseh proučevanih vrednostih največje dovoljene hitrosti. Pri vrednosti gostote 0,3 začnejo izpusti hitro naraščati že pri najvišji dovoljeni hitrosti 50 km/h in rastejo z višanjem najvišje dovoljene hitrosti (slika 6) od 255 g/km do 505 g/km, čeprav se pretok povečuje le do najvišje dovoljene hitrosti 50 km/h, potem pa ostaja podoben (slika 7). To pomeni, da pri enakih vrednostih gostote agresivnejša vožnja, značilna za višjo najvišjo dovoljeno hitrost, pri višji vrednosti slednje prispeva k višjim vrednostim izpustov, ne pa k višjim vrednostim pretoka (tudi ne k nižjim vrednostim pretoka). Zaključimo lahko, da začne s spremembo vrste prometnega toka iz faze prostega toka v fazo sinhroniziranega toka količina izpustov CO_2 hitro naraščati, medtem ko obseg prometa ostaja enak. Z zmanjševanjem pretoka količina izpustov CO_2 raste še hitreje (slika 5). Več interakcij med vozili namreč pripomore k večji frekvenci pospeševanja in zaviranja ter posledično večji količini izpustov pri podobnem pretoku.

3.3 Vpliv najvišje stopnje pospeškov na izpuste CO_2

V drugi analizi proučujemo vpliv najvišje stopnje pospeška na izpuste CO_2. Na sliki 8 je prikazan tridimenzionalni diagram izpustov CO_2 (v g/km) pri različnih vrednostih gostote (med 0 in 0,9) vozil in različnih najvišjih stopnjah pospeška (med 2 in 4 m/s^2). Največja dovoljena hitrost je bila konstantna pri 70 km/h. Rezultati kažejo, da se razlika v količini izpustov med različnimi najvišjimi stopnjami pospeševanja veča z večjo gostoto prometa.

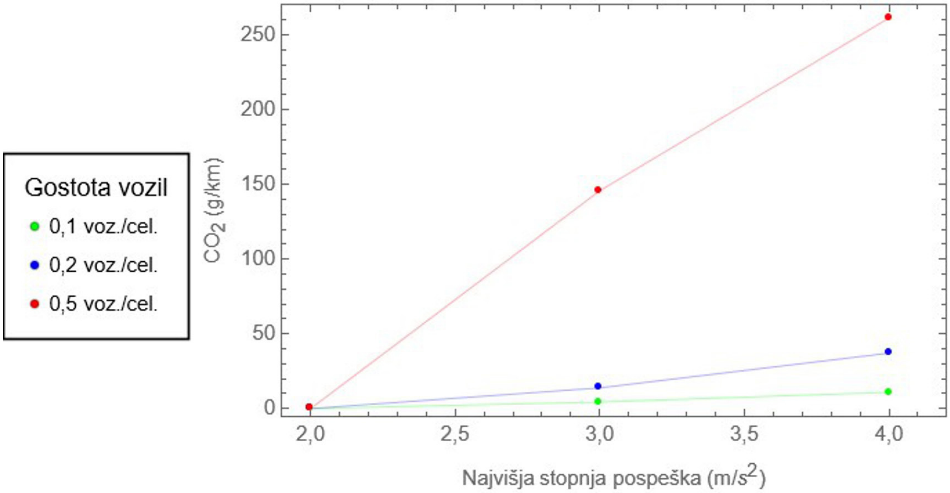
Slika 9 prikazuje različne količine izpustov pri različnih največjih stopnjah pospeševanja za vrednosti gostote 0,1, 0,2 oziroma 0,5. Pri gostoti 0,1 je interakcij med vozili malo, zato le redkokdaj pospešujejo, razen pri pospeševanju do najvišje dovoljene hitrosti, ki jo pozneje vzdržujejo.

Slika 8: Izpusti CO_2 kot funkcija najvišje stopnje pospeška in gostote.



Agresivni vozniki, ki, če je mogoče, pospešujejo s 4 m/s^2 (186 g/km), bi prispevali približno 6 % več izpustov CO_2 kot umirjeni vozniki z največjo stopnjo pospeševanja 2 m/s^2 (175 g/km). Pri gostoti 0,2 odstotek naraste na 15 % (od 186 g/km do 223 g/km), pri 0,5 pa na okoli 33 % (od 738 g/km do 999 g/km). Pri gostoti 0,9 agresivni vozniki (2861 g/km) prispevajo 60 % izpustov več kot umirjeni vozniki (1780 g/km).

Slika 9: Razlika v količini izpustov CO_2 med vožnjo z najvišjo in najnižjo stopnjo pospeševanja pri gostotah 0,1, 0,2 in 0,5 vozila/celico.



Razlike v količini izpustov nastanejo zaradi večje frekvence višjih stopenj pospeškov in pojemkov agresivnejših voznikov. Upoštevati je treba, da lahko agresivni vozniki z višjo najvišjo stopnjo pospeševanja pospešujejo tudi z nižjo stopnjo, če nimajo dovolj prostora, da bi pospešili z njihovo najvišjo mogočo stopnjo. Po drugi strani pa vedno zavrejo z enako stopnjo pojemka, ki predstavlja negativno vrednost njihove najvišje stopnje pospeška. Oboje vodi do bolj agresivne vožnje in posledično do visokih emisijskih vrednosti pri višjih gostotah, ko je več interakcij med vozili.

4 ZAKLJUČEK

V okviru raziskave so bile narejene simulacije prometnega toka, s čimer so bile analizirane značilnosti prometnega toka in vpliv različnih vrednosti gostote na pretok. Izračunan je bil tudi vpliv najvišje dovoljene hitrosti in največjega pospeška na izpuste CO_2. Simulacije prometnih tokov so bile narejene z razširjenim modelom LAI CA, ki smo ga v raziskavi nadgradili. Izpusti CO_2 iz prometa so bili izračunani z mikroskopskim emisijskim modelom PBL. V raziskavi smo proučevali prometni tok z namenom, da bi razumeli njegove značilnosti in ugotovili, na kakšen način bi lahko zmanjšali negativne vplive na okolje na odseku 1500 m dolge ceste z enim pasom, pri čemer smo se tokrat osredotočili na izpuste CO_2. Menimo, da razumevanje notranje dinamike prometa omogoča lažje in pravilnejše odločanje za ukrepe v prometu.

Temeljni diagrami simulacij prometnih tokov kažejo, da doseže prometni tok pri najvišji dovoljeni hitrosti 70 km/h največjo vrednost 2122 vozil/uro pri gostoti 0,25 vozila/celico. Pri 0,28 pride do nenadnega padca pretoka. Prometni tok se namreč že pred tem začne spreminjati iz faze prostega toka v fazo zastojev. Do gostote 0,22 je prometni tok v fazi prostega toka, pri čemer je povprečna hitrost blizu najvišje dovoljene hitrosti. Med gostotama je prometni tok v fazi sinhroniziranega toka, ko hitrost vozil pade za 16 km/h od največje dovoljene hitrosti. Hkrati se njihova hitrost stabilizira, vozila pa med seboj vzdržujejo podobno razdaljo na celotnem cestnem odseku. Prelomna točka nastopi, ko je gostota ρ>0,27, in sicer s povečanjem gostote le za 0,01, kar povzroči fazno spremembo prometnega toka iz sinhronizirane faze v fazo nastanka zastojev. Na tej točki hitrost vozil zaradi vzdrževanja varne razdalje vozil znatno pade.

S povečevanjem gostote v prometu od vrednosti 0,25 vozila/celico naprej pretok pada. Tako se ob zgoščanju prometa pretok in potovalna hitrost še zmanjšata, kar še poveča zastoje in izpuste CO_2. To povzroča še druge negativne posledice na okolje, na primer več dalj časa trajajočega hrupa in večjo zasedenost prostora z vozili. Omeniti velja tudi negativne gospodarske posledice, saj ljudje več časa preživijo v vozilih, kar povzroča utrujenost in povečuje verjetnost, da pride do prometnih nesreč. V času prometnih zgostitev bi bilo torej koristno zmanjšati gostoto prometa, da bi dosegli čim bolj optimalen pretok ali vsaj preprečili nadaljnje zgoščanje prometa. S tem bi povečali njegovo učinkovitost in hkrati zmanjšali negativne vplive na okolje. Zavedamo se, da je promet kompleksen sistem in da je velike spremembe v kratkem času težko doseči, saj zahtevajo dolgoročno načrtovanje. Vendar lahko že kratkoročno prispevamo k preprečevanju zastojev tako, da se, če je le mogoče, izogibamo vožnji v času prometnih zastojev, kar lahko dosežemo z občasnim delom od doma, uporabo javnega prevoza ter potovanji pred predvidenimi prometnimi konicami ali po njih. Omeniti velja tudi tehnološke rešitve. Avtomatsko povezovanje vozil v konvoje bi izboljšalo pretok prometa, k čemur bi prispevale tudi izboljšane spletne aplikacije, ki vozniku že pred začetkom potovanja ali na pomembnih križiščih pomagajo izbrati optimalno pot s stališča pretoka prometa. Zagotovo bi k zmanjšanju zastojev prispeval tudi učinkovitejši javni promet.

V raziskavi smo ugotavljali, kako na izpuste CO_2 vpliva najvišja dovoljena hitrost. Prišli smo do zaključka, da ima ta največji vpliv med vrednostma gostote vozil , ko je količina izpustov CO_2 pri najvišji dovoljeni hitrosti 110 km/h več kot dvakrat višja kot pri hitrosti 30 km/h. Pri omenjenih gostotah pride do faznih sprememb prometnega toka le pri višjih hitrostih, ko se prometni tok spremeni iz prostega v sinhronizirani tok. Pri višji najvišji dovoljeni hitrosti vozila namreč, kadar lahko, vozijo hitreje, zato pride do pogostejših interakcij (pospeševanja, zaviranja) med vozili, pri čemer začne količina izpustov hitro naraščati, čeprav obseg prometa ostaja podoben (slika 6). Pri gostoti 0,1 je promet pri vseh proučevanih hitrostih v prostem toku, zato ni velikih razlik v količini izpustov. Vendar pa je pri enaki gostoti pretok pri najnižji dovoljeni hitrosti približno petkrat manjši kot pri najvišji dovoljeni hitrosti, tako da pri tem velja upoštevati tudi gospodarski učinek prometa. Pri višjih gostotah, ko je prometni tok v fazi nastanka zastojev, hkrati s povečevanjem količine izpustov pada tudi pretok, in sicer pri vseh proučevanih omejitvah hitrosti. Dolgoročno bi bila rešitev napredna tehnologija, s pomočjo katere so vozila med seboj povezana in težijo k vožnji v konvojih. Tudi drugi morebitni ukrep je tehnološki, in sicer spreminjanje omejitve hitrosti glede na gostoto prometa na določenem odseku.

Raziskava vključuje tudi vpliv agresivnosti vožnje na izpuste, in sicer pri konstantni hitrosti 70 km/h in različnih pospeških. Rezultati kažejo, da se razlika med izpusti pri različnih najvišjih stopnjah pospeševanja veča z gostoto prometa. Pri gostoti 0,1 je interakcij med vozili malo, zato redko pospešujejo, razen pri pospeševanju do najvišje dovoljene hitrosti. Pri tem agresivni vozniki, ki stremijo k pospeševanju s 4 m/s^2, prispevajo približno 6 % več izpustov CO_2 kot umirjeni vozniki z najvišjo hitrostjo pospeševanja 2 m/s^2. Pri gostoti 0,2 razlika naraste na 15 %, pri 0,5 pa na okoli 33 %. Pri gostoti 0,9 je razlika v prispevku izpustov med agresivnimi in umirjenimi vozniki že več kot 60 %. Okoljsko najbolj sprejemljiva vožnja je torej umirjena vožnja s čim manj sunkovitimi pospeški, zato predlagamo spodbujanje umirjenega načina vožnje. S stališča gospodarskega učinka prometa pa ni dobro, da vozila vozijo veliko počasneje od omejitev, saj to še posebej pri manjši gostoti precej zmanjšuje pretok prometa. Zmanjševanje števila vozil v mestih spodbujajo prometni ukrepi, kot so uvedba novih avtobusnih povezav, parkirišča zunaj mestnih središč, zaprtja mestnih središč, uvedba rumenih pasov za avtobuse in sistemi izposoje koles. To prispeva k manjšim zastojem in povečanju pretoka prometa ter manjšim količinam izpustov. Seveda vsak izmed teh ukrepov zahteva natančne meritve, da bi lahko ovrednotili njegovo učinkovitost.

Informacije o nepovratnih sredstvih

Del raziskave je finančno podprla Javna agencija za raziskovalno dejavnost RS (raziskovalni program P2-0260).

Avtorja nimata finančnih ali nefinančnih interesov, ki bi jih morala razkriti.

Literatura in viri

Barlovic, R., Santen, L., Schadschneider, A., Schreckenberg, M., 1998. Metastable states in cellular automata for traffic flow, 5, str. 793–800. DOI: 10.1007/s100510050504.

Benjamin, S. C., Johnson, N. F., Hui, P. M., 1996. Cellular automata models of traffic flow along a highway containing a junction. Physics Department, Clarendon Laboratory, Oxford University, str. 1–18. DOI: 10.1088/0305-4470/29/12/018.

Chowdhury, D., Santen, L., Schadschneider, A., 2000. Statistical physics of vehicular traffic and some related systems. Physics Reports, 329, 4-6, str. 199–329. DOI: 10.1016/S0370-1573(99)00117-9.

De Vlieger, I., Keukeleere, D. D., Kretzschmar, G. J., 2000. Environmental effects of driving behaviour and congestion related to passenger cars. Atmospheric Environment, 34, 27, str. 4649–4655. DOI: 10.1016/S1352-2310(00)00217-X.

Escap, U., 2019. Using smart transport technologies to mitigate greenhouse gas emissions from the transport sector in Asia. URL: https://repository.unescap.org/handle/20.500.12870/344 (citirano 8. 1. 2024).

Feng, T., Liu, K., Liang, C., 2023. An improved cellular automata traffic flow model considering driving styles. Sustainability, 15, 2, str. 1–19. DOI: 10.3390/su15020952.

Glojek, K., Gregorič, A., Ogrin, M., 2019. Black carbon air pollution – case study of Loški Potok. Dela, 50, str. 25–43. DOI: 10.4312/dela.50.5-43.

Guzman, H., Larraga, M. E., Alvarez-Icaza, L., 2015. A two lanes cellular automata model for traffic flow considering realistic driving decisions. Journal of Cellular Automata, 10, 1-2, str. 65–93.

Guzman, H.A., Larraga, M.E., Alvarez-Icaza, L., Carvajal, J., 2018. A cellular automata model for traffic flow based on kinetics theory, vehicles capabilities and driver reactions. Physica A: Statistical Mechanics and its Applications, 491, str. 528–548. DOI: 10.1016/j.physa.2017.09.094.

Halakoo, M., Yang, H., Abdulsattar, H., 2023. Heterogeneity aware emission macroscopic fundamental diagram (e-MFD). Sustainability, 15, 2. DOI: 10.3390/su15021653.

Hoek, G., Brunekreef, B., Goldbohm, S., Fischer, P., van den Brandt, P. A., 2002. Association between mortality and indicators of traffic-related air pollution in the Netherlands: A cohort study. Lancet, 360, str. 1203–1209.

Ježek, I., 2015. Contribution of traffic and biomass burning to air pollution discriminated with Aethalometer measurements of black carbon. Doctoral thesis. Ljubljana: University of Ljubljana, Faculty of Mathematics and Physics, Department of Physics.

Ježek, I., Katrašnik, T., Westerdahl, D., Močnik, G., 2015. Black carbon, particle number concentration and nitrogen oxide emission factors of random in-use vehicles measured with the on-road chasing method. Atmospheric Chemistry and Physics, 15, str. 11011–11026.

Karafyllidis, I., Thanailakis, A., 1998. A model for predicting forest fire spreading using cellular automata. Ecological Modelling, 99, 1. DOI: 10.1016/S0304-3800(96)01942-4.

Kerner, B. S., Klenov, S. L., Wolf, D. E., 2002. Cellular automata approach to three-phase traffic theory. Journal of Physics A: Mathematical and General, 33, str. 9971–10013. DOI: 10.1088/0305-4470/35/47/303.

Knospe, W., Santen, L., Schadschneider, A., Schreckenberg, M., 2000. Towards a realistic microscopic description of highway traffic. Journal of Physics A: Mathematical and General, 33, str. 479–485. DOI: 10.1088/0305-4470/33/48/103.

Larraga, M. E., Alvarez-Icaza, L., 2010. Cellular automaton model for traffic flow based on safe driving policies and human reactions. Physica A: Statistical Mechanics and its Applications, 389, 23, str. 5425–5438. DOI: 10.1016/j.physa.2010.08.020.

Li, X., Li, X., Xiao, Y., Jia, B., 2016, Modeling mechanical restriction differences between car and heavy truck in two-lane cellular automata traffic flow model. Physica A: Statistical Mechanics and its Applications, 451, str. 49–62. DOI: 10.1016/j.physa.2015.12.157.

Maerivoet, S., De Moor, B., 2005. Cellular automata models of road traffic. Physics Reports, 419, 1, str. 1–64. DOI: 10.1016/j.physrep.2005.08.005.
Marzoug, R., Lakouari, N., Perez Cruz, J. R., Vega Gomez, C. J., 2022. Cellular automata model for analysis and optimization of traffic emission at signalized intersection. Sustainability, 14, 21. DOI: 10.3390/su142114048.
Nagel, K., Schreckenberg, M., 1992. A cellular automaton model for freeway traffic. Journal de Physique I, 2, 12, str. 2221–2229. DOI: 10.1051/jp1:1992277.
Ntziachristos, L., Gkatzoflias, D., Kouridis, C., Samaras, Z., 2009. COPERT: A European road transport emission inventory model. V: Athanasiadis, I. N., Rizzoli, A. E., Mitkas, P. A., Gómez, J. M. (ur.). Information technologies in environmental engineering. Springer, str. 491–504. DOI: 10.1007/978-3-540-88351-7_37.
Ogrin, M., 2007. Air pollution due to road traffic in Ljubljana. Dela, 27, str. 199–214.
Ogrin, M., 2018. Prometno obremenjevanje ozračja. V: Okoljski učinki prometa in turizma v Sloveniji. Ljubljana: Znanstvena založba Filozofske fakultete, str. 62–72. URL: https://ebooks.uni-lj.si/ZalozbaUL/catalog/view/60/129/1381 (citirano 8. 1. 2024).
Pan, W., Xue, Y., He, H. D., Lu, W. Z, 2018. Impacts of traffic congestion on fuel rate, dissipation and particle emission in a single lane based on NaSch Model. Physica A: Statistical Mechanics and its Applications, 503, str. 154–162. DOI: 10.1088/1748-9326/ac8b21.
Panis, L. I., Broekx, S., Liu, R., 2006. Modelling instantaneous traffic emission and the influence of traffic speed limits. Science of The Total Environment, 371, str. 270–285. DOI: 10.1016/j.scitotenv.2006.08.017.
Pinto, N., Antunes, A. P., Roca, J., 2021. A cellular automata model for integrated simulation of land use and transport interactions. International Journal of Geo-Information, 10, 3. DOI: https://doi.org/10.3390/ijgi10030149.
Quaassdorff, C., Smit, R., Borge, R., Hausberger, S., 2022. Comparison of microscale traffic emission models for urban networks. Environmental Research, 17, str. 1–15. DOI: 10.1088/1748-9326/ac8b21.
Rakha, H., Van Aerde, M., Ahn, K., Trani, A., 2000. Requirements for evaluating traffic signal control impacts on energy and emissions based on instantaneous speed and acceleration measurements. Transportation Research Record, 1738, str. 56–67. DOI: 10.3390/ijgi10030149.
Strle, D., Svetlin, D., Glojek, K., Kobal, M., Pogačnik, K., Ogrin, M., 2020. Meritve koncentracij črnega ogljika in dušikovega dioksida na Lavrici in v Kranju. Dela, 54, str. 5–27. DOI: 10.4312/dela.54.5-52.
Takayasu, M., Takayasu, H., 1993. 1/f noise in a traffic model. Fractals, 1, 4, str. 860–966. DOI: 10.1142/S0218348X93000885.
Treiber, M., Kesting, A., Thiemann, C., 2008. How much does traffic congestion increase fuel consumption and emissions? applying a fuel consumption model to the NGSIM trajectory data. TRB 87th Annual Meeting Compendium of Papers, DVD, str. 1–17. URL: https://trid.trb.org/view/848721 (citirano 8. 1. 2024).

Wolfram, S., 1983. Statistical mechanics of cellular automata. Reviews of Modern Physics, 55, str. 601–644. DOI: 10.1103/RevModPhys.55.601.
Xu, Q., Xing Zhu, A.X., Liu, J., 2023. Land-use change modeling with cellular automata using land natural evolution unit. Catena, 224. DOI: 10.1016/j.catena.2023.106998.
Xue, Y., Wang, X., Cen, B. L., Zhang, P., He, H. D., 2020. Study on fuel consumption in the Kerner–Klenov–Wolf three-phase cellular automaton traffic flow model. Nonlinear Dynamics, 102, str. 393–402. DOI: 10.1007/s11071-020-05947-2.
Zeng, J., Qian, Y., Li, J., Zhang, Y., Xu, D., 2023. Congestion and energy consumption of heterogeneous traffic flow mixed with intelligent connected vehicles and platoons. Physica A: Statistical Mechanics and its Applications, 609, str. 1–17. DOI: 10.1016/j.physa.2022.128331.

Andrej Rigler*, Goran Turk**

THE IMPACT OF VEHICLE DENSITY AND DRIVING STYLES ON TRAFFIC FLOW AND CO_2 EMISSIONS

COBISS 1.01
DOI: 10.4312/DZOB1160

Abstract

The purpose of the article is to study the traffic characteristics on a 1500 m long road with one lane and to find out how the flow and carbon dioxide (CO_2) emissions are affected by the density of vehicles, the speed limit, and the way of driving. The research uses a microscopic cellular automaton traffic model (hereafter CA), called the extended LAI model, which contains new functions and is upgraded for the calculation of discharges. Based on the results of traffic simulations, CO_2 emissions per kilometre driven were calculated using the model presented by Panis, Broekx and Liu (2006). The results show that the maximum flow of 2122 vehicles/hour is achieved at a maximum speed of 70 km/h and a density of 0.25 vehicles/cell. Between densities of 0.22 and 0.28 vehicles/cell, the traffic flow is in a synchronized phase, with the average speed dropping due to vehicle interaction. At higher densities, congestion occurs, the average speed continues to fall, and the amount of emissions increases. The top speed only affects CO_2 emissions at lower densities, but at higher densities, they are much more affected by the acceleration rate. We believe that it would be beneficial to reduce traffic density in times of traffic congestion to achieve the most optimal flow and reduce negative impacts on the environment, for example by encouraging occasional work from home, use of public transport, and trips before or after the expected traffic peaks.

Keywords: traffic flow, CO_2 emissions, microscopic traffic flow models, emission models, cellular automata, extended LAI model

*Department of Geography, Faculty of Arts, University of Ljubljana, Aškerčeva cesta 2, SI-1000 Ljubljana, Slovenia (Na jami 16, SI-1000 Ljubljana, Slovenia)
**Chair of Mechanics, Faculty of Civil and Geodetic Engineering, University of Ljubljana, Jamova 508, SI-1000 Ljubljana, Slovenia
e-mail: ar7918@student.uni-lj.si (andrej.rigler1@gmail.com), goran.turk@fgg.uni-lj.si
ORCID: 0000-0002-4596-3594 (G. Turk)

1 INTRODUCTION

Vehicular traffic is a source of different problems, namely, congestions, car accidents, and air pollution. In 2016, the transport sector was responsible for around 25 % of global CO_2 emissions, an increase of 71 % over 1990 levels. Fine particle air pollution can also increase the risk of lung cancer and cardiopulmonary mortality (Escap, 2019; Hoek et al., 2002; Marzoug et al., 2022). The impact of traffic on air pollution is particularly considerable right next to roads. Pollution due to traffic decreases rapidly with distance from roads (Ogrin, 2007; Strle et al., 2020). Location and weather conditions strongly influence the pollution (Glojek et al., 2019). Traffic is also a consumer of space. In cities where noise is also a growing problem, stationary traffic represents a major spatial burden (Ogrin, 2018).

De Vlieger, Keukeleere and Kretzschmar (2000) showed that driving style can reduce traffic emissions and vice versa. Ježek et al. (2015) found that the 25% of diesel-powered passenger vehicles that pollute the environment the most contribute 63 and 47% of black carbon and NO_X emissions, respectively.

For any measures to reduce emissions, it is essential to first assess the emissions. There are two main approaches to emission estimation: macroscopic and microscopic. The former refers to emission estimation at a larger scale, and the latter refers to emissions estimation of each vehicle (Ntziachristos et al., 2009; Panis, Broekx, Liu, 2006; Rakha et al., 2000). Microscopic models calculate emissions from traffic with the help of data on emission factors (EF) of vehicles and their activity. It is a bottom-up approach. There is another way of calculating emissions from traffic, namely "top-down", where the contributions of sources are determined on the basis of in-situ measurements of the concentrations of various tracers in the ambient air. Ježek (2015) used the tracking method to measure the emission factors of black carbon and NO_X for vehicles of different categories.

While microscopic models are highly accurate, they don't suit large-scale applications. Microscopic models need second-by-second vehicle trajectory data for emission estimation, which requires high computational power. On the other hand, macroscopic models are more computationally efficient for large-scale networks but usually offer lower accuracy, in comparison to microscopic methods. Macroscopic model inputs such as average network speed and density are easy to collect. Loop detectors, already available in many cities and highways, can provide the inputs for macroscopic models (Halakoo, Yang, Abdulsattar, 2023). Microscopic traffic models are necessary to be used in combination with microscopic traffic simulations. They model individual vehicles with realistic traffic flow. Among these, the cellular automata (CA) models are good option to model the traffic flow (Guzman et al., 2018).

The CA models can describe many physical systems and processes. They proved to be useful, not only in traffic flow modeling but also in many different applications, such as the spreading of forest fires, population growth, pedestrian behavior, etc. In geography, they are used for simulations of land use changes, as they are able to connect the interactions of different factors in space (Pinto, Antunes, Roca, 2021; Xu, Xing Zhu, Liu, 2023). Since CA models calculate the amount of phenomena in space, CA transport models can measure the impact of intersections, road narrowing, speed limits, or other traffic features and factors anywhere in the study area.

A CA model consists of a regular uniform n-dimensional lattice (or array) of cells. Different values of each cell are updated simultaneously at discrete time steps according to the values of its adjacent cells at the preceding time step (Karafyllidis, Thanailakis, 1998; Maerivoet, De Moor, 2005). In the case of the upgraded extended LAI model, the speed, acceleration, and distance traveled of all vehicles are updated simultaneously at each time step.

In the case of traffic CA models, road is discretised into cells of certain size. In single-cell models, each cell is either empty or contains a vehicle. Time is described in discrete time steps, and according to different rules, the states of cells in the system change in time in the sense that it mimics moving vehicles (Maerivoet, De Moor, 2005).

Traffic CA models have become popular in traffic flow modelling due to their efficient and fast performance in computer simulations. Based on a simple set of rules and low computational cost, they can conduct large-scale real simulations. They can also mimic realistic driving behaviour and consider drivers' psychological aspects (Benjamin, Johnson, 1996).

Wolfram's rule 184 is known as the first deterministic traffic flow CA model. It is based on the representation of how a central cell changes in time, depending on two adjacent cells. The physical meaning of the model is that a vehicle moves one step to the right if the space is empty or remains motionless if the space is occupied (Wolfram, 1983).

In 1992, Nagel and Schreckenberg (NaSch) constructed the first stochastic traffic CA model, which includes a stochastic part in one of its rules. With random breaking maneuvers, it can simulate spontaneous traffic jam formation. In the NaSch model, vehicles can speed up only by one level if they have space. The maximum velocity in the NaSch model is 5 (Nagel, Schreckenberg, 1992).

Traffic CA models evolved through time as authors introduced new rules for acceleration, maintaining distance and updating procedure (Barlovic et al., 1998; Benjamin, Johnson, 1996; Knospe et al., 2000; Takayasu, Takayasu, 1993). Kerner, Klenov, and Wolf (2005) made progress by incorporating synchronization distance into their KKW CA model. When a vehicle is within the zone of interaction (i.e., the synchronization distance), it always tries to adjust its speed to the speed of the vehicle in front (Kerner, Klenov, Wolf, 2002).

In 2010, Larraga and Alvarez-Icaza upgraded the CA approach with their LAI model (it is an abbreviation of the authors' names, Larraga and Alvarez-Icaza), which simulates free flow, congested traffic, synchronized flow, and other complex spatiotemporal patterns. At the same time, the model avoids complex rules, characteristic of models based on the KKW model. In the LAI model, vehicles adjust their speed according to the distance to the vehicle in front of them. Driver's response is based on a safety analysis, which consists of his reaction time, the vehicle's speed, the speed of the vehicle in front, and the gap between them (Larraga, Alvarez-Icaza, 2010). The LAI model was subsequently improved and extended (Guzman et al., 2015; Li et al., 2016).

There are also different microscopic emission models. The model, developed by Panis, Broekx, and Liu in 2018 (PBL model) needs only instant speed and acceleration rate data to calculate PM, VOC, CO_2, and NO_X emissions for urban traffic. The coefficients in the function are obtained from empirical observations. Some models use other data to calculate emissions, such as engine power, road gradient, or vehicle load (Quaassdorff et al., 2022).

Many authors have used a combination of CA models and microscopic emission models. Pan et al. (2018) studied the relationship between traffic flow, fuel rate, dissipation, and particle emissions on a single lane. They used the NaSch CA model for traffic simulations and the PBL model for PM emissions calculation.

Marzoug et al. (2018) studied traffic emissions at signalized intersections. They use the NaSch CA model and a lane-changing model for vehicle movement, traffic light algorithms for signalized intersections, and the PBL model for CO_2, PM, VOC, and NO_X calculation.

Xue et al. (2020) used the KKW three-phase CA model to simulate the traffic flow and study the fuel consumption of vehicles using the method proposed by Treiber, Kesting and Thiemann (2007) on one-way lanes under open boundary conditions. It uses Newton's formula to calculate mechanical power as a function of acceleration and velocity.

The purpose of the article is to study the traffic characteristics on a 1500 m long road with one lane and to find out how the flow and CO_2 emissions are affected by the density of vehicles, the speed limit, and the way of driving. The road is imaginary and does not represent an actual section of the road. By understanding the dynamics of the traffic flow, it is easier to take measures on busy road sections (for example, speed limits, road widening or narrowing, and traffic diversion), which help to reduce the flow and traffic load in the environment. In the Slovenian geographical literature and Slovenian scientific literature in general, we did not find the use of CA models. Although derived from physics, the CA models are also used in geography, especially in the study of land use changes. Also, in the Slovenian literature, we have not seen the invention of a traffic simulator without the use of tools that have already been developed for this purpose. The CA model is suitable for research because it can numerically evaluate a particular phenomenon in time and space. In transport studies, it calculates speeds, accelerations, and locations of vehicles in a unit of time. In combination with the emission model, it is suitable to estimate emissions. At the same time, it is relatively simple to develop a simulator. The CA model enables performing traffic simulations in relatively large areas. Due to the application of kinematics theory and realistic acceleration and deceleration rates, the extended CA LAI model imitates the actual traffic situation (Guzman et al., 2018).

2 METHODOLOGY

2.1 Traffic component

The model we used in our research is the LAI extended model, which we upgraded to calculate emissions. It originates from the LAI model and its collision avoidance logic that preserves safety. For both models, at each time step, the safe distance of the follower vehicle is calculated according to the speed of the follower vehicle, the speed of the leader vehicle, the emergency braking capability of both vehicles, and the distance between both vehicles. According to the calculated distance, the follower vehicle then decides if it is going to accelerate, keep its velocity, decelerate, or take an emergency braking action.

The authors introduced two novelties in the new version:

1. different limited acceleration and deceleration capabilities for different vehicles,
2. vehicles' acceleration is based on uniform accelerated motion instead of impulsive accelerated motion characteristic for most CA models.

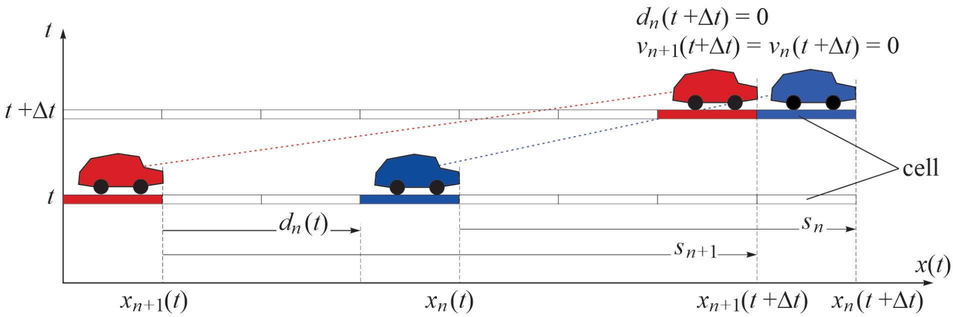
Also, the proposed model calculates three safe distances between vehicles with different driving capabilities. These distances are then used to determine the follower's decision according to the worst-case scenario. However, the improved model is more in line with the realistic traffic than the old one because it uses realistic acceleration/deceleration rates for the vehicles that approach smoothly to slower or stopped vehicles. Furthermore, it is based on the simple rules of kinematic theory and its parameters according to the neighbors' positions and velocities. The model derives from uniformly accelerated motion, where vehicle state evolution in time is described as follows:

$$x_n(\mathrm{t}) = x_{n_0} + v_{n_0}t + \frac{1}{2}a_n t^2 \quad (1)$$

$$v_n(\mathrm{t}) = v_{n_0} + a_n t \quad (2)$$

where x_n and v_n denote the position and velocity of the vehicle n, t is time, x_{n_0} and v_{n_0} are the initial position and velocity of the vehicle, respectively, and a_n is the acceleration. Parameter values for accelerations, decelerations and human reaction times derive from real-life observation (Guzman et al., 2018). Therefore, the model overcomes abrupt unrealistic deceleration actions and the complexity of CA models. Simulation results of the LAI extended model show that it can reproduce empirical findings (Guzman et al., 2018).

Figure 1: A schematic diagram for calculating the safe distance.



The LAI extended model is a probabilistic CA model that consists of N vehicles moving in one direction on a one-dimensional lattice of L cells. Each cell is either empty or is occupied by only one vehicle. Their velocities are values that vary from 0 to $v_{\max}$, which denotes its maximum velocity. Up to this point, there are differences between the LAI extended model and the version used in this research. Namely, in the first model, a vehicle can occupy more than one cell, but in the latter model, it can occupy only one cell. The length of a cell in the later model is 7.5 m, which is the size of a place each car occupies in a complete jam, while the LAI extended model amounts to 1 m (Nagel, Schreckenberg, 1992). Unlike in the LAI extended model, in the new version, the values of velocities are not integer values but real numbers. Regarding the position of a vehicle, two values relate to the vehicle's front bumper. The first value is the exact position of it on the road, and the other is the position that coincides with a sequential number of a cell. The second value is used to calculate emissions. However, except at the beginning, when the vehicle enters the roadway and occupies the entire cell and only one cell, it is later no longer in a single cell. Therefore, the cell value represents the cell that the vehicle entered entirely. The number coincides with a multiplier of the cell size. For example, if the vehicle has the position 7.5 m, it means it has just appeared on the lattice and occupied the first cell. At the position of 14 m, it still occupies the first cell with the remainder of 6.5 m. At position of 15 m, it has just occupied the second cell. There is no possibility that two vehicles would emerge in the same cell because there must be a minimum space gap of a cell size between them. Our upgraded model includes two time variables. The reaction time variable t_r is used to calculate safe distances to determine the new acceleration of a vehicle and is equal to 1 s, which corresponds to human reaction (Guzman et al., 2018).

Based on this acceleration, the other time variable corresponds to the time step Δt used to calculate the updated velocity and the position of a vehicle. Unlike t_r, the variable Δt does not depend on driving styles. This is the second difference with respect to the LAI extended model, which does not include the time variables, because time step and reaction time are always one.

2.2 Updating rules

Step 1:
Safe following distances calculation.

In the first step, the minimum safe following distance for vehicles $d_{\text{acc}n}$, $d_{\text{keep}n}$ or $d_{\text{dec}n}$, is determined, where the variables represent the distances between the leader vehicle n and the follower vehicle $n+1$, if the latter wishes to accelerate, keep its distance, or decelerate, respectively (Guzman et al., 2018).

Step 2:
Slow to acceleration.

According to the vehicle's velocity v_{n+1}, the stochastic noise parameter R_a is determined.

$$R_{\text{a}} = \min\left(R_{\text{d}}, R_0 + v_{n+1}\frac{R_{\text{d}}-R_0}{v_{\text{s}}}\right) \qquad (3)$$

where R_a is the stochastic noise parameter, which denotes the probability of accelerating based on the velocity of the vehicle. It is assumed that vehicles whose velocity is smaller than v_s in the previous time step have a lower probability of accelerating than the rest of the moving vehicles $v_{n+1}>v_s$ meaning that slow vehicles must wait longer before they can continue their journey. The stochastic parameter $R_a(<1)$ linearly interpolates between R_0 and R_d ($R_0 < R_d$) if v_{n+1} is smaller than the velocity v_s, which is in our case 8 m/s (Larraga, Alvarez-Icaza, 2010). All parameter values are defined in the chapter 3.1.

Step 3:
Decision making.

According to the vehicle's space gap $d_n(t)$, compared to previously calculated safety distances in step 1, the follower's acceleration is determined. Acceleration probabilities are also considered (step 2).

Step 3a:
Acceleration.

if $d_{\text{acc}_n} \leq d_n(t)$ then

$$a_{n+1}(t) = \begin{cases} a & \text{if randf()} \leq R_{\text{a}}, \\ 0 & \text{otherwise} \end{cases}$$

where $a_{n+1}(t)$ is the acceleration rate that the follower vehicle will use in the next time step Δt.

Step 3b:
Random slowing down.

if $d_{\text{keep}_n} \leq d_n(t) < d_{\text{acc}_n}$ then

$$a_{n+1}(t) = \begin{cases} -a & \text{if randf}() \leq R_s, \\ 0 & \text{otherwise} \end{cases}$$

where R_s denotes probability of random slowing down despite it has enough space to keep its speed.

Step 3c:
Braking.

if $d_{\text{dec}_n} \leq d_n(t) < d_{\text{keep}_n}$ then

$$a_{n+1}(t) = -a$$

Step 3d:
Emergency braking.

if $d_n(t) < d_{\text{dec}_n}$ then

$$a_{n+1}(t) = -a_{\max}$$

where $a_{\max}$ denotes emergency acceleration rate of the follower vehicle.

Step 4:
Action.

$$v_{n+1}(t + \Delta t) = \min(\max(0, v_{n+1}(t) + a_{n+1}(t)\Delta t), v_{\max})$$

where $v_{n+1}(t)$ is the velocity that the follower vehicle uses in the time step t, $v_{n+1}(t+\Delta t)$ is the velocity that the follower vehicle will use in the next time step $t+\Delta t$

Step 5:
Vehicle movement.

if $(a_{n+1}(t) \geq 0)$ then

$$x_{n+1}(t + \Delta t) = x_{n+1}(t) + v_{n+1}(t)\Delta t + \frac{a_{n+1}(t)\Delta t^2}{2}$$

where $x_{n+1}(t+\Delta t)$ is the position of the follower vehicle in the next time step $t+\Delta t$

if $(a_{n+1}(t+\Delta t)<0)$ then

$$x_{n+1}(t+\Delta t)=x_{n+1}(t)+v_{n+1}(t)\Delta t_s+\frac{a_{n+1}(t)\Delta t_s{}^2}{2}$$

where Δt_s is the time difference between t and the time when the vehicle stops. If this value is less than Δt, Δt_s should be used. The rule is written as follows:

$$\Delta t_s=\min\left(\Delta t,\mathrm{abs}\left(\frac{v_{n+1}(t)}{a_{n+1}(t)}\right)\right)$$

(Guzman et al., 2018).

2.3 CO_2 emission component

In this research, we use the PBL model (Panis, Broekx, Liu, 2006), which allows us to calculate the CO_2 emission of each vehicle at each iteration based on its acceleration (positive or negative) and its instantaneous speed. Panis, Broekx and Liu (2006) showed that this model is appropriate for vehicles' traffic emissions in cities, with a 95 % confidence. Based on empirical measurement and using the multiple non-linear regression technique, they proposed the following general emission function:

$$E_n(t)=\max(E_0,f_1+f_2v_n(t)+f_3v_n(t)^2+f_4a_n(t)+f_5a_n(t)^2+f_6v_n(t)a_n(t))\quad(4)$$

where $E_n(t)$ is the instantaneous emission (g/s) of vehicle. Variables $v_n(t)$ and $a_n(t)$ are the instantaneous speed and acceleration of the vehicle n at time t. E_0 is a lower limit of emission (g/s) specified for each vehicle and pollutant type, and f_1 to f_6 are emission constants specific for each vehicle and pollutant type. The model can predict CO_2, NOx, VOC, and PM emissions (Panis, Broekx, Liu, 2006). The PBL model is used in many studies, and it is also the default microscopic emission model in the Aimsun traffic simulator (Halakoo, Yang, Abdulsattar, 2023). The emission constants of the PBL model for CO_2 emissions for petrol and diesel passenger cars are given in Table 1.

Table 1: Parameters for Eq. (4).

Pollutant	Vehicle Type	E_0	f_1	f_2	f_3	f_4	f_5	f_6
CO_2	Petrol Car	0	$5{,}53 \cdot 10^{-1}$	$1{,}61 \cdot 10^{-1}$	$-2{,}89 \cdot 10^{-3}$	$2{,}66 \cdot 10^{-1}$	$5{,}11 \cdot 10^{-1}$	$1{,}83 \cdot 10^{-1}$
CO_2	Diesel Car	0	$3{,}24 \cdot 10^{-1}$	$8{,}59 \cdot 10^{-1}$	$4{,}96 \cdot 10^{-3}$	$-5{,}86 \cdot 10^{-1}$	$4{,}48 \cdot 10^{-1}$	$2{,}3 \cdot 10^{-1}$

2.4 The application of CA and PLB methods in geography

The CA transport model method combined with a microscopic emission model, such as the PBL model, is applicable in geographic science primarily because it can measure various phenomena anywhere in the space of study. With the findings, it is then possible to understand traffic phenomena and take measures that would, for example, help reduce its negative environmental impacts. In the case of the research we carried out, the method examines the flow, average speed, and CO_2 emissions on a 1500 m long one-way road depending on various parameters, density, maximum speed limit, and driving aggressiveness. The method also makes it possible to measure other emissions at specific locations, for example, at intersections, traffic lights, pedestrian zones, or larger systems of roads or streets. By determining the flow in different locations, we can also assess other effects of traffic on the environment and make it easier to decide on specific measures helpful for improving the efficiency of traffic.

2.5 Model and parameter settings

The simulation is conducted by Wolfram's Mathematica software, version 13.2. The model simulates a one-lane circular road with periodic boundary conditions. Each cell represents 7.5 m, and one cell is occupied of a maximum of one car. The determination of the cell size derives from the size of an occupied place by a car in a complete jam (Nagel, Schreckenberg, 1992).

Each time step is $\Delta t = 1$ s. The length of the road $L = 200$ corresponds to the actual road length of 1500 m. In the initial state, the model randomly distributes the vehicles on the road with an initial speed, which is also RANDOMLY selected between 0 and the highest possible speed in relation to the space the vehicle has in front of it. For calculation of the CO_2 emissions, different values for v_{max} were defined. Eventually, the safety distance estimation, depending on neighboring vehicles, adjusts the maximum velocity by using a quadratic equation, which determines the highest possible speed according to the prerequisite that they are not accelerating at the initial state. In this way, the model is safe and accident-free at the beginning. The density of vehicles on the road amounts to ρ=vehicle⁄cell. Their velocities and positions are updated according to the rules, described in the methodology chapter. The parameters of the model for the stochastic part are set to the same values as in the LAI extended model $R_{\text{d}} = 1$, $R_0 = 1$, v_{s}=8 m/s and R_s=0.01. The parameter v_s means that only vehicles with smaller velocity than 8 m/s can accelerate with delay (Guzman et al., 2018).

Defining acceleration and deceleration rates was a more complex task. Based on empirical observations, Guzman et al. (2018) used the value 8 m/s^2 for the maximum deceleration rate and 4 m/s^2 for the acceleration rate. In the second part of the study, in which they simulated heterogeneous flow, they used the last values for ordinary vehicles but different values for trucks. Their maximum deceleration rate is (4 m/s^2), while their acceleration rate was 2 m/s^2.

Zeng et al. (2023) used the value 3 m/s^2 for the acceleration rate. Feng, Liu and Liang (2023) considered different driving styles in their research. According to the information they collected during time measurement on the road section where the maximum velocity was 73.21 km/h, they concluded that 20 % of drivers are aggressive with acceleration and deceleration rate of 4 m/s^2, 20 % of drivers are calm with acceleration and deceleration rate of 1 m/s^2, and 60 % of drivers have moderate driving style with acceleration and deceleration rate of 2 m/s^2.

Based on the collected data, we determined the rate of acceleration for the drivers. We summarized the findings of Feng, Liu and Liang (2023). They concluded that 20% of drivers are aggressive, 60% of drivers are moderate, and 20% of drivers are calm. The aggressive drivers accelerate with an acceleration rate of 4 m/s^2, calm drivers with 2 m/s^2, and moderate drivers with 3 m/s^2. The maximum deceleration rate of aggressive and moderate drivers is 8 m/s^2, and the one of calm drivers is 4 m/s^2 (Table 2).

In contrast to Guzman et al. (2018) and Feng, Liu and Liang (2023), the model in this research allows aggressive drivers to accelerate with a lower acceleration rate if they don't have enough space to accelerate with their highest acceleration rate. On the other hand, as in Guzman et al. (2018), they decelerate with only one acceleration rate besides the emergency deceleration rate, which allows aggressive drivers to drive with higher velocity and start decelerating later when they are closer to the vehicle in front. Simulation data for the flow-density, and speed-density diagram, was generated by simulations of 400 seconds. For each density from 0 to 1 10 simulation runs are carried out. The results obtained are then averaged. For the calculation of the CO_2 emissions, different combinations for acceleration and deceleration rates were defined.

Table 2: The parameters of driving styles.

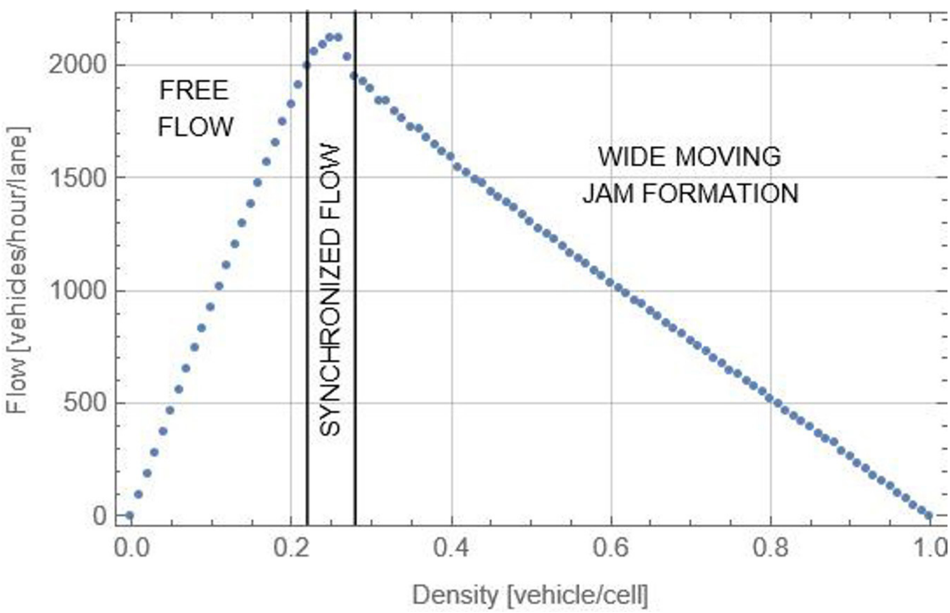
Driving style	Share of Vehicles	Maximum Acceleration	Deceleration	Emergency Deceleration
Aggressive Style	20 %	4 m/s^2	4 m/s^2	8 m/s^2
Moderate Style	60 %	3 m/s^2	3 m/s^2	8 m/s^2
Calm Style	20 %	2 m/s^2	2 m/s^2	4 m/s^2

3 SIMULATION RESULTS AND DISCUSSION

3.1 Fundamental diagram analysis

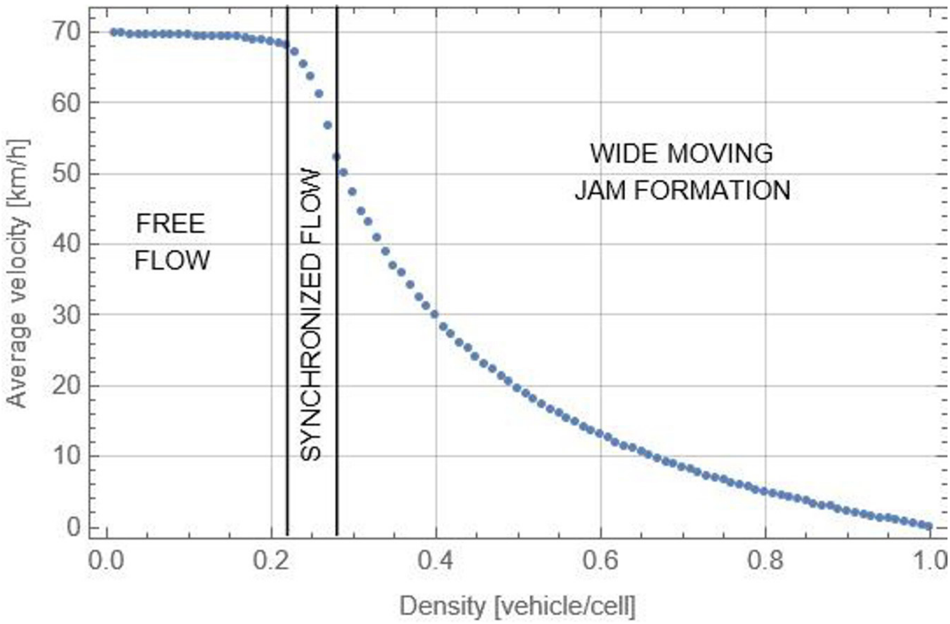
In Figure 2, the flow-density relation of the improved LAI extended model, the so-called fundamental diagram is presented. As seen, the traffic flow reaches its maximum value of 2122 vehicles/hour at the density of 0.25 vehicle/cell, the optimal density above which the traffic flow starts to decrease. Namely, at the density of 0.28, a sudden drop in a traffic flow process occurs and it changes into the congestion phase. The change from the free-flow phase to the synchronized-flow phase occurs at a density of 0.22, when the speed also starts to drop due to more interactions between the vehicles, but no congestion yet occurs. Synchronized flow at the maximum permitted speed of 70 km/h occurs between densities of vehicle/cell.

Figure 2: The flow-density diagram is obtained from the simulations that are carried out in the upgraded LAI extended model for the maximum velocity of 70 km/h.



In Figure 3, the speed-density relation of the improved LAI extended model is presented. It shows that at the synchronized flow region, the average speed drops by 16 km/h from maximum velocity. At the same time, their speed is still stabilized, and vehicles maintain a similar distance between them for the entire road section.

Figure 3: The speed-density diagram is obtained from the simulations that are carried out in the upgraded LAI extended model for the maximum velocity of 70 km/h.



Once the density exceeds 0.27 vehicle/cell, a break-even point is reached with an increase in density of only 0.01. The phase of synchronized flow changes into the phase of congestion (Figure 4c). At a density of 0.28 vehicle/cell, the speed of vehicles is no longer uniform over the entire road section, as congestion starts to appear. Because vehicles maintain a safety distance at a density of 0.28 vehicle/cell, their average speed drops significantly again (Figure 3).

On the other hand, the highest traffic flow in the upgraded LAI extended model at the maximum velocity of 115 km/h is at the density of 0.21 vehicle/cell. The findings are logical because higher speed demands a higher space gap between vehicles. Therefore, at higher speeds, they have enough space at lower densities. The upgraded LAI extended model reaches the highest traffic flow at higher densities than the original LAI extended model of Guzman et al. (2018). We believe it is due to flexible acceleration capabilities that enable vehicles to accelerate at smaller space gaps, although they don't reach the highest acceleration potential.

At different densities, different types of traffic conditions, free flow, synchronized traffic, and wide-moving jams occur as shown in Figure 4. Horizontal rows of dots represent the positions of the vehicles at certain time moving towards the right, while columns of dots represent time instances when the specific cell was occupied by a car. The red and the blue dots represent two specific cars (see also Figure 1).

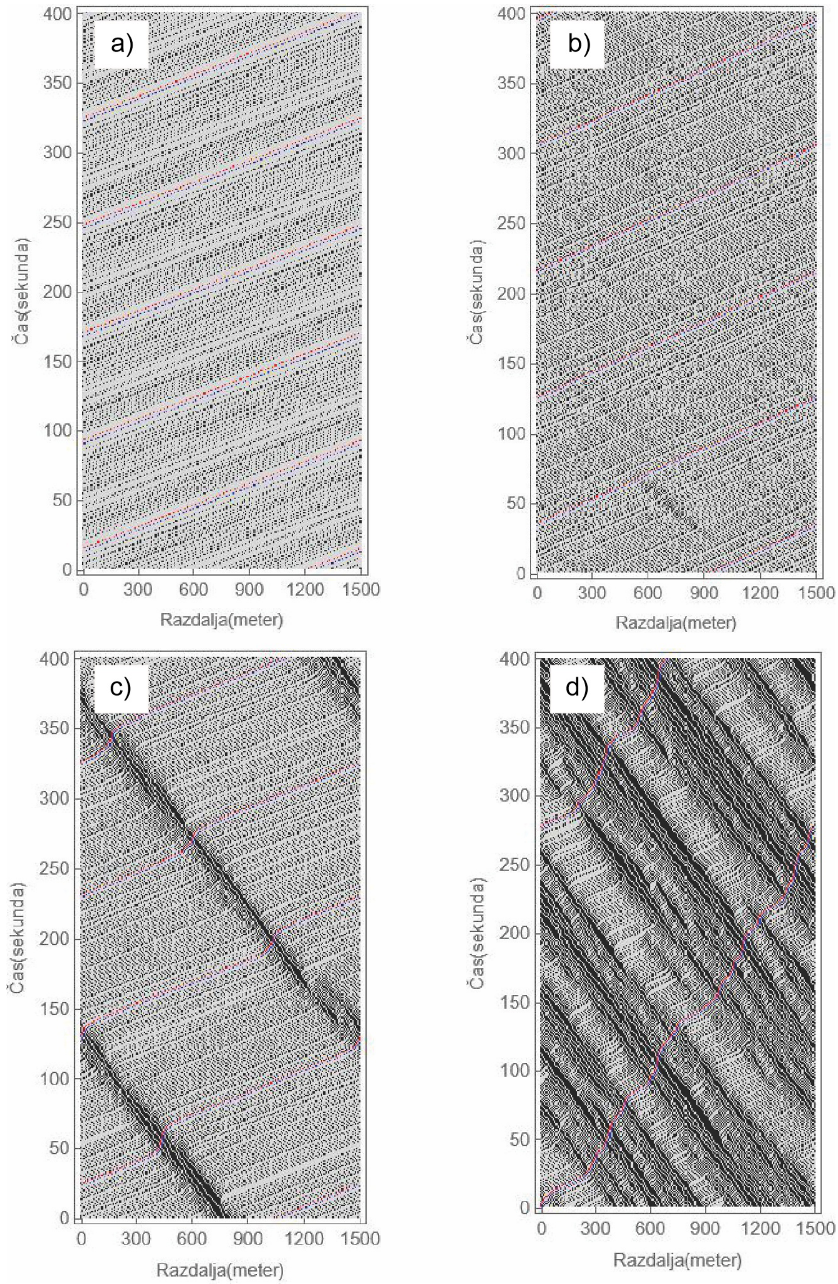


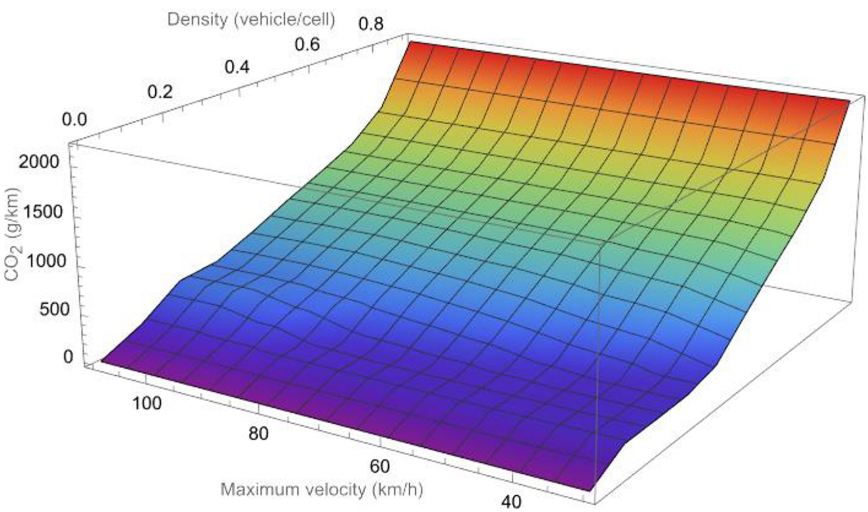
Figure 4: The spatio-temporal diagram of different traffic phases, free (4a), synchronized (4b) and jammed (4c and 4d) for the maximum velocity of 70 km/h.

Vehicles with high speeds when there is no congestion on the road are shown in Figure 4a. Vehicles can take the highest possible speed. When the road is congested, the vehicle's speed drops to zero. Wide-moving jams are shown in the Figure 4c and Figure 4d. The synchronized traffic flow occurs when the speeds drop a little, but the traffic flow is still capable of moving fluidly without jam formation (Figure 4b). Significantly, at the density of 0.27 vehicle/cell, the traffic flow is still in the synchronized phase, but already at 0.28 vehicle/cell, it turns into a jammed phase. Obviously, at the density of 0.27 vehicle/cell, the traffic flow is in the unstable phase because just a slight disorder changes the feature of the flow as is illustrated at the bottom of Figure 4b.

3.2 Impact of the maximum velocity on the CO_2 emissions and traffic flow

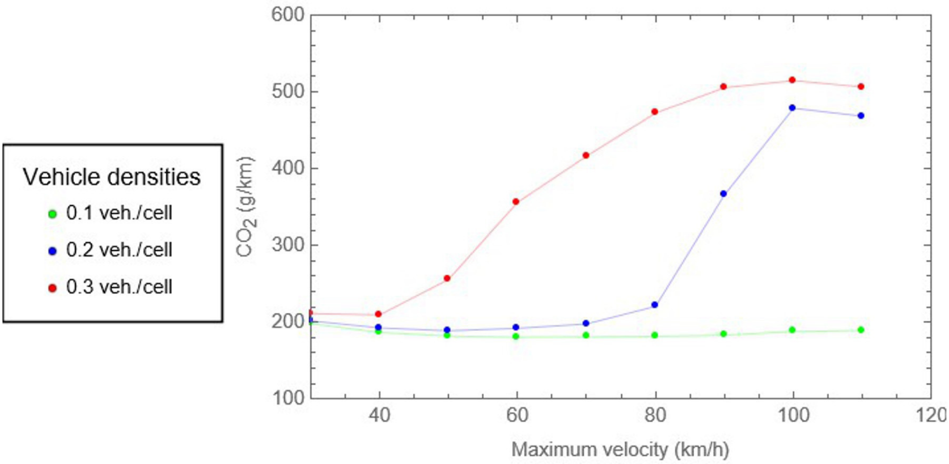
The three-dimensional diagram of CO_2 emissions (in g/km) under different density values (between 0 and 0.9 vehicle/cell) of vehicles and different maximum velocities (between 30 and 110 km/h) is shown in the Figure 5. We calculate the amount of emissions per kilometer driven. Results show that the emission values increase with higher densities. At densities of 0.7 and higher, the emission values are the same for all the maximum velocity values. Namely, the speed does not exceed even the lower maximum velocity threshold (30 km/h). Regardless of the maximum velocity, the velocities remain the same at high densities. At the density values between 0.2 and 0.4, the emission values are more than two times higher for the maximum velocity of 110 km/h than for the maximum velocity of 30 km/h (Figure 6). The reason for this phenomenon is the appearance of congestions, which at these densities occur only at higher speeds.

Figure 5: CO_2 emissions as the function of maximum velocity and density.



The graphs in the Figure 6 show different values of emissions at all studied maximum velocity values at the densities of 0.1, 0.2, and 0.3 vehicle/cell, respectively.

Figure 6: CO_2 emissions as the function of maximum velocity at the densities of 0.1, 0.2 and 0.3 vehicle/cell, respectively.



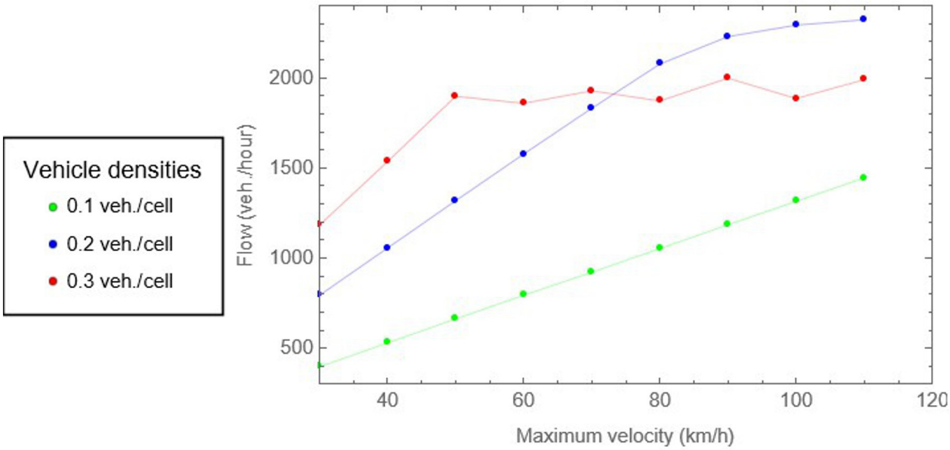
At the density of 0.1, there are no congestions at any maximum velocity value and no influence of congestions. The CO_2 emissions reach the lowest value at the velocity of 60 km/h which corresponds to the lowest emission rate of fuel consumption of some microscale traffic emission models for urban networks (Quaassdorff et al., 2022).

At the density of 0.2 and the maximum velocity of 80 km/h (as evident in the Figure 6), the value of emissions is like the value at the lower maximum velocity values. At the maximum velocity of 90 km/h, the emission value rapidly grows. Therefore, we conclude that at that point, congestions start to occur. At the density of 0.3, the process starts to occur already at lower maximum velocities.

The change of the type of a traffic flow affects the emissions the most, which is seen in the Figure 7. At the density value of 0.2 and maximum velocity values between 80 km/h and 100 km/h, CO_2 emissions more than double, but the traffic flow still grows with the growing maximum velocity at the same parameter values.

At the density value of 0.1, traffic flow grows proportionately with the maximum velocity (Figure 7), but the emissions stay almost constant (Figure 5). It proves that traffic remains at the free flow phase at all studied maximum velocity values. At the density value of 0.3, emissions start to grow rapidly already at the maximum velocity of 50 km/h, and they continue to grow (Figure 6), although traffic flow grows only till the maximum velocity of 50 km/h and then remains similar at higher velocities (Figure 7). It means that at the same density values, more aggressive driving at higher

Figure 7: Traffic flow as the function of maximum velocity at the densities of 0.1, 0.2 and 0.3 vehicle/cell, respectively.



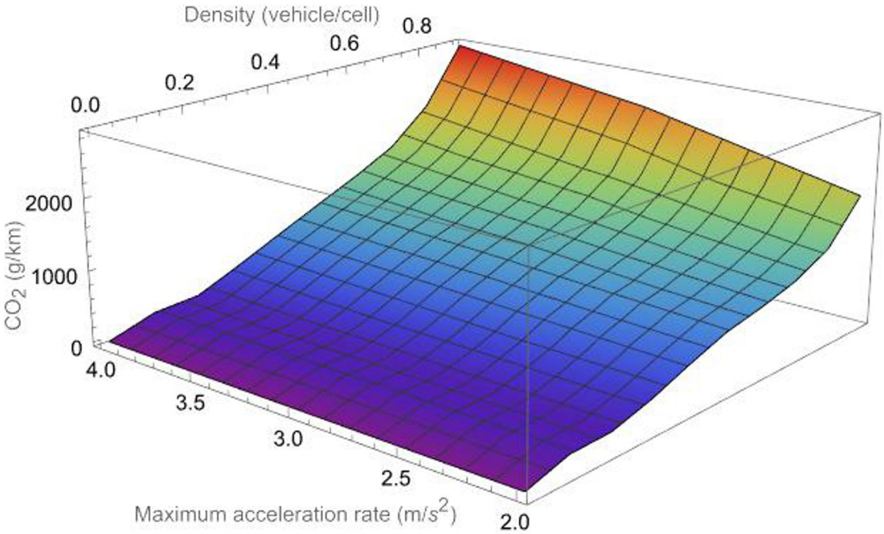
maximum velocity contributes to higher emission values but not higher traffic flow values (also does not contribute to lower traffic flow values). We can conclude that with the change of traffic flow type from free flow to synchronized flow CO_2 emissions start to grow rapidly although the traffic volume stays similar. With the decrease in the traffic flow, CO_2 emissions grow even faster (Figure 5). Namely, more interactions between vehicles contribute to more acceleration and braking and, consequently, higher emissions at similar traffic flow.

3.3 The impact of the maximum acceleration rate on the CO^2 emissions

In the second analysis, we examine the impact of the highest acceleration on the emissions. The three-dimensional diagram of CO_2 emissions (in g/km) under different density values (between 0 and 0.9) of vehicles and different maximum acceleration rates (between 2 and 4 m/s^2) is shown in Figure 8. The maximum velocity was constant at 70 km/h. Results show that the higher the density, the larger the difference between the emissions at different maximum acceleration rates.

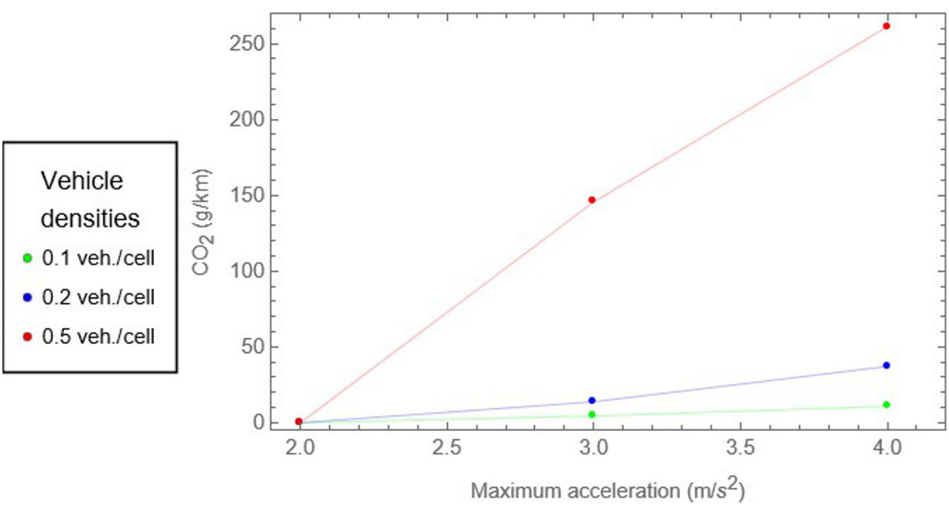
Figure 9 shows different values of emissions at different maximum acceleration rates and densities of 0.1, 0.2, and 0.5, respectively. At the density of 0.1, there are few interactions between vehicles, so they rarely accelerate except when accelerating to the maximum velocity, which they later maintain.

Figure 8: CO_2 emissions as the function of maximum acceleration rate and density.



Aggressive drivers, which tend to accelerate with 4m/s^2, would contribute to around 6 % more CO_2 emissions than moderate drivers with a maximum acceleration rate of 2 m/s^2. At the density of 0.2, the percentage grows to 15 %, and at 0.5 to around 33 %. At the density of 0.9, the difference is more than 60 %.

Figure 9: The difference in CO_2 emissions between driving with the highest and the lowest maximum acceleration rate at the densities of 0.1, 0.2 and 0.5 vehicle/cell, respectively.



These differences occur due to a higher frequency of higher acceleration and deceleration rates. It should be noted that aggressive drivers with a higher maximum acceleration rate can accelerate with a lower acceleration rate if they do not have enough space to accelerate with a maximum acceleration rate. On the other hand, they always brake with the same rate of deceleration, which represents the negative value of their maximum rate of acceleration. Both lead to more aggressive driving and consequently large emission values at higher densities when there are more interactions between vehicles.

4 CONCLUSION

As part of the research, simulations of the traffic flow were made to analyze the characteristics of the traffic flow and the influence of different density values on the traffic flow. The influences of the maximum velocity and the maximum acceleration rate by different densities on CO_2 were later discovered. The traffic flow simulations were carried out by the upgraded CA extended LAI model. Traffic CO_2 emissions were later calculated using the PBL microscopic emission model. In the research, we studied the traffic flow with the aim of understanding its characteristics and finding out how to reduce negative environmental impacts on a 1,500 m long single-lane road section, focusing this time on CO_2 emissions. We believe that understanding the internal dynamics of traffic makes it easier and more correct to make decisions about traffic measures.

Fundamental diagrams of traffic flow simulations show that at the maximum velocity of 70 km/h the traffic flow reaches its maximum value of 2122 vehicles/hour at the density of 0.25 vehicles/cell. At 0.28, a sudden drop in the traffic flow process occurs. Before reaching it, the traffic flow starts changing from the free-flow phase to the congestion phase. Up to a density of 0.22, the traffic flow is in the free-flow phase, with the average speed close to the maximum velocity. Between density values of $0.22 < \rho < 0.28$ the traffic flow is in the synchronized phase, when the average speed drops by 16 km/h from maximum velocity. At the same time, their speed stabilizes, and vehicles maintain a similar distance between them for the entire road section. The breaking point occurs when the density > 0.27 with an increase in density of only 0.01. It leads to a change in the traffic flow into a wide-moving jam formation. At that point, the vehicles' speed dropped significantly to maintain safe vehicle distances.

As the traffic density increases from the value of 0.25 vehicle/cell onwards, the traffic flow decreases. Therefore, as the traffic density increases, the traffic flow and speed are further reduced, which increase congestion and CO_2 emissions. It contributes to other negative environmental impacts, such as louder noise, which lasts longer, and higher occupancy of space on roads. It is also worth mentioning the negative economic consequences, as people spend more time in vehicles, causing fatigue and thus making traffic accidents more likely to occur.

Therefore, it would be useful to reduce the traffic density to achieve the most optimal flow or at least prevent further traffic congestion during rush hours. It would increase its efficiency and at the same time reduce negative impacts on the environment. We are aware that transport is a complex system and that significant changes in a short time are difficult to achieve. However, we can already contribute to the prevention of congestion in the short term by possibly avoiding driving during traffic congestion, by occasionally working from home, using public transport, traveling before or after scheduled traffic peaks, and using online applications to choose the most favorable route to avoid traffic jams. Significant changes require long-term planning. More efficient public transport would probably contribute to reducing congestion. Technological solutions are also worth mentioning.

In this research, we determined how CO_2 emissions were affected by the maximum velocity. We concluded that this has the most significant impact between vehicle density values of $0.2<\rho<0.4$ when the amount of CO_2 emissions is more than twice as high at the maximum velocity of 110 km/h than at 30 km/h. At the mentioned densities, phase changes in the traffic flow only occur at higher maximum velocity values when the traffic flow changes from free to synchronized. Namely, at a higher maximum velocity, vehicles drive faster when they can, so there are more frequent interactions (acceleration, braking) between vehicles, and the amount of emissions starts to increase rapidly, although the traffic volume remains similar (Figure 6). At the density of 0.1, the traffic is free-flowing at all speeds studied, so there are no significant differences in the amount of emissions. However, at the same density, the flow at the lowest maximum velocity is approximately five times lower than the highest maximum velocity. Therefore, the economic impact of the traffic must also be taken into account. At higher densities, when the traffic flow is in the phase of wide-moving jam formation, simultaneously with the increase in the amount of emissions, the flow decreases at the same time, namely for all speed limits studied. In the long term, the solution would be advanced technology, with the help of which vehicles are connected and tend to drive in platoons. Another measure is again a technological one, namely to change the maximum velocity depending on the traffic density at a specific section.

The influence of emissions due to driving aggressiveness was also discovered namely, at the constant velocity value of 70 km/h and different acceleration. Results show that the higher the density, the larger the difference between the emissions at different maximum acceleration rates. At the density of 0.1, there are few interactions between vehicles, so they rarely accelerate except when accelerating to the maximum velocity. Aggressive drivers, which tend to accelerate with $4 m/s^2$, would contribute to around 6 % more CO_2 emissions than calm drivers with a maximum acceleration rate of $2 m/s^2$. At the density of 0.2, the difference grows to 15 %, and at 0.5 to around 33 %. At the density of 0.9, the difference is more than 60 %. Therefore, the most environmentally adequate driving is the calm driving with as few impulsive accelerations as possible. So, we suggest encouraging a mild driving style. From the point of view of the economic impact of traffic, it is not appropriate to drive much slower than the maximum velocity of the particular road section, as this significantly reduces the flow of traffic, especially at lower densities. Transport measures such as the introduction of new bus links, car parks outside city centers, closures of city centers, the introduction of yellow bus lanes, and bicycle rental systems encourage a reduction in the number of vehicles in cities. It contributes to less congestion, increased flow, and lower emissions. Of course, each of these measures would have to be measured to be able to evaluate its effectiveness.

Grant information

Part of the research was financially supported by the Slovenian research Agency (research program P2-0260).

The authors have no relevant financial or non-financial interests to disclose.

References

Barlovic, R., Santen, L., Schadschneider, A., Schreckenberg, M., 1998. Metastable states in cellular automata for traffic flow, 5, pp. 793–800. DOI: 10.1007/s100510050504.

Benjamin, S. C., Johnson, N. F., Hui, P. M., 1996. Cellular automata models of traffic flow along a highway containing a junction. Physics Department, Clarendon Laboratory, Oxford University, pp. 1–18. DOI: 10.1088/0305-4470/29/12/018.

Chowdhury, D., Santen, L., Schadschneider, A., 2000. Statistical physics of vehicular traffic and some related systems. Physics Reports, 329, 4-6, pp. 199–329. DOI: 10.1016/S0370-1573(99)00117-9.

De Vlieger, I., Keukeleere, D. D., Kretzschmar, G. J., 2000. Environmental effects of driving behaviour and congestion related to passenger cars. Atmospheric Environment, 34, 27, pp. 4649–4655. DOI: 10.1016/S1352-2310(00)00217-X.

Escap, U., 2019. Using smart transport technologies to mitigate greenhouse gas emissions from the transport sector in Asia. URL: https://repository.unescap.org/handle/20.500.12870/344 (accessed 08.01.2024).

Feng, T., Liu, K., Liang, C., 2023. An improved cellular automata traffic flow model considering driving styles. Sustainability, 15, 2, pp. 1–19. DOI: 10.3390/su15020952.

Glojek, K., Gregorič, A., Ogrin, M., 2019. Black carbon air pollution – case study of Loški Potok. Dela, 50, pp. 25–43. DOI: 10.4312/dela.50.5-43.

Guzman, H., Larraga, M. E., Alvarez-Icaza, L., 2015. A two lanes cellular automata model for traffic flow considering realistic driving decisions. Journal of Cellular Automata, 10, 1-2, pp. 65–93.

Guzman, H.A., Larraga, M.E., Alvarez-Icaza, L., Carvajal, J., 2018. A cellular automata model for traffic flow based on kinetics theory, vehicles capabilities and driver reactions. Physica A: Statistical Mechanics and its Applications, 491, pp. 528–548. DOI: 10.1016/j.physa.2017.09.094.

Halakoo, M., Yang, H., Abdulsattar, H., 2023. Heterogeneity aware emission macroscopic fundamental diagram (e-MFD). Sustainability, 15, 2. DOI: 10.3390/su15021653.

Hoek, G., Brunekreef, B., Goldbohm, S., Fischer, P., van den Brandt, P.A., 2002. Association between mortality and indicators of traffic-related air pollution in the Netherlands: A cohort study. Lancet, 360, pp. 1203–1209.

Ježek, I., 2015. Contribution of traffic and biomass burning to air pollution discriminated with Aethalometer measurements of black carbon. Doctoral thesis. Ljubljana: University of Ljubljana, Faculty of Mathematics and Physics, Department of Physics.

Ježek, I., Katrašnik, T., Westerdahl, D., Močnik, G., 2015. Black carbon, particle number concentration and nitrogen oxide emission factors of random in-use vehicles measured with the on-road chasing method. Atmospheric Chemistry and Physics, 15, pp. 11011–11026.

Karafyllidis, I., Thanailakis, A., 1998. A model for predicting forest fire spreading using cellular automata. Ecological Modelling, 99, 1. DOI: 10.1016/S0304-3800(96)01942-4.

Kerner, B. S., Klenov, S. L., Wolf, D. E., 2002. Cellular automata approach to three-phase traffic theory. Journal of Physics A: Mathematical and General, 33, pp. 9971–10013. DOI: 10.1088/0305-4470/35/47/303.

Knospe, W., Santen, L., Schadschneider, A., Schreckenberg, M., 2000. Towards a realistic microscopic description of highway traffic. Journal of Physics A: Mathematical and General, 33, pp. 479–485. DOI: 10.1088/0305-4470/33/48/103.

Larraga, M. E., Alvarez-Icaza, L., 2010. Cellular automaton model for traffic flow based on safe driving policies and human reactions. Physica A: Statistical Mechanics and its Applications, 389, 23, pp. 5425–5438. DOI: 10.1016/j.physa.2010.08.020.

Li, X., Li, X., Xiao, Y., Jia, B., 2016, Modeling mechanical restriction differences between car and heavy truck in two-lane cellular automata traffic flow model. Physica A: Statistical Mechanics and its Applications, 451, pp. 49–62. DOI: 10.1016/j.physa.2015.12.157.

Maerivoet, S., De Moor, B., 2005. Cellular automata models of road traffic. Physics Reports, 419, 1, pp. 1–64. DOI: 10.1016/j.physrep.2005.08.005.

Marzoug, R., Lakouari, N., Perez Cruz, J. R., Vega Gomez, C. J., 2022. Cellular automata model for analysis and optimization of traffic emission at signalized intersection. Sustainability, 14, 21. DOI: 10.3390/su142114048.

Nagel, K., Schreckenberg, M., 1992. A cellular automaton model for freeway traffic. Journal de Physique I, 2, 12, pp. 2221–2229. DOI: 10.1051/jp1:1992277.

Ntziachristos, L., Gkatzoflias, D., Kouridis, C., Samaras, Z., 2009. COPERT: A European road transport emission inventory model. In: Athanasiadis, I. N., Rizzoli, A. E., Mitkas, P. A., Gómez, J. M. (eds.). Information technologies in environmental engineering. Springer, pp. 491–504. DOI: 10.1007/978-3-540-88351-7_37.

Ogrin, M., 2007. Air pollution due to road traffic in Ljubljana. Dela, 27, pp. 199–214.

Ogrin, M., 2018. Prometno obremenjevanje ozračja. V: Okoljski učinki prometa in turizma v Sloveniji. Ljubljana: Znanstvena založba Filozofske fakultete, str. 62–72. URL: https://ebooks.uni-lj.si/ZalozbaUL/catalog/view/60/129/1381 (accessed 08.01.2024).

Pan, W., Xue, Y., He, H. D., Lu, W. Z., 2018. Impacts of traffic congestion on fuel rate, dissipation and particle emission in a single lane based on NaSch Model. Physica A: Statistical Mechanics and its Applications, 503, pp. 154–162. DOI: 10.1088/1748-9326/ac8b21.

Panis, L. I., Broekx, S., Liu, R., 2006. Modelling instantaneous traffic emission and the influence of traffic speed limits. Science of The Total Environment, 371, pp. 270–285. DOI: 10.1016/j.scitotenv.2006.08.017.

Pinto, N., Antunes, A. P., Roca, J., 2021. A cellular automata model for integrated simulation of land use and transport interactions. International Journal of Geo-Information, 10, 3. DOI: https://doi.org/10.3390/ijgi10030149.

Quaassdorff, C., Smit, R., Borge, R., Hausberger, S., 2022. Comparison of microscale traffic emission models for urban networks. Environmental Research, 17, pp. 1–15. DOI: 10.1088/1748-9326/ac8b21.

Rakha, H., Van Aerde, M., Ahn, K., Trani, A., 2000. Requirements for evaluating traffic signal control impacts on energy and emissions based on instantaneous speed and acceleration measurements. Transportation Research Record, 1738, pp. 56–67. DOI: 10.3390/ijgi10030149.

Strle, D., Svetlin, D., Glojek, K., Kobal, M., Pogačnik, K., Ogrin, M., 2020. Meritve koncentracij črnega ogljika in dušikovega dioksida na Lavrici in v Kranju. Dela, 54, pp. 5–27. DOI: 10.4312/dela.54.5-52.

Takayasu, M., Takayasu, H., 1993. 1/f noise in a traffic model. Fractals, 1, 4, pp. 860–966. DOI: 10.1142/S0218348X93000885.

Treiber, M., Kesting, A., Thiemann, C., 2008. How much does traffic congestion increase fuel consumption and emissions? applying a fuel consumption model to the NGSIM trajectory data. TRB 87th Annual Meeting Compendium of Papers, DVD, pp. 1–17. URL: https://trid.trb.org/view/848721 (accessed 08.01.2024).

Wolfram, S., 1983. Statistical mechanics of cellular automata. Reviews of Modern Physics, 55, str. 601–644. DOI: 10.1103/RevModPhys.55.601.

Xu, Q., Xing Zhu, A.X., Liu, J., 2023. Land-use change modeling with cellular automata using land natural evolution unit. Catena, 224. DOI: 10.1016/j.catena.2023.106998.

Xue, Y., Wang, X., Cen, B. L., Zhang, P., He, H. D., 2020. Study on fuel consumption in the Kerner–Klenov–Wolf three-phase cellular automaton traffic flow model. Nonlinear Dynamics, 102, pp. 393–402. DOI: 10.1007/s11071-020-05947-2.

Zeng, J., Qian, Y., Li, J., Zhang, Y., Xu, D., 2023. Congestion and energy consumption of heterogeneous traffic flow mixed with intelligent connected vehicles and platoons. Physica A: Statistical Mechanics and its Applications, 609, pp. 1–17. DOI: 10.1016/j.physa.2022.128331.

Alen Čotar*, Darko Ogrin*

SREDNJA RELATIVNA VARIABILNOST PADAVIN V SLOVENIJI V OBDOBJU 1991–2020

COBISS 1.01
DOI: 10.4312/dela.61.75-98

Izvleček

Zaradi velikih razlik v višini padavin med slovenskimi pokrajinami je kot pokazatelj njihove spremenljivosti v obdobju 1991–2020 uporabljena srednja relativna variabilnost. Letna variabilnost je analizirana za 174 padavinskih postaj, giblje se v razponu med 8 in 18 %. Letne padavine so najbolj variabilne v zahodni in severozahodni Sloveniji. Sezonsko variabilnost smo prikazali za 37 reprezentativnih postaj. Najbolj spremenljive so zimske padavine s srednjo relativno variabilnostjo okoli 40 %, kar je posledica sprememb sredozemske ciklogeneze. V ostalih letnih časih je variabilnost med 20 in 25 %.

Ključne besede: klimatogeografija, variabilnost padavin, srednja relativna variabilnost padavin, spreminjanje podnebja

MEAN RELATIVE PRECIPITATION VARIABILITY IN SLOVENIA FOR THE PERIOD 1991–2020

Abstract

Given the considerable disparities in precipitation amounts in the various regions of Slovenia, the mean relative variability was used as an indicator of precipitation variability in the period 1991–2020. The annual variability analyzed for 174 precipitation stations ranges from 8 % to 18 %. The highest annual precipitation variability was observed in western and northwestern Slovenia. Seasonal variability was assessed for 37 representative stations. Winter precipitation exhibits the greatest variability,

*Oddelek za geografijo Filozofske fakultete Univerze v Ljubljani, Aškerčeva 2, SI-1000 Ljubljana, Slovenija
e-pošta: cotar.alen@gmail.com, darko.ogrin@ff.uni-lj.si
ORCID: 0000-0002-2458-6435 (D. Ogrin)

characterized by a mean relative variability of approximately 40 %, which is primarily due to fluctuations of the Mediterranean cyclogenesis. In the other seasons, the variability ranges from 20 % to 25 %.

Keywords: climatogeography, precipitation variability, mean relative precipitation variability, climate change

1 UVOD

Slovenija je kljub skromnim geografskim dimenzijam podnebno raznolika država (Ogrin in sod., 2023), kar velja tudi za padavine. V povprečju pade letno v Sloveniji okoli 1400 mm padavin, največ v območju alpsko-dinarske pregrade (od 1600 do več kot 3000 mm), najmanj pa na jugozahodu (900–1000 mm) in severovzhodu države (800–1000 mm). Padavine v kombinaciji s temperaturami opredeljujejo večino slovenskega podnebja za vlažno ali zelo vlažno, le Slovenska Istra na jugozahodu ter nižine in gričevja na severovzhodu in vzhodu imajo polvlažno podnebje (Ogrin in sod., 2013). Severovzhodni del države ima zmerno celinski padavinski režim z viškom padavin poleti in nižkom pozimi, ki proti jugozahodu prehaja v zmerno sredozemskega z viškom padavin v jeseni in primarnim nižkom na prehodu zime v pomlad ter sekundarnim nižkom julija in avgusta. Pomembna značilnost padavin v zmernih geografskih širinah je njihova velika variabilnost, bistveno večja kakor je variabilnost temperaturnega režima. Pri tem Slovenija ni izjema, kvečjemu nasprotno; dolgoletna povprečja so lahko močno presežena, ali pa je višina padavin v posameznih letih, sezonah ali mesecih globoko pod povprečjem. Preobilje ali pomanjkanje padavin ima negativne učinke tako za naravo kakor za družbo. Prevladujoče mnenje je, da so padavine v zadnjih letih vse bolj variabilne oziroma da nihajo od enega ekstrema do drugega. Zaradi tega je poznavanje njihove spremenljivosti zelo pomembno za prilagajanje na vse bolj ekstremno vreme in podnebje v sedanjosti, pa tudi za pripravo strategij prilagajanja za prihodnje podnebne razmere.

Glavni namen prispevka je analizirati spremenljivost višine padavin v Sloveniji v pravkar zaključenem standardnem klimatološkem obdobju 1991–2020. Več pozornosti smo namenili variabilnosti letne višine padavin in njenim regionalnim razlikam, ki smo jo analizirali za vse razpoložljive padavinske postaje. Zanimala nas je tudi primerjava s predhodnim standardnim klimatološkim obdobjem 1961–1990 in razlike v variabilnosti med njima. Vpogled v sezonsko variabilnost, ki je še večja od variabilnosti letnih padavin, smo dobili z analizo reprezentativnih postaj za posamezne pokrajinske enote, podnebne tipe in padavinska območja Slovenije. Glede na velike regionalne razlike v namočenosti smo za mero spremenljivosti uporabili srednjo relativno variabilnost.

Študij, ki analizirajo padavine v Sloveniji, je precej, nabor literature, ki govori o variabilnosti padavin, pa je precej skromen. Prvo temeljito delo o variabilnosti je v okviru analize padavin v Sloveniji naredil Furlan (1955; 1961). V doktorski disertaciji

(Furlan, 1955) opozarja, da je izražanje variabilnosti s srednjo absolutno vrednostjo na Slovenskem nepraktično, ker primerjava med posameznimi območji zaradi velikih razlik v višini padavin ni mogoča. Letno in mesečno variabilnost je analiziral za 36 postaj v 16-letnem obdobju 1925–1940, kar je za tovrstne analize neobičajno kratek niz. Prostorsko sliko variabilnosti je prikazal z izolinijami, ki jih je imenoval »izanomale relativne variabilnosti«. Ugotavlja, da je letna variabilnost najvišja vzdolž alpsko-dinarske pregrade in znaša med 14 in 16 % (največ 18 %), drugod po Sloveniji je večinoma med 13 in 14 %. Pri mesečni variabilnosti je prišel do sklepa, da se s povečevanjem celinskega značaja padavin variabilnost zmanjšuje. Najmanjša, pod 50 %, je na severovzhodu Slovenije, kjer so padavine najmanj izdatne, največja pa v Alpskih pokrajinah (70–80 %) in v zaledju Obsredozemskih pokrajin (okrog 60 %).

Variabilnost padavin sta v poročilu o podnebni spremenljivosti Slovenije v obdobju 1961–2011 prikazala tudi Vertačnik in Bertalanič (2017). Uporabila sta različne statistične kazalce variabilnosti (primerjava absolutnih vrednosti, standardnih odklonov, kvartilnih razponov in linearnih trendov), za raven Slovenije tudi odklon povprečne višine padavin v posameznih letnih časih od povprečja za obdobje 1961–2011. Kot najbolj variabilne izpostavljata padavine pozimi, saj je zima povsod v Sloveniji najmanj namočen letni čas. Sledijo spomladanske in jesenske padavine, najmanjša je spremenljivost poleti.

Študija Kobala (2022) se ukvarja s prostorsko variabilnostjo padavin v Sloveniji po letnih časih. To je, kako se višina padavin spreminja med padavinskimi postajami glede na njihovo medsebojno oddaljenost. S pomočjo analize razdalje razgradnje korelacije za 160 padavinskih postaj v obdobju december 2009–november 2019 ugotavlja, da je prostorska variabilnost največja poleti, ko prevladujejo konvektivne padavine, na katere imajo velik vpliv lokalni dejavniki (npr. relief), zaradi česar so padavine prostorsko razporejene zelo neenakomerno. Najmanjša je prostorska variabilnost pozimi in jeseni, saj takrat prevladujejo obsežne frontalne in orografske padavine.

Spremenljivost padavin v Sloveniji je bila tudi tema nekaterih študentskih zaključnih del na Oddelku za geografijo Filozofske fakultete Univerze v Ljubljani. Ozebek (2015) je na osnovi manjšega števila reprezentativnih padavinskih postaj za posamezne podnebne tipe primerjala srednjo letno in sezonsko relativno variabilnost med obdobji 1961–1990 in 1991–2010. Ugotavlja, da se letna variabilnost med obdobjema ni bistveno spremenila, sezonska pa se je pri vseh letnih časih, razen spomladi, v drugem obdobju povečala, najbolj pozimi in poleti. Po podobni metodologiji, vendar za 62 reprezentativnih padavinskih postaj in s poudarkom na prostorski interpolaciji točkovnih podatkov, je primerjavo letne variabilnosti padavin med standardnima klimatološkima obdobjema 1961–1990 in 1991–2020 naredil tudi Čotar (2024). Čotarjeva analiza za obdobje 1991–2020, dopolnjena z izračunom letne variabilnosti za vse padavinske postaje v Sloveniji in sezonske za 37 reprezentantov posameznih naravnih enot, podnebnih tipov (Ogrin in sod., 2023) in padavinskih območij, je bila tudi osnova za pripravo tega prispevka.

Za presojo spremenljivosti padavin v Sloveniji so pomembne tudi študije, ki obravnavajo to problematiko v bližnjih državah. Za Hrvaško in Bosno in Hercegovino so srednjo relativno variabilnost raziskovali Maradin (2011) in Maradin in sod. (2014), v južni Srbiji Miletić in Vuletić (2023) in v območju Alp Formeta in sod. (2021). Za celotno Evropo je variabilnost padavin proučeval Zveryaev (2004).

2 METODE DELA

Podatke za 174 padavinskih postaj v Sloveniji za obdobje 1991–2020 (ARSO, 2021) smo pridobili na Agenciji Republike Slovenije za okolje (ARSO). Na ARSO so podatke najprej kontrolirali in jih s pomočjo sodobnih programskih orodij homogenizirali ter odstranili spremembe, ki niso posledica podnebnega dogajanja (Vertačnik in sod., 2016). V prvem koraku smo s pomočjo homogeniziranih podatkov v programskem okolju Excel izračunali srednjo absolutno letno variabilnost padavin:

$$V_a = \frac{1}{n}\sum_{i=1}^{n}\left|P_i - \overline{P_l}\right|$$

V_a – Absolutna variabilnost padavin
$_{Pi}$ – Višina padavin v letu i
$_{Pl}$ – Povprečna višina padavin proučevanega obdobja

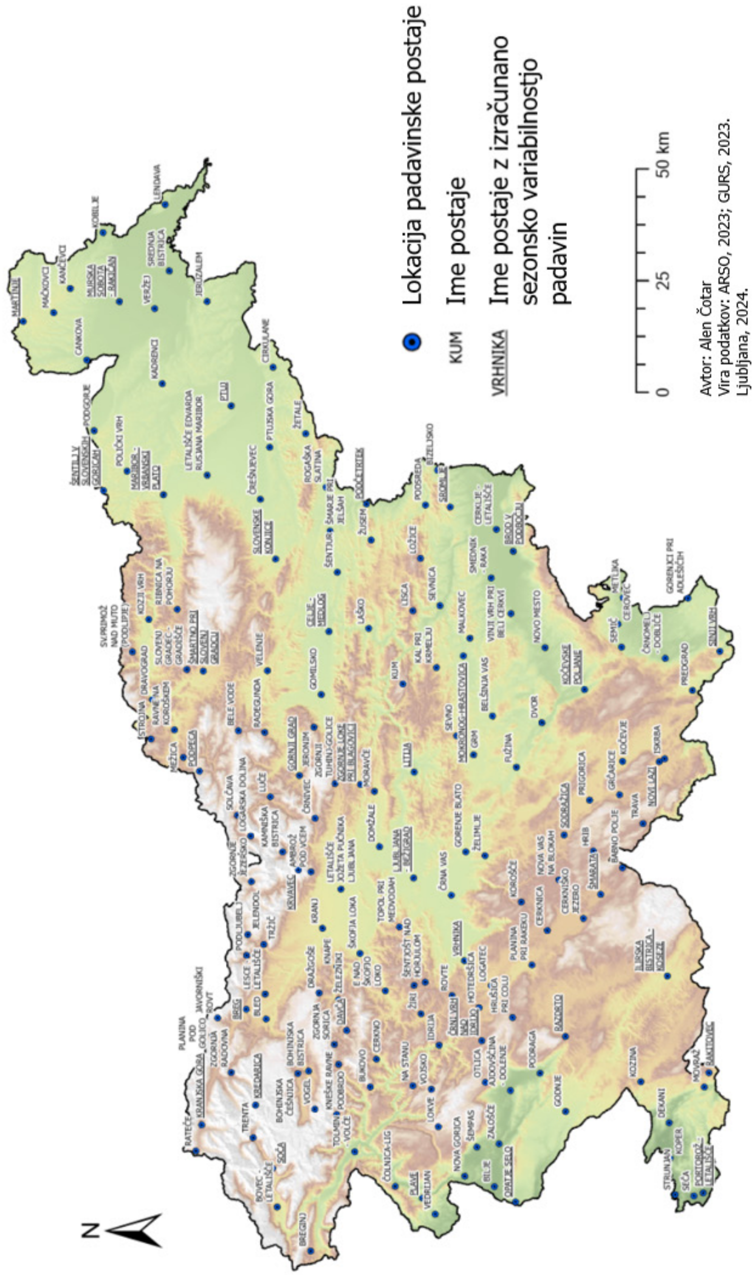
Že predhodni avtorji, ki so se ukvarjali z variabilnostjo padavin (npr. Furlan, 1955; 1961; Maradin, 2011; Maradin in sod., 2014) so poudarjali, da je z absolutno variabilnostjo mogoče primerjati nekaj padavinskih postaj z območja, kjer pade približno enaka višina padavin, in da ta kazalec ni primeren za večja območja, kjer so razlike v padavinah velike. Ker Slovenija spada med tovrstna območja, smo absolutne vrednosti variabilnosti preračunali v relativne:

$$V_r = \frac{100\,\overline{V_a}}{\overline{P_l}}$$

Vr – Relativna variabilnost padavin
Va – Povprečna absolutna variabilnost padavin proučevanega obdobja
Pl – Povprečna višina padavin proučevanega obdobja

Letno variabilnost smo izračunali za vse razpoložljive padavinske postaje za obdobje 1991–2020 (slika 1), sezonsko pa za 37 reprezentativnih postaj. Uporabili smo klimatološke letne čase, izračun sezonske variabilnosti je potekal na enak način kot za izračun letne variabilnosti. Prostorsko je Slovenija zadovoljivo pokrita s padavinskimi postajami (povprečno ena postaja na 116,5 km^2), mreža je nekoliko redkejša predvsem na severovzhodu in v južni Sloveniji, z vidika padavinskih gradientov tudi v gorskem svetu.

Slika 1: Prostorska razporeditev padavinskih postaj v Sloveniji 1991–2020.



Za prostorsko interpolacijo točkovnih vrednosti relativne variabilnosti smo uporabili program ArcGIS Pro 10.8.1, v katerem smo izdelali tudi kartografsko gradivo. Interpolirane vrednosti lahko dobimo s pomočjo različnih modelov. Vsak model vsebuje določene predpostavke o podatkih in na podlagi teh z različnimi izračuni ustvari različne napovedi. Posledično so nekateri modeli bolj primerni za obdelavo določenih podatkov kot pa drugi (ESRI, 2024a; 2024b). Zaradi upoštevanja prostorske avtokorelacije med vhodnimi podatki in zmožnostjo prikaza ocenjenih napak za interpolirane vrednosti, je bilo v raziskavi uporabljeno orodje *Kriging*. Za izvedbo *Kriginga* je pomembno, da imamo dovolj veliko število vzorčnih točk, ki so ustrezno razporejene. Premajhno število točk ne daje optimalnih rezultatov, preveliko z neustrezno prostorsko razporeditvijo prav tako ne. Pri povprečni letni relativni variabilnosti padavin smo pri interpolaciji upoštevali 174 točk, kar ocenjujemo kot zadostno število za raven Slovenije, prostorska razporeditev pa ni optimalna. Sezonskih vrednosti relativne variabilnosti padavin zaradi premajhnega števila točk (37) nismo interpolirali. *Kriging* temelji na teoriji regionalnih spremenljivk, ki predpostavlja, da je prostorska variacija pojava statistično homogena po vsej površini oziroma da je na vseh lokacijah moč opaziti isti vzorec variacije. Sama prostorska avtokorelacija pa sledi načelu, da so si bližnji pojavi med sabo bolj podobni kot oddaljeni.

Po analizi podatkov in preizkusu različnih modelov smo med več vrstami *Kriginga* izbrali *Universal Kriging*, ki je pogosto uporabljena metoda pri delu z okoljskimi pojavi (Columbia …, 2024; ESRI, 2024c). *Universal Kriging* se je v našem primeru izkazal kot primerna metoda, saj upošteva prostorske trende v podatkih, ki so pogosto povezani z drugimi okoljskimi pojavi, kot so npr. nadmorska višina in druge topografske značilnosti površja. Če obstaja velika soodvisnost med dvema okoljskima pojavoma, je smiselno uporabiti *CoKriging*. Vendar pa lahko prekomerno vključevanje informacij povzroči pretirano prilagajanje modela podatkom, kar zmanjša točnost napovedi (Mooney in sod., 2018). V našem primeru vključevanje dodatnih pojavov v analizo ni bilo potrebno, saj je korelacija med nadmorsko višino, ki je v Sloveniji pomemben modifikator padavin, in njihovo variabilnostjo zelo šibka ($r = -0{,}11$).

Velika prednost *Universal Kriginga* je prilagodljivost variogramskega modela podatkom, saj poleg prostorske variabilnosti upošteva tudi prostorske trende, kar je v našem primeru omogočilo kakovostnejšo interpolacijo prostorskih vzorcev variabilnosti padavin v primerjavi z enostavnejšimi metodami, kot je npr. *Ordinary Kriging.* Slednja prav tako vključuje prilagajanje variogramskega modela podatkom, vendar se osredotoča zgolj na prostorsko variabilnost. Odločitev za izbor metode *Universal Kriging* pred *Ordinary Krigingom* je lahko tudi subjektivna, saj v literaturi ni specifično določeno, kako izrazit mora biti prostorski trend v podatkih, da ga lahko uporabimo. V primeru, da je naša presoja napačna, lahko da izbrana metoda manj kakovostne rezultate. Zato je pri interpolaciji priporočljivo pred dokončnim izborom preizkusiti različne metode in se za najbolj primerno odločiti na osnovi primerjave njihovih rezultatov (Kriging, 2024).

3 REZULTATI IN RAZPRAVA

3.1 Srednja letna relativna variabilnost padavin

Srednja letna variabilnost padavin za slovenske padavinske postaje v obdobju 1991–2020 se giblje v razponu med 8 in 18 %, kar je podobno, kot so Maradin in sod. (2014) izračunali za Hrvaško ter Bosno in Hercegovino za obdobje 1961–1990. Povprečna vrednost za raven Slovenije je 12,2 %, mediana 11,9 %, variacijski razmik pa 9,5 %. To pomeni, če v določenem letu pade na ravni Slovenije do okoli 12 % več ali manj padavin, kot znaša dolgoletno povprečje, lahko to vsoto jemljemo v okviru običajne spremenljivosti. Najmanjšo letno variabilnost so v obravnavanem obdobju imele padavinske postaje Gomilsko in Gornji Grad (8,4 %) ter Ložice na Kozjanskem (8,5 %), največjo pa Gorenjci pri Adlešičih (17,9 %), Kranjska Gora (17,8 %) in Strunjan (17,7 %).

Preglednica 1: Nekateri kazalci variabilnosti padavin v Sloveniji za izbrane postaje v obdobju 1991–2020.

Padavinska postaja	Povpr. letna višina pad. (mm)	Najvišja višina v mm (leto)	Najnižja višina v mm (leto)	Srednja letna relativna variabilnost (%)
Krvavec	1696	2243 (2013)	1334 (2003)	10,2
Železniki	1783	2489 (2014)	1285 (2015)	13,5
Zgornje Jezersko	1797	2413 (2014)	1354 (2006)	11,7
Breg (Žirovnica)	1598	2267 (2014)	1089 (2011)	13,4
Javorniški Rovt	2008	2999 (2014)	1497 (2006)	14,6
Bohinjska Bistrica	2028	2947 (2014)	1432 (2011)	14,6
Kredarica	2062	2573 (2000)	1497 (2011)	12,0
Kranjska Gora	1774	2721 (2006)	1165 (2006)	17,8
Soča	2501	3534 (2014)	1508 (2005)	16,3
Bukovo	2102	3051 (2014)	1453 (2015)	14,1
Črni Vrh nad Idrijo	2468	3826 (2010)	1709 (2015)	13,0
Otlica	2285	3459 (2010)	1619 (2011)	14,2
Lokve	2382	3448 (2010)	1602 (2015)	15,9
Plave	1851	2854 (2010)	1156 (2006)	15,8
Opatje selo	1389	2124 (2014)	857 (2007)	16,8
Kozina	1313	1923 (2010)	898 (2003)	14,2
Rakitovec	1452	1984 (2010)	1031 (2011)	14,6
Portorož – letališče	958	1462 (2014)	595 (2015)	17,0

Padavinska postaja	Povpr. letna višina pad. (mm)	Najvišja višina v mm (leto)	Najnižja višina v mm (leto)	Srednja letna relativna variabilnost (%)
Ilirska Bistrica – Koseze	1409	2285 (2014)	979 (2011)	14,2
Razdrto	1561	2201 (2010)	1134 (2007)	12,3
Nova vas na Blokah	1545	2224 (2014)	1055 (2011)	10,4
Šmarata	1449	2220 (2014)	933 (2011)	12,2
Grčarice	1559	2117 (2014)	1120 (2011)	11,1
Ljubljana – Bežigrad	1322	1875 (2010)	918 (2011)	15,7
Vrhnika	1581	2146 (2010)	1175 (2011)	11,3
Želimlje	1397	1838 (2004)	1057 (2011)	10,9
Litija	1176	1523 (2014)	754 (2003)	11,5
Zg. Loke, Blagovica	1289	1647 (2014)	926 (2011)	11,1
Žusem	1125	1428 (2014)	734 (2003)	10,7
Bizeljsko	998	1278 (2014)	602 (2003)	10,7
Sromlje	1007	1286 (2014)	524 (2003)	11,0
Brod v Podbočju	1093	1384 (2019)	731 (2011)	11,3
Mokronog – Hrastovica	1173	1447 (2014)	784 (2011)	10,8
Dvor	1218	1615 (2014)	878 (2003)	10,0
Kočevske Poljane	1376	1841 (2014)	956 (2011)	9,4
Sinji Vrh	1461	2125 (2010)	965 (2003)	12,0
Žetale	1128	1422 (2014)	729 (2011)	12,2
Celje – Medlog	1117	1436 (2014)	705 (2003)	9,5
Gornji Grad	1509	1996 (2014)	1164 (2011)	8,4
Podpeca	1440	1956 (2014)	1030 (2011)	12,8
Letališče E. R. Maribor	938	1238 (2014)	689 (2003)	8,6
Šmartno pri Slov. Gradcu	1183	1498 (2014)	883 (2018)	9,5
Ribnica na Pohorju	1329	1725 (2014)	1044 (2011)	10,7
Šentilj v Slov. goricah	993	1272 (2014)	681 (2003)	11,3
Kadrenci	902	1144 (2014)	624 (2003)	12,3
Ptuj	898	1250 (2014)	571 (2011)	13,2
Murska Sobota – Rakičan	812	1093 (2014)	515 (2003)	12,4
Martinje	811	1061 (2014)	526 (2003)	11,9

Čotar (2024) je po enaki metodologiji analiziral povprečno letno relativno variabilnost padavin za 62 reprezentativnih postaj za posamezne podnebne tipe in padavinska območja Slovenije za obdobje 1961–1990. Povprečna variabilnost na ravni Slovenije je bila v tem obdobju nekoliko nižja kot v obdobju 1991–2020: povprečje 10,9 %, mediana 10,8 %, variacijski razmik 7. Najmanjšo variabilnost so izkazovale postaje Davča (7,9 %), Kočevje (8,1 %) in Javorniški Rovt (8,4 %), največjo pa Mačkovci na Goričkem (14,9 %), Ilirska Bistrica (13,7 %) in Cerovec v Beli krajini (14,3 %).

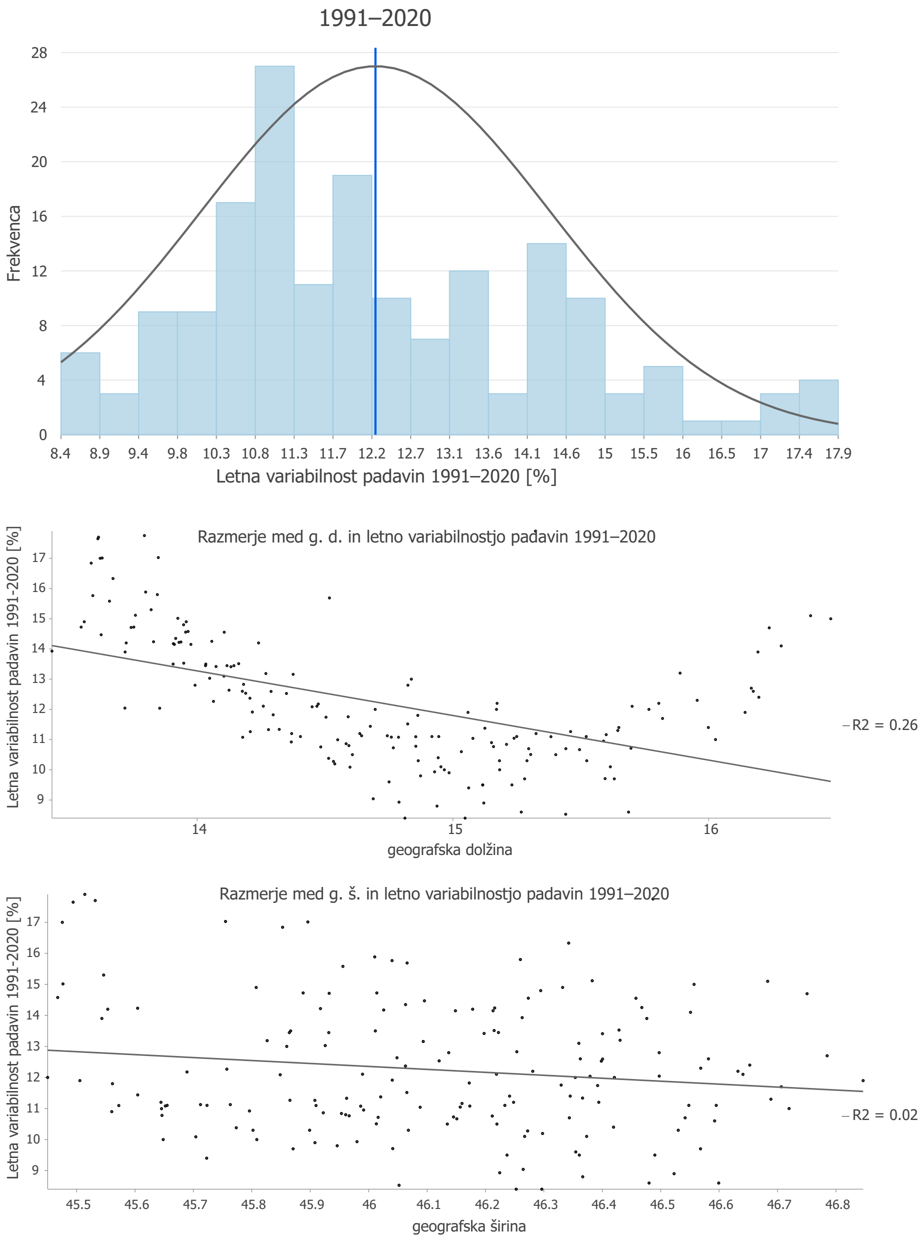
Vrednosti, ki smo jih izračunali za obdobje 1991–2020 in Čotar (2024) za obdobje 1961–1990, so nižje, kakor jih je izračunal Furlan (1955; 1961) za 36 padavinskih postaj za obdobje 1925–1940. Po Furlanovih izračunih za 16-letno obdobje pred 2. svetovno vojno je znašala srednja letna variabilnost okoli 15 %. Največjo variabilnost je ugotovil v severozahodnem in jugovzhodnem delu alpsko-dinarske pregrade ter na skrajnem severovzhodu Slovenije, nad 16 % (npr. Savica 18,2 %; Predel 18,1 %; Sodražica 16,4 %; Sv. Barbara v Halozah, sedanje Cirkulane, 18,2 %; Murska Sobota 16,7 %). Najnižjo pa v pasu, ki poteka pravokotno na alpsko-dinarsko pregrado od Tržaškega zaliva čez osrednjo Slovenijo do Pohorskega Podravja, pod 14 % (npr. Strunjan 13,1 %; Ljubljana 13,6 %; Trebnje 12,4 %; Slovenj Gradec 12,4 %) (Furlan, 1961, str. 83). Furlanovi izračuni so omejeno primerljivi z izračuni za obdobji 1961–1990 in 1991–2020, saj upošteva le polovico 30-letnega standardnega obdobja, za padavine pa je značilno, da so zelo spremenljive in je pogosto tudi 30-letno obdobje prekratko za ugotavljanje njihovih splošnih značilnosti.

Prostorska slika srednje letne relativne variabilnosti padavin

Prvi korak pred izvedbo prostorske interpolacije točkovnih podatkov je bila analiza podobnosti normalni porazdelitvi. Frekvenčna porazdelitev podatkov letne relativne variabilnosti padavin za obdobje 1991–2020 je podobna normalni (slika 2). To odražajo vrednosti koeficienta asimetrije (0,6) in koeficienta sploščenosti (2,8) ter prikaz na histogramu, ki kaže podobo zvonaste krivulje.

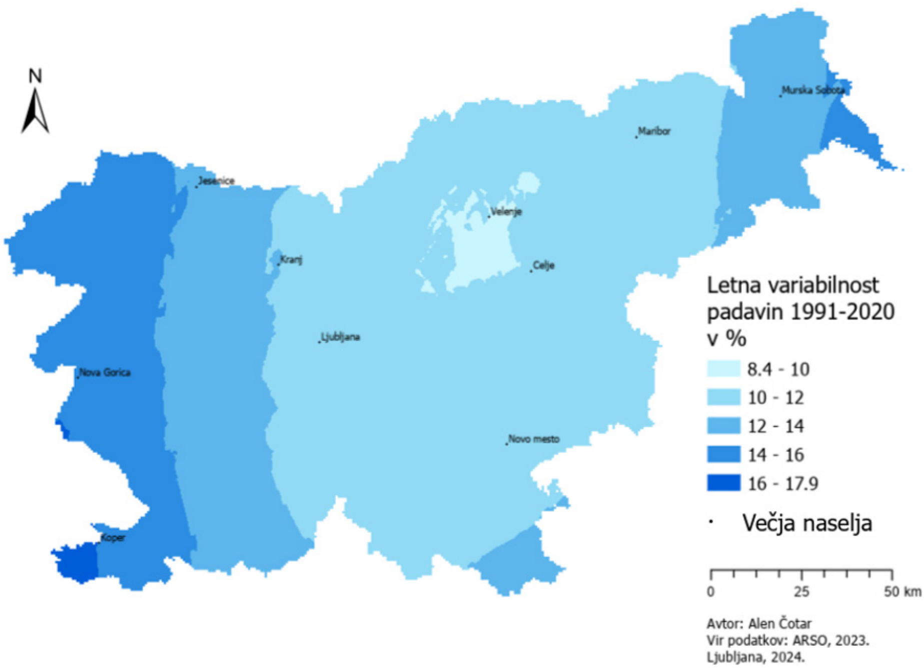
Primerjava med geografsko dolžino in letno variabilnostjo padavin je pokazala izrazit trend zmanjševanja variabilnosti proti vzhodu z nagibom korelacijske premice −1,48 x in korelacijskim koeficientom 0,26, ki nakazuje na šibko negativno korelacijo. Razmerje med geografsko širino in letno variabilnostjo je pokazalo neznatno korelacijo med spremenljivkama z neizrazitim trendom (R = −0,02). Ker je v podatkih prisoten prostorski trend, smo za interpolacijo izbrali metodo *Universal Kriging*. Po preizkusih z različnimi modeli in primerjavi napak ocene posameznih modelov smo ugotovili, da se podatki najbolje prilegajo J-Besselovi funkciji, s katero smo pridobili končen rezultat interpolacije.

Slika 2: Frekvenčna porazdelitev srednje letne relativne variabilnosti padavin v obdobju 1991–2020 (zgoraj) in prikaz prostorskih trendov v podatkih (spodaj).



Prostorska upodobitev relativne variabilnosti letne višine padavin za obdobje 1991–2020 (slika 3) kaže zanimivo podobo. Padavine so najbolj variabilne v zahodni Sloveniji in na skrajnem vzhodu Prekmurja (nad 14 %). Po obsegu izstopa zahodna Slovenija vzdolž meje z Italijo. Za slovenske razmere podpovprečno variabilnost ima vzhodni del osrednje Slovenije z najnižjimi vrednostmi (pod 10 %) med Celjsko in Velenjsko kotlino. Slika ne sovpada ne z letno razporeditvijo padavin, ne z razporeditvijo padavinskih režimov, ne s podnebnimi tipi Slovenije in je le šibko povezana z višinsko strukturo, ki je pomemben modifikator padavinske slike Slovenije. Pearsonov korelacijski koeficient med letno relativno variabilnostjo padavin in nadmorsko višino je le –0,11, kar pomeni, da se z naraščanjem nadmorske višine variabilnost padavin le malenkost zmanjšuje. Ugotovimo lahko, da imajo območja znotraj istega podnebnega tipa ali padavinskega režima ter s podobno nadmorsko višino in letno višino padavin zelo različno povprečno letno relativno variabilnost padavin. Prav tako ne moremo popolnoma pritrditi trendu, ki nakazuje zmanjševanje variabilnosti od zahoda proti vzhodu, saj so območja z največjo variabilnostjo na zahodu in severovzhodu ter delno jugovzhodu Slovenije. Primerjava s sosednjo Hrvaško (Maradin in sod. 2014, str. 14) nakazuje nadaljevanje območja z večjo variabilnostjo na severovzhodu in jugovzhodu Slovenije na hrvaško stran. Podobno je tudi zahodna Slovenija, še posebej

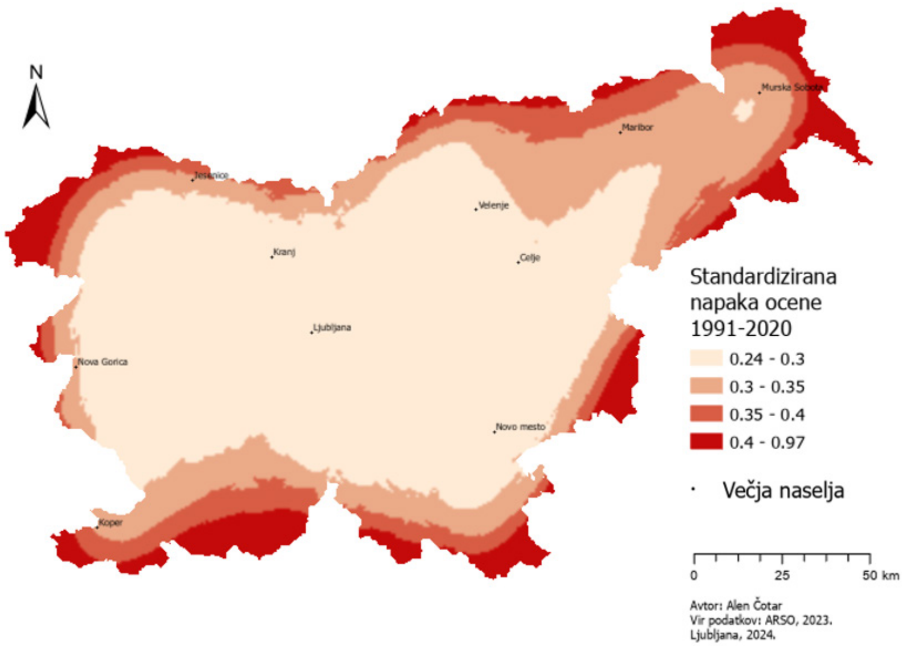
Slika 3: Srednja letna relativna variabilnost padavin v Sloveniji v obdobju 1991–2020.



njen severozahodni del, v tem kontekstu del južnih Alp z na splošno veliko količino padavin, ki so posledica, zlasti v hladni polovici leta, ciklonske aktivnosti v severnem Sredozemlju in medletnih sprememb te aktivnosti, kar pogojuje tudi večjo variabilnost padavin (Brugnara, Maugeri, 2019).

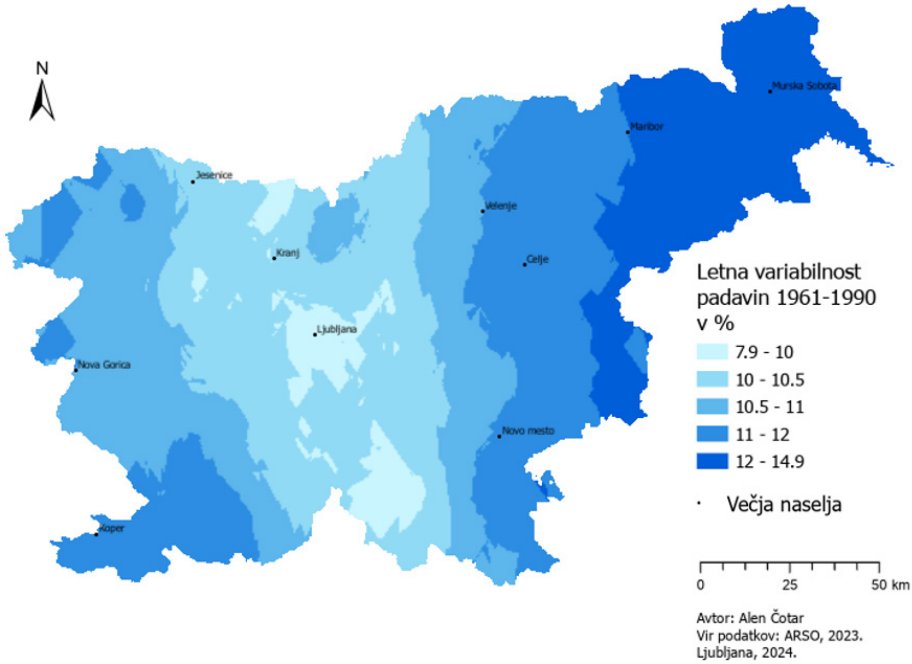
Zanesljivost interpoliranih vrednosti je na splošno največja v bližini merilnih postaj in se z oddaljevanjem od njih povečuje. Zemljevid standardiziranih napak ocene (slika 4) kaže na verodostojnost izvedene interpolacije z J-Besselovo funkcijo, saj napake ocene niso nikjer višje od enega standardnega odklona. Slika je najbolj zanesljiva v osrednjih delih Slovenije, nekoliko manj v obmejnih območjih, kar bi lahko izboljšali z vključitvijo obmejnih padavinskih postaj v sosednjih državah.

Slika 4: Standardizirane napake ocen srednje letne relativne variabilnosti padavin v Sloveniji za obdobje 1991–2020.



Prostorska razporeditev srednje letne relativne variabilnost padavin v Sloveniji v obdobju 1991–2020 se glede najvišjih vrednosti razlikuje od slike za obdobje 1961–1990 (Čotar, 2024). V predzadnjem standardnem klimatološkem obdobju so bile padavine najbolj spremenljive na vzhodu in severovzhodu države, okoli slovenskega povprečja se je variabilnost gibala v večjem delu zahodne Slovenije, v osrednji Sloveniji je od severa proti jugu potekal pas z najbolj stabilnimi padavinami (slika 5). Iz primerjave slik za obe obdobji razberemo trend krepitve variabilnosti letnih padavin v zadnjih desetletjih v zahodnem delu, slabitve na vzhodu in severovzhodu države ter razširitev in pomik območja z najbolj stabilnimi padavinami iz osrednje Slovenije proti vzhodu.

Slika 5: Srednja letna relativna variabilnost padavin v Sloveniji v obdobju 1961–1990 (Čotar, 2024, str. 25).



Pojasnjevanje prostorske slike srednje letne variabilnosti padavin je za obe obdobji težavna naloga. V obdobju 1961–1990 je bila variabilnost največja na vzhodu in severovzhodu Slovenije, to je v gričevnato-ravninskem delu države, kjer pade v povprečju najmanj padavin in ima zmerno celinski padavinski režim z viškom poleti. Okoli slovenskega povprečja je bila v zahodni Sloveniji, ki je reliefno bolj razgibana in ima zmerno sredozemski padavinski režim z viškom v jeseni. Severozahodni deli zahodne Slovenije spadajo med najbolj namočene pri nas, jugozahodni pa med bolj skope s padavinami. Območje z najmanjšo variabilnostjo v osrednjih delih večinoma sovpada z lego na celinski strani alpsko-dinarske pregrade in z območjem prehoda zmerno sredozemskega v zmerno celinski padavinski režim. Izjema so le južni deli države.

Še težje pojasnimo prostorsko sliko za obdobje 1991–2020. Variabilnost padavin je največja v območjih, ki so bodisi najmanj namočena (gričevnati jugozahod in ravninski severovzhod Slovenije), bodisi najbolj namočena (hriboviti do gorati zahod) in imajo najbolj izrazite poteze zmerno sredozemskega (zahodni deli) ali zmerno celinskega padavinskega režima (severovzhod Slovenije). Najmanjša pa je ponovno v območju prehoda med obema padavinskima režimoma, le da se je to območje v zadnjem klimatološkem obdobju razširilo proti vzhodu in severovzhodu države in sovpada z razširitvijo zmerno sredozemskega na račun zmerno celinskega padavinskega režima (Ogrin in sod., 2023).

Če združimo sliki za obe obdobji, lahko postavimo domnevo, da so letne padavine v Sloveniji najbolj stabilne v osrednjih delih države, kjer sta oba viška padavin približno izenačena in prihaja do izrazitejšega prepletanja vzrokov za viške padavin pri obeh režimih: (sredozemske) ciklogeneze, ki je z orografskim dodatkom glavni vir padavin v zahodni in južni Sloveniji v hladni polovici leta, in različnih meteoroloških razmer, ki privedejo do močnejše konvekcije v topli polovici leta, kar ima večji vpliv na padavine na vzhodu in severovzhodu Slovenije. Iz primerjave prostorske razporeditve variabilnosti za obdobji 1961–1990 in 1991–2020 se nakazuje tudi sklep, da so padavine najbolj variabilne na zahodu oziroma vzhodu in severovzhodu Slovenije, kjer ima na nastanek padavin večji vpliv le en dejavnik.

3.2 Vpogled v sezonsko variabilnost padavin

Variabilnost padavin po letnih časih je večja od spremenljivosti letnih padavin in ima tudi izrazitejše posledice za naravo in družbo, bodisi pretirana namočenost ali izostanek običajnih padavin. Sezonsko variabilnost smo analizirali za 37 padavinskih postaj (preglednica 2). Izbrali smo jih kot reprezentante različnih naravnih enot, podnebnih tipov, območij z različno višino padavin in padavinskih režimov v Sloveniji.

Preglednica 2: Srednja sezonska relativna variabilnost padavin v Sloveniji v obdobju 1991–2020.

Padavinska postaja	Pomlad (%)	Poletje (%)	Jesen (%)	Zima (%)
Portorož – letališče	27,2	33,7	26,3	40,0
Rakitovec	23,3	28,6	24,7	38,0
Razdrto	25,0	25,6	23,4	44,0
Opatje selo	24,1	30,3	27,8	44,6
Plave	23,1	24,8	26,0	46,0
Ilirska Bistrica – Koseze	21,2	21,5	27,9	41,1
Črni Vrh nad Idrijo	23,2	20,4	26,6	35,0
Vrhnika	20,8	17,5	25,0	37,5
Ljubljana – Bežigrad	21,6	19,3	27,2	37,9

Padavinska postaja	Pomlad (%)	Poletje (%)	Jesen (%)	Zima (%)
Krvavec	19,7	22,4	21,8	37,3
Breg pri Žirovnici	23,3	21,4	25,6	46,5
Davča	21,5	21,8	25,4	42,0
Kranjska Gora	20,8	19,0	24,2	45,6
Kredarica	24,3	14,6	21,7	38,6
Soča	24,1	20,6	26,3	50,6
Gornji Grad	21,7	20,0	24,5	39,9
Podpeca	19,9	20,4	24,4	44,2
Šmartno pri Sl. Gradcu	20,6	19,9	22,0	40,8
Zg. Loke pri Blagovici	20,3	21,5	26,4	38,4
Litija	22,7	21,5	28,3	39,4
Šmarata	23,0	22,5	27,8	39,6
Sodražica	19,9	24,9	26,5	36,9
Kočevske Poljane	22,4	22,5	25,4	31,7
Novi Lazi	19,4	20,6	26,1	32,2
Sinji vrh (Bela krajina)	19,3	24,3	26,5	31,4
Mokronog – Hrastovica	22,4	20,5	24,3	36,4
Brod v Podbočju	21,1	23,1	24,9	23,9
Sromlje	23,8	24,6	25,3	32,9
Celje – Medlog	23,8	23,2	24,8	38,4
Podčetrtek	23,1	25,1	26,0	36,2
Slovenske Konjice	25,7	24,6	24,4	37,8
Ptuj	26,8	24,2	24,5	42,1
Maribor – Vrbanski plato	24,7	24,0	24,5	39,5
Šentilj v Slov. goricah	28,0	25,2	23,4	42,6
Murska Sobota – Rakičan	27,0	22,6	28,6	39,5
Martinje	27,4	23,6	26,0	42,1
Povprečje	*22,9*	*22,8*	*25,4*	*39,1*
Najvišja variabilnost (padavinska postaja)	*28,0 (Šentilj)*	*33,7 (Portorož)*	*28,6 (M. Sobota)*	*50,6 (Soča)*
Najnižja variabilnost (padavinska postaja)	*19,3 (Sinji vrh)*	*14,6 (Kredarica)*	*21,7 (Kredarica)*	*23,9 (Brod v Podbočju)*

Iz podatkov v preglednici 2 je razvidno, da po variabilnosti izrazito izstopajo zimske padavine (povprečna variabilnost vseh analiziranih postaj je 39 %). Zanje velja, da so v okviru običajne spremenljivosti, če pade določeno zimo na kateri od padavinskih postaj od tretjine do polovice več ali manj padavin, kakor znaša dolgoletno povprečje. Zimski meseci, še posebej januar in februar, pogosto tudi marec, so običajno najbolj skopi s padavinami. To velja za vse podnebne tipe in podtipe v Sloveniji, enako tudi za oba padavinska režima. Da so zimske padavine pri nas najbolj variabilne, ugotavljata tudi Vertačnik in Bertalanič (2017).

Zimske padavine so večinoma ciklonalnega porekla, v Sloveniji tudi z izrazitim orografskim dodatkom. Eden od vzrokov za večjo variabilnost padavin pozimi (deloma tudi jeseni) v primerjavi z ostalimi letnimi časi je spremenljivost ciklogeneze v Sredozemlju, ki je poglavitni vir padavin v Sloveniji v hladni polovici leta. V letih (obdobjih), ko je ciklonalna aktivnost v Sredozemlju (predvsem nad Genovskim zalivom) pogostejša in izrazitejša, pade v zimski polovici leta v Sloveniji, še posebej v zahodni in južni ter na alpsko-dinarski pregradi več padavin in obratno. Periodičnost ciklogeneze v Sredozemlju opisujeta mediteranska oscilacija (*Mediterranean Oscillation*, MO) – nihanje zračnega tlaka med zahodnim in vzhodnim Sredozemljem ter zahodnomediteranska oscilacija (*West Mediterranean Oscillation*, WeMO) – nihanje zračnega tlaka med zahodnim in osrednjim Sredozemljem (med azorskim anticiklonom in genovskim ciklonom). Obe sta pozimi tesno povezani s t. i. severnoatlantsko oscilacijo (*North Atlantic Oscillation*, NOA), to je z intenzivnostjo azorskega anticiklona in islandskega ciklona (Criado-Aldeanueva, Soto-Navarro, 2020; Formeta in sod., 2021; Milošević in sod., 2016; Sen, Ogrin, 2015; Sušelj, Bergant, 2006 idr.). Za južno Evropo in Sredozemlje so z vidika zimskih padavin pomembne negativne faze oscilacij, ko ni prevlade azorskega anticiklona nad zahodnim Sredozemljem oziroma je pogosta ciklogeneza nad osrednjim Sredozemljem (MO), ko je v prevladi nizek zračni tlak nad Ligurskim morjem (WeMO) in ko sta pri NAO obe barični tvorbi šibkejši in cikloni potujejo proti vzhodu južneje, kar sovpada s pogostejšimi prodori hladnih front nad območje Alp in pogostejšo ciklogenezo v Sredozemlju.

Po raziskavi Sušlja in Berganta (2006) kažeta indeksa MO (iMO) in NAO (iNAO) v obdobju 1952–2002 naraščajoč trend, kar kaže na vse pogostejša sušna obdobja v Sredozemlju oziroma manjšo pojavnost sredozemskih ciklonov. Dobršen delež variabilnosti iOM in iNAO pripada periodam, daljšim od 10 let, kar se odraža tudi v variabilnosti padavin in pretokov rek v Sloveniji, ki so z obema indeksoma tesno povezani. Manjši delež variabilnosti pripada periodam med 2,2 in 2,7 let ter 3,5-letni periodi. Iz raziskave za omenjeno obdobje izhaja, da sta bili nadpovprečno sušni prva polovica sedemdesetih in prva polovica devetdesetih let prejšnjega stoletja, nadpovprečno mokra pa šestdeseta leta in začetek osemdesetih let.

Od ostalih letnih časov je variabilnost padavin nekoliko večja jeseni (okoli 25 %), ko ima večina Slovenije, razen severovzhodnega dela, primarni višek padavin. Kljub temu pa so tudi v tem delu države jesenske padavine večinoma bolj spremenljive kakor poletne, ko je običajno višek padavin. Relativna variabilnost spomladanskih in poletnih padavin je približno enaka, v povprečju se giblje nekaj pod 23 %. Padavine v topli polovici leta ne kažejo tesnejših povezav z atmosferskimi cirkulacijami (Milošević in sod., 2016; Sušelj, Bergant, 2006), imajo pa nanje izrazitejši vpliv lokalni dejavniki, npr. vpliv reliefa na konvekcijo in proženje neviht, ter meteorološke situacije, ki vplivajo na močnejšo konvekcijo, npr. višinska jedra, mimohod vremenske fronte in polje enakomernega tlaka.

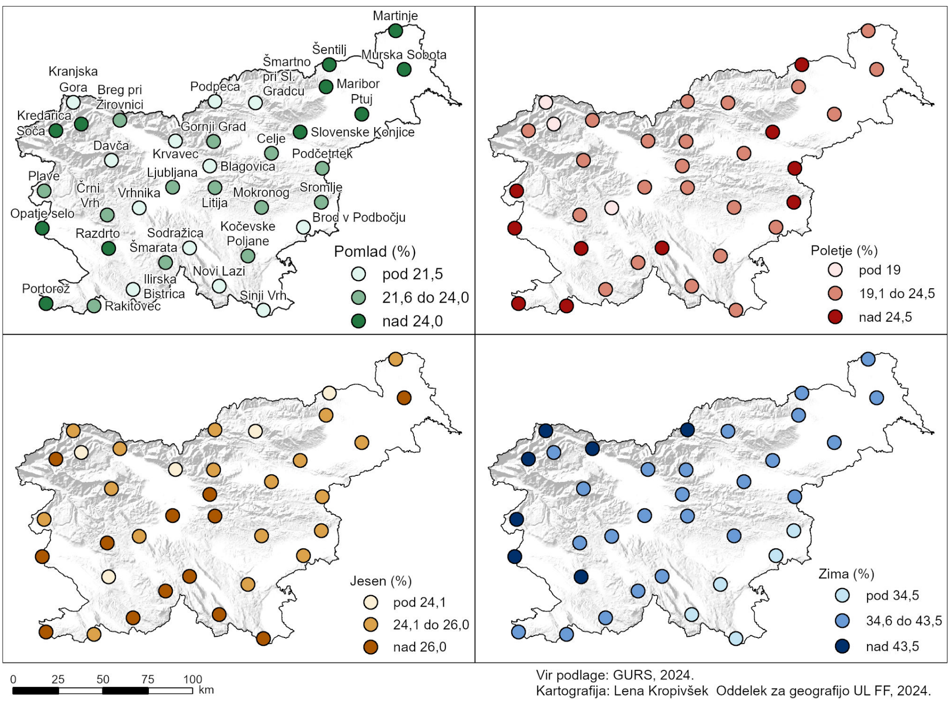
Manjša variabilnost spomladanskih in poletnih padavin je z vidika rastlinstva in kmetijstva dober podatek, saj večja zanesljivost (in zadostnost) padavin v tem času pomeni manjšo sušno ogroženost. Poletna suša pa postaja kljub temu v zadnjih desetletjih vse večja grožnja zaradi vse višjih temperatur in večje evapotranspiracije, najbolj v jugozahodnih ter vzhodnih in severovzhodnih delih države, kjer so padavine količinsko manj izdatne. V obdobju 1991–2020 so se povprečne letne temperature v Sloveniji v primerjavi z obdobjem 1961–1990 povišale v povprečju za 1–1,5 °C ne glede na podnebni tip, sezonske podobno, le jeseni so se manj segrele (Ogrin, 2024, str. 99–106). Dodatno k večji sušni ogroženost prispeva tudi trend zniževanja višine padavin. V zadnjem standardnem klimatološkem obdobju so se padavine spomladi in poleti v primerjavi z obdobjem 1961–1990 zmanjšale do 15 %, zimske ne kažejo večjih sprememb, jesenske pa so se povečale do 20 % (Ogrin, 2024, str. 99–106).

Prostorska interpolacija sezonske variabilnosti padavin zaradi premajhnega števila analiziranih postaj ni bila narejena. Iz prikazov za posamezne letne čase (slika 6) tudi ni možno zanesljivo sklepati o prostorskem vzorcu razporejanja variabilnosti. Spomladanske padavine imajo za jesenskimi najmanjše razlike v variabilnosti med posameznimi deli Slovenije. Variacijski razmik je glede na analizirane padavinske postaje 8,7 %, z najnižjo vrednostjo na Sinjem Vrhu v Beli krajini (19,3 %) in najvišjo v Šentilju v Slovenskih goricah (28,0 %). Postaje z najvišjimi vrednostmi variabilnosti so večinoma skoncentrirane na zahodu in vzhodu Slovenije, to je v območjih, kjer spomladi pade bodisi največ (severozahod: nad 400 mm), oziroma najmanj padavin (jugozahod in vzhod Slovenije: pod 300 mm) (Pomladna povprečna višina …, 2024).

Povezava med poletnimi padavinami in variabilnostjo je nekoliko drugačna. Gorati severozahodni del Slovenije, ki je poleti najbolj namočen (600–1000 mm), ima majhno do srednjo variabilnost, kar kaže na večjo stabilnost pogojev za nastanek konvektivnih padavin. Najbolj so poletne padavine variabilne v jugozahodni in deloma vzhodni Sloveniji, kjer poleti pade 200–400 mm padavin, kar spada med slabšo namočenost v tem letnem času pri nas. Ni pa v tej skupini Prekmurja, kjer poleti prav tako pade malo padavin (250–300 mm; Poletna povprečna višina …, 2024). Razpon variabilnosti poletnih padavin (19,1 %) je večji od razpona spomladanskih, z najvišjo vrednostjo v Portorožu (33,7 %) in najnižjo na Kredarici (14,6 %).

Variabilnost jesenskih padavin se giblje v razponu med 21,7 (Kredarica) in 28,6 % (Murska Sobota), kar je najmanjši razpon med letnimi časi in govori v prid večji zanesljivosti jesenskih padavin v Sloveniji. Postaje z najvišjo variabilnostjo prevladujejo v zahodni in južni Sloveniji, v Prekmurju in deloma v Posavskem hribovju. Vzporednic med prostorsko razporeditvijo višine jesenskih padavin in njihovo variabilnostjo ni možno potegniti. Drugače je z zimskimi padavinami, ki izstopajo po najvišji sezonski variabilnosti (povprečje skoraj 40 %), kar povezujemo, kot smo že omenili, s spremembami sredozemske ciklogeneze. Vpliv slednje je v Sloveniji najbolj očiten v zahodnih delih, še posebej v območju alpsko-dinarske pregrade, kjer so v njenih zahodnih in severnih delih skoncentrirane tudi padavinske postaje z najbolj variabilnimi zimskimi padavinami. Alpsko-dinarska pregrada je pozimi najbolj namočen predel Slovenije z višino padavin med 300 in 800 mm; za primerjavo: severovzhodna Slovenija jih prejme tudi pod 150 mm (Zimska povprečna višina …, 2024). Najmanjšo zimsko variabilnost ima jugovzhodni del Slovenije, tudi nekatera območja, ki ležijo neposredno v zavetrju dinarske pregrade (Novi Lazi, Kočevske Poljane, Sinji Vrh). Zimske padavine variirajo v razponu med 50,6 % (Soča) in 23,9 % (Brod v Podbočju v dolini spodnje Krke; variacijski razmik 26,7 %).

Slika 6: Povprečna sezonska relativna variabilnost padavin v Sloveniji v obdobju 1991–2020.



Vir podlage: GURS, 2024.
Kartografija: Lena Kropivšek Oddelek za geografijo UL FF, 2024.

4 SKLEP

Mreža padavinskih postaj v Sloveniji je gosta, ena postaja na dobrih 100 km^2 ozemlja, in v zadostni meri pokriva vse njegove geografske, tudi podnebne značilnosti. Določen manko postaj je v severovzhodni, južni Sloveniji in z vidika padavinskih gradientov tudi v gorskem svetu. Zaradi velikih razlik v višini padavin med posameznimi območji Slovenije, na skrajnem severovzhodu jih je v obdobju 1991–2020 letno padlo pod 900 mm, na skrajnem jugozahodu pod 1000 mm in v območju alpsko-dinarske pregrade med 1500 in več kot 3000 mm (ARSO, 2021), smo kot mero variabilnosti izbrali srednjo relativno variabilnost, ki omogoča primerjavo med območji z velikimi razlikami v višini padavin. Največjo pozornost smo posvetili srednji letni relativni variabilnosti, ki smo jo izračunali za vseh 174 padavinskih postaj. Za 37 reprezentativnih postaj za posamezne naravne enote, podnebne tipe in padavinska območja Slovenije smo analizirali tudi srednjo sezonsko relativno variabilnost. Za prostorsko interpolacijo srednje letne relativne variabilnosti je bil uporabljen J-Besselov model metode *Universal Kriging*. Podatkov sezonske variabilnosti zaradi premajhnega števila analiziranih padavinskih postaj in s tem povezane prevelike napake ocene nismo interpolirali. Metoda *Universal Kriging* spada med osnovne in najpogosteje uporabljene interpolacijske metode pri prikazovanju okoljskih podatkov, ki daje dobre rezultate pri gosti in enakomerno razporejeni točkovni mreži. Zlasti slednje za mrežo padavinskih postaj in podatkov zanje za Slovenijo v celoti ne drži. Z uporabo novejših, npr. Bayesovih metod empiričnega Bayesovega *Kriginga*, ki nadgrajujejo obstoječe metode *Kriginga* z uporabo modela intrinzične naključne funkcije, bi bil prostorski prikaz variabilnosti padavin v Sloveniji kakovostnejši. Mnenja pa smo, da je tudi obstoječi prikaz dovolj zanesljiv za ugotavljanje regionalnih razlik v variabilnosti letnih padavin pri nas.

Relativna variabilnost povprečne letne višine padavin se v Sloveniji po podatkih za obdobje 1991–2020 giblje med 8,4 in 17,9 %, s srednjo vrednostjo nekaj nad 12 %. Variabilnost se je v primerjavi z obdobjem 1961–1990 (Čotar, 2024) povečala za 1,3 %. Povečanje ni veliko in ga lahko imamo glede na raziskave Furlana (1961) za čas pred 2. svetovno vojno, ko je bila variabilnost še nekoliko višja, za običajno nihanje tega pojava. Nimamo pravih argumentov za trditev, da je povečanje variabilnosti v zadnjem obdobju posledica povečevanja ekstremnih padavinskih dogodkov, čeprav nekatere raziskave kažejo, da se npr. število dni s padavinami nad 30 oziroma 50 mm v Sloveniji na splošno povečuje (Mužina, 2024).

Prostorska slika letne relativne variabilnosti za obdobje 1991–2020 kaže, da je variabilnost največja v zahodnem in skrajnem severovzhodnem delu Slovenije, podpovprečna za slovenske razmere pa v vzhodnem delu osrednje Slovenije. V primerjavi z obdobjem 1961–1990 se je variabilnost padavin povečala v zahodnem delu države, zmanjšala v vzhodnem in severovzhodnem, območje z manjšo variabilnostjo pa se je razširilo in pomaknilo iz osrednje Slovenije proti vzhodu. Sledilo je razširitvi zmerno sredozemskega padavinskega režima, natančneje, v tem delu Slovenije so padavine med letom enakomerneje razporejene in je razlika med jesenskim in poletnim viškom padavin manjša. Kljub temu pa se prostorske razporeditve variabilnosti ne da zanesljivo povezati z razporeditvijo podnebnih tipov, z razporeditvijo letne višine padavin in z razporeditvijo padavinskih režimov. Postaje znotraj posameznih podnebnih tipov, s približno enako letno vsoto padavin ali podobnim padavinskim režimom, imajo lahko različno variabilnost. Do podobne ugotovitve glede povezave variabilnosti in prostorske razporeditve letnih padavin je za Hrvaško prišel tudi Maradin (2011), medtem ko je glede padavinskega režima ugotovil, da je variabilnost večja v južnih delih Hrvaške, ki ima manj padavinskih dni in izrazitejše poteze maritimnega padavinskega režima z viškom padavin pozimi.

Če upoštevamo prostorsko razporeditev srednje letne relativne variabilnosti padavin za obe obravnavani obdobji, lahko postavimo domnevo, da so letne padavine v Sloveniji najbolj stabilne v osrednjih delih države, kjer sta oba viška padavin približno izenačena in prihaja do izrazitejšega prepletanja vzrokov za viške padavin pri obeh režimih: (sredozemske) ciklogeneze, ki je z orografskim dodatkom glavni vir padavin v hladni polovici leta v zahodni in južni Sloveniji, ki ima zmerno sredozemski padavinski režim, ter različnih meteoroloških razmer, ki privedejo do močnejše konvekcije v topli polovici leta, ki ima večji vpliv na padavine na vzhodu in severovzhodu Slovenije z zmerno celinskim padavinskim režimom. Nakazuje se tudi sklep, da so padavine najbolj variabilne na zahodu oziroma vzhodu in severovzhodu Slovenije, kjer ima na nastanek padavin večji vpliv le en dejavnik.

Pri sezonski variabilnosti izrazito izstopa zima s povprečno variabilnostjo nekaj manj kot 40 %, kar je skoraj dvakratnik spomladanske ali poletne variabilnosti. Nekoliko večja, 25 %, je variabilnost jesenskih padavin. Zima je letni čas, ko v Sloveniji, ne glede na podnebni tip ali padavinski režim, količinsko pade najmanj padavin. Večjo variabilnost zimskih padavin (delno tudi jesenskih) pojasnjujejo v literaturi (npr. Milošević in sod., 2016; Sušelj, Bergant, 2006 idr.) s spremembami sredozemske ciklogeneze, predvsem nad Genovskim zalivom, ki je poglavitni vir padavin za Slovenijo v hladni polovici leta. V topli polovici leta na padavine v večji meri ne vplivajo atmosferske cirkulacije, ampak lokalni dejavniki za njihov nastanek, npr. vpliv reliefa na konvekcijo ipd.

Prostorski vzorec razporejanja sezonske variabilnosti padavin zaradi manjšega števila analiziranih padavinskih postaj, kljub njihovi reprezentativnosti za različne podnebne tipe, prostorsko razporeditev padavin in padavinske režime, ni povsem zanesljiv in ne kaže enotne podobe. Iz analiziranih podatkov izhaja, da so spomladanske padavine najbolj variabilne na zahodu in vzhodu države, poletne v jugozahodni in deloma vzhodni Sloveniji, jesenske v zahodnem, južnem in severovzhodnem delu ter na območju Posavskega hribovja, pozimi pa izrazito na zahodu Slovenije, kjer je vpliv sredozemske ciklogeneze najbolj izrazit.

Raziskava ponuja dober vpogled v variabilnost padavin v Sloveniji v zadnjem standardnem klimatološkem obdobju, še posebej letne višine padavin. Bolj verodostojno sliko v obmejnih območjih bi dobili z vključitvijo padavinskih postaj v sosednjih državah, pri sezonski variabilnosti tudi z vključitvijo vseh padavinskih postaj, za katere so na razpolago podatki. Dodatna pojasnila o spremenljivosti padavin bi tudi dobili, če bi ob višini padavin upoštevali še število dni s padavinami, kar je pomembno predvsem v območjih z manj padavinami, na kar opozarjajo tudi nekatere študije (npr. Juras, 1995, cit. po Maradin, 2014).

Viri in literatura

ARSO [Agencija Republike Slovenije za okolje], 2021. Podatki o mesečni in letni višini padavin za Slovenijo v obdobju 1991–2020; zemljevid povprečne letne višine padavin za obdobje 1991–2020. Ljubljana: Agencija Republike Slovenije za okolje.

Brugnara, Y., Maugeri, M., 2019. Daily precipitation variability in the southern Alps since the late 19th century. International Journal of Climatology, 39, 8, str. 3492–3504. DOI: 10.1002/joc.6034.

Columbia University Mailman School of Public Health, 2024. Kriging interpolation. URL: https://www.publichealth.columbia.edu/research/population-health-methods/kriging-interpolation (citirano 23. 1. 2024).

Criado-Aldeanueva, F., Soto-Navarro, J., 2020. Climatic indices over the Mediterranean Sea: A review. Applied Sciences, 10. DOI: 10.3390/app10175790.

Čotar, A., 2024. Primerjava variabilnosti padavin v Sloveniji med obdobjema 1961–1990 in 1991–2020. Diplomsko delo. Ljubljana: Oddelek za geografijo, Filozofska fakulteta, Univerza v Ljubljani.

ESRI, 2024a. An overview of the Interpolation toolset. ArcGIS Pro. URL: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/an-overview-of-the--interpolation-tools.htm (citirano 10. 1. 2024).

ESRI, 2024b. Comparing interpolation methods. ArcGIS Pro. URL: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/comparing-interpolation--methods.htm (citirano 11. 1. 2024).

ESRI, 2024c. How Kriging works. URL: https://pro.arcgis.com/en/pro-app/latest/tool-reference/3d-analyst/how-kriging-works.htm (citirano 30. 1. 2024).

Formeta G., Sadegni, S., Kam, J., Tootle G., 2021. Atlantic Ocean variability and European Alps winter precipitation. Water, 13, 3377. DOI: 10.3390/w13233377.

Furlan, D., 1955. Padavine v Sloveniji. Doktorska disertacija. Ljubljana: Oddelek za geografijo, Filozofska fakulteta, Univerza v Ljubljani. URL: http://www.dlib.si/?URN=URN:NBN:SI:DOC-FSG7GP7R (citirano 8. 11. 2023).

Furlan, D., 1961. Padavine v Sloveniji. Geografski zbornik, 6, str. 5–160. URL: (citirano 9. 11. 2023).

Juras, J., 1995. Metode za procjenu vremenske promjenljivosti količina oborina. Doktorska disertacija. Zagreb: Prirodoslovno-matematična fakulteta, Univerza v Zagrebu.

Kobal, M., 2022. Prostorska variabilnost sezonske količine padavin v Sloveniji v obdobju 2010–2019. Acta Silvae et Ligni, 127, str. 39–49. DOI: 10.20315/ASetL.127.3.

Kriging, 2024. ScienceDirect. URL: https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/kriging (citirano 10. 11. 2024).
Maradin, M., 2011. Geografski aspekt razlika u varijabilnosti padalina kontinentskog i maritimnog pluviometrijskog režima u Republici Hrvatskoj. Doktorska disertacija. Zagreb: Oddelek za geografijo, Prirodoslovno-matematična fakulteta, Univerza v Zagrebu.
Maradin, M., Madžar, I., Perutina, I., 2014. Geografska raspodjela varijabilnosti padalina u Hrvatskoj i Bosni i Hercegovini. Hrvatski geografski glasnik, 76, 2, str. 5–26.
Miletić, M., Vuletić, J., 2023. Statistical analysis of the mean relative variability of monthly, seasonal and annual precipitation at the main synoptic stations in the south Morava sub-basin to the Korvingrad hydrological station. Collection of Papers – Faculty of Geography at the University of Belgrade, 71, str. 79–90.
Milošević, D., Savić, S., Pantelić, M., Stankov, U., Žiberna, I., Dolinaj, D., Leščešen, I., 2016. Variability of seasonal and annual precipitation in Slovenia and its correlation with large-scale atmospheric circulation. Open Geosciences, 8, 1, str. 593–605. DOI: 10.1515/geo-2016-0041.
Mooney, S., J., Bader, M., D., Lovasi, G., S., Neckerman, K., M., Rundle, A., G., Teitler, J., O., 2018. Using universal kriging to improve neighborhood physical disorder measurement. Sociological Methods & Research. 49, 4, str. 1163–1185. DOI: 10.1177/0049124118769103.
Mužina, G., 2024. Trendi intenzivnih padavin v Sloveniji v obdobju 1961–2020. Diplomsko delo. Ljubljana: Oddelek za geografijo, Filozofska fakulteta, Univerza v Ljubljani.
Ogrin, D., 2024. Nekateri vidiki spreminjanja podnebja na Slovenskem v instrumentalnem obdobju. V: Lampič, B., Ogrin, D. (ur.). Ljudje in okoljske spremembe skozi čas. Ljubljana: Založba Univerze v Ljubljani, str. 81–110.
Ogrin, D., Repe, B., Štaut, L., Svetlin, D., Ogrin, M., 2023. Podnebna tipizacija Slovenije po podatkih za obdobje 1991–2020. Dela, 59, str. 5–89. DOI: 10.4312/dela.59.5-89.
Poletna povprečna višina padavin 1981–2010. URL: https://meteo.arso.gov.si/met/sl/climate/maps/seasonal-mean-precipitation-maps/ (citirano 14. 9. 2024).
Pomladna povprečna višina padavin 1981–2010. URL: https://meteo.arso.gov.si/met/sl/climate/maps/seasonal-mean-precipitation-maps/ (citirano 14. 9. 2024).
Sen, A., K., Ogrin, D., 2015. Analysis of monthly, winter, and annual temperatures in Zagreb, Croatia, from 1964 to 2010: the 7.7-year cycle and the North Atlantic Oscillation. Theoretical and Applied Climatology. DOI: 10.1007/s00704-015-1388-z.
Sušelj, K., Bergant, K., 2006. Sredozemski oscilacijski indeks in vpliv na podnebje Slovenije. Raziskave s področja geodezije in geofizike: zbornik predavanj, str. 101–110.
Vertačnik, G., Vičar, Z., Bertalanič, R., 2016. Podnebna spremenljivost Slovenije v obdobju 1961–2011, 2 Kontrola in homogenizacija podatkov. Ljubljana: Agencija RS za okolje.
Vertačnik, G., Bertalanič, R., 2017. Podnebna spremenljivost Slovenije v obdobju 1961–2011, 3 Značilnosti podnebja Slovenije. Ljubljana: Agencija RS za okolje.

Zimska povprečna višina padavin 1981–2010. URL: https://meteo.arso.gov.si/met/sl/climate/maps/seasonal-mean-precipitation-maps/ (citirano 26. 9. 2024).

Zveryaev, I., I., 2004. Seasonality in precipitation variability over Europe. Journal of Geophysical Research - Atmospheres, 109. DOI: 10.1029/2003JD003668.

MEAN RELATIVE PRECIPITATION VARIABILITY IN SLOVENIA FOR THE PERIOD 1991–2020

Summary

Precipitation levels vary significantly across Slovenian regions. In the extreme northeast, annual precipitation during the period 1991–2020 was less than 900 mm, while in the extreme southwest it was below 1000 mm. In the alpine-dinaric barrier, annual totals ranged between 1500 mm and over 3000 mm. To account for these considerable regional disparities, mean relative precipitation variability was chosen as a measure, facilitating comparison between areas with large differences in precipitation amounts. The primary focus was placed on the mean annual relative variability, calculated for all 174 precipitation stations. Additionally, mean seasonal relative variability was analyzed for 37 representative stations. For spatial interpolation of mean annual relative variability, the J-Bessel model of the Universal Kriging method was employed. Due to the limited number of precipitation stations analyzed and the resulting high estimation error, no interpolation was conducted for seasonal variability.

For the period 1991–2020, the relative variability of average annual precipitation in Slovenia ranged between 8,4 % and 17,9 %, with a mean value slightly above 12 %. This represents a 1,3 % increase compared to the 1961–1990 period. When comparing the periods 1961–1990 and 1991–2020 with the 16-year period 1925–1940, analyzed by Furlan (1961) for 36 precipitation stations, it becomes evident that pre-World War II variability was slightly higher, around 15 %.

The highest annual relative variability during 1991–2020 was observed in the western and far northeastern parts of Slovenia, while in the eastern part of central Slovenia, it was below the national average. Compared to the period 1961–1990, precipitation variability increased in the western part of the country and decreased in the eastern and northeastern regions. The area of lower variability shifted from central Slovenia towards the east. The spatial distribution of variability does not reliably correlate with climate types, total annual precipitation amounts, or precipitation regimes. Sites within the same climate type, with similar annual precipitation amounts or precipitation regimes, may exhibit varying degrees of variability.

Winter stands out significantly in terms of seasonal variability, with an average just below 40 %. This is nearly twice as high as the variability observed in spring and summer. Autumn precipitation variability is slightly higher, at 25 %. Winter is the season with the least precipitation in Slovenia, regardless of climate type or precipitation regime. The increased variability in winter precipitation can be attributed to changes in Mediterranean cyclogenesis, which is the primary source of precipitation for Slovenia during the cold half of the year. In the warm half of the year, precipitation is less influenced by atmospheric circulations and more by local factors, such as orographic effects on convection.

The spatial distribution of seasonal precipitation variability is less reliable due to the small number of analyzed precipitation stations and does not provide a consistent pattern. The data indicate that spring precipitation variability is highest in the western and eastern parts of the country, summer precipitation in southwestern and parts of eastern Slovenia, and autumn precipitation in the west, south, and northeast. Winter precipitation is most variable in western Slovenia, where the influence of Mediterranean cyclogenesis is strongest.

Martina Jakovčić*, Karlo Mak**

RE-MAPPING ZAGREB'S URBAN SPACE: IN SEARCH FOR GAY RESIDENTIAL CORE

COBISS 1.01
DOI: 10.4312/dela.61.99-119

Abstract

Areas with a higher concentration of queer population are a well-established feature of the spatial structure in major cities across the Global North. However, there is a conspicuous lack of research on queer population within post-socialist cities. This paper addresses this gap by exploring the possibility of a higher concentration of queer men population in the Croatia's capital, Zagreb. Based on the analysis of various spatial datasets, we assumed the existence of a queer men's residential core in Zagreb, described its position within the city's spatial structure, and examined the spatial dynamics of its development. Our findings reveal that the urban geography of Zagreb is less heterosexual than is usually perceived. Additionally, we demonstrate how the global patterns of the queer community spatialization have adapted within the post-socialist context with all its local specificities that enabled the unique integration of queer man spaces into Zagreb's post-socialist urban structure.

Keywords: queer residential core, pink consumption, Zagreb, post-socialist city

*Department of Geography, Faculty of Science, University of Zagreb, Trg Marka Marulića 19, 10000 Zagreb, Croatia
**Antun Gustav Matoš Grammar School, Andrije Hebranga 26, 10430 Samobor, Croatia
e-mail: mjakovci@geog.pmf.hr, karlo.mak2@skole.hr
ORCID: 0000-0001-5555-4383 (M. Jakovčić), 0000-0001-7058-0299 (K. Mak)

KARTIRANJE ZAGREBŠKEGA URBANEGA PROSTORA: V ISKANJU GEJEVSKEGA REZIDENČNEGA JEDRA

Izvleček

Območja z večjo koncentracijo kvirovske skupnosti so uveljavljena značilnost prostorske strukture večjih mest na globalnem severu. Vendar pa obstaja pomanjkanje raziskav o kvirovski skupnosti v postsocialističnih mestih. Članek želi odpraviti omenjeno vrzel, saj raziskuje možnost večje koncentracije moške kvirovske populacije v hrvaški prestolnici Zagrebu. Na podlagi analize različnih zbirk prostorskih podatkov smo predpostavili obstoj rezidenčnega jedra kvirovskih moških v Zagrebu, opisali njegov položaj v prostorski strukturi mesta in preučili prostorsko dinamiko njegovega razvoja. Naše ugotovitve kažejo, da je urbana geografija Zagreba manj heteroseksualna, kot se zdi na prvi pogled. Poleg tega smo pokazali, kako so se globalni vzorci prostorske organizacije kvirovske skupnosti prilagodili postsocialističnemu kontekstu in njegovim lokalnim posebnostim, ki so omogočile edinstveno integracijo kvirovskih moških prostorov v postsocialistično urbano strukturo Zagreba.

Ključne besede: kvirovsko stanovanjsko jedro, rožnata potrošnja, Zagreb, postsocialistično mesto

1 INTRODUCTION

The queer consumption places[1] in Zagreb mainly concern the consumption entertainment system and are concentrated in the wider city center. Their distribution roughly coincides with the greater spatial concentration of gay dating applications users (Mak, Jakovčić, 2023). Considering that the spatialization of the queer community[2] in the West originated primarily in gay clubs (Collins, Drinkwater, 2017; Lugosi, 2007; Mattson, 2015), queer geographies provide a useful framework for understanding the role of space and place in the production of sexual identities and communities. This concept highlights how spaces such as gay clubs, have shaped queer identities and communities, while also highlighting the impact of these spatial relationships on social justice (Mayhew, 2023). This paper aims to examine the existence of a concentration

1 Although there is no consensus on the appropriate terminology to describe queer consumption, Mak and Jakovčić (2021) suggest the term "pink consumption" due to its broad applicability. Other terms, such as "LGBT consumption" or "queer consumption," either do not encompass all gender and sexual minorities or, while comprehensive, imply additional meanings that can be somewhat confusing. Therefore, later in this paper we adopt the term "pink consumption". We define pink consumption places as those specifically intended for queer people and/or that communicate openness to and welcome queer communities (Mak, Jakovčić, 2023).

2 The term "queer" is used as an umbrella term for all sexual and gender minorities, without implying any additional meanings.

of queer male population, i.e. of a residential core of queer men in Zagreb. We hypothesize that a higher concentration of pink consumption places leads to a higher concentration of user profiles on gay dating applications, and that the above indicators potentially point to a higher concentration of queer men. By confirming the hypothesis, we would be contributing to what Collins and Drinkwater (2017) call the re-mapping of social space with clear indications that it is less heterosexual than is commonly assumed. Research on the spatialization of queer communities is well-documented in Western societies (Clement, 2022; Ghaziani, 2022; Gorman-Murray, Nash, 2017; Hess, Bitterman, 2021; Howard, 2013; Podmore, Bain, 2021; Poltz, 2022). However, similar studies are lacking in the context of post-socialist cities. Using Zagreb as a case study, we aim to address this gap in literature. In the paper we will try to determine: 1) the residential core of queer male population in Zagreb; 2) the timing of its emergence and 3) the spatial dynamics of its development.

2 SPATIALIZATION OF THE QUEER COMMUNITY

2.1 Spatialization of the queer community in the West

In the initial phase of queer spatialization at the beginning of the 20th century, key gathering points were pink consumption places, such as gay clubs, pubs, and bars—almost the only public venues where queer people could meet each other and spend their free time (Collins, Drinkwater, 2017; Lugosi, 2007; Mattson, 2015). Although these places were usually located in less safe neighborhoods and subject to police raids, pink consumption places provided greater safety than any other public space. This safety enabled the formation of the core of the spatialization of the queer community (Hinrichs, 2021).

Gay neighborhoods emerged around pink consumption places as queer residential areas. They were mostly located in the immediate vicinity of city centers. The shift of queer community spatialization toward the city center is the result of several interwoven processes, with suburbanization and deindustrialization being key factors (Gorman-Murray, Nash, 2017). The spatialization of the queer community has thus evolved alongside urban development, taking into account the particularities of each case. For example, in 1930s San Francisco, suburbanization was accompanied by the reinforcement of heteronormative sexuality through more favorable loan conditions and housing subsidies for (heterosexual) married couples with children. At the beginning of the 1940s, this policy was further strengthened and, together with the post-war baby boom, contributed to the acceleration of the suburbanization process. Unmarried and queer people were simultaneously excluded from these benefits. As a result, the USA inadvertently encouraged changes in the demographic and sexual urban geography (Howard, 2013), as poorer population with different socio-demographic characteristics remained in the cities.

At the same time, the deindustrialization process caused commercial and residential property prices to fall (Gorman-Murray, Nash, 2017). This reinforced conditions for a greater spatial concentration of people of lower socioeconomic status. In such circumstances, gay neighborhoods began to form, usually located in abandoned and/or undesirable spaces near city centers, where real estate and rents were cheap(er) (Hess, Bitterman, 2021).

The gay neighborhoods not only marked the beginning of residential gathering for queer people, but also created more favorable conditions for the establishment of queer businesses and the emergence of new places and forms of pink consumption (Poltz, 2022). This was a prerequisite for entering the mature development phase of queer community spatialization. The gentrification process transformed gay neighborhoods from marginal areas, often resembling slums at the beginning of their development, into commercially successful districts organized around pink consumption and predominantly inhabited by an increasingly affluent queer community, as seen in West Hollywood, Greenwich Village in New York City, or Castro in San Francisco (Poltz, 2022).

However, gentrification did not stop there. In the next stage, it led to a dispersal of the queer population due to rising housing prices. With the increasing social acceptance of sexual and gender minorities, gay neighborhoods ceased to function as a spatial response to experienced oppression. At the same time, technological developments meant that gay neighborhoods were no longer crucial for queer socialization, as the widespread use of the internet created a new, virtual space for sociability. Gentrification also led to changes in socioeconomic conditions, resulting in decreased investments from queer people in the businesses of pink commercial facilities, which contributed to a wave of their closure (Hess, Bitterman, 2021). For instance, in London, over fifty percent of these venues closed between 2006 and 2016 (Ghaziani, 2022). Simultaneously, more queer-friendly people from wealthier social strata moved into gay neighborhoods (Clement, 2022). Thus, gay neighborhoods contributed to reurbanization, urban revitalization, and changed social attitudes towards queer people. Yet, they also became unaffordable to the queer community itself—the very community that created and transformed them (Poltz, 2022).

2.2 Spatialization of the queer community in Zagreb

The spatialization of the queer community in Zagreb does not coincide chronologically with that of the West. Nor can it be concluded that it follows the development patterns of pink consumption in post-socialist Europe, since the spatialization of the queer community there only took place at the very end of the socialist period. Even then, queer spatialization was limited to less publicly visible places and the first Pride parades (Burmaz, 2014; Dimitrov, 2014; Lorencova, 2006; Pitonak, 2022; Stella, 2013). However, (post)socialist cities and societies were marked by common development obstacles to the emergence of pink consumption. First, the socialist elites' disdain for capitalism, consumption, and consumer society in general, as well as state control over the economy during socialism, made the emergence of pink consumption places impossible, as they are hardly possible without a free market. Secondly, with an emphasis on industrialization, there was an intensive migration of the population to cities, urbanization in post-socialist Central and Eastern Europe was gaining momentum at the same time as the cores of gay neighborhoods were forming in the West due to deindustrialization and suburbanization. Thirdly, just as pink consumption cannot develop without a free market, the democratic deficit of socialist societies did not support it either. The repressive state apparatus made it impossible to organize the queer movement almost until the collapse of socialism. It is true, the repressive apparatus also hindered a freer development of the queer movement in the West, but it was significantly weakened from the end of the 1960s (Pitonak, 2022).

In any case, the development of pink consumption and the spatialization of Zagreb's queer community cannot be understood within the Western European or Anglo-American framework. Similarly, the experiences of Central and Eastern Europe cities are modest and do not provide an adequate basis for comparison. Therefore, considering local specificities emerges as the only reasonable option. There are important differences that distinguish Zagreb from most other post-socialist European cities, making it possible to discuss the development of pink consumption places, and thus about the beginnings of the spatialization of queer community even during socialism.

First, Yugoslav society was freer and more consumer-oriented than the rest of socialist Europe. The song *Tata kupi mi...* [*Dad, buy me...*] by Ivo Robić and Zdenka Vučković from 1957, which openly celebrates consumption, could never become a hit in a society lacking a consumer mentality. In addition, in the late 1950s and early 1960s, personal consumption in Yugoslavia grew by more than 10 % per year (Duda, 2004). On the other hand, while most of Central and Eastern European countries experienced increased political opportunities after the collapse of socialism—leading to the rise of activism and the creation of the first queer organizations (Darakchi, 2019; Francoeur, Noonan, 2003; Mikulak, 2019; Pitonak, 2022)—Croatia was drawn into armed conflict, during which conservatism and traditional values were reinforced (Bilić, Stubbs, 2015). It is precisely for this reason that the democratization of society, i.e. greater acceptance of the queer community, took place later. Not so much in parallel with the economic transition, but much more during the Croatia's accession to the European Union (Bilić, Stubbs, 2016; Čemažar, Mikulin, 2017). The lengthy EU accession negotiations played a key role in improving the legal standing of the queer community in Croatia and mitigating the effects of the re-traditionalization of society in the 1990s. Therefore, it is also difficult to draw parallels with the rest of the post-Yugoslav societies, as most of them are still not part of the EU, while Slovenia, which is already a member, did not experience war on such a scale and duration in the 1990s.

Based on this, we argue that the development of pink consumption and the process of spatialization of the queer community in Zagreb are completely specific and different from other cases in post-socialist Europe.

To explain why gay neighborhoods never formed in Zagreb, we compare its urban development with that of American cities, as the spatialization of the queer community is best documented in the US. We have seen that the processes of deindustrialization and suburbanization significantly contributed to the emergence of gay neighborhoods in the US after the Second World War. However, intensive urbanization stimulated by industrial development took place in Zagreb in the same period (Vresk, 1997). Socialist societies focused their economic development on traditional industry for much longer than was economically viable, which delayed the deindustrialization and suburbanization processes (Pacione, 2009). The suburbanization of Zagreb only began in the 1970s, and was driven in a planned manner—by the decentralization of city functions. This process intensified in the 1980s, when the Zagreb agglomeration entered the phase of relative decentralization of housing (Vresk, 1997), while in the 1990s, absolute decentralization of its population development occurred (Bašić, 2005).[3]

The increasing depopulation and functional transformation of the central parts of Zagreb since the 1970s (Vresk, 1997), did not lead to the spatialization of the queer community. The relatively homogenous socio-spatial structure (Prelogović, 2004) prevented the formation of a concentration of cheap(er) residential buildings as gathering place for poorer and/or oppressed social groups. Furthermore, the economic basis on which gay neighborhoods could function could hardly exist under the conditions of a planned economy (Pacione, 2009). Socio-legal circumstances also did not favor the creation of pink consumption places and spatialization of the queer community, as (male) homosexuality was only decriminalized in 1977 (Vouk Nikolić, 2022), and socialism inherited the practice of conservative bourgeois moralization from the period that preceded it, and therefore sexuality, especially minority sexuality, was taboo (Béres-Deák, 2022). Of course, this does not mean that the queer community did not exist prior to the end of socialism; but rather that it was not officially recognized and often remained "hidden" from public view.

Although the LGBT movement in Zagreb and the rest of Yugoslavia began to develop at the end of the 1980s, its progress was abruptly halted in the 1990s due to the war, rising homophobia, and growing conservatism (Stepanović, 2022; Vouk Nikolić, 2022). The transition process from a planned to a market economy also resulted in changes in the socio-spatial structure of the city, with increasing social polarization being the most notable shift (Prelogović, 2004). However, unlike in Anglo-American

3 The relative decentralization of housing in the city region means that the growth of the population in the surrounding area is relatively higher than the growth in the population of the home city (Vresk, 1997). Similarly, the absolute decentralization of housing implies an absolute greater increase in the number of inhabitants of the surrounding area compared to the home city.

and Western European cities, the population of higher socioeconomic status was concentrated in the central parts of Zagreb (Prelogović, 2009).

Following the development of gay neighborhoods in the US, this would suggest that space for the concentration of the LGBT population (cheaper housing, lower socioeconomic status) opened up on the outskirts of the city—where new planned residential areas emerged after 2000, similar to abandoned industrial sites (Mlinar, 2009). However, given the traditional inhospitality of the city's periphery towards sexual and gender minorities, and the significantly lower population density, such a concentration was unlikely to occur.[4] Additionally, Zagreb experienced a different historical and geographical development compared to Western cities. While post-industrial cities emerged in Western societies as early as the 1970s, shifting from manufacturing to service sector development (Backović, 2005), in post-socialist cities, significant and rapid changes in the retail and service sectors only became noticeable in the 1990s. Thus, the economic transition played a key role in changing the socio-spatial structure of Zagreb (Prelogović, 2004; 2009), leading to increased commercialization of the city center, the expansion of the central business district and a certain degree of gentrification (Slavuj, Cvitanović, Prelogović, 2009). This post-socialist development also led to the belated emergence of pink consumption places as a basis for the spatialization of the Zagreb's queer community.

3 METHODOLOGY

The lack of official statistical data is a common problem in research concerning the queer population and significantly limits the understanding of the characteristics of this social group.[5] Since official statistics in Croatia also do not track sexual and gender minorities, the spatial distribution of the queer population can only be estimated. We will base the reconstruction on the application of several different datasets that more or less directly concern the queer male community. First, during May and June 2021, data on pink consumption places in Zagreb was collected through 14 semi-structured interviews.[6] The initial respondents were provided by the Zagreb-based queer organizations "Zagreb Pride" and "Iskorak," while the sample was expanded using the snowball sampling technique. Second, data on the

4 After all, the socio-spatial structure of a city has not proven to be a key factor in the concentration of the queer population. Amsterdam for example, has a relatively even socioeconomic spatial distribution of the population, and no clustering of queer people in residential areas has been observed (Poltz, 2022). Therefore, it can be argued that gentrification in Zagreb has occurred in opposition to the queer movement, and not as a result of it, as it was the case in the US.

5 Western countries are increasingly successful in collecting data on the sexuality of their population, either through national surveys of a large sample, as in the USA (Conron, Goldberg, 2020), or through questions in census questionnaires as in England and Wales (Barton, 2023). None of these methods have yet been used in Croatia.

6 The Interviews were part of a wider research conducted in preparation for a doctoral thesis. For this work, only data on the location of pink consumption places were used. Only 29 of them were recognized.

spatial distribution of the profiles of its users was collected using the queer men dating application Romeo in the spring of 2022.[7] The two datasets were also used in the study by Mak and Jakovčić (2023). Although previous research has shown that pink consumption places are central to the spatialization of queer communities, we do not claim that the Romeo application users set the location to their actual place of residence. To better identify the core of the queer male population, we used data from 2021 Census on the marital status of the population specifically focusing on never-married men.[8] Comparing city neighborhoods where the proportion of never-married men exceeds the city average with neighborhoods that show a higher concentration of Romeo application user profiles could support the thesis regarding a potential core of the queer male population. Similar data also exists for the 2001 and 2011 censuses, based on the current administrative division of the City of Zagreb.[9] Finally, if the data on the spatial distribution of never-married men, serves at least partially as evidence of the queer male population, it should reflect the general distribution of population density. High population density is a key factor for queer life – often even a more important factor than the total population (see for example Jubany et al., 2021) – since it allows them anonymity, which in turn provides safety and facilitates freer expression of queer identity.[10] The methodology used to delineate the queer men's residential core is only partially adequate, due to the lack of direct statistical data. As a result, all findings from this research are approximate estimates of the queer men's residential location.

7 The Romeo application allows for the collection of data on the location of its users. Although the provided locations are not entirely reliable (± 50 meters), even approximate data can be useful. However, it is important to recognize the methodological limitations of this approach. First, the Romeo application is primarily intended for queer individuals who identify as male. Second, not all queer individuals use this application, and a single individual may have multiple open profiles. Furthermore, the user's location in the app does not necessarily correspond to their actual place of residence, as individuals can manually adjust their location according to their preferences and needs. Finally, the spatial distribution of Romeo app users may be significantly influenced by tourists and other visitors to the city, rather than its residents alone, which means a higher concentration of users can typically be expected in tourist areas, especially in the historic city center.

8 This is not to imply that all never-married men are part of the queer community, nor that some married men are not part of the queer community. Regarding the available data on marital status, we opted for never-married men since previously collected data on users of dating applications concerned men. Furthermore, the research by Mak and Jakovčić (2023) found that the majority of users of pink consumption places are men.

9 Data on never-married men at the level of city neighborhoods of the City of Zagreb are also available for the year 1961. However, the administrative division at that time was significantly different, so it is not comparable with the current situation. Furthermore, due to the different migration characteristics, it is less likely that the potential "excess of never-married men" is related to the queer male population.

10 In the study by Mak and Jakovčić (2023), it was determined that the consumer shopping system is not recognized as pink at all, although it also includes very strictly controlled consumer facilities such as suburban shopping centers. However, the suburban area is marked by a significantly different population density, so visiting the shopping center entails exposure to a more hostile part of the city.

4 RESULTS AND DISCUSSION

Since we have the strongest base for the existence of a core of the queer male population in Zagreb for the most recent period, the discussion will be presented in reverse chronological order. For the period 2021–2022, we have the most comprehensive dataset, including the spatial distribution of the Romeo application users, number and spatial distribution of pink consumption places and the data on never-married men. We do not have data from dating applications for 2001 and 2022, and for earlier periods, data on pink consumption places are increasingly scarce. The further we investigate the past, the less reliable the available data becomes.

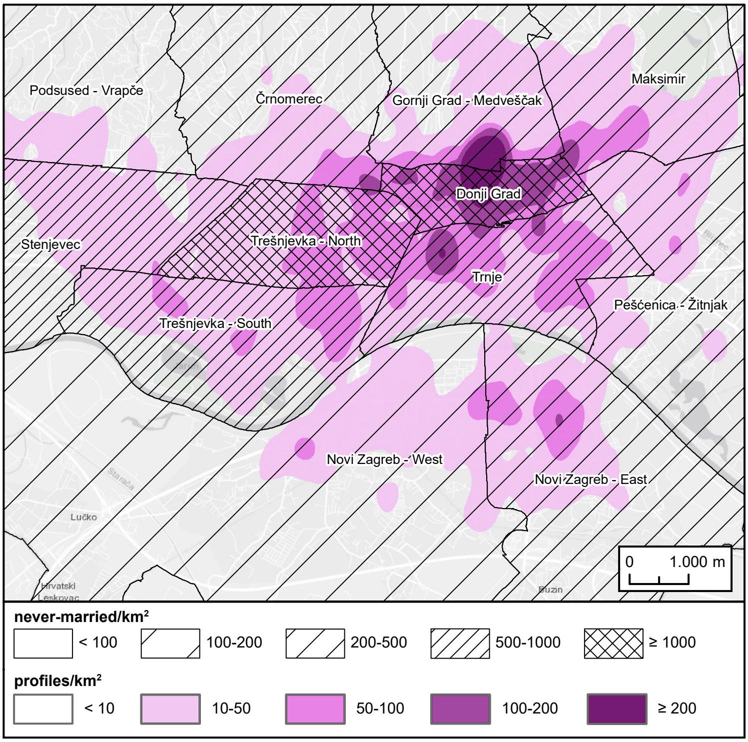
4.1 Queer men's residential core in Zagreb in the early 2020s

An analysis of the spatial distribution of Romeo app user profiles (N = 3,693) shows that their concentration is primarily in the central part of the city. This area, along with submountainous region of the Medvednica Mountain to which it is adjacent, forms a traditional residential zone of the more affluent population (Prelogović, 2009). This concentration coincides with a higher concentration of pink consumption places, and it is reasonable to assume that, for safety reasons, many Romeo application users set their location to a pink consumption place, rather than their actual place of residence.[11]

However, if Romeo users are indeed setting the location to the place of residence, it would indicate a significant concentration of queer male population in the city center. The thesis that the city's central neighborhoods truly represent the core of Zagreb's queer male population is also supported by the spatial distribution of never-married men (Figure 1). Although not entirely reliable, the method of "excess" number of never-married men seems indicative, especially when combined with other data. Therefore, it is very likely that the neighborhoods of Donji Grad (Lower Town), Trešnjevka-North and Trnje, apart from being the base of pink economic activity (Mak, Jakovčić, 2023), also serve as the residential core of Zagreb's queer male population.

11 Since most of these places are coffee shops and nightclubs, their concentration can be explained, according to the work of Skočir and Šakaja (2017), by the need for security that a central location provides. In addition, safety is considered one of the basic characteristics of pink consumption places (Kates, 2002; Pereira, Ayrosa, 2012).

Figure 1: Spatial density of never-married men (2021) and of Romeo application user profiles (2022) in Zagreb.[12]



Data sources: CBS, 2021; Romeo, 2022.

Since the early 2000s, the socio-legal position of queer people in Croatia has improved significantly (Vouk Nikolić, 2022). Despite these advancements and the established concentration of the queer male population in the city center, it remains unlikely that a spatially separated gay neighborhood will emerge in Zagreb. Western societies have shown that the liberalization of social attitudes leads to a deconcentration of the queer population. After all, Zagreb's queer men residential core coexists with the majority population of heterosexual orientation—in the very same area. It largely coincides with the most densely populated neighborhoods: Donji Grad (Lower Town),

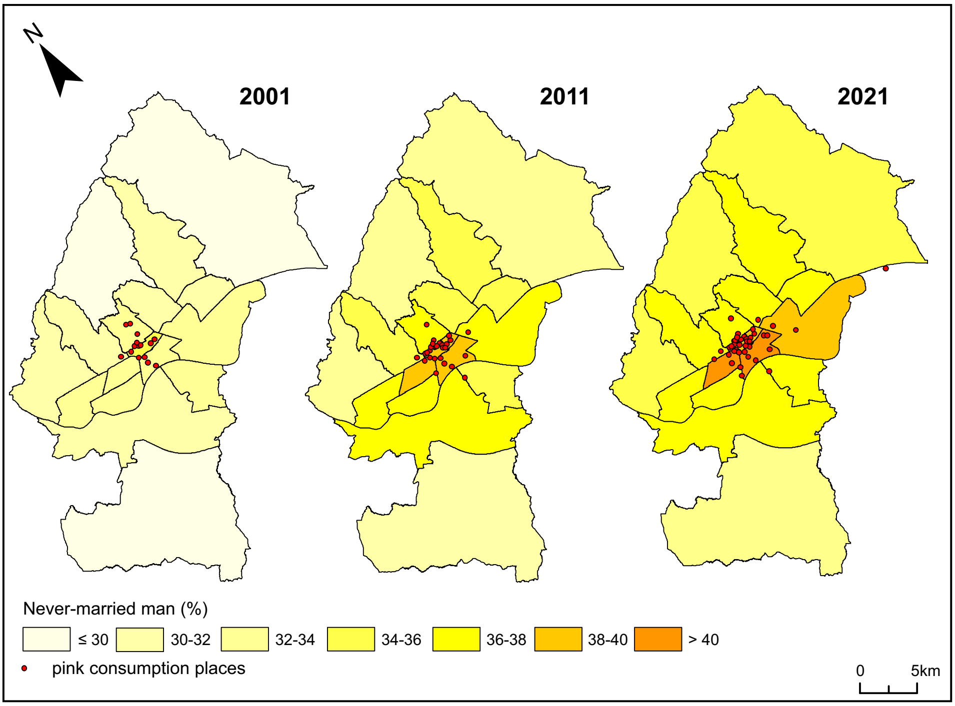
12 The mapping of Romeo application user locations extended from the city center to the outskirts until at least one new profile was found within 500 meters of the last identified profile. For this reason, some districts were not mapped at all, while others were only partially covered. Since we do not have data on Romeo app user profiles for all districts of Zagreb, we mapped their spatial density using the Kernel Density function in ArcMap. This data was then overlaid with the spatial density data of never-married men available at the district level, as this is the lowest spatial level for which data is available.

Trešnjevka-North and Trnje (CBS, 2021). Thus, population density proves to be an unusually important factor for the spatialization of the queer community in the post-socialist city, as it provides anonymity which provides (relative) safety, allows for freer expression of queer identity, and reduces social stigmatization and violence (Braun, Cleff, Walter, 2015; Clement, 2022).

4.2 Development of the queer men's spatial distribution from 1999 to 2021

We have no data to confirm that there was a pronounced concentration of the LGBT population in Zagreb in the period between 1999 and 2021. However, it was during this period that the first pink consumption places emerged that publicly communicated their openness to the queer community, which undoubtedly enabled the process of its spatialization.

Figure 2: Spatial distribution of pink consumption places and the share of never-married men by Zagreb city neighborhoods in the period 2001–2021.



Data source: CBS, 2001; 2011; 2021; interviews.

The first club in Zagreb that publicly communicated its openness towards sexual and gender minorities, i.e. the first gay club in Zagreb, was *Bad Boy* in the Ksaver neighborhood, which opened in 1999 (Štulhofer et al., 2003). As this club soon closed, the *Global* club became the key place of nightlife for LGBT people in Zagreb. In the early 2010s, there were three gay clubs in Zagreb — *g.CLUB* in Savska Street, *Rush* in Amruševa Street and *HotPot* in Petrinjska Street. Later, *Rush* was moved to Savska Street, where *g.CLUB* closed (Hermann, 2016), but due to the COVID-19 pandemic, *Rush* was also permanently closed.

Table 1: Share of never-married men in Zagreb 2001–2021.

Neighborhood	2001	2011	2021	Change 2011/2001	Change 2021/2011
Brezovica	28.95	31.43	33.09	2.48	1.66
Črnomerec	31.75	35.51	37.58	3.76	2.07
Donja Dubrava	31.88	36.16	36.27	4.28	0.11
Donji Grad	34.57	38.52	39.44	3.95	0.92
Gornja Dubrava	31.43	34.78	36.07	3.35	1.29
Gornji Grad-Medveščak	33.10	36.03	37.80	2.93	1.77
Maksimir	31.07	34.45	36.13	3.38	1.68
Novi Zagreb-East	33.12	35.05	37.46	1.93	2.41
Novi Zagreb-West	31.65	36.54	36.37	3.39	-0.17
Peščenica-Žitnjak	32.17	37.26	38.41	5.09	1.15
Podsljeme	29.16	32.07	34.15	2.91	2.08
Podsused-Vrapče	31.51	32.96	34.25	1.45	1.29
Sesvete	29.97	32.92	34.53	2.95	1.61
Stenjevec	33.27	36.13	36.51	2.86	0.38
Trešnjevka-South	33.45	36.61	37.85	3.16	1.24
Trešnjevka-North	32.49	39.51	40.88	7.02	1.37
Trnje	33.15	38.74	40.05	5.59	1.31
City of Zagreb	32.17	35.77	37.02	3.60	1.25

Data Source: CBS, 2001; 2011; 2021.

Based on the overview of the business activities of gay clubs and the data on the changing share of never-married men in Zagreb's neighborhoods (Figure 2), several observations can be made. First, the peak of Zagreb's gay club scene occurred in the early 2010s. Notably the 2011 Census showed a significantly higher increase in the share of never-married men compared to both the previous and the subsequent census (Table 1). This suggests that the emergence of pink consumption places contributed to the spatialization of the queer community in Zagreb. Additionally, this spatialization process was much more dynamic in the 2000s[13] than in the 2010s.[14]

Second, during the 2000s, there was an intra-city redistribution of the concentration of never-married men (Figure 2). A significant increase in their share was recorded in the city neighborhoods of Trešnjevka-North, Trnje and Donji Grad (Table 1), setting these areas apart from the rest of Zagreb. This indicates that they became the centers of queer male population. This distribution remained unchanged into the early 2020s, and the data presented in the previous section suggest that it has become permanent.

Finally, the decline in the number of gay clubs towards the end of the 2010s[15] coincides with a significantly slower growth in the share of never-married men during that decade. This suggests that the process of spatialization of the Zagreb queer men's community is slowing down and possibly coming to an end.

4.3 "Pre-phase" of the spatialization of queer community in Zagreb

The earliest data on the number and spatial distribution of never-married men in Zagreb are available for the year 1961. At that time, 29.6% of never-married men lived in the city. By 2001, the proportion had risen to only 32.2%. It follows that the assumed spatialization and concentration of queer male community Zagreb during this period was an extremely slow process, if it took place at all. Both today and in the early 1960s, a significantly higher concentration of never-married men was recorded in the central city neighborhoods (Donji Grad, Gornji Grad) (Table 2). However, since the territorial boundaries of Zagreb's city districts in 1961 differed from those of today, the data are not fully comparable.

---

13 The liberalization of the legal framework (e.g. the *Same-Sex Life Partnership Act* or the *Anti-Discrimination Act*) and social attitudes towards queer people, as well as the beginning of the organization of queer associations (*Iskorak, Zagreb Pride, Domino*...) and Pride parades possibly contributed to the faster growth of the number of gay clubs and the spatialization of the LGBT community.

14 The largest increase in the proportion of never-married men in the 2010s was recorded in the neighborhood of Novi Zagreb-East (+2,41 %). Based on the data on the spatial distribution of Romeo application users in 2022, it can be assumed that the increase in the proportion of never-married men in the 2010s is due (among other reasons) to the concentration of the queer population in the area (around) the Mamutica residential building (Figure 2). Mamutica is the largest residential building in Zagreb, which implies a large demographic mass and thus guarantees anonymity, which has already been noted as a very important feature when choosing a place to live for members of the queer community.

15 The decline in the number of gay clubs is not a phenomenon that occurred only in Zagreb, nor is it solely because of the COVID-19 pandemic. The dissolution of gay neighborhoods and the reduction in the number of pink consumption places is also recognized trend in Western countries as well, and it is interpreted in different ways. For example, through changes in family life for same-sex couples, which includes the adoption of children (Bitterman, Hess, 2021), the increasing acceptance of queer people that makes them feel safe even outside of exclusive queer areas, gentrification, the increase in the number of heterosexual orientation visitors to pink places and spaces, the ability of queer people to connect with each other through digital channels, and so on (Ghaziani, 2022).

Table 2: Marital status of men over the age of 15 in Zagreb municipalities in 1961.

Municipality	Total	Never-married		Married	Widowed	Divorced	Unknown
		N	%				
Črnomerec	16,368	4,995	30.5	10,456	384	470	63
Donji Grad	15,312	5,209	34.0	9,070	384	580	69
Gornji Grad	7,915	2,660	33.6	4,746	191	281	37
Maksimir	18,488	5,477	29.6	12,046	479	414	72
Medveščak	20,084	5,721	28.5	13,193	452	612	106
Pešćenica	10,212	3,118	30.5	6,597	171	247	79
Remetinec	10,267	2,406	23.4	7,379	363	88	31
Susedgrad	14,112	3,863	27.4	9,593	303	247	106
Trešnjevka	26,820	8,288	30.9	17,144	590	708	90
Trnje	18,940	5,674	30.0	12,403	305	425	133
Zagrebačka Dubrava	10,105	2,545	25.2	7,109	215	174	62
Zagreb	168,623	49,956	29.6	109,736	3,837	4,246	848

Data source: FBS, 1961.

In the 1970s, important socio-spatial changes took place that could have significantly contributed to the formation of the core of the queer population in Zagreb. First, the suburbanization of Zagreb's population and the functional transformation of the central parts of the city began during this decade (Vresk, 1997). As we have seen, suburbanization is one of the key urban-geographical processes that contributed to the spatial concentration of sexual minorities in the West. Furthermore, male homosexuality was decriminalized in Croatia in 1977. Finally, at the very end of the decade the first points of consumption-related gatherings among queer people in Zagreb started to emerge, which can be seen as the initial cores of the queer community's spatialization. Early key venues included *Splendid* in Zrinjevac, the *Club of Literary Workers,* and the *Club of Film Artists*. By the 1980s, other important spots like the *Croatian Association of Artists* (at the coffee shop *Kod Stipe*) and *Bacchus* located in the city center, had become notable gathering places (Dobrović, Bosanac, 2007). The sexual revolution, which had its echoes in Yugoslavia during the 1970s, also likely contributed to the formation of the core of the spatialization of the Zagreb queer community (Miljan, 2018). However, the HIV/AIDS epidemic in the 1980s (Anušić, Kovač, 2021) and the particularly strong re-traditionalization during the 1990s likely slowed this process. Since even the places where queer people gathered did not communicate their openness publicly and thus remained largely invisible, the period from the 1970s to the end of the 1990s can be considered the "pre-phase" of the spatialization of queer community in Zagreb.

Despite its limited scope, this period is crucial for understanding the development and dynamics of the spatialization of the queer community in Zagreb, since it laid the groundwork for a more permanent queer presence, even in the face of continuous socio-political challenges.

5 CONCLUSIONS

The paper presents the thesis that a residential core of queer men exists in Zagreb. Our thesis is supported by multiple datasets, whose overlap suggests that the urban geography of Zagreb is less heterosexual than it might appear at first glance. Roughly following the patterns of spatialization of queer communities in the West, albeit with a considerable time lag and significant deviations, the spatialization of the queer men's community in Zagreb was preceded by the emergence and development of pink consumption places.

They appeared timidly as early as the 1970s, bolstered by the echoes of the sexual revolution. However, the HIV/AIDS epidemic in the 1980s, coupled with the war in the 1990s hampered further development. It wasn't until 1999 that the first openly gay club was opened in Zagreb, marking the true beginning of the spatialization of the Zagreb queer men's community.

The extremely dynamic development of pink consumption places in Zagreb in the 2000s was reflected both in their number and in the clear spatial concentration in the city center. At the same time, the place of residence of never-married men also changed—they also gravitated towards the city center. Both processes were strengthened by the liberalization of the legal framework and social attitudes towards queer people. However, during the 2010s, the growth of both pink consumption places, and the share of never-married men slowed. Their spatial distribution remained largely unchanged, and in 2022, it largely coincided with the spatial distribution of profiles on Romeo dating application. According to all the above indicators, the city neighborhoods of Donji Grad (Lower Town), Trešnjevka-North and Trnje stand out as centers of queer men's residence.

Unlike some cities where gay neighborhoods are distinct, Zagreb's queer men's residential core is not spatially segregated; instead, it coexists with a heterosexual population in areas of high population density. This density provides anonymity, fostering a sense of safety and helping queer people manage the stress associated with minority status.

The development of queer men's residential core in Zagreb highlights the complexity and dynamism of post-socialist urban life. Areas with a greater concentration of queer male population, which are simultaneously shaped by social processes and the feedback influence on these same social processes, reflect both global patterns of urban population relocation, as well as their local specificities that led to the subtle integration of the queer community into the framework of the urban fabric.

However, the research has limitations due to the lack of official statistical data on sexual and gender minorities, which prevents a more comprehensive understanding of the residential distribution of queer men. As such, our findings should be understood as approximate estimates. To improve the results, future studies could incorporate a broader range of data sources and methods, including information on queer women and housing advertisements in queer media, to provide a more holistic view of the entire queer community and its dynamics.

References

Anušić, N., Kovač, V., 2021. The impact of moral panic on morbidity of sexually transmitted diseases in SR Croatia at the beginning of the HIV/AIDS pandemic. Radovi, 53, 1, pp. 267–304.

Backović, V., 2005. Evropski gradovi u postsocijalističkoj transformaciji. Sociologija, 47, 1, pp. 27–44.

Barton, C., 2023. 2021 census: What do we know about the LGBT+ population? URL: https://commonslibrary.parliament.uk/2021-census-what-do-we-know-about-the-lgbt-population/ (accessed 05.01.2024).

Bašić, K., 2005. Apsolutna decentralizacija u populacijskom razvoju Zagrebačke aglomeracije. Hrvatski geografski glasnik, 67, 1, pp. 63–80.

Béres-Deák, R., 2022. Out in the country and in the city: Discourses and practices of being out in the Hungarian LGBTQ community. In: Blidon, M., Brunn, S. D. (eds.). Mapping LGBTQ spaces and places. A changing world. Springer: Cham, pp. 555–568.

Bilić, B., Stubbs, P., 2015. Unsettling 'the urban' in post-Yugoslav activisms: 'Right to the city' and pride parades in Serbia and Croatia. In: Jacobsson, K. (ed.). Urban grassroots movements in Central and Eastern Europe. Ashgate: Farnham, pp. 119–138.

Bilić, B., Stubbs, P., 2016. Beyond EUtopian promises and disillusions: A conclusion. In: Bilić, B. (ed.). LGBT activism and Europeanisation in the post-Yugoslav space: On the rainbow way to Europe. Palgrave Macmillan: London, pp. 231–248.

Braun, K., Cleff, T., Walter, N., 2015. Rich, lavish and trendy. Is lesbian consumers' fashion shopping behaviour similar to gay's? A comparative study of lesbian fashion consumption behaviour in Germany. Journal of Fashion Marketing and Management, 19, 4, pp. 445–466, DOI: 10.1108/JFMM-10-2014-0073.

Burmaz, B., 2014. Gej klubovi u Beogradu: unutrašnja periferizacija kvir prostora. In: Blagojević, J., Dimitrijević, O. (eds.). Među nama: neispričane priče gej i lezbijskih života. Hartefakt Fond: Beograd, pp. 190–209.

CBS [Croatian Bureau of Statistics], 2001. Population aged 15 and over by sex and marital status, by cities / municipalities. 2001. Census. URL: https://web.dzs.hr/Eng/censuses/Census2001/Popis/E01_02_09/E01_02_09.html (accessed 29.11.2023).

CBS [Croatian Bureau of Statistics], 2011. Population aged 15 and over, by legal marital status, age and sex. 2011 Census. URL: https://web.dzs.hr/Eng/censuses/census2011/results/htm/e01_01_15/E01_01_15.html (accessed 29.11.2023).

CBS [Croatian Bureau of Statistics], 2021. Population aged 15 and over, by legal marital status, age and sex, by towns/municipalities. 2021 Census. URL: https://podaci.dzs.hr/en/statistics/population/ (accessed 06.12.2023).

Čemažar, S. A., Mikulin, T., 2017. Europeizacija kao (ne)prijateljica: razvoj LGBT pokreta u Hrvatskoj. Mali levijatan, 19, 4, pp. 29–58.

Clement, N., 2022. 'The whole neighbourhood is becoming gay!' Reflections on the effects of geolocated dating apps on the practice and perception of the urban space of gay men in major French cities. In: Blindon, M., Brunn, S. D. (eds.). Mapping LGBTQ spaces and places. A changing world. Cham: Springer, pp. 147–168.

Collins, A., Drinkwater, S., 2017. Fifty shades of gay: social and technological change, urban deconcentration and niche enterprise. Urban Studies, 54, 3, pp. 765–785. DOI: 10.1177/0042098015623722.

Conron, K. J., Goldberg, S. K., 2020. Adult LGBT population in the United States. URL: https://williamsinstitute.law.ucla.edu/wp-content/uploads/LGBT-Adult-US-Pop-Jul-2020.pdf (accessed 07.01.2024).

Darakchi, S., 2019. Emergence and development of LGBTQ studies in post-socialist Bulgaria. Journal of Homosexuality, 67, 3, pp. 325–334. DOI: 10.1080/00918369.2018.1534413.

Dimitrov, S., 2014. Gej i lezbijski klubovi u Beogradu: društveni prostori, identiteti, otpor. In: Blagojević, J., Dimitrijević, O. (eds.). Među nama: neispričane priče gej i lezbijskih života. Hartefakt Fond: Beograd, pp. 210–226.

Dobrović, Z., Bosanac, G., 2007. Usmena povijest homoseksualnosti u Hrvatskoj. Zagreb: Domino.

Duda, I., 2004. U potrazi za blagostanjem. O povijesti dokolice i potrošačkog društva u Hrvatskoj 1950-ih i 1960-ih. Zagreb: Srednja Europa.

FBS [Federal Bureau of Statistics], 1967. Vital, ethnic and migration features. Results for municipalities. 1961 Census. Beograd.

Francoeur, R., Noonan R. (eds.), 2003. The Continuum complete international encyclopedia of sexuality. New York-London: Continuum.

Ghaziani, A., 2022. Belonging in gay neighborhoods and queer nightlife. In: Fischer, N. L., Westbrook, L., Seidman, S. (eds.). Introducing the new sexuality studies. London: Routledge, pp. 540–550.

Gorman-Murray, A., Nash, C., 2017. Transformations in LGBT consumer landscapes and leisure spaces in the neoliberal city. Urban studies, 54, 3, pp. 786–805. DOI: 10.1177/0042098016674893.

Hermann, E., 2016. Kako se kalio Zagrebački LGBT clubbing. URL: https://voxfeminae.net/pravednost/kako-se-kalio-zagrebacki-lgbt-clubbing/ (accessed 26.06.2022).

Hess, D. B., Bitterman, A., 2021. Who are the people in your gayborhood? Understanding population change and cultural shifts in LGBTQ+ neighborhoods. In: Bitterman, A., Hess, D. B. (eds.). The life and afterlife of gay neighborhoods: Renaissance and resurgence. Cham: Springer, pp. 3–39.

Hinrichs, D. W., 2021. Foreword. In: Bitterman, A., Hess, D. B. (eds.). The life and afterlife of gay neighborhoods: Renaissance and resurgence. Cham: Springer, pp. vii–ix.

Howard, C., 2013. Building a „family-friendly" metropolis: Sexuality, the state, and postwar housing policy. Journal of Urban History, 39, 5, pp. 933–955. DOI: 10.1177/0096144213479322.

Jubany, O., Adiego, J., Mas Grau, J., 2021. There is LGBTQ life beyond the big city: Discources, representations and experiences in two medium-sized Spanish cities. Journal of Homosexuality, 69, 11, pp. 1908–1927. DOI: 10.1080/00918369.2021.1933787.

Kates, S., 2002. The protean quality of subcultural consumption: An ethnographic account of gay consumers. Journal of Consumer Research, 29, 3, pp. 383–399. DOI: 10.1086/344427.

Lorencova, V., 2006. Becoming visible: Queer in postsocialist Slovakia. ProQuest Dissertations & Theses.

Lugosi, P., 2007. Queer consumption and commercial hospitality. Communitas, myths and the production of liminoid space. International Journal of Sociology and Social Policy, 27, 3/4, pp. 163–174. DOI: 10.1108/01443330710741093.

Mak, K., Jakovčić, M., 2021. Pink consumption areas: Research accomplishments and future perspectives. Croatian Geographical Bulletin, 82, 2, pp. 59–77. DOI: 10.21861/HGG.2021.83.02.03.

Mak, K., Jakovčić, M., 2023. 'Gay space is wherever I am': The outlines of pink consumption spaces in Zagreb. Geographica Pannonica, 27, 2, pp. 91–103. DOI: 10.5937/gp27-42432.

Mattson, G., 2015. Style and the value of gay nightlife: Homonormative place making in San Francisco. Urban Studies, 52, 16, pp. 3144–3159. DOI: 10.1177/0042098014555630.

Mayhew, S., 2023: A dictionary of geography. Sixth Edition. Oxford: Oxford University Press.

Mikulak, M., 2019. Between the market and the hard place: neoliberalization and Polish LGBT movement. Social Movement Studies, 18, 5, pp. 550–565. DOI: 10.1080/14742837.2019.1598353.

Miljan, Z., 2018. Seksualna revolucija u Hrvatskoj 1960-ih i 1970-ih godina, doktorska disertacija. Zagreb: Sveučilište u Zagrebu.

Mlinar, I., 2009. Zagrebačka stambena naselja nakon 2000. godine. Prostor. Znanstveni časopis za arhitekturu i urbanizam, 37, 1, pp. 159–169.

Pacione, M., 2009. Urban geography. A global perspective. London: Routledge.

Pereira, S., Ayrosa, E., 2012. Between two worlds: an ethnographic study of gay consumer culture in Rio de Janeiro. Brazilian Administration Review, 9, 2, 211–228.

Pitonak, M., 2022. A decade of Prague Pride: Mapping origins, seeking meanings, understanding effects. In: Blindon, M., Brunn, S. D. (eds.). Mapping LGBTQ spaces and places. A changing world. Cham: Springer, pp. 417–444.
Podmore, J., Bain, A., 2021. Whiter queer suburbanisms? Beyond heterosuburbia and queer metronormativities. Progress in Human Geography, 45, 5, pp. 1254–1277. DOI: 10.1177/0309132520979744.
Poltz, K., 2022. Space and identity: Comparing the production of queer spaces in Amsterdam and Hong Kong. In: Blindon, M., Brunn, S. D. (eds.). Mapping LGBTQ spaces and places. A changing world. Cham: Springer, pp. 341–370.
Prelogović, V., 2004. The socio-spatial structure of the city: the example of Zagreb. Hrvatski geografski glasnik, 66, 1, 29–46.
Prelogović, V., 2009. Primjena faktorske analize u istraživanje socio-prostorne strukture grada: primjer Zagreba. Hrvatski geografski glasnik, 71, 1, pp. 67–85.
Romeo, 2022. Romeo – your GPS-position, your security. URL: www.romeo.com/en/care/locations (accessed 26.06.2022).
Skočir, D., Šakaja, L., 2017. Prostorni aspekti posjećenosti kafića u Zagrebu: dobne i rodne razlike. Acta Geographica Croatica, 43/44, pp. 37–58.
Slavuj, L., Cvitanović, M., Prelogović, V., 2009. Emergence of problem areas in the urban structure of post-socialist Zagreb. Spatium, 21, pp. 76–83.
Stella, F., 2013. Queer space, pride, and shame in Moscow. Slavic Review, 72, 3, pp. 458–480. DOI: 10.5612/slavicreview.72.3.0458.
Stepanović, N., 2022. Policy makes a family: Croatian LGBTQ movement and the struggle for fostering rights. In: Blindon, M., Brunn, S. D. (eds.). Mapping LGBTQ spaces and places. A changing world. Cham: Springer, pp. 45–56.
Štulhofer, A., Hiršl-Hećej, V., Mrkšić, Ž., Korać, A., Hoblaj, P., Ivkanec, I., Mamula, M., Tiljak, H., Buljan-Flander, G., Sagasta, S., Bosanac, G., Karlović, A., Mimica, J., 2003. Croatia. In: Francoeur, R., Noonan, R. (eds.). The continuum complete international encyclopedia of sexuality. New York, London: Continuum, pp. 241–258.
Vouk Nikolić, M. (ed.), 2022. Uđite u naša 4 zida. Izložba povodom 20 godina Povorke ponosa u Hrvatskoj. Zagreb: Tifološki muzej.
Vresk, M., 1997. Suburbanizacija Zagreba. Hrvatski geografski glasnik, 59, pp. 49–71.

KARTIRANJE ZAGREBŠKEGA URBANEGA PROSTORA: V ISKANJU GEJEVSKEGA REZIDENČNEGA JEDRA

Povzetek

»Kvirovska« geografija je uporaben okvir za razumevanje vloge prostora in kraja pri oblikovanju spolnih identitet in skupnosti. Ta koncept poudarja, kako so prostori, kot so gejevski klubi, oblikovali kvirovske identitete in skupnosti, hkrati pa izpostavlja vpliv teh prostorskih odnosov na družbeno pravičnost (Mayhew, 2023). Namen tega prispevka je preučiti obstoj koncentracije kvirovske moške populacije oziroma rezidenčnega jedra kvirovskih moških v Zagrebu. Trdimo, da večja koncentracija rožnatih potrošniških krajev vodi do večje koncentracije uporabniških profilov na aplikacijah za gejevske zmenke in da omenjeni kazalniki potencialno kažejo na večjo koncentracijo kvirovskih moških. V članku na primeru Zagreba raziskujemo: 1) rezidenčno jedro kvirovske moške populacije; 2) čas njegovega nastanka in 3) prostorsko dinamiko njegovega razvoja.

V začetni fazi prostorske umestitve kvirovske skupnosti v zahodnih državah so bila mesta rožnate potrošnje, kot so gejevski klubi, pubi in bari, skoraj edina javna mesta, kjer so se pripadniki kvirovske skupnosti lahko srečevali in preživljali prosti čas (Collins, Drinkwater, 2017; Lugosi, 2007; Mattson, 2015). Okoli rožnatih krajev potrošnje so počasi začele nastajati gejevske soseske kot kvirovska stanovanjska območja. Njihov nastanek je bil rezultat več prepletajočih se procesov, med katerimi sta imela ključno vlogo suburbanizacija in deindustrializacija (Gorman-Murray, Nash, 2017). Gejevske soseske so se običajno nahajale v zapuščenih in/ali nezaželenih prostorih v bližini mestnih središč, kjer so bile nepremičnine in najemnine poceni (Hess, Bitterman, 2021).

Gejevske soseske so ustvarjale ugodnejše pogoje za ustanavljanje kvirovskih podjetij ter pojav novih krajev in oblik rožnate potrošnje (Poltz, 2022). Kasneje je proces gentrifikacije gejevske soseske iz obrobnih območij spremenil v komercialno uspešna okrožja, organizirana okoli rožnate potrošnje in pretežno naseljena z vse bolj premožno kvirovsko skupnostjo (Poltz, 2022). To je pripeljalo do rasti cen stanovanj in najemnin, kar je povzročilo izseljevanje in razpršitev kvirovske populacije.

Prostorska umestitev kvirovske moške skupnosti v Zagrebu se je razlikovala od tiste v zahodnih državah. Prva mesta rožnate potrošnje so se sramežljivo pojavila že v sedemdesetih letih prejšnjega stoletja. Vendar je epidemija aidsa v osemdesetih letih skupaj z vojno v devetdesetih zavrla njihov nadaljnji razvoj. Šele leta 1999 so v Zagrebu odprli prvi odkrito gejevski klub, kar je pomenilo pravi začetek prostorske umestitve zagrebške kvirovske moške skupnosti.

Izjemno dinamičen razvoj prostorov za rožnato potrošnjo v Zagrebu po letu 2000 se je odražal tako v njihovem številu kot v jasni prostorski koncentraciji v središču mesta. Hkrati se je spremenil tudi kraj bivanja nikoli poročenih moških – tudi oni so gravitirali proti mestnemu središču. Oba procesa sta se okrepila z liberalizacijo pravnega okvira in družbenega odnosa do istospolno usmerjenih oseb. Vendar se je v letu 2010 rast tako krajev rožnate potrošnje kot deleža nikoli poročenih moških upočasnila. Njuna prostorska porazdelitev je ostala večinoma nespremenjena, leta 2022 pa se je v veliki meri ujemala s prostorsko porazdelitvijo profilov v aplikaciji za zmenke Romeo. Glede na vse navedene kazalnike kot središča bivanja kvir moških izstopajo mestne četrti Donji Grad, Trešnjevka - sever in Trnje. V nasprotju z nekaterimi mesti, kjer so gejevske soseske ločene, zagrebško kvirovsko moško stanovanjsko jedro ni prostorsko ločeno, temveč sobiva s heteroseksualno populacijo na območjih z visoko gostoto prebivalstva. Ta gostota zagotavlja anonimnost, spodbuja občutek varnosti in pomaga pripadnikom kvirovske skupnosti pri obvladovanju stresa, povezanega s statusom manjšine.

Razvoj stanovanjskega jedra kvirovskih moških v Zagrebu kaže na kompleksnost in dinamičnost postsocialističnega mestnega življenja. Območja z večjo koncentracijo kvirovske moške populacije, ki jih hkrati oblikujejo družbeni procesi in povratni vplivi na te iste družbene procese, odražajo tako globalne vzorce preseljevanja mestnega prebivalstva kot tudi njihove lokalne posebnosti, ki so pripeljale do subtilne integracije kvirovske skupnosti v okvir mestnega tkiva.

Zaradi pomanjkanja uradnih statističnih podatkov o spolnih in seksualnih manjšinah je ugotavljanje natančne prostorske porazdelitve kvirovskih moških zelo oteženo, kar vpliva na celovitejše razumevanje problematike. Ugotovitve raziskave je treba razumeti kot približne ocene. Za izboljšanje rezultatov bi lahko prihodnje študije vključile širši nabor virov podatkov in metod, vključno z informacijami o kvirovskih ženskah in s stanovanjskimi oglasi v kvirovskih medijih, da bi zagotovili celovitejši pogled na celotno kvirovsko skupnost in njeno dinamiko.

Arsim Ejupi*, Shkumbin Lushaj*, Edon Shemsedini*

REGIONAL IDENTITY OF RUGOVA REGION IN KOSOVO

COBISS 1.01
DOI: 10.4312/dela.61.121-142

Abstract

This article explores the complexity of regional identity in the context of the Rugova region of Kosovo, examining how historical, cultural, geographical and social factors shape people's feelings and connections to their place of origin. Through a mixed-method the research explores the formation and evolution of regional identity over time. Findings reveal a strong sense of belonging to the Rugova community, transcending geographical boundaries and generational shifts. The analysis proves also the significance of cultural heritage, traditions, and geographical features in fostering regional identity, while also highlighting concerns about the impact of modernization and globalization on the preservation of traditions. Ultimately, the study elucidates the complex interplay between individual experiences, societal changes, and external influences in shaping regional identity dynamics, offering insights into the multifaceted nature of identity construction and preservation in the Rugova region.

Keywords: region, identity, Rugova, belonging

* Department of Geography, Faculty of Mathematical & Natural Sciences, University of Prishtina "Hasan Prishtina", 10000, Boulevard George Bush, Prishtinë, Kosova
e-mail: arsim.ejupi@uni-pr.edu, edon.shemsedini@gmail.com, lushajshkumbin@gmail.com
ORCID: 0000-0002-6749-2244 (A. Ejupi), 0009-0008-1470-2333 (E. Shemsedini), 0009-0000-8661-1395 (S. Lushaj)

REGIONALNA IDENTITETA REGIJE RUGOVA NA KOSOVU

Izvleček

Članek obravnava kompleksnost regionalne identitete v kontekstu regije Rugova na Kosovu in proučuje, kako zgodovinski, kulturni, geografski in družbeni dejavniki oblikujejo občutja in povezave posameznikov z njihovim krajem izvora. S pristopom mešanih metod raziskava proučuje oblikovanje in razvoj regionalne identitete skozi čas. Ugotovitve razkrivajo močan občutek pripadnosti skupnosti Rugove, ki presega geografske meje in generacijske premike. Analiza opozarja tudi na pomen kulturne dediščine, tradicij in geografskih značilnosti pri spodbujanju regionalne identitete, hkrati pa izpostavlja pomisleke glede vpliva modernizacije in globalizacije na ohranjanje tradicij. Na koncu članek pojasnjuje kompleksno medsebojno delovanje med posameznikovimi izkušnjami, družbenimi spremembami in zunanjimi vplivi pri oblikovanju dinamike regionalne identitete ter ponuja vpogled v večplastno naravo konstrukcije in ohranjanja identitete v regiji Rugova.

Ključne besede: regija, identiteta, Rugova, pripadnost

1 INTRODUCTION

The regional identity has not been given enough importance in geographical research for a long time, as traditional approaches to the region and regionalism were of little significance (Paasi, 2003). Over time, the region and regional identity have become important categories for geographers, reviving academic and institutional research, and have become part of political debates since 1990 (Paasi, Zimmerbauer, 2011). Today, regional identity is one of the main objectives of European Union (EU) territorial policies, promoting regional cohesion and competition among regions (Prokkola, Zimmerbauer, Jakola, 2012). The concept of "identity" relates to answering the question: "Who am I?". Often this question becomes differentiated and leads to other questions like: "Where do I come from?" and "Where do I belong?" (Pohl, 2001). Based on these questions, we observe that regional identity is not an isolated individual status quo, but plays an essential role in the context of social development (Pohl, 2001). The initial theoretical assumption is that the region as a social construct influences the creation of regional identity, which is linked to identity politics and foreign policy (Pace, 2006). Regional identity is formed and changed within the context of social and cultural interactions of a region. This development is influenced by a variety of sources, including individual childhood experiences, personal space perception, and other experiences (Pohl, 2001). Regional identity is an integral part of every state, and these two aspects are deeply interconnected but vary from one state to another.

Kosovo, like any other state, has several regional identities represented in its ethnogeographic regions. Ejupi (2022) noted that in the case of Kosovo, regional identity is a lower scale identity than the Albanian identity. Although Kosovo is a small territory, it has very diverse natural conditions which are reflected in regional differences. The Dukagjini plain, the Kosovo plain, Rugova, Anamorava and Drenica are some of the regions that are distinguished not only by their natural conditions, but also by their social, demographic and economic characteristics.

Borders drawn and revised throughout history, physical characteristics of the region, regional stereotypes, and population characteristics form the basis for the formation of ethnogeographic regions (Terlouw, 2001). In the territory of Kosovo, there are several ethnogeographic regions distinguished by borders, physical characteristics (relief, climate), population (although in more than 90% of these regions in Kosovo, Albanians are the overwhelming majority), culture (dialects, customs, traditions, clothing, cuisine, etc.). Regional differences based more on ethnogeographic characteristics and less on natural conditions have led to the formation of regions with elements of regional identity, such as the Rugova region. The authentic mountainous landscape (alpine), the rich natural and cultural heritage enable the regional identification and differentiation of Rugova. Throughout history, this region has been occupied by various rulers, starting from ancient periods, Ottoman period, Yugoslav period, etc. However, the inhabitants of the area have continued to preserve the traditional ethnographic characteristics of the area, giving this region the attributes of a distinct geographic region.

The regional identity of this region survives and is maintained through social and cultural combinations, expressing the customs, traditions, and unique relationships of the inhabitants living in Rugova. This paper aims to present how the regional identity of Rugova has formed and changed over time, emphasizing the importance of the natural landscape, the history of the region, and culture in shaping the sentiments regarding the region. Socio-economic influences on the formation of the region and the efforts of the population to preserve and promote the cultural heritage of Rugova will also be analyzed. It should be emphasized that the change and development of regional identity are long and complex processes that may undergo changes over time, in different situations and circumstances. Nowadays, the Rugova region, like many other regions, has evolved based on various factors. It is important for us to recognize how much this region has changed from the past and to what extent political, economic, social, and cultural factors have influenced the changes in the regional identity of this region.

2 LITERATURE REVIEW

Before delving into the issues of regional identity, we need to define the "region", which is the fundamental unit of research on regional identity (Zepeda, 2020). The definition of region is a very fundamental concept for geographical studies and at the same time very difficult to define precisely (Robinson, 1953). Since ancient Greek and Roman times, the part of geography that studied the region was called regional geography, used to describe the physical and human characteristics of regions and nations (Bailly, 2009). The word "region" comes from the Latin *regere*, which means to manage, but at that time it meant managing the kingdom or empire (Bailly, 2009). In the broadest sense, the region is defined as a delimited area that possesses a certain unity or organizational structure (Bailly, 2009). The concept of "region" gained importance in the 19th century when explorers presented newly discovered lands to European geographic societies (Bailly, 2009). Today, based on scientific dictionaries, the definition of the region is understood as: (a) an area of unspecified size on the Earth's surface, the elements of which form a functional environment; (b) the region is part of a system of regions covering the globe; and (c) a distinct part of the Earth, with climatic or economic characteristics (Gregory et al., 2009). The region is often studied as a product of the interaction of individuals or social groups in different economic, political, and cultural contexts (Vujadinović, Šabić, 2017). There are three different approaches in contemporary geography to identify the region: (a) the region is treated as a response to contemporary economic processes; (b) it is presented as a medium for social interaction, harmonizing with people, nature, and society in specific times and spaces; and (c) the region appears as a center of identification (Gilbert, 1988, as cited in Vujadinović, Šabić, 2017).

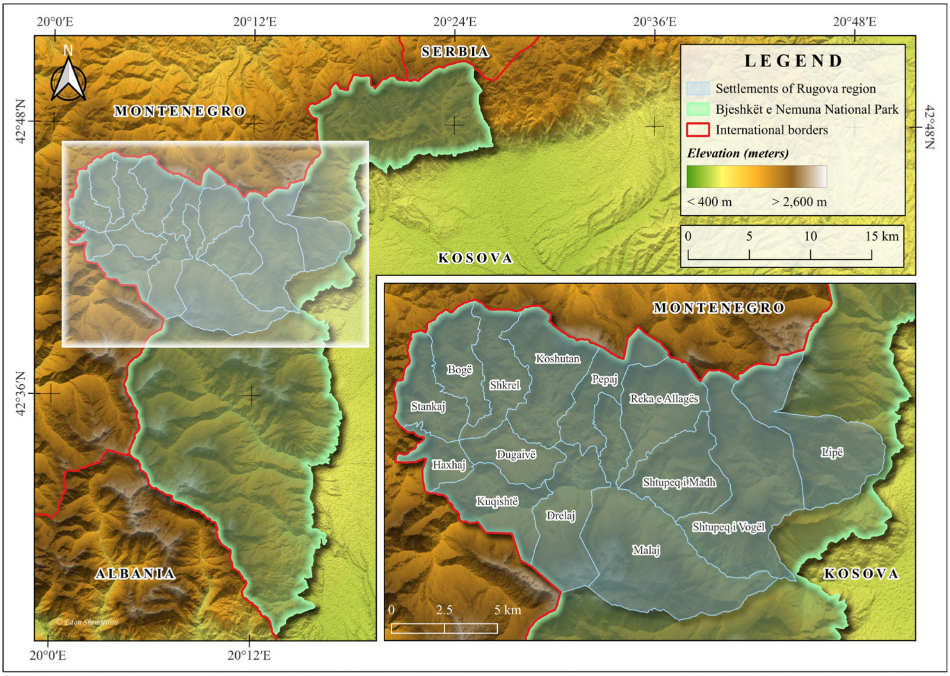
Given that the region is the subject of study for geographers, it is not surprising that there have been many geographers who deal with regional identity and its spatial expression (Ejupi, 2022). Like the region, regional identity is a concept that became attractive in the 1980s and is recognized as an important element in the creation of regions as social and political spaces (Paasi, 2009). People need to feel they belong to a social group, share a common identity with others, and distinguish themselves from others in how they perceive themselves as individuals in the society they live in (Hildebrandt, Trüdinger, 2021). Regarding the definition of regional identity, there are many ambiguities and changes in human stereotypes (Turner, 2010). According to Paasi (2011), identity is a category that combines many elements, making it one of the most important categories for study by social and cultural sciences. Identity, fundamentally, is self-recognition and recognition by society, while those who are different are categorized as others (Culcasi, 2011, as cited in Stiperski, Ejupi, 2023). Meanwhile, Ejupi (2022) states that regional identity is a set of characteristics that define the peculiarities of an individual or group, especially in relation to similarities or differences between individuals or other groups.

The formation of regional identity depends on a variety of factors. These factors are related to the region where the person lives. The type of landscape can play an important role, along with the socio-economic and cultural characteristics of the population in the region (Anděl, Balej, Bobr, 2019). In one way or another, regional identity is not just a personal feeling about the place but is an integral part of the collective (Pohl, 2001). Regional identity narratives rely on various elements, such as ideas about nature, natural landscapes, cultural environments, ethnicities, dialects, etc. All of these are used to construct regional identities (Passi, 2003). The distinctiveness of each region, beyond natural, social, and economic factors, is shaped by the behavior and attitude of individuals toward the region. This includes their recognition of the local environment, their societal role and status, among other factors. This phenomenon, known as affiliation (individual perception of geographical space), is examined in the way individuals or broader social groups perceive themselves within a regional context (collective consciousness of regional affiliation) (Šabić, Pavlović, 2007). By integrating socio-psychological attitudes of the population toward regional identity alongside geographical criteria, it further underscores the uniqueness of each geographical region. What is problematic in many studies discussing regional identity is not that identity is something to be taken for granted and enduring, but that it is considered a feature, something that regions have (Kuss, 2007, as cited in Prokkola, Zimmerbauer, Jakola, 2012). According to sociologist Nikolas Entrikin, countries and regions have no inherent or "inborn" meaning or "identity", but people assign and value them in relation to their needs; in other words, the construction of region and regional identity is a consequence of politics, economy, culture and community interests (Prokkola, Zimmerbauer, Jakola, 2012). Regional identity differs from various forms of localism, nationalism, and patriotism (Pohl, 2001). Above all, regional identity is a cultural, social, and psychological phenomenon, but also political, although the latter depends on the degree of influence (Pohl, 2001). According to Pohl (2001), regional identity consists of 4 intensities: (I) when a person has vague feelings about a specific region where they live, (II) close ties to the region where they live, (III) a person has a stronger level of regional identity where an individual not only feels connected to a particular region but also actively accepts and identifies with that region, and (IV) a person has a higher level of regional identity where an individual not only accepts to identify with a region, but also takes active steps to contribute to the improvement or advancement of that region. Understanding regional identity often begins with the assumption that surveys of ordinary people can reveal the nature and power of identity, which often results in theoretical and methodological challenges in the study of human behavior (Paasi, 2009).

3 STUDY AREA

Rugova is a mountainous region that stretches in the western part of Kosovo. This area begins from the source of the Lumbardhi i Pejës/Pećka Bistrica River and continues until its exit from the Rugova Gorge, thus extending into the upper and middle sectors of the Lumbardhi i Pejës/Pećka Bistrica (Çavolli, 1997; Hysenaj, 2015).

Figure 1: Geographical location of the Rugova region (author: E. Shemsedini).



The Rugova region is situated within the Bjeshkët e Nemuna (serb: Prokletije) also known as the Albanian Alps (Lajçi et al., 2017). It stretches in an east–west direction, being 20 km long and 10 km wide (Ivanović, 1988). Rugova has an area of 197 km^2, which is 4.6% of the Dukagjini Plain, and it is inhabited by 203 residents, based on the Population Registry data from 2011 (ASHAK, 2019; 2020; ASK, 2011; Çavolli, 1997). Rugova, with its position, exhibits the characteristics of a border region. It is located between two states, Kosovo, to which it belongs, and Montenegro, which surrounds it on all three sides, north, west, and south. Rugova is a typical mountainous region. About 96% of its territory is above 1000 meters above sea level, while 4% consists of lower parts where the elevation does not exceed 1000 meters, found mainly from Peja/Peć to Kuqishtë/Kućište, these lowlands are located along the Lumbardhi i Pejës/Pećka Bistrica River (Çavolli, 1980).

Figure 2: A picturesque part of the Rugova region (Photo: Sh. Lushaj, 2023).

4 METHODOLOGY

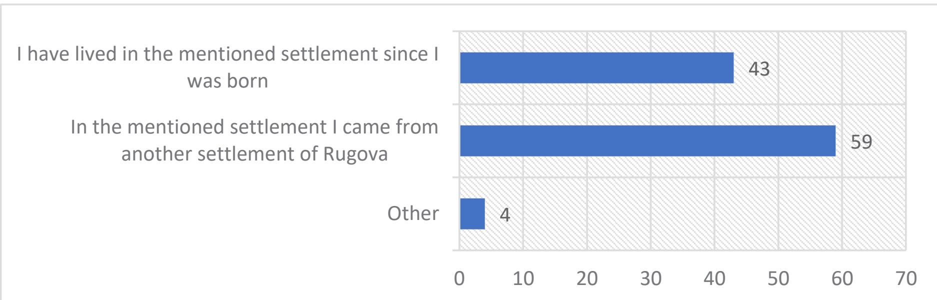
The methodology of this work is based on a survey that was used as a quantitative tool to study and describe the natural, social and cultural characteristics of the Rugova region. The total number of respondents in this study amounted to 106 individuals. They were selected using the snowball sampling method. Finally, the findings from the survey were analyzed and interpreted. The data analysis was carried out using the SPSS program (Statistical Package for the Social Sciences).

Considering that this paper deals with regional identity in the Rugova region, our sample population, besides focusing on this region and its 14 villages, also includes respondents from the municipalities of Peja/Peć, Pristina/Priština, Gjakova/Đakovica, Prizren/Prizren, Istog/Istok, Deçan/Dečani, etc., as well as a small number of individuals living outside of Kosovo but with family ties to the Rugova region. With the help of GIS software, various maps were created to illustrate and depict the geographical dimensions of the Rugova region.

5 RESULTS AND DISCUSSION

The various natural, social, economic, cultural, anthropological elements, etc., provide the starting point for the analysis of regional identity through which the forms and ways in which people are connected to their place, history, cultural heritage, their sense of being residents of this region, the proximity between the residents, etc. are examined. All these elements play a role that, in one form or another, is becoming increasingly important when it comes to identifying the region, in this case, the Rugova region chosen for the research. Rugova, as one of the numerous regions of Kosovo, has a well expressed and preserved regional identity. This is evident in the detailed analysis of the respondents' answers regarding what we call the identity of Rugova. The proximity between the Municipality of Peja/Peć and the Rugova region has influenced the fact that the majority of residents or others with various connections to the Rugova region are from the Municipality of Peja/Peć, indicating that this municipality has the largest concentration of Rugova residents.

Figure 3: Categorization of respondents' residences according to their origin.

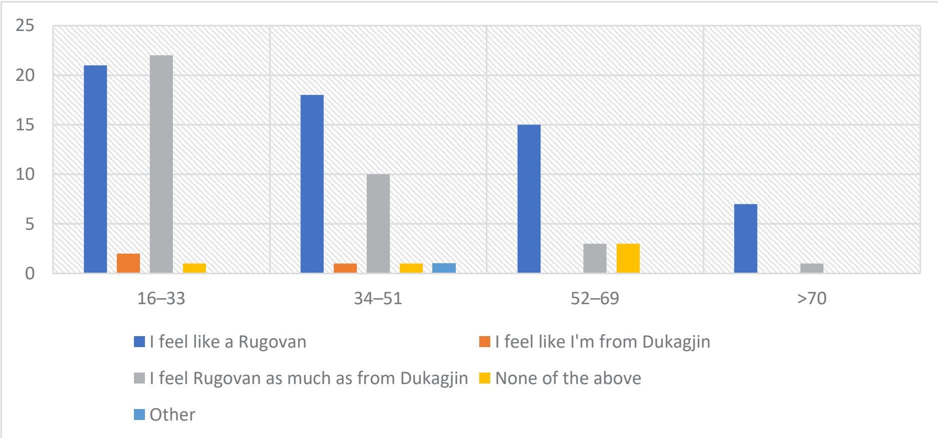


Data source: Questionnaire, 2023, n = 106.

The analysis of the data on the respondents' place of residence yielded interesting results. For instance, over 55% of them come from another settlement within Rugova, while around 40.6% have lived in their current place of residence since birth (Figure 3). Conversely, only a small portion, approximately 3.8%, were born outside the Rugova region but have familial ties to the area. This indicates considerable population mobility within Rugova itself and a strong emotional and cultural connection of individuals to this area, even if they may have migrated from their birthplaces.

The analysis of regional identity in the Rugova region includes an in-depth study of the influence of historical, cultural, geographical factors, etc. on the formation and development of this identity. It also includes an examination of the historical aspects of the region's development, including the historical events that have influenced the formation of regional identity.

Figure 4: Determination of regional affiliation by age group.



Data source: Questionnaire, 2023, n = 106.

The majority of respondents stated that they identify themselves as members of the Rugova community or feel Rugovans even though they live in different places, both inside and outside Rugova. This indicates a very strong attachment to the Rugova region, regardless of where they live. From the results, it emerges that approximately 60% of all respondents identify or feel themselves to be Rugovan (Figure 4). The term “Rugovan” implies that the inhabitants are from Rugova, born there, live there, or even if they are not born there, they have strong family ties to the area. Another widespread sense of belonging is the feeling of being both Dukagjinas and Rugovan. About 35% of respondents declared themselves as both Rugovan and Dukagjinas. A symbolic number of respondents indicated that they felt neither Rugovan nor Dukagjinas, totaling only 5 or 4.7%. Other categories are only very slightly represented.

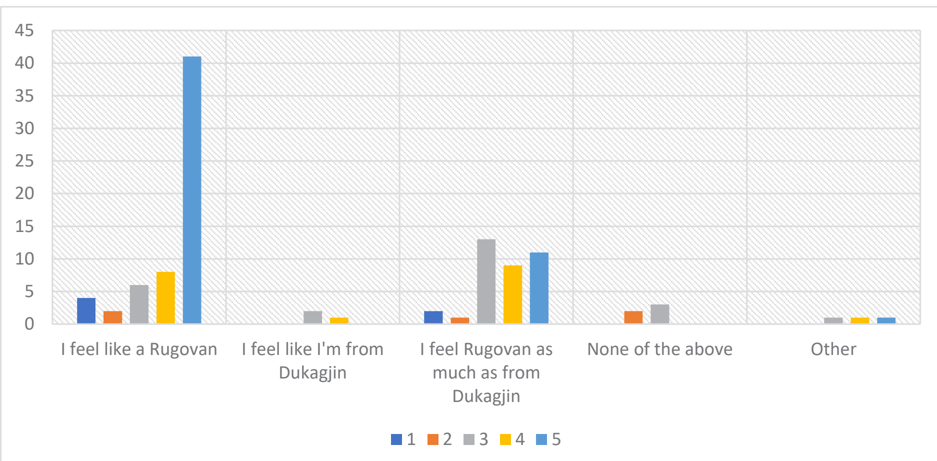
A further categorization of regional sense of identity is shown in Figure 4, which provides an insight into the distribution of identity based on the age groups of individuals. A more detailed description of the table includes an analysis of regional identity, changes and differences in regional perceptions across age groups and provides a deeper understanding of the relationships between regional identity and the age of the individuals studied. These results show how feelings and perceptions of regional belonging may vary and evolve across different stages of a person’s life.

The youngest age group, 16–33 years old, shows an imbalance regarding the sense of regional belonging. In this group, there is a shift in feelings regarding regional identity, especially in how they feel about the Rugova region. Most of the respondents in this group were born and raised outside of Rugova, bringing different perspectives on regional identity. In total, 47.8% of participants in this group expressed feeling as much Rugovan as Dukagjinas. An important fact is that 45.6% of respondents feel Rugovan, indicating a strong connection to the region. What is more interesting about these respondents is that most of them were not born or do not have direct ties to this region. In this group, only 4.3% feel like Dukagjinas, while 2.3% do not feel they belong to any of the aforementioned categories.

In the 34–51 age group, 57.8% of respondents expressed a strong Rugovan identity. Many in this group were born in Rugova but now live elsewhere in Kosovo, with few still residing there. This strong sense of belonging reflects a deep connection to the region. Despite living outside Rugova, Rugovan identity remains important to the majority in this age group, who may resist changes to their identity. Additionally, over 30% feel both Rugovan and Dukagjinian simultaneously, while 3.2% identify solely as Dukagjinian, 3.2% have no strong identity feelings, and 3.2% identify differently.

In the age groups 52–69 and 70 years and older, a strong sense of belonging to Rugovan identity is evident, which is influenced by having been born and raised in the region. In the 52–69 age group, 71.4% expressed feeling Rugovan, with 14.3% feeling both Rugovan and Dukagjinian, and 14.3% not identifying strongly with any category. Among those aged 70 and older, 87.5% feel Rugovan, while 12.5% feel both Rugovan and Dukagjinian. This shows that older people in the study group identify strongly as Rugovan, which is probably due to the fact that they were born and live in this region. Younger groups show a sense of dual identity, reflecting evolving perceptions of identity across the generations.

Figure 5: Level of identification of respondents with their regional identity.

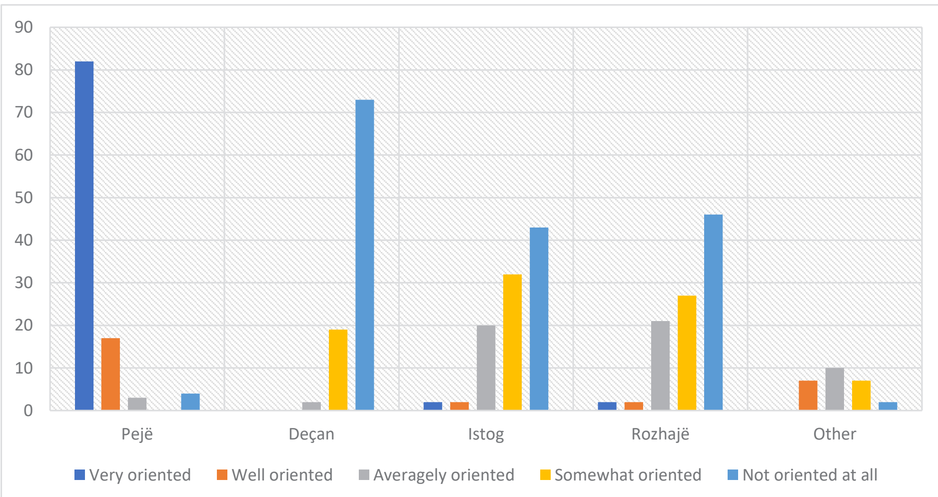


Data source: Questionnaire, 2023, n = 106.
Note: Scale 1–5, 1 – not identified at all, 2 – somewhat identified, 3 – moderately identified, 4 – well identified, 5 – very identified

Among those identifying as Rugovans, the majority show a strong connection and clear identification with this identity. Over half of these participants strongly identify as Rugovans, with only a few (4 participants) feeling no connection at all to this identity. Others who identify with both Rugovan and Dukagjinian identities describe themselves as moderately determined (see Figure 5). In total, 13 participants feel moderately identified, 11 very identified and 9 well identified. These findings indicate a broad spectrum of identification and determination between Rugova and Dukagjin, suggesting a simultaneous connection and belonging to both regions.

Concerning the question of how close the respondents feel to other residents of Rugova, we can observe a variety of responses. Nearly half (47%) reported a strong connection, while less than a quarter (21%) felt less close. This reflects a strong connection and retained sense of identity with their original community, despite early or recent changes in place of residence.

Figure 6: The cities and directions to which the residents of Rugova are oriented.[1]



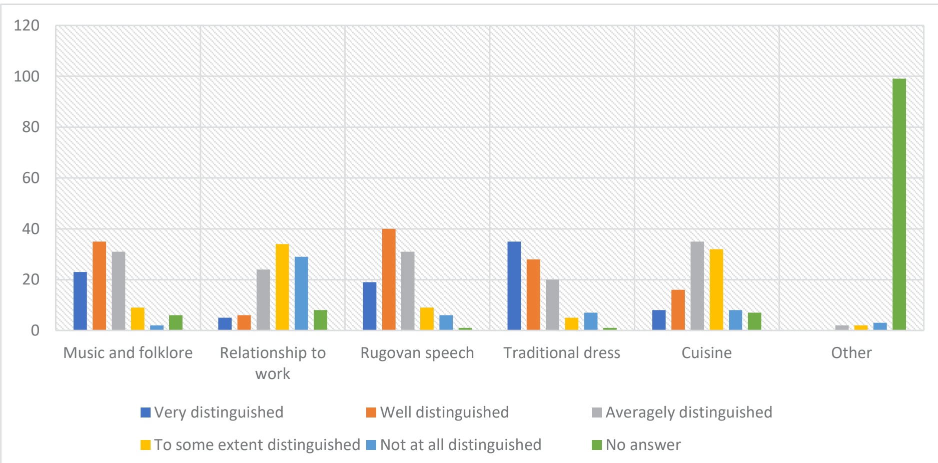
Data source: Questionnaire, 2023, n = 106.

A key part of the research is assessing the orientation of Rugova residents who have relocated during migrations. Understanding the historical migration patterns, mainly to the Dukagjin Plain and nearby areas, helps clarify their orientation. This study used various measurement variables to explore this orientation. These variables cover cities near Rugova and Peja/Peć, as well as other cities and countries outside Kosovo that are

1 The cities mentioned in the chart have alternative names in different languages. For example, Peja is also known as Peć, Deçan is referred to as Dečani, Istog is called Istok, and Rozhajë is known as Rožaje.

preferred destinations. Analyzing these characteristics has given a clearer perspective on how Rugova residents orient themselves during migration. Over two-thirds of survey participants indicated that during migration, residents of Rugova are primarily oriented towards Peja/Peć and its surrounding settlements (see Figure 6). This is due to the proximity and ease of relocation to Peja/Peć. A smaller percentage mentioned orientation towards Rozhajë/Rožaje in Montenegro, influenced by its border location and cultural ties with neighboring communities. Additionally, 12.3% of participants noted moderate orientation towards cities like Prishtina/Priština, Gjakova/Đakovica, Prizren/Prizren, and foreign countries such as Germany, Norway, the United States, and Switzerland.

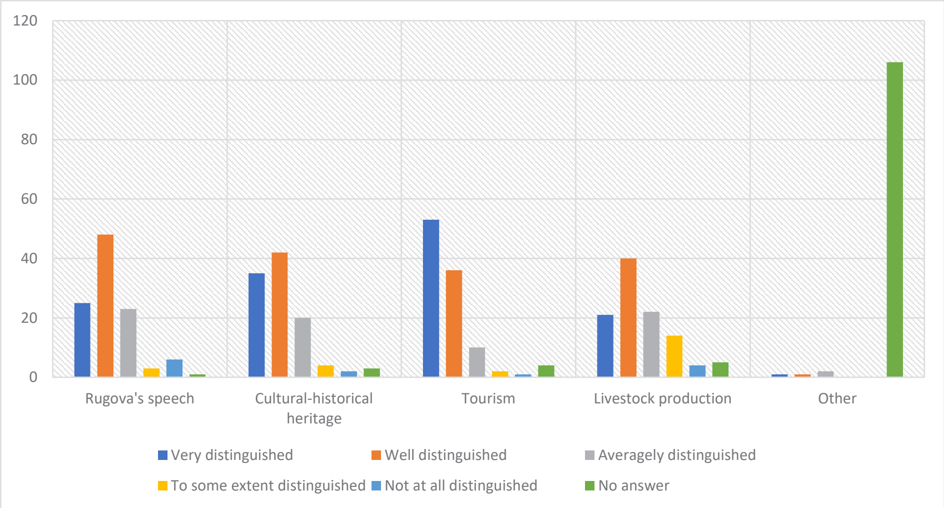
Figure 7: Respondents' assessment of what distinguishes Rugovans from other residents of Dukagjin.



Data source: Questionnaire, 2023, n = 106.

Another aspect of regional identity focuses on what sets apart the people of Rugova from other Dukagjin inhabitants. Data analysis shows that cultural, social, and economic factors play a significant role in shaping their identity and living environment (see Figure 7). Music, folklore, work relationships, the Rugova dialect, traditional clothing, and cuisine highlight the differences between Rugovans and other Dukagjin residents. A majority of respondents (54.7%) view music and folklore as key elements distinguishing Rugovans from other Dukagjin residents. Respondents also note that the Rugova dialect differs significantly, with 55.6% considering it a distinguishing feature. Traditional clothing is similarly seen as distinct by 68.9% of respondents. However, opinions vary on Rugova cuisine, with many perceiving no significant differences from Dukagjin. Additional differences highlighted by respondents include trust, lifestyle, hospitality, family ties, mentality, and physical appearance.

Figure 8: Respondents' assessment of the characteristics that distinguish and identify Rugovans.



Data source: Questionnaire, 2023, n = 106.

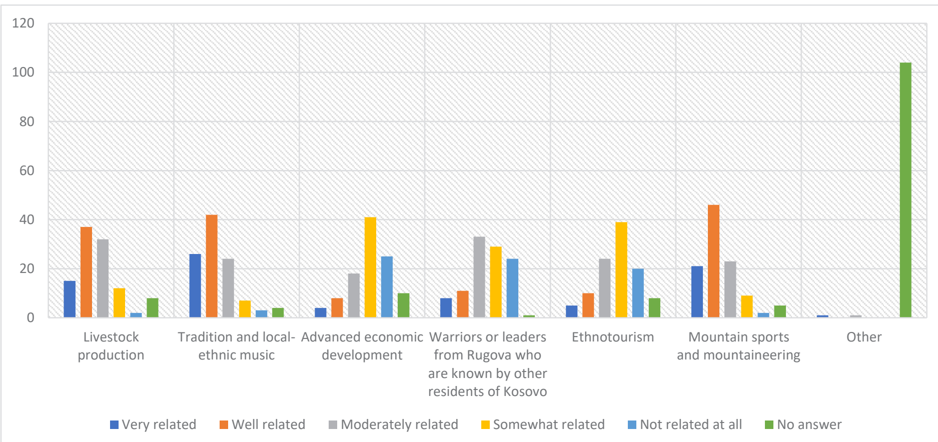
It is worth emphasizing that the inhabitants of the Rugova region and those who identify themselves as such have a variety of characteristics that distinguish them from others and help them to identify themselves as Rugovans. This region has many distinguishing features, but some stand out more clearly than others. Key distinguishing elements include the Rugova dialect, cultural-historical heritage, tourism, and livestock products (see Figure 8). The analysis of the survey shows that the Rugova dialect is highly rated for its role in community identification. Approximately 24% of participants consider it 'very distinctive', underscoring its strong influence on their identity. The results show that many participants rate the cultural-historical heritage as 'good' (18%), 'very distinctive' (40%), or 'very identifying' (33%) among Rugovan residents. Tourism is the most agreed-upon distinguishing feature, with 50% stating it strongly identifies Rugovans, while only 1% disagree. Additionally, 38% of participants consider livestock products as a well-distinguished characteristic of Rugovans. This suggests that livestock products play a crucial role in distinguishing Rugovans from other residents. Around 20% of participants rated them as 'very distinctive,' highlighting their significant influence on identity.

Important elements associated with Rugova's regional identity include livestock products, traditional music, economic development, notable leaders, ethno-tourism, mountain sports, and other factors highlighted by survey participants.

The analysis shows that livestock products play a crucial role in connecting Rugova residents with their identity. About half of the participants (49%) see livestock as the primary link to the region, with 30% rating this connection as average, and 19% perceiving it as weak (see Figure 9). The survey participants state that the residents are more closely associated with their region through traditions and local-ethnic music. In fact, most of them see this connection as very strong (64.2%). A minority (2.8%) have doubts about the connection between tradition, music, and regional identity.

Economic development is not strongly linked according to most participants (62%), who consider it weak or unimportant. Regarding the warriors or leaders from Rugova known in Kosovo, responses vary from 'somewhat connected' (27%) to 'moderately connected' (31%). A significant number (22.6%) believe that there is no connection between fighters and the Rugova region.

Figure 9: Respondents' assessment of what other residents of Rugova most often associate Rugova with.



Data source: Questionnaire, 2023, n = 106.

The majority of respondents (85%) believe that the other residents of Rugova are most connected to their region through sports, especially mountain sports and mountaineering (Figure 9). This can easily be confirmed as most mountain sports, skiing and mountaineering, are very common in this region. However, a very small number (6%) do not share this opinion. It is worth noting that a very small number believe that other residents of Rugova are most connected to their region through food.

To the question 'Do you think that Rugova is sufficiently recognized by the residents of Kosovo', respondents gave different answers. Over 60% answered yes, while about 35% answered no. A very small number (4%) did not answer this question, while only 1% think otherwise. This confirms our a priori assertion that the Rugova region is known by the other residents of Kosovo.

Another very important aspect of the regional identity of a region are also the traditional arts of the region, the music, or even the special dances that have special cultural significance. What adds diversity to a region is the fact that these arts, music, or dances are accepted, loved by people, and preserved by them with enthusiasm. These sentiments are also shared by the residents of Rugova, who identify closely with these cultural elements. The traditional arts, music, and dances in Rugova are highly distinctive and deeply valued by residents, enduring through time. Participants in the survey overwhelmingly identify traditional dances as integral to the region's cultural identity. The 'Dance of Rugova' is widely recognized as a prominent traditional dance, performed during local festivals with energy and grace. Other notable dances include the sword dance, featuring historic yataghan swords, and the 'spinning of the tray by women', a unique and cherished traditional form accompanied by song, considered highly significant by many respondents.

Respondents in Rugova also highlight men's songs, traditional sword calls, lahuta songs (a special Albanian instrument), and leaf instruments as distinctive elements. Today, according to survey participants, various annual festivals in Rugova serve to preserve regional identity and remind people of their heritage. These festivals not only entertain but also foster community unity and strengthen bonds within the region.

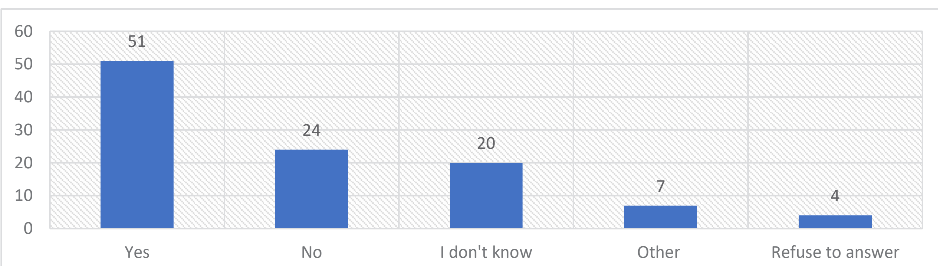
The main festival aimed at strengthening identity and entertainment is the 'Traditional Games'. The traditional sports held at this festival are tug of war, arm wrestling, stone throwing, wrestling, pole climbing, horse races, kapuqash game, stone throwing, etc. But besides these games, there are also other festivals such as the Rugova Camping Festival, etc. Other sports that are practiced in this region today, according to the respondents are: hiking, horseback riding, rock climbing, skiing, mountaineering, mountain biking, etc. Rugova is therefore a very suitable place for the development of mountain sports or even winter sports, but also for dangerous sports that increase people's adrenaline levels.

Figure 10: Traditional dance of Rugova (photo: V. Dumoshi, 2020).

Another characteristic of the Rugova region is the traditional Rugova cuisine, which does not differ much from other cuisines in Dukagjin and Kosovo in general. Given the small size of Kosovo and the predominantly Albanian population, as in Rugova where 100% of the population is Albanian, it is to be expected that all respondents note similarities in the cuisine of the different regions of Kosovo. According to 90% of all survey participants, the identifying food, or the food that identifies the Rugova region, is boiled cornmeal. Boiled cornmeal is a traditional dish typically prepared with animal fat or milk, though sometimes other fats are used. It also contains cornmeal flour, cheese according to preference, and salt. Boiled cornmeal in earlier times was made only on certain occasions such as when an important guest came, there were various festivals, or other things. But there are also many other well-known foods throughout Kosovo, such as flija, kaqamaku, various types of pies, shllina, abundant tamale, paqamurri, leqeniku, korelana, corn bread, pepper with maize, bread made of cornmeal, boiled cheese, walnut cake, etc. Therefore, considering all the responses given by the respondents, we see that all the foods are similar everywhere in Kosovo, as well as in Rugova. This is a good indicator of the uniformity of the Rugova region with other parts of Kosovo.

The survey participants were divided into two groups regarding the impact of modernization and globalization on the preservation of traditions and customs in Rugova, sparking questions about the future. Some survey participants believe that the future will be positively influenced by the advancement of new technologies, which will bring greater advantages and development opportunities. The other group expresses pessimism regarding the influence of modernization and globalization on the traditions and customs of this region. This group assumes that the Rugova region and its people will not be able to preserve their traditions and cultures in the future due to population movements and the world becoming smaller as a result of technological and information developments, and that they will therefore change and adapt to more modern and global ones. Some expressed that the identity as inhabitants of Rugova will change for the worse in the future, some others expressed that it will be very

Figure 11: Attitudes towards the continuation of life in Rugova.



Data source: Questionnaire, 2023, n = 106.

difficult to preserve it in the future due to external influences, while one group goes to the other extreme and assumes that the regional identity of this region will disappear forever. In contrast, another group of respondents believes that the identity of the residents of Rugova will evolve but will never disappear as an identity. In addition, there are also those who believe that the identity will remain unchanged.

The fact that a considerable percentage of respondents (48%) expressed a willingness to return and live in Rugova in the future is very important. A smaller proportion (23%), on the other hand, expressed a lack of intention to return to Rugova in the future to continue their lives. Another portion of respondents (19%) expressed uncertainty about whether they would continue to live in Rugova. On the other hand, 6% expressed a desire to live in Rugova only on weekends, while 4% refused to give an answer (Figure 11).

Survey data shows a slight difference in opinions on youth engagement in preserving regional identity, with 40% believing the youth are actively involved and 36% thinking otherwise—a 4% difference. Additionally, 16% are unsure. Most people believe that youth should play a key role in maintaining this identity, especially amidst technological and global changes. There is hope that the youth will help keep the Rugova identity alive for the future.

Figure 12: A view of some houses in a village in Rugova (photo: Sh. Lushaj, 2023).

6 CONCLUSIONS

The results of the research highlight the complex dynamics of regional identity in the Rugova region of Kosovo. Some of the key findings are as follows: the majority of respondents feel a strong connection to the Rugova region, with approximately 60% identifying or feeling themselves to be Rugovan, indicating a deep emotional and cultural attachment to the area. Despite the significant mobility of the population within Rugova, residents have retained a strong sense of identity, even those who were born outside the region but have family ties. The majority of respondents (over 55%) have moved within Rugova, indicating a strong attachment to the region. The results show that regional identity varies between the different age groups. Older individuals show a stronger attachment to the Rugova identity, while younger ones, especially those who were born and raised outside of Rugova, display a shift in identity perceptions.

Elements such as the Rugova dialect, traditional arts, music, dances, cuisine, and festivals play significant roles in distinguishing Rugovans from other inhabitants of Dukagjin. These cultural markers contribute to a sense of belonging and identity preservation.

There is uncertainty regarding the influence of modernization and globalization on the preservation of Rugovan traditions and customs. While some believe in the resilience of regional identity, others express concerns about its potential erosion over time. There is a slight difference in opinion regarding the active engagement of the younger generation in preserving regional identity. While some are optimistic about their involvement, others express concerns, emphasizing the importance of youth engagement in maintaining Rugova's identity into the future. A significant percentage of respondents expressed a willingness to return and live in Rugova in the future, indicating a strong attachment to their homeland, even though they currently live elsewhere.

All the aforementioned findings indicate that regional identity among the residents of Rugova and people originating from this region plays a very important role in shaping them as individuals, while the fact that there is a strong sense of community among the residents speaks volumes about the preservation of regional identity. From the research results, it can be concluded that the future of this identity is promising, as people are determined to continue living in this region. However, it is worrying that the commitment of young people to preserving the regional identity of this region is insufficient. Many Rugova residents hope that their regional identity will continue to be preserved, and that young people will engage in its preservation because as such, it has survived through centuries when others sought to erase it, and the younger generation should cherish it with even greater sympathy. This identity is not a mere identity that some residents of a region have and should be proud of, but it is an integral and inseparable part of Kosovo's history.

Overall, the findings reflect a multifaceted understanding of regional identity in

Rugova, which is shaped by historical, cultural, social and economic factors, and emphasise the importance of preserving this identity amidst ongoing societal changes.

References

Anděl, J., Balej, M., Bobr, L., 2019. Landscape types and regional identity – by example of case study in Northwest Bohemia. AUC Geographica, 54, 1, pp. 81–91. DOI: 10.14712/23361980.2019.8.

ASHAK [Akademia e Shkencave dhe e Arteve e Kosovës], 2019. Leksikon: Vendbanimet e Kosovës: Tabloja fizike-hapësinore, Demografike dhe funksionale. Vëll. 2, Vendbanimet rurale. Prishtinë.

ASHAK [Akademia e Shkencave dhe e Arteve e Kosovës], 2020. Leksikon: vendbanimet e Kosovës: tabloja fizike-hapësinore, demografike dhe funksionale. Vëll. 3, Vendbanimet rurale, M-ZH. Prishtinë.

ASK [Agjencia e Statistikave të Kosovës], 2011. Regjistrimi i popullsisë, ekonomive familjare dhe banesave në Kosovë 2011: Popullsia sipas gjinisë, etnicitetit dhe vendbanimit. Prishtinë.

Bailly, A., 2009. Regional geography. In: Geography, Encyclopedia of life support systems (EOLSS), vol. II. URL: https://www.eolss.net/sample-chapters/c01/e6-14-03-10.pdf (accessed 10.04.2024).

Çavolli, R., 1980. Rugova – Kontribut diferencimit regjional gjeografik, Buletini i FSHMN, 5, Prishtina, pp. 209–224.

Çavolli, R., 1997. Gjeografia regjionale e Kosovës. Enti i Teksteve dhe i Mjeteve Mësimore i Kosovës. Prishtinë, pp. 356–359.

Ejupi, A., 2022. Expression of regional identity in urban toponomy of major Kosovar cities. AUC Geographica, 57, 1, pp. 31–38. DOI: 10.14712/23361980.2022.3.

Gregory, D., Johnston, R., Pratt, G., Watts, M., Whatmore, S. (eds.), 2009. The Dictionary of human geography, 5th ed. Chichester: Blackwell Publishing, pp. 630–632. URL: https://www.scirp.org/reference/referencespapers?referenceid=2410719 (accessed 01.04.2024).

Hildebrandt, A., Trüdinger, E. M., 2021. Belonging and exclusion: the dark side of regional identity in Germany. Comparative European Politics, 19, pp. 146–163. DOI: 10.1057/s41295-020-00230-5.

Hysenaj, V., 2015. Socioonomastika e Rugovës. Universiteti Shtetëror i Tetovës, pp. 1–8.

Ivanović, M., 1988. Narodna nošnja Kosova Rugovo. Zagreb: Kulturno Prosvjetni Sabor Hrvatske, pp. 33–55.

Lajçi, N., Baruti, B., Lajçi, Xh., Kelmendi, M., 2017. Assessment of groundwater quality in village Pepaj, Rugova Region, Kosova. Journal of International Environmental Application and Science, 12, 2, pp. 103–111. URL: https://dergipark.org.tr/tr/download/article-file/569703 (accessed 10.04.2024).

Paasi, A., 2003. Region and place: Regional identity in question. Progress in Human Geography, 27, 4, pp. 475-485. DOI: 10.1017/S0260210509008456.

Paasi, A., 2009. The resurgence of the regional and regional identity: theoretical perspectives and empirical observations on regional dynamics in Europe. Review of International Studies, 35, pp. 121–146. DOI: 10.1017/S0260210509008456.

Paasi, A., 2011. Regional environmental governance: Interdisciplinary perspectives, theoretical issues, comparative designs (REGov): The region, identity, and power, Procedia Social and Behavioral Sciences. 14, 10, pp. 9–16. DOI: 10.1016/j.sbspro.2011.03.011.

Paasi, A., Zimmerbauer, K., 2011. Theory and practice of the region: A contextual analysis of the transformation of Finnish regions. Treballs de la Societat Catalana de Geografia, 71-72, pp. 163–178.

Pace, M., 2006. The politics of regional identity: Meddling with the Mediterranean. Journal of International Relations and Development, 10, pp. 316–318.

Pohl, J., 2001. Regional identity. International Encyclopedia of the social & behavioral sciences, pp. 12917–12921. URL: https://www.researchgate.net/publication/289475664_Regional_Identity (accessed 10.04.2024).

Prokkola, E. K., Zimmerbauer, K., Jakola, F., 2012. Performance of regional identity in the implementation of European cross-border initiatives. European Urban and Regional Studies, 22, 1, pp. 104–117. DOI: 10.1177/0969776412465629.

Robinson, G. W. S., 1953. The geographical region: Form and function. Scottish Geographical Magazine, 69, 2, pp. 49–58. DOI: 10.1080/00369225308735539.

Stiperski, Z., Ejupi, A., 2023. Tracing the development of Kosovar and Albanian identities using urban toponyms. Southeast European and Black Sea Studies, 24, 3, pp. 537–557. DOI: 10.1080/14683857.2023.2185366.

Šabić, D., Pavlović, M., 2007. Regionalna svest i regionalni identitet. Zbornik radova, 55, pp. 151–158. URL: https://scindeks.ceon.rs/article.aspx?artid=0351-465X0755151S.

Terlouw, K., 2001. Regions in geography and the regional geography of semiperipheral development. Tijdschrift voor Economische en Sociale Geografie, 92, pp. 76–87. DOI: 10.1111/1467-9663.00140.

Turner, B., 2010. The construction of spatial regional identities: The case of the Baltic in a global context. Asia Eur J, 8, pp. 317–326 DOI: 10.1007/s10308-010-0270-y

Vujadinovič, S., Šabić, D., 2017. The importance of regions in geographical research. Zbornik radova - Geografski fakultet Univerziteta u Beogradu, 65, 1a, pp. 195–208. DOI: 10.5937/zrgfub1765195V.

Zepeda, B., 2020. Region, nation, and locality: Collective identities in Latin America. Revista Latinoamericana de Opinión Pública, 9, 2, pp. 149–165. DOI:10.14201/rlop.22934.

REGIONALNA IDENTITETA REGIJE RUGOVA NA KOSOVU

Povzetek

Kljub svoji skromni velikosti se Kosovo ponaša z raznoliko paleto naravnih krajin, skozi čas pa ga je oblikovala zapletena geopolitična in zgodovinska dinamika, kar je vplivalo na oblikovanje različnih regionalnih identitet na njegovem ozemlju. Rugova, kot ena od številnih regij Kosova, ima dobro izraženo in ohranjeno regionalno identiteto. To je razvidno iz rezultatov izvedene anketne raziskave oziroma podrobne analize odgovorov anketirancev o tem, kar imenujemo identiteta Rugove. Analiza vključuje poglobljeno proučitev vplivov zgodovinskih, kulturnih, geografskih in drugih dejavnikov na oblikovanje in razvoj te identitete. Rezultati pomagajo razumeti občutja lokalnega prebivalstva glede vprašanja regionalne identitete v Rugovi. Ugotovitve osvetljujejo večplastnost regionalne identitete, ki zajema naravne, družbene, gospodarske, kulturne in antropološke elemente.

Kljub mobilnosti prebivalstva velik del anketirancev izkazuje globoko čustveno in kulturno navezanost na Rugovo. Ključna ugotovitev je, da identifikacija s skupnostjo Rugove presega geografske meje. Izraz »Rugovan« ne označuje le kraja izvora, temveč globoko zakoreninjen občutek kulturne identitete in pripadnosti. Poleg tega sobivanje identitet *Rugovan* in *Dukagjini* poudarja prepletanje med regionalnimi pripadnostmi in širšimi kulturnimi konteksti. Na dojemanje regionalne identitete pomembno vpliva starost, pri čemer so v različnih starostnih skupinah prisotni različni vzorci. Medtem ko starejše generacije izkazujejo trdno zvestobo regionalni identiteti, mlajše starostne skupine kažejo bolj tekoč in spreminjajoč se občutek pripadnosti, na katerega vplivajo različne življenjske izkušnje in družbeni konteksti. Kulturni elementi, kot so glasba, folklora, tradicionalna umetnost in kulinarika, se pojavljajo kot vidni označevalci regionalne identitete, ki razlikujejo njene prebivalce od prebivalstva sosednjih regij. Festivali in tradicionalne igre ne služijo samo ohranjanju kulturne dediščine, temveč tudi spodbujanju kohezije skupnosti in krepitvi kolektivne identitete. Regionalna identiteta je tudi vir kolektivnega ponosa.

Zaključki opozarjajo na pet ključnih vidikov:

- Ponos na identiteto: večina prebivalcev, vključno z mlajšimi generacijami, izraža ponos na svojo rugovsko identiteto, kar predstavlja pomemben dejavnik njenega ohranjanja.
- Posebnost Rugove: anketiranci v veliki večini dojemajo Rugovo kot drugačno od drugih delov Kosova, to edinstvenost pa pripisujejo njeni glasbi, folklori, tradicionalni noši in narečju.
- Turizem in kulturna dediščina: anketiranci poudarjajo turizem in kulturno dediščino kot ključna identifikatorja Rugove.

- Kulinarična dediščina: hrana ima velik pomen za prebivalce Rugove in je še en odločilni dejavnik njihove identitete.
- Zgodovinska zavest: zgodovinska zapuščina regije močno odmeva med prebivalci, saj odraža globoko razumevanje in spoštovanje njihove skupne preteklosti.

Ti vidiki skupaj poudarjajo ključno vlogo regionalne identitete pri oblikovanju individualnih identitet prebivalcev Rugove. Tesno prepletene skupnostne vezi dodatno prispevajo k njenemu ohranjanju. Čeprav se zdi prihodnost te identitete obetavna, obstaja zaskrbljenost zaradi premajhne zavzetosti mladih za njeno ohranitev. Mnogi prebivalci upajo, da bodo mlajše generacije dejavno sodelovale pri varovanju svoje regionalne identitete, pri čemer se bodo zavedale njenega trajnega pomena. Med anketiranci je prisotna negotovost glede vplivov modernizacije in globalizacije na ohranjanje regionalne tradicije in običajev. Medtem ko nekateri izražajo zaupanje v odpornost regionalne identitete, drugi kažejo zaskrbljenost glede njene morebitne razvodenitve skozi čas. Čeprav trenutno prebivajo drugje, jih veliko izraža željo po vrnitvi in bivanju v Rugovi, kar opozarja na njihovo globoko zakoreninjeno navezanost na domačo regijo.

NAVODILA AVTORJEM ZA PRIPRAVO PRISPEVKOV V ZNANSTVENI REVIJI DELA

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 (https://journals.uni-lj.si/Dela). Revija je uvrščena v mednarodne baze in ima mednarodni uredniški odbor.

V prvem delu so objavljeni znanstveni (1.01 in 1.02 po kategorizaciji COBISS) članki. V drugem delu se objavljajo informativni prispevki v rubriki Poročila, in sicer biografski prispevki (obletnice, nekrologi), predstavitve geografskih monografij in revij, prispevki o pomembnejših geografskih prireditvah in drugih dogodkih idr.

Znanstveni prispevki so lahko objavljeni v treh jezikovnih različicah: samo v slovenskem jeziku, dvojezično slovensko-angleško, samo v angleškem jeziku. Avtor sam poskrbi za jezikovno ustreznost svojega besedila in prevoda (vključno z izvlečkom, ključnimi besedami in povzetkom). Če je besedilo jezikovno neustrezno, ga uredništvo vrne avtorju, ki mora poskrbeti za lektorski pregled besedila.

1. Sestavine prispevka:
   1. **Naslovna stran**
      - naslov prispevka;
      - ime in priimek avtorja/avtorjev (brez akademskih nazivov);
      - poštni naslov avtorja (npr. Oddelek za geografijo Filozofske fakultete Univerze v Ljubljani, Aškerčeva cesta 2, SI-1000 Ljubljana, Slovenija);
      - avtorjev elektronski naslov;
      - ORCID (če je na voljo);
      - izvleček (1000 znakov skupaj s presledki);
      - ključne besede (do 6 ključnih besed).
   2. **Besedilo prispevka**
      - Do 40.000 znakov s presledki; v primeru daljših prispevkov naj se avtor predhodno posvetuje z urednikom.
      - Prispevek naj bo razdeljen na poglavja. Delitev na podpoglavja naj bo uporabljena le izjemoma.
      - V primeru, da bo prispevek objavljen le v slovenskem jeziku, je treba pripraviti povzetek v angleškem jeziku (skupaj s presledki od 5000 do 8000 znakov). Na koncu povzetka je lahko navedeno ime prevajalca.

2. Za pripravo naslovne strani ter besedila prispevka uporabite predlogi dokumenta, ki sta dostopni na https://journals.uni-lj.si/Dela/. 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. Besedilo naj ne vsebuje avtomatskega oštevilčenja oziroma avtomatskih vrstičnih oznak.

3. Slikovno in tabelarično gradivo mora biti oblikovano skladno z navodili, objavljenimi na spletni strani revije (https://journals.uni-lj.si/Dela/). Vse slike (karte, grafikoni, fotografije in podobno) morajo biti oddane kot samostojne datoteke (ne v datoteki z besedilom!). Za slikovno gradivo, za katero avtorji nimajo avtorskih pravic, morajo avtorji od lastnika avtorskih pravic pridobiti dovoljenje za objavo.

4. Slike in preglednice morajo biti oštevilčene z arabskimi številkami v zaporedju, kot se pojavljajo v besedilu. Imeti morajo naslov, ki je postavljen nad sliko/preglednico. Med številko in naslovom je dvopičje. Vire podatkov, predstavljenih na slikah in v preglednicah, se navaja pod sliko/preglednico (izjema so karte, kjer se vire podatkov navaja na sami karti). Največja širina slik/preglednic je 125 mm. Najmanjša dovoljena velikost besedila je 8 pt za preglednice in 6 pt za slike.

Priprava slikovnega gradiva:

- Fotografije: TIFF ali JPG format (najmanjša ločljivost 300 pik na palec (dpi)).
- Karte in podobno grafično gradivo: PDF format, izjemoma ob predhodnem posvetu z urednikom ostali vektorski (AI, CDR, SVG, EPS) oziroma rastrski formati (TIFF, JPG).
- Grafikoni: izdelani morajo biti s programom Excel ali sorodnim programom (avtorji jih oddajo skupaj s podatki v izvorni datoteki, npr. Excelovi preglednici).

5. Prispevke je treba oddati na spletni strani https://journals.uni-lj.si/Dela/ v OJS aplikaciji.

6. Revija Dela od 1. 1. 2025 za navajanje virov uporablja APA standard (trenutno 7. različica) Ameriškega psihološkega združenja (*American Psychological Association*). Avtorji so dolžni upoštevati način citiranja ter oblikovanje seznama virov in literature, kot je to navedeno v navodilih na spletni strani revije (https://journals.uni-lj.si/Dela/).

7. Znanstveni prispevki bodo recenzirani. Recenzentski postopek je praviloma anonimen, opravita ga dva kompetentna recenzenta. Recenzenta prejmeta prispevek brez navedbe avtorja, avtor pa prejme recenzentove pripombe brez navedbe recenzentovega imena. Uredniški odbor lahko na predlog recenzentov zavrne objavo prispevka.

8. Pogoji za objavo:
    - Revija sprejema prispevke, ki še niso bili objavljeni oziroma v času oddaje (ter v času trajanja recenzijskega postopka) niso v procesu recenziranja pri drugi reviji.
    - Vsi prispevki morajo zadostiti tehničnim in vsebinskim zahtevam, objavljenim na spletni strani revije.
    - Pisci besedila potrjujejo, da so avtorji oddanega prispevka, 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.
    - Avtorji jamčijo, da je delo njihova avtorska stvaritev, da na njem ne obstajajo pravice tretjih oseb in da z njim niso kršene kakšne druge pravice. V primeru zahtevkov tretjih oseb se avtorji zavezujejo, da bodo varovali interese založnika ter mu povrnili škodo in stroške.
    - Avtorji obdržijo materialne avtorske pravice ter založniku priznajo pravico do prve izdaje članka z licenco Creative Commons Attribution-ShareAlike 4.0 International License (priznanje avtorstva in deljenje pod istimi pogoji). To pomeni, da se lahko besedilo, slike, grafi in druge sestavine dela prosto distribuirajo, reproducirajo, uporabljajo, priobčujejo javnosti in predelujejo, pod pogojem, da se jasno in vidno navede avtorja in naslov tega dela in da se v primeru spremembe, preoblikovanja ali uporabe tega dela v svojem delu predelava lahko distribuira le pod licenco, ki je enaka tej.
    - Avtorji lahko sklenejo dodatne ločene pogodbene dogovore za neizključno distribucijo različice dela, objavljene v reviji (npr. oddaja v institucionalni repozitorij ali objava v knjigi), z navedbo, da je bilo delo prvič objavljeno v tej reviji.
    - Pred postopkom pošiljanja ali med njim lahko avtorji delo objavijo na spletu (npr. v institucionalnih repozitorijih ali na svojih spletnih straneh), k čemur jih tudi spodbujamo, saj lahko to prispeva k plodnim izmenjavam ter hitrejšemu in obsežnejšemu navajanju objavljenega dela.

INSTRUCTIONS FOR AUTHORS PREPARING ARTICLES FOR THE SCIENTIFIC JOURNAL – DELA

The scientific journal DELA is a periodical publication of the Department of Geography, Faculty of Arts, University of Ljubljana, published since 1985. The journal focuses on presenting scientific and professional achievements in all fields of geography and related disciplines. Since 2000, it has been published biannually in both print and electronic formats (accessible at https://journals.uni-lj.si/Dela). The journal is indexed in international databases and supported by an international Editorial Board.

Research and review articles are published in the first part of the journal. Biographical articles (e.g., anniversaries, obituaries), reviews of geographical monographs and journals, reports on major geographical and related events, and other informative contributions are published in the second part.

Scientific articles may be published in one of three language configurations: Slovene only, bilingual Slovene-English, English only. The author is responsible for ensuring the linguistic quality of their manuscript, including abstracts, keywords, and summaries. If the submission is deemed linguistically inadequate, it will be returned to the author by the editorial board for correction. Authors must arrange for professional proofreading or translation as necessary.

1. Articles preparation guidelines. All articles must include Title page and Article text:

   1. **Title page**
      - 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 1000 characters with spaces);
      - Keywords (up to six keywords).

   2. **Article text**
      - up to 40,000 characters with spaces; for longer articles, consult the editor prior to submission;
      - Articles must be structured into chapters. Sub-chapters may only be used in exceptional cases.

2. Use the templates available on the journal's website (https://journals.uni-lj.si/Dela/) to prepare the title page and the article text. The digital manuscript should avoid formatting, styles, word splitting, automatic numbering, automatic line breaks,

underlining, etc. Authors may use only bold and/or italic text. The text should be in full lower case (including titles and subtitles, except for capital letters), without unnecessary abbreviations, contractions and acronyms.

3. Figures and tables must comply with the instructions published on the journal's website (https://journals.uni-lj.si/Dela/). Submit all figures (charts, graphs, photographs, etc.) as stand-alone files (not in a text file!). Authors must provide proof of permission to publish any copyrighted graphic material not created by them.

4. Number all figures and tables sequentially using Arabic numerals (e.g., Figure 1: Title, Table 1: Title). Place titles above figures and tables with a colon separating the number and title. Provide data sources below the figure/table (maps should display sources directly on the map). The maximum width of figures/tables is 125 mm. The minimum font size is 8 pt for tables and 6 pt for figures.

File formats:

- Photographs: TIFF or JPG format (minimum resolution 300 dpi).
- Maps and similar graphic material: PDF format (other vector formats such as AI, CDR, SVG, EPS, or raster formats like TIFF, JPG, may be used after consulting editors).
- Graphs: Submit in Excel or a related program, along with the source data (e.g., Excel spreadsheet).

5. Submissions must be made online in Open Journal System at https://journals.uni-lj.si/Dela/.

6. From 1 January 2025, DELA are using the APA standard (currently version 7) of the American Psychological Association for citing sources. Authors are required to follow the citation and reference list formatting as specified in the instructions on the journal's website (https://journals.uni-lj.si/Dela/).

7. Scientific articles will be peer reviewed. The peer-review process is anonymous, carried out by two competent reviewers. Reviewers receive an article without the author's name being revealed, the author of the article receives the reviewer's comments, without being given any reviewers' names. Based on recommendations from the reviewers the Editorial Board may refuse to publish the article.

8. Authors wishing to have their article published in the journal agree to the following conditions:

- The journal accepts submissions that have not yet been published or are not under review by another journal at the time of submission (and during the review process).

- All submissions must meet the technical and content requirements published on the journal's website.
- Listed authors confirm that they are the authors of the submitted article, intended for publication in the journal DELA, a publication of the Ljubljana University Press, Faculty of Arts [Znanstvena založba Filozofske fakultete Univerze v Ljubljani] (University of Ljubljana, Faculty of Arts, Aškerčeva 2, 1000 Ljubljana). Decisions concerning graphic design and technical production of the work and the conditions of its marketing are at the discretion of the publisher.
- Authors guarantee that the work is their own original composition, that no third parties have rights to the work, and that the article does not violate any other rights. In the case of third-party claims authors undertake to protect the interests of the publisher and cover the publisher's damages and costs.
- Authors retain copyright and recognize the publisher's right of first publication; the article will be licensed under a Creative Commons Attribution-ShareAlike 4.0 International License (attribution of authorship and shared authorship are covered by the same conditions). This means that text, pictures, graphs and other components of the work can be freely distributed, reproduced, used, communicated to the public and processed, provided that author's name and the article title are clearly and prominently indicated, and that in cases where changes or modifications are made or the work is used in other work, it can be distributed only under a license identical to this one.
- Authors may enter into additional separate contractual arrangements for non-exclusive distribution of the version of the work, published in the journal (e.g. submit it to an institutional repository or publish it in a book), with an acknowledgement that the work was first published in this journal.
- Before the submission process or during it authors can publish work on the internet (e.g. in institutional repositories or on their own websites), which we also encourage, as this can contribute to a fruitful exchange as well as rapid and widespread referencing of the published work.

Adherence to these guidelines is essential for a smooth review and publication process. For any clarification, authors are encouraged to check journal's website or contact the editorial team.

DELA 61
Oddelek za geografijo, Filozofska fakulteta Univerze v Ljubljani
Department of Geography, Faculty of Arts, University of Ljubljana

Založnik – Published by
Založba Univerze v Ljubljani

Izdajatelj – Issued by
Znanstvena založba Filozofske fakultete Univerze v Ljubljani;
Oddelek za geografijo, Filozofska fakulteta Univerze v Ljubljani

Za založbo – For the Publisher
Gregor Majdič, rektor Univerze v Ljubljani

Za izdajatelja – For the Issuer
Mojca Schlamberger Brezar, dekanja Filozofske fakultete

Upravnik – Editorial Secretary
Nejc Bobovnik

Naročila – Orders
Oddelek za geografijo, Filozofska fakulteta
Aškerčeva 2, p.p. 580, SI-1001 Ljubljana, Slovenija
e-mail: nejc.bobovnik@ff.uni-lj.si

Cena – Price
15 €

Fotografija na naslovnici/Cover photo:

Maribor, drugo največje slovensko mesto, je bil leta 2012 skupaj s portugalskim mestom Guimarães izbran za Evropsko prestolnico kulture (foto: D. Cigale).

Maribor, the second largest Slovenian city, was selected as the European Capital of Culture in 2012, together with the Portuguese city of Guimarães (photo: D. Cigale).