ULOGA GEOGRAFSKOG PREDTERCIJARNOG OBRAZOVANJA U RAZVOJU BIOEKONOMIJE

THE ROLE OF PRE-TERTIARY GEOGRAPHY EDUCATION IN THE DEVELOPMENT OF BIOECONOMICS

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U radu se obrađuje inovativno gospodarstvo bioekonomija i uloga geografskog obrazovanja u njezinu razvoju. Svrha bioekonomije je razviti gospodarstva s „niskom razinom emisija u cilju razvoja primarnog sektora (poljoprivreda, ribarstvo, šumarstvo), sigurne i dostatne opskrbe hranom, potičući primjenu biomase u industriji, štiteći bioraznolikost i okoliš“ (Europska komisija, 2012.). Transformacija klasičnoga linearnog modela ekonomije u bioekonomiju zahvaća prijelaz s uporabe fosilnih izvora na bioobnovljive, kao i prijelaz s linearnog na kružno gospodarstvo. Ključnu ulogu za razvoj bioekonomije uz poduzetnike, vlast/politiku, znanstvene institucije, međunarodnu suradnju ima i formalno, neformalno i informalno obrazovanje svakog pojedinca involviranog u ovo područje gospodarstva. Primarni cilj ovoga rada je istaknuti ulogu geografskog obrazovanja u razvoju kružnoga gospodarstva (bioekonomije) kojemu teži Republika Hrvatska preko razvojnog smjera 3 „Zelena i digitalna tranzicija“ (Nacionalna razvojna strategija 2030, 2020.). Sekundarni ciljevi rada su analizirati osnovne teorijske značajke bioekonomije, strukturu zaposlenosti i strukturu ostvarenog prometa u sektorima bioekonomije u državama Europske unije s posebnim naglaskom na stanje u Republici Hrvatskoj. Rezultati rada pokazuju da je hrvatska bioekonomija tek u početnom ciklusu razvoja. U predmetnom kurikulumu Geografije za osnovne škole i gimnazije (2019.) značajan je broj odgojno-obrazovnih ishoda koji se odnose na izvore energije, klimu i klimatske promjene, ekosustave, bioraznolikost, razvoj pametnih gradova, a usvajanje tih ishoda pridonosi stjecanju kompetencija nužnih za razvoj novih pristupa inovativnijih gospodarstava. U radu su primijenjene kvantitativne i kvalitativne metode rada. Analiza sadržaja kurikuluma, posebice razrade ishoda koji su u funkciji daljnjeg razvoja bioekonomije, temelj je za oblikovanje tema stručnog usavršavanja učitelja i nastavnika geografije kako bi inovativnije i učinkovitije vodili proces učenja i poučavanja tih sadržaja.
Ključne riječi: bioekonomija, Europska unija, kružno gospodarstvo, kurikulum, predtercijarno geografsko obrazovanje, Republika Hrvatska

The paper presents an innovative economy - bioeconomy and explains the role of geography education in its development. The aim of the bioeconomy is to develop low-emission economies focused on developing the primary sector (agriculture,

fishing, forestry), food security and sufficiency, encouraging the use of biomass in industry, protecting biodiversity and the environment (European Commission, 2012). The shift from the traditional linear model of economy to the bioeconomy entails a move away from fossil resources and toward bio-renewable resources as well as a transition from a linear to a circular economy. Alongside entrepreneurs, the government/policies, scientific institutions, and international cooperation, formal, non-formal and informal education of every stakeholder in this economic area plays a key role in the development of the bioeconomy. The primary goal of this paper is to emphasize the role of geography education in and for the development of circular economy (bioeconomy), which is an aim of the Republic of Croatia defined by Development Direction 3, "Green and Digital Transition" (National Development Strategy 2030, 2020.). The secondary objectives of this paper are to analyse general theoretical features of the bioeconomy as well as employment and turnover structure in the EU bioeconomy sectors, with a special emphasis on the situation in the Republic of Croatia. The results of the work show that the Croatian bioeconomy is only in the initial cycle of its development. The Geography curriculum for primary schools and grammar schools (2019) contains a significant number of educational outcomes that concern energy sources, climate and climate change, ecosystems, biodiversity and the development of smart cities. Adopting these outcomes may contribute to the acquisition of competencies necessary for the development of new approaches of more innovative economies. The research was conducted using quantitative and qualitative methods. The analysis of the curricular content, especially the elaborations of outcomes geared toward a further development of the bioeconomy, is the basis for shaping professional development training for geography teachers to enable a more innovative and efficient management of the learning and teaching of these contents.

Key words: bioeconomy, European Union, circular economy, curriculum, pre-tertiary geography education, Republic of Croatia

UVOD

Globalni razvoj svjetskoga gospodarstva od druge polovice 20. stoljeća obilježava rast uz povremene krize. Uz pozitivne, prisutne su i negativne posljedice tog rasta kao što su onečišćenje okoliša, klimatske promjene, smanjenje ili nestanak biološke raznolikosti, geopolitičke napetosti. Utjecaji ljudskih aktivnosti i svjetske ekonomije na okoliš su veliki, a s porastom svijesti o tim utjecajima na planet Zemlju sve je veća potreba za tranzicijom prema održivom gospodarstvu odnosno održivom razvoju. Pojam održivi razvoj sve se češće zamjenjuje pojmom bioekonomija (engl. *bioeconomy* ili *bio-based economy*). Bioekonomija je relativno nov i trenutačno snažno prihvaćen pristup, a odnosi se na gospodarstva temeljena na inovativnim metodama zamjene fosilnih izvora inteligentnom i učinkovitom uporabom materijala i procesa na biološkoj osnovi (Schlaile, Urmetzer, 2019.).

Europska komisija usvojila je strategiju[1] o usmjeravanju europske ekonomije prema bioekonomiji odnosno „održivom gospodarstvu koje koristi resurse u cilju smanjenja potreba za novim resursima i zamjenom fosilnog ugljika s obnovljivim ugljikom iz biomase“ (Kulišić, 2020., 5). Cilj europske strategije bioekonomije je razvoj inovativnog, učinkovitog i konkurentnog društva koje usklađuje sigurnost hrane s održivom uporabom bioloških obnovljivih izvora u industrijske svrhe, istodobno osiguravajući zaštitu okoliša (Europska Komisija, 2012.). Od 2019. godine nova strategija rasta Europske unije kojom se želi kontinent transformirati u klimatski neutralno, pravedno i prosperitetno društvo s modernim, resursno učinkovitim i konkurentnim gospodarstvom je *Zeleni plan* (Europska komisija, 2019.).

Jedan od nacionalnih razvojnih smjerova Republike Hrvatske odnosi se na bioekonomiju i poticanje kružnoga gospodarstva, a ugrađen je u razvojni smjer 3 *Zelena i digitalna tranzicija*. „Zelena i digitalna tranzicija promicat će se prelaskom na čistu energiju, poticanjem zelenih i plavih ulaga-

[1] Strategija bioekonomije i Akcijski plan podupire tri ključna aspekta: razvijanje novih tehnologija i procesa za bioekonomiju; razvijanje tržišta i konkurentnosti u sektorima temeljenim na biomasi; poticanje donositelja politika i dionika na međusektorsku suradnju (Kulišić, 2020.).

INTRODUCTION

The development of the global economy in the second half of the 20th century and onward has been defined by growth and intermittent crises. This growth has had positive as well as negative consequences, such as environmental pollution, climate change, biodiversity loss, and geopolitical tensions. Human activities and the world economy have had a major impact on the environment. However, the growing awareness about planetary ramifications has created a push for a transition toward a sustainable economy or sustainable development. As a concept, sustainable development is being progressively supplanted by the terms 'bioeconomy' or 'bio-based economy'. As a relatively new approach with staunch advocates, bioeconomy is an economy based on innovative methods that replace fossil sources with intelligent and efficient bio-based materials and processes (Schlaile, Urmetzer, 2019).

The European Commission adopted a strategy[1] to direct the European economy toward a bioeconomy or 'a sustainable economy that uses resources with the aim to diminish the need for new resources and replace fossil carbon with renewable carbon from biomass' (Kulišić, 2020, 5). The aim of the European Bioeconomy Strategy is to develop a more innovative, efficient, and competitive society that reconciles food security with the sustainable use of renewable biological resources for industrial purposes, while ensuring environmental protection (European commission, 2012). In 2019, the EU adopted the Green Deal, a new growth strategy that aims to transform the continent into a climate-neutral, fair, and prosperous society with a modern, resource-efficient, and competitive economy (Europska komisija, 2019).

One of the national development directions of the Republic of Croatia – Development Direction 3, *Green and Digital Transition* – advocates the bioeconomy and circular economy. 'The green and digital transition will be fostered by making a switch to clean energy, supporting green and blue

[1] The Bioeconomy Strategy and Action Plan supports three key areas: developing new technologies and processes for the bioeconomy; developing markets and competitiveness in biomass-based sectors; promoting intersectoral cooperation between policy-makers and stakeholders (Kulišić, 2020).

nja, jačanjem samodostatnosti u hrani, razvojem kružnog gospodarstva, prilagodbom klimatskim promjenama, očuvanjem i obnovom ekosustava i bio-raznolikosti te razvojem održive i pametne mobilnosti i povezivosti" (Nacionalna razvoja strategija 2030, 2020., 4).

Globalni i neravnomjerni razvoj gospodarstva, izazovi klimatskih promjena, pad bioraznolikosti, sve veća potrošnja resursa zahtijevaju tranziciju dosadašnjeg načina rada, poslovanja, upravljanja, ali i obrazovanja. „Pitanje održivoga razvoja i sudjelovanje u odgovornome vrednovanju prirodnih resursa koji neće nepovratno uništiti okoliš ne mogu se razumjeti bez geografije" (Kurikulum geografije za osnovne škole i gimnazije, 2019., 2). Geografija može pridonijeti razvoju bioekonomije i kroz predtercijarno i tercijarno obrazovanje sadržajima koji se uče i poučavaju u osnovnoj i srednjoj školi, ali i položajem u odnosu na druge predmete, međupredmetne teme i područja kurikuluma (Kurikulum geografije za osnovne škole i gimnazije, 2019.).

Primarni cilj ovoga rada je analizirati ulogu i potencijale geografskog predtercijarnog obrazovanja u razvoju bioekonomije i kružnog gospodarstva kojemu teži Republika Hrvatska preko razvojnog smjera 3 „Zelena i digitalna tranzicija" (Nacionalna razvoja strategija 2030, 2020.). Sekundarni ciljevi rada su analizirati osnovne teorijske značajke bioekonomije, strukturu zaposlenosti i strukturu ostvarenog prometa u sektorima bioekonomije u državama Europske unije s posebnim naglaskom na stanje u Republici Hrvatskoj. Ključne teme strategije bioekonomije u Europskoj uniji su *sigurnost u opskrbi hranom*, *održivo gospodarenje prirodnim resursima*, *smanjenje ovisnosti o neobnovljivim resursima*, *klimatske promjene – prevencija i prilagodba*, *radna mjesta i osiguranje konkurentnosti Europe*. Uloga i potencijali geografskog obrazovanja analizirani su prema navedenim ključnim temama.

PREGLED ODABRANIH DOSADAŠNJIH ISTRAŽIVANJA

Ruski biolog F. I. Baranoff početkom 20. stoljeća proučavao je ribolovnu ekonomiju i, prema H. S. Gordonu (1954.), to je početak bioekonomi-

investments, strengthening food self-sufficiency, establishing a circular economy, adapting to climate change, preserving and restoring ecosystems and biodiversity, and developing sustainable and smart mobility and connectivity' (Nacionalna razvoja strategija 2030, 2020, 4).

The uneven global economic development, climate change challenges, biodiversity loss, and the ever-escalating consumption of resources call for a change of the status quo in labour, business, management, and education. 'The challenge of sustainable development and participation in a responsible valuation of natural resources that will not irreversibly destroy the environment cannot be understood without geography' (Kurikulum geografije za osnovne škole i gimnazije, 2019, 2). Pre-tertiary and tertiary education in geography may contribute to the development of the bioeconomy through instructional contents taught at the primary and secondary levels as well as its position relative to other subjects, cross-curricular topics, and curricular areas (Kurikulum geografije za osnovne škole i gimnazije, 2019).

The primary goal of this paper is to analyse the role and potential of pre-tertiary geography education in and for the development of the bioeconomy and circular economy, which is the aim of the Republic of Croatia defined by Development Direction 3, 'Green and Digital Transition' (Nacionalna razvoja strategija 2030, 2020). The secondary goals of this paper are to analyse the general theoretical features of the bioeconomy as well as employment and turnover structure in the EU bioeconomy sectors, with a special emphasis on the situation in the Republic of Croatia. The key topics of the EU Bioeconomy Strategy are: *food security*, *sustainable management of natural resources*, *reducing dependence on non-renewable resources*, *climate change – mitigation and adaptation*, and *creating jobs and maintaining European competitiveness*. The role and potential of education in geography are analysed in accordance with these key topics.

OVERVIEW OF SELECTED RESEARCH

According to H. S. Gordon (1954), the bioeconomy has its roots in the research on fishery economics conducted by the Russian biologist F. I. Bar-

je. Pojam *bioekonomije* kao teorijske mogućnosti 1970-ih i 1980-ih razvija Nicholas Georgescu-Roegen koji je utjecao na proučavanje i strukturu *ekološke ekonomije* kroz ideju rasta (Georgescu-Roegen, 1975.). Prema Georgescu-Roegenu, pojam bioekonomije označava određeni problem s kojim se ljudsko društvo suočava, odnosno čovjek kao i svako živo biće mora se boriti protiv zakona entropije. Nadalje, tehnologija produžuje ljudsko biološko tijelo omogućujući mu da proširi polje svojega djelovanja (Vivien i dr., 2019.). I dok je pojam bioekonomije u početku imao filozofsko tumačenje, potkraj 20. stoljeća razvilo se znanstveno poimanje bioekonomije. Biotehnologija, kao jezgra bioekonomije, temelji se na tehnoznanosti, odnosno novoj industrijskoj paradigmi (Patermann, Aguilar, 2018.). Nositelj drugog tumačenja je OECD (*Organisation for Economic Co-operation and Development*) koji ovaj koncept analizira kroz biološke znanosti koje mogu razriješiti probleme današnjice (ublažavanje klimatskih promjena, poboljšanje zdravstvenih uvjeta i kvalitete života). Poljoprivredna biotehnologija omogućuje porast prinosa, a biotehnologija značajno pridonosi ekonomskoj produktivnosti (OECD, 2009.; Vivien i dr., 2019.). Danas prihvaćeno tumačenje odnosi se na procese biopročišćavanja, koje je Europska komisija primijenila za poljoprivredu, šumarstvo, ribarstvo, kao i za kemiju i biotehnologiju. Biopročišćavanje je središte ekološke transformacije biomasa (Londo, Meeusen, 2010.; Europska komisija, 2012., 2018.; Vivien i dr., 2019.). Bioekonomija se odnosi na transformaciju gospodarstva koje se u velikoj mjeri temelji na fosilnim gorivima u gospodarstvu s učinkovitijim korištenjem obnovljivih resursa i sirovina koji se proizvode održivom uporabom usluga ekosustava s kopna i vode (Bennich, Belyazid, 2017.). Bioekonomija predstavlja proizvodnju obnovljivih bioloških resursa i pretvaranje tih resursa i tokova otpada u proizvode s dodanom vrijednošću, kao što su hrana, hrana za životinje, proizvodi koji se temelje na biološkoj osnovi kao i bioenergiju (Europska komisija, 2012., 2018.; Vivien i dr., 2019.). Ključnu ulogu za razvoj bioekonomije uz poduzetnike, vlast/politiku, znanstvene institucije i međunarodnu suradnju imaju formalno, neformalno i informal-

anoff at the beginning of the 20th century. In the 1970s and 1980s, Nicholas Georgescu-Roegen was the first to envision *the bioeconomy* as a theoretical possibility and influenced the study and structure of *environmental economy* through his idea of growth (Georgescu-Roegen, 1975). Georgescu-Roegen considered that the term defined a specific challenge faced by the human society: man, like every living creature, must fight against the law of entropy. According to him, technology augments the biological human body and allows for a broader scope of action (Vivien et al., 2019). Whereas the initial conception had a philosophical bend, at the end of the 20th century, the bioeconomy evolved into a scientific concept. Biotechnology, as the core of bioeconomy, is based on technoscience and a new industrial paradigm (Patermann, Aguilar, 2018). The Organization for Economic Co-operation and Development (OECD) pioneered this second interpretation by analysing the concept from the perspective of biological sciences that may help solve our pressing issues (mitigating climate change, improving health conditions and quality of life). Agricultural biotechnology boosts crop productivity, and biotechnology has a significant positive effect on economic productivity (OECD, 2009; Vivien et al., 2019). Today, the common interpretation refers to bioremediation processes, which are applied by the European Commission in the areas of agriculture, forestry, fishing, as well as chemistry and biotechnology. Bioremediation is at the heart of the ecological transformation of biomass feedstocks (Londo, Meeusen, 2010; Europska komisija, 2012, 2018; Vivien et al., 2019). The bioeconomy stands for a shift from a largely fossil fuel-based economy to a more efficient economy that is based on renewable resources and raw materials produced through a sustainable use of land and water ecosystem services (Bennich, Belyazid, 2017). The bioeconomy entails the production of renewable biological resources and the transformation of these resources and waste flows into value-added products, such as food, animal feed, bio-based products, and bioenergy (Europska komisija, 2012, 2018; Vivien et al., 2019). Alongside entrepreneurs, the government/policies, scientific institutions, and international cooperation, formal, non-formal, and informal education/learning of every stakeholder in

no obrazovanje/učenje svakog pojedinca involviranog u ovo područje gospodarstva.

S obzirom na to da u njemu aktivno sudjeluju brojne znanstvene discipline, poput agronomije, ekologije, biotehnologije, nanotehnologije, IT-a, inovacijski potencijal bioekonomije je velik (Rajh, 2017.). Bioekonomija predstavlja inovativna gospodarstva s niskom razinom emisija plinova u cilju razvoja primarnog sektora (poljoprivreda, ribarstvo, šumarstvo). Drugi ciljevi bioekonomije su sigurnost i dostatnost opskrbe hranom, održivo korištenje obnovljivih bioloških resursa u industriji uz istovremenu zaštitu bioraznolikosti i okoliša (Europska komisija, 2012., 2018.). Za bioekonomiju se često koristi sinonim zelena ekonomija (engl. *green economy*). Zelena ekonomija ne odnosi se isključivo na bioproizvode i proizvodnju energije, već ističe sve obnovljive izvore energije, ekološke vidove proizvodnje i procese recikliranja te veliku pozornost pridaje društvenoj prihvatljivosti gospodarskih aktivnosti i kao takva predstavlja sveobuhvatniji pristup (Bioekonomija i šumarska politika, 2, 2015). Dio bioekonomije je kružno gospodarstvo (engl. *circular economy*) koje čini zatvoreni krug strujanja sirovina, materije i energije u nekoliko faza i po svojoj je namjeni i dizajnu obnavljajuća ili regenerirajuća.

O važnosti geografske znanosti u bioekonomiji i povezano s njome socijalno-tehničke tranzicije (STT) posljednje se desetljeće intenzivno raspravljalo, s naglaskom na proučavanje prostora i prostornih odnosa te energetskih tokova (Smith i dr., 2010.; Neville, Dauvergne, 2012.; Huber, 2015.; Murphy, 2015.; Calvert i dr., 2017.). Početnu ulogu imala je ekološko-ekonomska geografija koja bioekonomiju nastoji objasniti suradnjom STT područja i geografije (Huber, 2012.; Birch, Tyfield, 2013.; Calvert, 2016.). Geografija energije kroz socioekološke odnose istražuje primjenu alternativnih „low carbon" izvora energije, posebno biogoriva i biomase. Primjena ovih izvora energije izazov je za očuvanje šumskih ekosustava, posebno na sjeveru Europe (Lovrić i dr., 2020.). Geografija kao interdisciplinarna znanost ovu problematiku istražuje kroz četiri multisektorski povezana područja. Ta su područja socijalna analiza prostornih odnosa, geopolitika

this economic area plays a key role in the development of a bioeconomy.

Owning to active contributions from various scientific disciplines, such as agronomy, environmental science, biotechnology, nanotechnology, and the IT, the bioeconomy has a major innovation potential (Rajh, 2017). The bioeconomy is an innovative economy with low gas emissions focused on developing the primary sector (agriculture, fishing, forestry). Other goals of the bioeconomy are food security and sufficiency, the sustainable industrial use of renewable biological resources, as well as preserving biodiversity and environmental protection (Europska komisija, 2012, 2018). Bioeconomy is often synonymous with green economy. A green economy goes beyond bio-products and energy production and is concerned with all renewable energy sources, ecological modes of production, recycling processes, and spotlighting socially acceptable economic activities; as such, it represents a more comprehensive approach (Bioekonomija i šumarska politika, 2, 2015). The circular economy is a building block of the bioeconomy. It is a multi-stage, closed-loop flow of raw materials, matter, and energy that is restorative and regenerative by design and purpose.

The importance of geographic science for the bioeconomy and the related socio-technical transition (STT) has been discussed extensively over the past decade, with a focus on the study of space, spatial relations, and energy flows (Smith et al., 2010; Neville, Dauvergne, 2012; Huber, 2015; Murphy, 2015; Calvert et al., 2017).

In the early phase, environmental economic geography tried to explain the bioeconomy as a collaboration between STT areas and geography (Huber, 2012; Birch, Tyfield, 2013; Calvert, 2016). Energy geography has explored socio-environmental relations and the application of alternative low-carbon energy sources, especially biofuels and biomass. These energy sources pose a challenge to forest ecosystems conservation, especially in the north of Europe (Lovrić et al., 2020). As an interdisciplinary science, geography approaches these issues from four multisectoral perspectives. These perspectives are the social analysis of spatial relations, geopolitics and geoeconomics in global trade flows, especially energy trade, the role of

i geoekonomija u globalnim tokovima trgovine, posebno trgovini energijom, uloga geografije u STT području te uvođenje novih tehnologija, poput GIS-a (Haddad, Anderson, 2008.; Kurka i dr., 2012.; Anejionu i dr., 2020.; Nørstebø i dr., 2020.).

METODE

Nakon odabira i interpretacije odabrane literature i izvora, postavljena su sljedeća istraživačka pitanja: Koje su karakteristike promijenjene paradigme s linearnog na kružno gospodarstvo? Postoje li značajniji pomaci u razvoju bioekonomije u Republici Hrvatskoj posljednjih desetak godina? Obuhvaća li predmetni kurikulum Geografije za osnovne škole i gimnazije odgojno-obrazovne ishode koji se odnose na ključne teme EU Strategije bioekonomije?

U radu se provjeravaju sljedeće hipoteze:

- Promjena paradigme iz linearnog u kružno gospodarstvo pridonosi održivosti.
- U Hrvatskoj je bioekonomija u začecima razvoja pa će za njezin budući razvoj veliku ulogu imati obrazovanje.
- Predmetni kurikulum Geografije za osnovne škole i gimnazije dobro je polazište za obrazovanje o održivosti i bioekonomiji.

U radu su primijenjene kvantitativne i kvalitativne metode rada te metoda komparacije i deskripcije. Metodom komparacije i deskripcije obrazložen je teorijski okvir bioekonomije i kružnoga gospodarstva. Kvantitativnim metodama (deskriptivna statistika) analizirane su odabrane varijable o veličini bioekonomije u državama Europske unije (EU-28) i Republici Hrvatskoj (ukupni promet i dodana vrijednost 2017.) te zaposlenost po sektorima u bioekonomiji 2008. i 2017. godine. Od kvalitativnih metoda primijenjena je analiza sadržaja predmetnoga kurikuluma Geografije za osnovne škole i gimnazije, temeljena na ključnim riječima u ishodima učenja. Izdvojeni su ishodi učenja povezani s ciljevima EU Strategije bioekonomije. Rezultati analize sadržaja kurikuluma polazište su u oblikovanju smjernica učinkovitog

geography in STT, and the introduction of new technologies, such as GIS (Haddad, Anderson, 2008; Kurka et al., 2012; Anejionu et al., 2020; Nørstebø et al., 2020).

METHODS

The selection and interpretation of literature and sources raised the following research questions: What are the features of the paradigm shift from a linear to a circular economy? Have there been any significant advances in the evolution of a bioeconomy in the Republic of Croatia over the last ten years? Does the Geography curriculum for primary and 'gimnazija' secondary schools include learning outcomes that correlate with the key topics of the EU Bioeconomy Strategy?

The research tested following hypotheses:

- A paradigm shifts from a linear to a circular economy supports sustainability.
- Given that the bioeconomy in Croatia is in its early stages, education will play a major role in its future development.
- The primary and secondary school curriculum for Geography is a good starting point for education about sustainability and the bioeconomy.

The research was conducted using quantitative and qualitative methods as well as comparative and descriptive methods. The theoretical framework of the bioeconomy and circular economy was defined using comparative and descriptive methods. Quantitative methods (descriptive statistics) were used to analyse selected variables representing the size of bioeconomies in the EU member states (EU-28) and the Republic of Croatia (2017 total turnover and added value) as well as employment by bioeconomy sector in 2008 and 2017. Qualitative methods were used to analyse the content of the primary and secondary school curricula for Geography based on keywords of its learning outcomes. Learning outcomes associated with the EU Bioeconomy Strategy objectives were highlighted. The results of the curricular content analysis are a starting point for creating guidelines for effective and efficient teaching and learning about bioeco-

učenja i poučavanja postulata bioekonomije u Geografiji i srodnim predmetima. Samo se učinkovitim obrazovanjem, posebice geografskim, može pripremiti mlade za uspješne odgovore na životne izazove u 21. stoljeću.

REZULTATI I RASPRAVA

Promjena paradigme – s linearnog na kružno gospodarstvo

Održiva bioekonomija ključna je za borbu protiv klimatskih promjena i degradacije zemljišta i ekosustava. Transformacija klasičnoga linearnog modela ekonomije u bioekonomiju zahvaća prijelaz s uporabe fosilnih izvora na bioobnovljive, kao i prijelaz s linearnog na kružno gospodarstvo. Za linearno gospodarstvo karakteristično je da se otpad kao jedan od rezultata procesa proizvodnje baca u okoliš. Linearno gospodarstvo temeljilo se na načelu: uzmi – proizvedi – upotrijebi – baci s pretpostavkom neograničenosti i lake dostupnosti materijalnih resursa. Osnovna ideja koncepta kružnoga gospodarstva je stvoriti zatvoreni krug proizvodnje i potrošnje, pri čemu bi se unos materijala i stvaranje otpada smanjilo na minimum. Model kružnoga gospodarstva, za razliku od linearnog modela, usmjeren je na načelo: smanji – ponovno koristi – recikliraj – redizajniraj – preradi – upotrijebi. Kružno gospodarstvo ističe se kao potencijalno rješenje za održivi ekonomski razvoj te je sastavni dio bioekonomije. Ono čini zatvoreni krug strujanja sirovina, materije i energije u nekoliko faza (Franklin-Johnson i dr., 2016.; Andabaka, 2018.; Andabaka i dr., 2018.). Ta je industrijska ekonomija obnavljajuća ili regenerirajuća po svojoj namjeni i dizajnu (URL 1). Jedna od ključnih postavki u kružnom gospodarstvu jest: *otpad je hrana*. Svi materijali i proizvodi koji su došli do kraja svojeg vijeka trajanja postaju sirovine za proizvodnju nove robe. Glavna misao vodilja kružnoga gospodarstva je ostvariti koncept *zero waste* (0 % otpada).

U početnom ciklusu razvoja kružno gospodarstvo imalo je osnovu 3R (engl. *reduce – reuse – recycling*), a danas je ona proširena na 6R komponenti (engl. *reduce – reuse – recycling – redesign – remanufacturing – recover*), odnosno smanjiti

nomy principles in Geography classes and related subjects. Only effective education, especially in Geography, can prepare young people to successfully address the 21st century challenges.

RESULTS AND DISCUSSION

Paradigm shift – from linear to circular economy

A sustainable bioeconomy is key to combating climate change and land and ecosystem degradation. The shift from the traditional linear model of the economy to a bioeconomy entails a move away from fossil resources and toward bio-renewable resources as well as a transition from linear to circular economy. In the linear economy, waste is released into the environment as a by-product of the production process. The linear economy is based on the principle of 'take – produce – use – throw away' and assumes an unlimited and easy access to material resources. The central tenet of a circular economy is creating a closed loop of production and consumption with a minimal inflow of new materials and waste generation. Unlike the linear model, the founding principle of the circular economy is 'reduce – reuse – recycle – redesign – remanufacture – recover'. The circular economy stands out as a potential solution for a sustainable economic development and is an integral part of the bioeconomy. It engenders a multi-stage, closed-loop flow of raw materials, matter, and energy (Franklin-Johnson et al., 2016; Andabaka, 2018; Andabaka et al., 2018). It is an industrial economy that is restorative and regenerative by purpose and design (URL 1). A key principle of the circular economy is *waste is food*. All materials and products that have reached the end of their useful life become raw materials to produce new goods. The main governing principle of the circular economy is working toward zero waste.

In its early stages, the circular economy was based on the concept of the 3 Rs (reduce – reuse – recycle), but this has now been expanded to 6 Rs (reduce – reuse – recycle – redesign – remanufacture – recover) (Jawahir, Bradley, 2016). The global economy has been moving away from the linear production model and embracing a circular model that has a lower im-

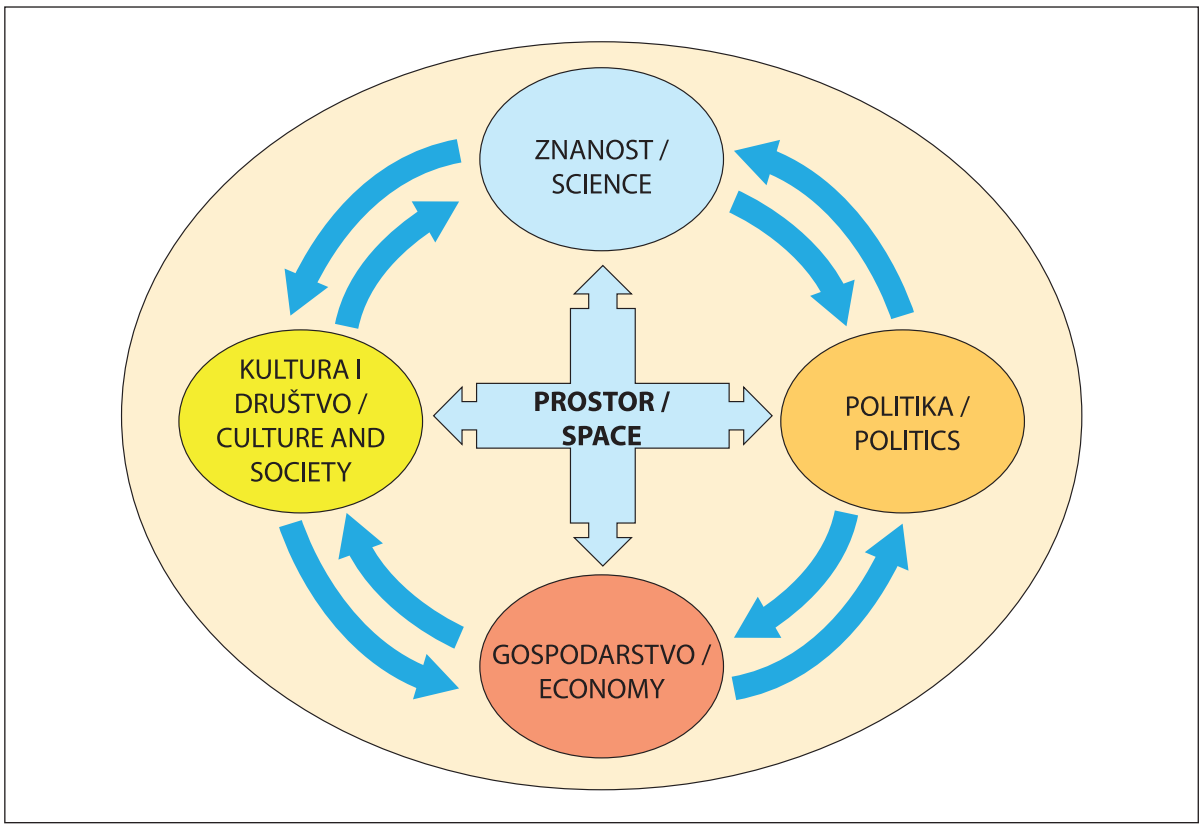
– ponovno koristiti – reciklirati – redizajnirati – preraditi – uporabiti (Jawahir, Bradley, 2016.). Stoga svjetsko gospodarstvo napušta linearni model proizvodnje i prihvaća kružni model kroz koji smanjuje opterećenost okoliša i povećava sigurnost opskrbe, uvodi inovacije i otvara nova radna mjesta.

Takav prijelaz zahtijeva međusobnu povezanost svih ključnih elemenata u funkcioniranju sustava. Početni sustav povezanosti temeljio se na *Triple Helix* modelu, koji je izričito naglašavao važnost visokog obrazovanja za inovacije. U tom modelu naglasak je na proizvodnji znanja i inovacija u gospodarstvu pa je kompatibilan s ekonomijom znanja. Uključivanjem javnosti, nevladinih udruga, medija i kulture odnosno uz *znanost, politiku, gospodarstvo* uključivanjem *kulture i društva* nastaje sustav tzv. *Quadruple Helix* model u kojemu održivi razvoj ekonomije znanja zahtijeva suradnju s društvom znanja. Osim političkih, državnih prava i sloboda potrebno je uzeti u obzir i utjecaj na prirodni okoliš odnosno na *prostor* čime nastaje peta cjelina sustava tzv. *Quintuple Helix* model koji naglašava nužnost socioekološke tranzicije društva i gospodarstva u 21. stoljeću (Sl. 1.).

pact on the environment, improves supply security, facilitates innovation, and creates new jobs.

This transition requires interconnectivity between all key elements of the system. The initial interconnectivity system was based on a triple helix model, which explicitly stressed the importance of higher education for innovation. According to this model, the focus of the economy is on the production of knowledge and innovation, making it compatible with the knowledge economy. The addition of *culture and society* to *science, politics, and economy* and the involvement of the public, non-governmental organizations, the media, and cultural institutions has given rise to a quadruple helix model, which requires cooperation with the knowledge society for a sustainable development of the knowledge economy. In addition to political and state rights and freedoms, consideration should be given to the impact on the natural environment or *space* as the fifth element in the so-called quintuple helix model, which calls attention to the need for a socio-environmental transition of society and economy in the 21st century (Fig. 1).

Nature is seen as an endless source of ideas and processes, so the aim is to use biomimetics to try



Slika 1. *Quintuple Helix model – naglasak na prirodni okoliš (prostor)*
Figure 1 *Quintuple Helix model - emphasis on the natural environment (space)*

Priroda je neiscrpan izvor ideja i postupaka pa se biomimikrijom nastoje oponašati najbolja rješenja iz prirode i primijeniti ih u proizvodnim ciklusima. Industrijska ekologija odavno promovira kružni sustav korištenja otpada kao sirovine ili energenata. Kalundborg simbioza već je gotovo pedeset godina primjer uspješnoga kružnoga gospodarstva (Šiljković, 2011.).

Promjenom paradigme s linearnog na kružno gospodarstvo uz povezanost svih ključnih elemenata u funkcioniranju sustava uvažavajući ekološki osjetljiv model, to jest peterostruku spiralu (*Quintuple Helix* model) (Sl. 1.) može se pridonijeti održivosti sustava čime je potvrđena prva hipoteza postavljena u ovome radu.

BIOEKONOMIJA U EUROPSKOJ UNIJI I REPUBLICI HRVATSKOJ – STANJE I PERSPEKTIVE

Pokazatelji veličine bioekonomije u državama Europske unije (EU-28) 2017. godine su 2454 milijarde eura prometa i 685 milijardi eura dodane vrijednosti.[2] Ukupan broj zaposlenih bio je 18,6 milijuna[3] (9 % ukupno zaposlenih). Prema sektorima zaposlenosti u bioekonomiji (Piotrowski i dr., 2018.; Ronzon i dr., 2020.), najveći je udio zaposlenih u sektoru *poljoprivrede*. Slijedi zaposlenost u sektorima: *hrana, pića i duhan*; *proizvodnja drva i namještaja*; *bio bazirani tekstil*; *papir*; *šumarstvo*; *bio bazirane kemikalije*, *plastika i vrećice*, a najmanji je udio (manje od 1 % zaposlenih) u sektoru *ribarstva i akvakulture*; *tekuća biogoriva i bio bazirana električna energija* (URL 2) (Sl. 2.).

Od svih zaposlenih u bioekonomiji, udio zaposlenih u poljoprivredi 2017. godine bio je 52 % (3 postotna boda manje nego 2008. godine). Sektor *hrane, pića i duhana* bilježi porast u udjelu zaposlenih 2017. godine u odnosu na 2008. godinu za 3,8 postotnih bodova, a pad u udjelu zaposlenosti bilježe sektori *proizvodnje drva i namještaja* te *bio bazirani tekstil*. Ostali sektori bilježe blagi porast ili stagnaciju u udjelima zaposlenih (Sl. 2.). Indeks

[2] EU-27: 2232 milijarde eura prometa i 614 milijardi eura dodane vrijednosti u 2017. godini

[3] EU-27: 17,5 milijuna zaposlenih

to imitate nature's best solutions and apply them in production cycles. Industrial ecology has long been promoting a circular system that uses waste as a raw material or energy source. The Kalundborg symbiosis has been an example of a successful circular economy for almost 50 years (Šiljković, 2011).

Shifting the paradigm from linear to circular economy, the interconnectivity between all key elements of the system, and adopting an ecologically sensitive quintuple helix model (Fig. 1) may promote the sustainability of the system, thus confirming the first hypothesis presented in this paper.

BIOECONOMY IN THE EUROPEAN UNION AND THE REPUBLIC OF CROATIA – SITUATION AND PERSPECTIVES

In 2017, the indicators of the size of the bioeconomy in the EU member states (EU-28) were the EUR 2,454 billion turnover and EUR 685 billion added value.[2] The total employment was 18.6 million[3] (9% of total persons employed). Based on the employment (Piotrowski et al., 2018; Ronzon et al., 2020), *Agriculture* had the largest share of workers among all bioeconomy sectors. This was followed by the employment in the following sectors: *food, beverage, and tobacco*; *wood and furniture production*; *bio-based textiles*; *paper*; *forestry*; *bio-based chemicals*, *plastics, and bags*; the smallest employment share (less than 1% of persons employed) was in *fisheries and aquaculture*, *liquid biofuels*, *and bio-based electricity* (URL 2) (Fig. 2).

In 2017, the share of agricultural workers in total employment in the bioeconomy was 52% (3 percentage points less than in 2008). In 2017, the *food, beverage, and tobacco* sector had a 3.8 percentage point increase in employment share compared to 2008, but *wood and furniture production* and *bio-based textiles* recorded a drop in employment. The employment shares in other industries either rose slightly or stagnated (Fig. 2). In 2017, the index of change in total employment in the bioec-

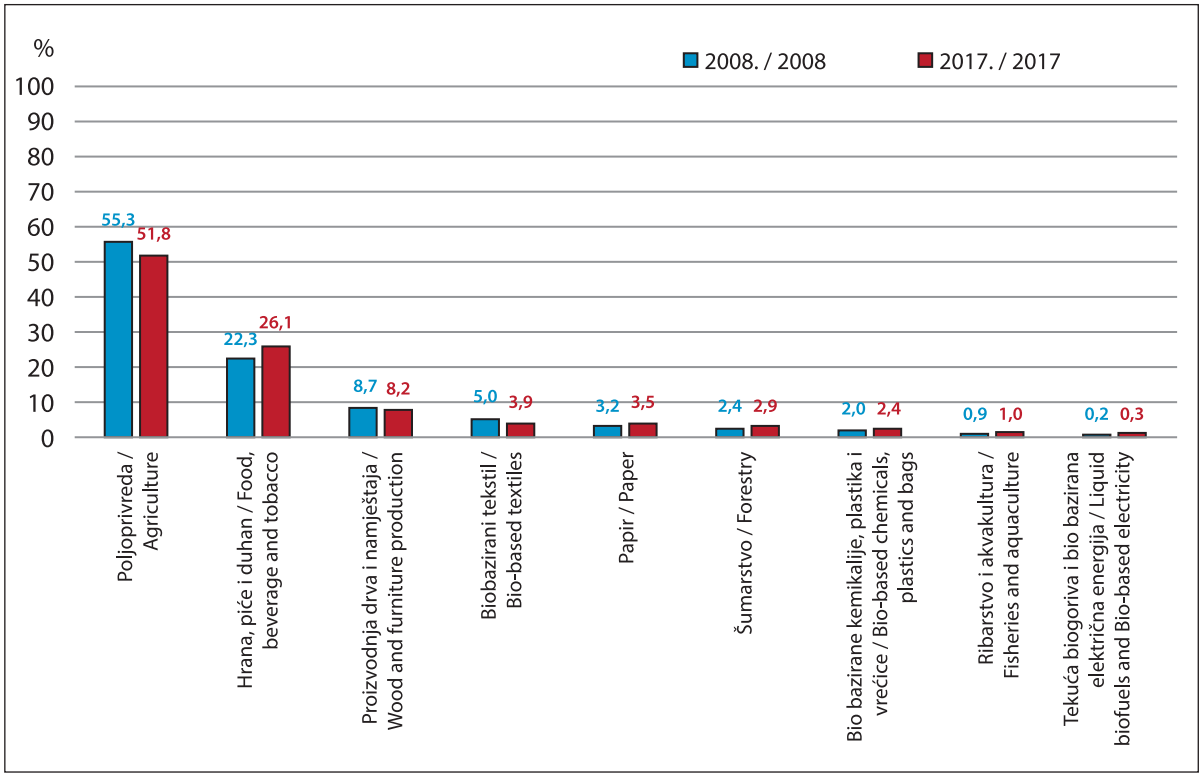
[2] EU-27: EUR 2,232 billion turnover and EUR 614 billion added value in 2017.

[3] EU-27: 17.5 million employees.

promjene ukupnog broja zaposlenih u bioekonomiji 2017. godine u odnosu na 2008. godinu je 87,9 (a ukupnog broja zaposlenih u svim djelatnostima 102). Gledano po pojedinim sektorima, smanjenje zaposlenosti zabilježeno je gotovo u svim sektorima osim *šumarstva*, sektora koji bilježi porast za 6,7 % i sektora proizvodnje *hrane, pića i duhana* koji bilježe blagi porast za oko 2,5 %, dok je u promatranome razdoblju najznačajniji porast zaposlenosti u sektoru proizvodnje električne energije iz biomase koja je zabilježila rast od 262,1 %. Taj porast Kulišić (2020.) objašnjava paketom potpora za proizvodnju električne energije iz obnovljivih izvora u bruto finalnoj potrošnji energije EU-a do 2020. godine (Ronzon i dr., 2020.). Prema podacima EUROSTAT-a (URL 3), 2017. godine stopa ukupne nezaposlenosti porasla je za 0,9 postotnih bodova u odnosu na 2008. godinu. Pod utjecajem svjetske financijske krize i lančanih posljedica koje je uzrokovala, stope ukupne nezaposlenosti rasle su od 2008. do 2014. godine, od tada se smanjuju, ali su 2017. godine u 19 država članica Europske unije još uvijek bile veće od onih 2008. godine.

Za razliku od broja zaposlenih, koji u promatranome razdoblju bilježi pad, u sektorima bioekonomy was 87.9 when compared to 2008 figures (whereas total employment in all activities was 102). Looking at individual sectors, almost every sector had a drop in employment except *forestry*, which had a 6.7% increase and the *food, beverage, and tobacco* production sector, which had a slight increase of about 2.5%. The biopower production sector had the most significant employment growth during the observed period, 262.1%. According to Kulišić (2020), this growth was a result of subsidies for energy generation from renewable resources in the gross final energy consumption in the EU until 2020 (Ronzon et al., 2020). According to EUROSTAT data (URL 3), in 2017, the total unemployment rate increased by 0.9 percent compared to 2008 figures. Due to the effects of the global financial crisis and the resulting chain of consequences, total unemployment rose between 2008 and 2014, but has been on the decline since. However, in 2017, 19 EU member states still had higher unemployment that in 2008.

In contrast to the shrinking employment over the observed period, bioeconomy sectors experienced a turnover growth of 16.1%. This growth was greater in biomass processing than in biomass production.



Slika 2. *Zaposlenost po sektorima u bioekonomiji za države Europske unije (EU-28) 2008. i 2017. godine (u %)*
Figure 2 *Employment by sectors in the bioeconomy for the countries of the European Union (EU-28) in 2008 and 2017 (%)*
Izvor / Source: URL 2

nomije ostvaren je rast prometa i to za 16,1 %, više u sektorima koji prerađuju biomasu nego u sektorima koji je proizvode. To se može objasniti rastom produktivnosti i značajnim udjelom zaposlenih u radno intenzivnijem sektoru proizvodnje biomase (poljoprivreda). Pojedinačno najveći promet ostvaren je u proizvodnji *hrane, pića i duhana*, u visini od 1,241 milijarde eura te u proizvodnji biomase u *poljoprivredi* 449 milijardi eura što je 68,9 % ukupnog prometa bioekonomije EU-28 u 2017. godini. Među sektorima bioekonomije, porast prometa bilježe sektor *bio bazirana električna energija* (251,4 %), *tekuća biogoriva* (41 %) i *bio bazirane kemikalije*, *plastika i vrećice* (25,4 %). Proizvodnja električne energije iz biomase koja je ostvarila najveći porast prometa od 2008. do 2017. godine čini tek 0,9 % ukupnog prometa bioekonomije Europske unije u 2017. godini (Tab. 1.).

U Republici Hrvatskoj najveći je udio zaposlenosti u bioekonomiji također u sektoru *poljoprivrede* i u sektoru *hrane, pića i duhana*, kao i u državama

This may be explained by the increase in productivity and a more significant employment in the more labour-intensive sector of biomass production (agriculture). Sectors with the highest respective turnovers were food, beverage, and tobacco production (EUR 1.241 billion) and agricultural production of biomass (EUR 449 billion), which alone accounted for 68.9% of the total turnover in the EU-28 bioeconomy in 2017. Among bioeconomy sectors, turnover increase was recorded in bio-based electricity (251.4 %), liquid biofuels (41%), and bio-based chemicals, plastics, and bags (25.4 %). Between 2008 and 2017, biopower production had the greatest turnover growth, but this still accounted for only 0.9% of the total EU bioeconomy turnover in 2017 (Tab. 1).

Like other EU member states, the bioeconomy of the Republic of Croatia also had the greatest employment in *agriculture* and *food, beverage, and tobacco*. This was followed by the *wood and furniture production*, *forestry*, *bio-based textiles*, *fisheries and aquaculture*, and *paper* sector. As was the case

Tablica 1. *Promet po sektorima u bioekonomiji u državama Europske unije 2008. i 2017. godine*
Table 1 *Turnover by sectors of the bioeconomy in the European Union in 2008 and 2017*

Sektor bioekonomije (RH) / Bioeconomy sector (Croatia)	2008. / 2008		2017. / 2017		Indeks promjene (2017./ 2008.) Index of change (2017/2008)
	Promet u mlrd. EUR / Turnover in billion EUR	Udio prometa (%) / Share of turnover (%)	Promet u mlrd. EUR / Turnover in billion EUR	Udio prometa (%) / Share of turnover (%)	
Poljoprivreda / Agriculture	402,0	19,0	449,6	18,3	111,8
Šumarstvo / Forestry	42,4	2,0	50,5	2,1	119,3
Ribarstvo i akvakultura / Fisheries and aquaculture	12,8	0,6	15,3	0,6	119,7
Hrana, piće i duhan / Food, beverage and tobacco	1040,5	49,2	1 241,5	50,6	119,3
Bio bazirani tekstil / Bio-based textiles	90,0	4,3	79,9	3,3	88,9
Proizvodnja drva i namještaja / Wood and furniture production	186,7	8,8	187,5	7,6	100,4
Papir / Paper	165,9	7,8	195,9	8,0	118,1
Bio bazirane kemikalije, plastika i vrećice / Bio-based chemicals, plastics and bags	157,8	7,5	197,8	8,1	125,4
Tekuća biogoriva / Liquid biofuels	10,7	0,5	15,0	0,6	141,0
Bio bazirana električna energija / Bio-based electricity	6,0	0,3	21,1	0,9	351,4
Ukupno promet / Total turnover	2 114,5	100,0	2 454,2	100,0	116,1

Izvor / Source: URL 2

Europske unije. Slijede sektori *proizvodnja drva i namještaja*, *šumarstvu*, *bio baziranom tekstilu*, *ribarstvu i akvakulturi* te *papiru*. Kao i u državama Europske unije, najmanji je udio zaposlenih (manje od 1 % zaposlenih) u sektorima *tekuća biogoriva* i *bio bazirana električna energija* (Sl. 3.).

Udio zaposlenih u poljoprivredi 2017. godine bio je 42,6 % što je za oko 10 postotnih bodova manje nego 2008. godine. Sektor *hrane, pića i duhana* bilježi porast u udjelu zaposlenih 2017. godine u odnosu na 2008. godinu za 8,7 postotnih bodova. Porast u udjelu zaposlenosti zabilježio je i sektor *proizvodnje drva i namještaja* (za tri postotna boda). Sektori koji bilježe neznatan porast i/ili stagnaciju su *papir, bio bazirane kemikalije i plastika i vrećice, tekuća biogoriva i bio bazirana električna energija*, dok ostali sektori bilježe pad u udjelima zaposlenih 2017. godine u odnosu na 2008. godinu (Sl. 3.). Indeks promjene u broju zaposlenih u bioekonomiji 2017. godine u odnosu na 2008. godinu iznosio je 62,2 što znači da se broj zaposlenih smanjio za 37,8 %, a to je znatno više od prosjeka EU-28. Gledano po pojedinim sektorima, smanjenje zaposlenosti zabilježeno je gotovo u svim sektorima osim u sektorima *papir, bio bazirane kemikalije, plastika i vrećice* te u sektoru *bio bazirana električna energija* koji bilježi i u Republici Hrvatskoj i u EU-28 najveći rast. Smanjenje broja zaposlenih u bioekonomiji u Hrvatskoj može se objasniti općim trendovima u hrvatskom gospodarstvu. U razdoblju 2008. – 2017. EU-28 zabilježio je mali rast ukupne zaposlenosti (indeks 102), dok je Hrvatska u istome razdoblju zabilježila pad ukupne zaposlenosti (indeks 95,6 po čemu je pripadala skupini šest država s najvećim padom zaposlenosti[4]). Uz smanjenje stope zaposlenosti i starenje stanovništva, na zaposlenost u bioekonomiji utječe i struktura vanjske migracije stanovništva Hrvatske. Utvrđivanje snage utjecaja pojedinog faktora (uzročnika pada zaposlenosti općenito i u bioekonomiji) trebalo bi istražiti u posebnom radu.

U 2017. godini hrvatska bioekonomija ostvarivala je 11,3 milijarde eura prometa i 3,4 milijarde eura dodane vrijednosti što je činilo manje od 1 % ukupnoga ostvarenog prometa i manje od 1 % dodane vrijednosti bioekonomije na razini EU-28.

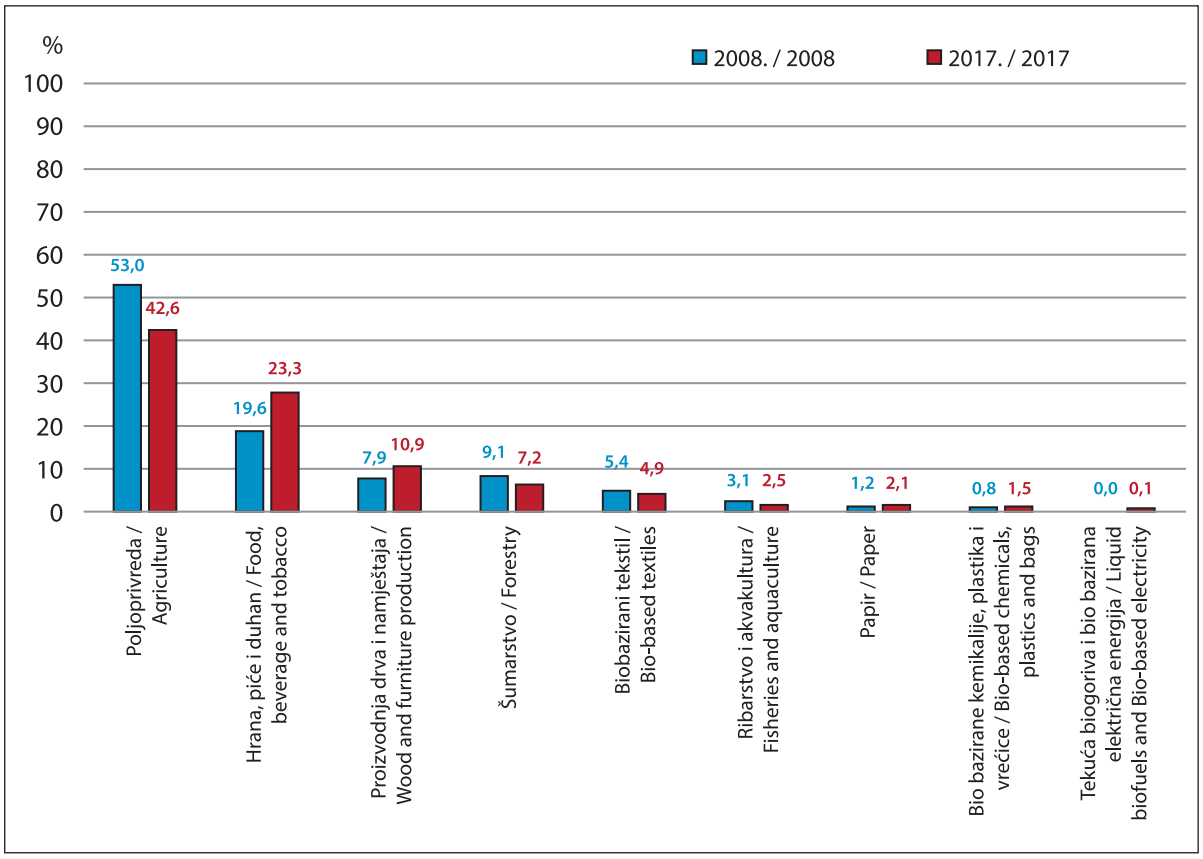
[4] Veći pad zaposlenosti zabilježen je u Portugalu, Litvi, Bugarskoj, Rumunjskoj i Latviji.

in other EU countries, the *liquid biofuels* and *bio-based electricity* sectors had the lowest employment share (less than 1% of persons employed) (Fig. 3).

In 2017, the share of agriculture sector in employment was 42.6%, which was about 10 percentage points less than in 2008. The *food, beverage, and tobacco* sector had an 8.7% employment growth in 2017 compared to 2008. The share of the labour force employed in *wood and furniture production* also increased (by three percentage points). *Paper, bio-based chemicals and plastics and bags, liquid biofuels and bio-based electricity* sectors had minor increases in employment or stagnated, whereas employment dropped in other sectors in 2017 compared to 2008 (Fig. 3). Compared to 2008, in 2017, the index of change in total bioeconomy employment was 62.2, meaning that the number of workers decreased by 37.8%, which was significantly higher than the EU-28 average. Looking at sectors individually, employment decreased in almost all sectors except in *paper, bio-based chemicals, plastics and bags*, and *bio-based electricity*, which had the greatest growth both in the Republic of Croatia and in the EU-28. The decrease in bioeconomy employment in Croatia may be explained by general trends in its economy. Between 2008 and 2017, the EU-28 saw a small rise in total employment (employment index was 102), whereas in the same period, Croatia recorded a decline in total employment (employment index was 95.6, making it one of the six countries with the largest employment decline)[4]. In addition to the declining employment rate and aging population, bioeconomy employment is also affected by the emigration structure of Croatia's population. The strength of influence of individual factors (the cause of employment decline in general and in the bioeconomy) should be investigated and determined in a separate paper.

In 2017, the Croatian bioeconomy generated EUR 11.3 billion turnover and EUR 3.4 billion added value, which was less than 1% of total turnover and less than 1% of added value of the EU-28 bioeconomy. 'The average productivity of the Croatian bioeconomy is below the EU-28 average

[4] Portugal, Lithuania, Bulgaria, Romania, and Latvia had a larger employment decline.



Slika 3. *Zaposlenost po sektorima u bioekonomiji u Republici Hrvatskoj 2008. i 2017. godine (%)*
Figure 3 *Employment by sectors in the bioeconomy in the Republic of Croatia in 2008 and 2017 (%)*
Izvor / Source: URL 2

„Prosječna produktivnost u bioekonomiji Hrvatske ispod je prosjeka EU-28: 13000 eura dodane vrijednosti po zaposlenom i 41000 eura prometa po zaposlenom (Kulišić, 2020., 15). U sektorima bioekonomije uz pad broja zaposlenosti, zabilježen je i pad prometa 2017. godine u odnosu na 2008. godine i to za 3,2 % što je ispod prosjeka EU-28 koji bilježe porast prometa.

Među sektorima bioekonomije najveći dio prometa ostvaren je u sektoru *hrane, pića i duhana* (50,4 %), zatim u *poljoprivredi* (21,2 %) te u sektoru *proizvodnja drva i namještaja* (11,1 %). Perspektive budućeg razvoja ogledaju se u razvoju sektora koji bilježe porast prometa 2017. godine u odnosu na 2008. godinu, a to su *bio bazirana električna energija*, zatim proizvodnja *papira*, *bio bazirane kemikalije, plastika i vrećice* i *proizvodnja drva i namještaja* (Tab. 2.).

Prema navedenim pokazateljima može se zaključiti da je hrvatska bioekonomija u začecima razvoja, ali s dobrim potencijalima pogotovo u sektorima bioekonomije koji bilježe povećanje prometa. S obzirom na razvojne smjerove kojima Hrvatska

EUR 13,000 added value per worker and EUR 41,000 turnover per worker' (Kulišić, 2020, 15). In addition to decreasing employment, in 2017, bioeconomy sectors also experienced a 3.2% turnover decrease compared to 2008. This was below the EU-28 average, which had a turnover increase.

Bioeconomy sectors with the largest turnover share were *food, beverage, and tobacco* (50.4%), followed by *agriculture* (21.2%) and *wood and furniture production* (11.1%). Development prospects rest on the development of sectors that had an increase in turnover in 2017 compared to 2008, namely *bio-based electricity*, *paper*, *bio-based chemicals, plastics, and bags*, and *wood and furniture production* (Tab. 2).

Based on the above indicators, we may conclude that the Croatian bioeconomy is still in its infancy, but shows good potential, especially in the sectors that had turnover growth. Bearing in mind the Croatian development directions from strategic documents such as the *2030 National Development Strategies* which involve the bioeconomy and circular economy, education and the application of

Tablica 2. *Promet po sektorima u bioekonomiji u Republici Hrvatskoj 2008. i 2017. godine*
Table 2 *Turnover by sectors in the bioeconomy in the Republic of Croatia in 2008 and 2017*

Sektor bioekonomije (RH) / Bioeconomy sector (Croatia)	2008. / 2008		2017. / 2017		Indeks promjene (2017./2008.) / Index of change (2017/2008)
	Promet u mil. EUR / Turnover in mil. EUR	Udio prometa (%) / Share of turnover (%)	Promet u mil. EUR / Turnover in mil. EUR	Udio prometa (%) / Share of turnover (%)	
Poljoprivreda / Agriculture	3 288,4	28,2	2 398,2	21,2	72,9
Šumarstvo / Forestry	358,6	3,1	354,5	3,1	98,9
Ribarstvo i akvakultura / Fisheries and aquaculture	201,5	1,7	299,8	2,7	148,8
Hrana, piće i duhan / Food, beverage and tobacco	5 699,5	48,8	5 696,4	50,4	99,9
Bio bazirani tekstil / Bio-based textiles	518,8	4,4	431,5	3,8	83,2
Proizvodnja drva i namještaja / Wood and furniture production	1 000,7	8,6	1 259,4	11,1	125,9
Papir / Paper	241,4	2,1	366,9	3,2	152,0
Bio bazirane kemikalije, plastika i vrećice / Bio-based chemicals, plastics and bags	359,3	3,1	465,7	4,1	129,6
Tekuća biogoriva / Liquid biofuels	7,6	0,1	0,5	0,0	6,4
Bio bazirana električna energija / Bio-based electricity	1,1	0,0	33,6	0,3	2 947,3
Ukupno promet / Total turnover	11 676,9	100,0	11 306,7	100,0	96,9

Izvor / Source: URL 2

teži i koji su navedeni u strateškim dokumentima poput *Nacionalne razvojne strategije 2030*, a koji se odnose na bioekonomiju i kružno gospodarstvo veliku će ulogu u nadolazećem razdoblju imati obrazovanje i primjena *Quintuple Helix* modela. Time je potvrđena druga hipoteza u radu.

PREDTERCIJARNO GEOGRAFSKO OBRAZOVANJE U REPUBLICI HRVATSKOJ I BIOEKONOMIJA

Prijelaz društva prema bioekonomiji nije uspješan ako se u društvu kao cjelini ne dogode određene strukturne i kulturološke promjene usmjerene prema obrazovnim institucijama (Sotigu i dr., 2020.). Namjera je strukturirati (pred) tercijarne kurikulume koji bi osigurali formalno obrazovanje kompetentnih radnika za nadolazeću bioindustriju.

the quintuple helix model may play a major role in the upcoming period. This confirms the second hypothesis of this paper.

PRE-TERTIARY GEOGRAPHY EDUCATION IN THE REPUBLIC OF CROATIA AND BIOECONOMICS

The social transition toward the bioeconomy cannot succeed without certain structural and cultural changes aimed at educational institutions in society (Sotigu et al., 2020). The goal is to design a (pre-) tertiary curricula that can provide formal education to competent workers in the upcoming bioindustry.

However, judging from the current school curricula, the education system seems to be at odds with the bioeconomy. On the one hand, students' education regarding this economy sector is lacking, and on the other, there are no training op-

Međutim, odnos obrazovnog sustava i bioekonomije u dosadašnjim je školskim kurikulumima u određenom nesuglasju. Niti su učenici dovoljno obrazovani za taj sektor gospodarstva niti je sadašnjim zaposlenicima omogućeno usavršavanje vještina i produbljivanje postojećeg znanja, ali se po tome Hrvatska ne razlikuje od drugih država (Sotigu i dr., 2020.).

U većini država Europe sve veći naglasak stavlja se na STEM područje (znanost, tehnologija, inženjerstvo, matematika) kao ključnu komponentu u prevladavanju toga nesuglasja. Koncept bioekonomije može se ugraditi u sve komponente STEM učenja, posebice u općeobrazovnim predmetima (biologija, kemija, geografija) i strukovnom obrazovanju koje obuhvaća tehnologiju recikliranja, oporabe, uklanjanje i izradu projektne dokumentacije.

Kroz cjelokupno predtercijarno obrazovanje koncept bioekonomije uključuje se u obrazovni proces na tri komplementarne razine (Hakovirta, Lucia, 2019.). U školskim ustanovama klasičnim metodama poučavanja, uz stjecanje potvrda, dopusnica, certifikata, bioekonomija se poučava formalno.

Kontinuiranim profesionalnim razvojem kroz različite konferencije, stručne skupove, seminare i tečajeve učenici se s bioekonomijom upoznaju informalno. Informalni je način obrazovanja najliberalniji i najrizičniji zato što polazi od spontanog interesa učenika iskazanog kroz razgovor, istraživanja, eksperimente (Hakovirta, Lucia, 2019.). Igre, izvanškolske i izvannastavne aktivnosti dio su informalnog načina učenja. *Online* učenjem, virtualnim komunikacijama učenici razmjenjuju svoje znanje i vještine stečene u procesu poučavanja na seminarima, ljetnim školama, kroz terenski rad ili samostalnom izradom studije slučaja (Sacchi i dr., 2021.).

U okviru STEM područja informalno i neformalno učenje uključuje i posjete muzejima, galerijama, knjižnicama, industrijskim pogonima, infrastrukturnim objektima povezanim s bioekonomijom, poput odlagališta otpada, reciklažnih dvorišta ili uređaja za pročišćavanje voda, rasadnicima bilja… Kod urbane populacije učenika ovakav način poučavanja nije problem, no problem se javlja kod marginaliziranih i ranjivih skupina (učenici s posebnim potrebama, učenici slabijega socijalnog statusa) s nekvalitetnom školskom in-

portunities for the current labour force to improve and broaden their skills and knowledge. However, Croatia is similar to other countries in this regard (Sotigu et al., 2020).

The majority of European countries are progressively shifting their focus toward the STEM (science, technology, engineering, mathematics) field as a key component in overcoming this conflict. The concept of bioeconomy can be incorporated into any component of STEM education, especially general education subjects (biology, chemistry, geography) as well as vocational education that covers recycling, recovery, disposal technologies, and writing project documentation.

Throughout pre-tertiary education, the concept of bioeconomy is included in the educational process at three complementary levels (Hakovirta, Lucia, 2019). At schools, the bioeconomy is taught formally using traditional teaching methods, along with the acquisition of certificates and licenses.

Students can learn about the bioeconomy in informal settings as part of continuous professional development at various conferences, professional meetings, seminars, and in training courses. Informal education is the most liberal form of education, as well as the riskiest, since it stems from students' spontaneous interest and manifests itself through conversation, research, and experiments (Hakovirta, Lucia, 2019). Games, extracurricular and after-school activities are part of informal learning. Online learning enables students to communicate virtually and exchange knowledge and skills they have acquired in seminars, summer schools, through field work or independently, by working on case studies (Sacchi et al., 2021).

Considering STEM fields, informal and non-formal learning includes visits to museums, galleries, libraries, industrial plants, infrastructure facilities related to the bioeconomy, such as landfills, recycling centres, or water treatment plants, plant nurseries, etc. This teaching method is normally readily available to urban student populations but may pose a challenge when working with marginalized and vulnerable groups (special needs students, low socioeconomic status students) and students with poor school infrastructure. However, these are key areas in the development of informal learning (Hakovirta, Lucia, 2019). During

frastrukturom. Upravo su takva područja ključna za razvoj informalnog učenja (Hakovirta, Lucia, 2019.). U doba pandemije, a i potresa koji je pogodio područje Banovine (prosinac, 2020.), pokazalo se da učenici iz udaljenih ruralnih područja ne samo da ne mogu pohađati nastavu *in situ*, već je zbog uništene infrastrukture često onemogućena i *online* nastava.

Nije svaki oblik učenja primjenjiv na sve učenike, stoga se uravnoteženom kombinacijom sva tri pristupa može potaknuti interes učenika za STEM područja. Nedostatak obrazovnog sustava je i nedovoljna suradnja učenika različitih školskih ustanova na lokalnoj i regionalnoj razini. Osim školskih natjecanja, minimalna je suradnja na zajedničkim projektima u lokalnoj zajednici. Škole su ostale izolirane na horizontalnoj i na vertikalnoj razini. STEM znanosti omogućuju veću komunikaciju među školama na analizi stanja u lokalnom okolišu i na području biologije (šumski ekosustavi naselja – općine – regije, parkovne površine, urbani vrtovi), kemije (industrija u naselju, općini ili regiji, otpadne tvari…), fizike (analiza telekomunikacijskih mreža u naselju, općini, gradu). Osim stjecanja stručnih znanja, ovakva suradnja razvija i socijalne vještine kod učenika, ali i među nastavnicima koji često (osim na stručnim skupovima i privatno) ne komuniciraju u zajedničkom interesu škola i zajednice kojoj pripadaju.

Od školske godine 2019./2020. prve generacije učenika petog razreda osnovne škole i prvog razreda gimnazije, a od školske godine 2020./2021. i učenici šestog razreda osnovne škole te drugog i trećeg razreda gimnazije obrazuju se po novouvedenom predmetnom kurikulumu Geografije. Sve generacije učenika predmetne nastave osnovne škole obrazovat će se po predmetnom kurikulumu od 2022./2023., dok su učenici svih razreda gimnazije uključeni u punu primjenu predmetnoga kurikuluma Geografije već od školske godine 2021./2022.

Analizira li se sadržaj ishoda učenja u kurikulumu nastavnog predmeta Geografija s aspekta ključnih tema EU strategije bioekonomije, može se ustvrditi da su za svaku od njih osigurani dobri preduvjeti za odgovarajuće obrazovanje (Tab. 3).

Prva ključna tema *sigurnost u opskrbi hranom*

the pandemic and after Banovina earthquake of December 2020, students from remote rural areas were not only unable to attend classes in situ but were also often unable to participate in online classes due to infrastructural damage.

Since not every form of learning can be applied to every student, stimulating students' interest in the STEM fields will require striking a balance among the three approaches. Another weakness of the education system is insufficient cooperation among students from different schools at the local and regional level. Apart from school competitions, there are negligible opportunities for cooperation on joint projects in the local community. Schools remain both horizontally and vertically isolated. STEM sciences enable greater communication and collaboration among schools concerning analyses of local environments as well as research in the area of biology (forest ecosystems in a settlement/municipality/region, park areas, urban gardens), chemistry (industry in a settlement, municipality, or region, waste...), and physics (analysis of telecommunication networks in a settlement, municipality, city). In addition to acquiring professional knowledge, this kind of cooperation also provides opportunities to develop social skills for both students and teachers, who often do not interact with each other (except at professional meetings and privately) to serve the common interest of their schools and communities.

A new Geography curriculum has been introduced in the 2019-2020 school year to the first generation of fifth graders in primary schools and first year students in secondary schools. In 2020-2021, it was also introduced in the sixth grade of primary school and the second and third grades of secondary school. Starting from 2022-2023, all primary school students will receive instruction based on the subject curriculum, whereas the new Geography curriculum will be fully implemented in all years of the 'gimnazija' secondary schools from the 2021-2022 school year.

When we analyse the content of learning outcomes from the Geography curriculum based on the key topics of the EU Bioeconomy Strategy, we may conclude that there are sound conditions in place for relevant education in each of these areas (Tab. 3).

As the first key topic, *food security* is covered by the GEO Secondary School C.4.1 as one of the outcomes

Tablica 3. *Povezanost odgojno-obrazovnih ishoda u kurikulumu nastavnog predmeta Geografije i ključnih tema EU strategije bioekonomije*
Table 3 *The relationship between educational outcomes from the Geography curriculum and key topics of the EU Bioeconomy Strategy*

Ključna tema EU Strategije Bioekonomije / Key topic of the EU Bioeconomy Strategy	**Odgojno-obrazovni ishod u kurikulumu Geografije / Educational outcome from the Geography curriculum**	**Razrada odgojno-obrazovnih ishoda (odabrani sadržaji) / Elaboration of educational outcomes (selected content)**
1. Sigurnost u opskrbi hranom / Food security	GEO SŠ C.4.1. Učenik istražuje važnost poljoprivrede te analizira neravnomjernu dostupnost hrane u svijetu. / GEO Secondary School C.4.1. Students investigate the importance of agriculture and analyze unequal food distribution in the world.	– analizira prirodno-geografske i društveno-geografske čimbenike koji utječu na razvoj i mogućnosti različitih oblika poljoprivredne proizvodnje / analyze the natural geographical and socio-geographical factors that influence the development and potentials of various forms of agricultural production – uspoređuje najveće proizvođače i izvoznike/uvoznike glavnih prehrambenih poljoprivrednih proizvoda prema statističkim podacima FAO-a / compare the largest producers and exporters/importers of the main agricultural crops according to FAO statistics – analizira globalnu dostupnost hrane i načine rješavanja problema pothranjenosti i gladi u svijetu / analyze the global food availability and solutions to the global problem of malnutrition and hunger – raspravlja o primjeni suvremenih tehnologija u proizvodnji hrane / discuss the application of modern technologies in food production – raspravlja o održivoj poljoprivredi / discuss sustainable agriculture
2. Održivo gospodarenje prirodnim resursima / Sustainable management of natural resources	GEO SŠ B.C.2.8. Učenik analizira strukturu, rezerve i prostorni raspored energetskih izvora i mineralnih sirovina, prepoznaje važnost sirovina i energije za gospodarski razvoj. / GEO Secondary School BC2.8. Students analyze the structure, reserves, and spatial distribution of energy sources and mineral feedstocks, recognize the importance of was material and energy for economic development.	– razlikuje i objašnjava važnost resursa i sirovina / distinguish and explain the importance of resources and raw materials – pomoću geografske karte analizira prostorni raspored neobnovljivih i obnovljivih izvora energije / use a geographical map to analyze the spatial distribution of non-renewable and renewable energy sources – argumentirano raspravlja o važnosti i obvezi korištenja obnovljivih izvora energije te zauzima stav o njihovu korištenju / argue the importance and responsibility of using renewable energy sources and take a position on their use – analizira energetske potencijale, proizvodnju i potrošnju električne energije u zavičaju i Hrvatskoj / analyze energy potentials, electricity production, and consumption in their region and in Croatia – uspoređuje proizvodnju i potrošnju energije u Hrvatskoj s odabranim državama u Europi i svijetu / compare energy production and consumption in Croatia with selected countries in Europe and the world
3. Smanjenje ovisnosti o neobnovljivim resursima / Reducing dependence on non-renewable resources	GEO OŠ C.6.4. Učenik navodi i opisuje prirodna bogatstva, sirovine i izvore energije, navodi vrste onečišćenja i mjere zaštite te objašnjava važnost selektiranja otpada. / GEO Primary School C.6.4. Students list and describe natural resources, raw materials, and energy sources, list types of pollution and prevention measures and explain the importance of waste sorting.	– navodi i opisuje prirodna bogatstva, sirovine i izvore energije / list and describe natural resources, raw materials, and energy sources – razlikuje obnovljive od neobnovljivih izvora energije i objašnjava utjecaj njihova korištenja na okoliš / distinguish between renewable and non-renewable energy sources and explain their impact on the environment – navodi primjere onečišćenja okoliša na lokalnoj i globalnoj razini / list examples of environmental pollution at the local and global level – opisuje važnost selektiranja i recikliranja otpada / describe the importance of waste sorting and recycling – navodi moguće mjere zaštite od onečišćenja / list pollution prevention options – samostalno ili u skupini istražuje u zavičaju vrste onečišćenja / investigate types of pollution in their region, independently or in groups – analizira i prezentira prikupljene podatke te raspravlja o mogućim mjerama zaštite / analyze and present collected data and discuss prevention options

Ključna tema EU Strategije Bioekonomije / Key topic of the EU Bioeconomy Strategy	Odgojno-obrazovni ishod u kurikulumu Geografije / Educational outcome from the Geography curriculum	Razrada odgojno-obrazovnih ishoda (odabrani sadržaji) / Elaboration of educational outcomes (selected content)
3. Smanjenje ovisnosti o neobnovljivim resursima / Reducing dependence on non-renewable resources	GEO OŠ C.A.B.8.1. Učenik analizira prirodno-geografska obilježja polarnih područja, izdvaja specifične uvjete života i prilagodbe živih bića te objašnjava mogućnosti i ograničenja iskorištavanja njihovih prirodnih resursa. / GEO Primary School C.A.B.8.1. Students analyze natural geographic features of the polar regions, focusing on the characteristic living conditions and adaptations of living organisms, and explain the options and limitations of exploiting their natural resources.	– navodi specifične klimatske uvjete polarnih područja i njihov utjecaj na tlo i živi svijet / list the characteristic climate conditions of the polar regions and their impact on the soil and the living world – razlikuje pojavne oblike leda na kopnu i u moru / differentiate between different ice forms on land and sea ice – navodi primjere i objašnjava mogućnosti i ograničenja iskorištavanja prirodnih resursa polarnih područja / give examples and explain the possibilities and limitations of exploiting natural resources in polar regions
	GEO SŠ C.B.3.1. Učenik analizira održivo upravljanje resursima mora i podmorja s primjerima iz svijeta i Hrvatske. / GEO Secondary School CB3.1. Students analyze sustainable management of sea and deep-sea resources with examples from the world and Croatia.	– opisuje iskorištavanje i mogućnosti iskorištavanja mora i podmorja kao izvora energije i hrane / describe legislation on sea and deep-sea exploitation and give examples from the world and Croatia – opisuje zakonsku regulativu u iskorištavanju mora i podmorja s primjerima iz svijeta i Hrvatske / describe the exploitation and exploitation options of the sea and deep sea as energy and food sources – objašnjava ekonomsku ulogu kontinentskog plićaka / explain the economic role of the continental shelf – analizira važnost offshore vađenja rudnoga bogatstva te opisuje glavna ograničenja i opasnosti / analyze the importance of offshore mining and describe the main limitations and hazards – analizira važnost i održivost morskoga ribarstva i marikulture / analyze the importance and sustainability of sea fishing and mariculture – opisuje obilježja i posljedice El Niña / describe the features and consequences of El Niño – objašnjava ekološku ulogu i vrijednost koraljnih grebena i mangrova, njihovu ugroženost i potrebu zaštite / explain the environmental role and value, endangered status, and need for the protection of coral reefs and mangroves – objašnjava potrebu i mogućnosti zakonske zaštite dijelova mora i podmorja na primjeru Hrvatske / explain the need and options for legal protection of parts of the sea and deep-sea using Croatia as an example
4. Klimatske promjene – prevencija i prilagodba / Climate change – prevention and adaptation	GEO OŠ B.6.5. Učenik opisuje atmosferu i vrijeme, objašnjava najvažnije klimatske elemente, prikuplja i analizira podatke o vremenu te obrazlaže važnost vremenske prognoze./ GEO Primary School B.6.5. Students describe the atmosphere and weather, explain the most important climate elements, collect and analyze weather data, and explain the importance of weather forecasting.	– opisuje atmosferu te položaj i važnost troposfere / describe the atmosphere and the position and importance of the troposphere – objašnjava najvažnije klimatske elemente / explain the most important climate elements – obrazlaže važnost prikupljanja podataka o vremenu i važnost vremenske prognoze / explain the importance of collecting weather data and weather forecasting – opisuje da se zrak zagrijava od podloge te s tim povezuje pad temperature u troposferi s porastom nadmorske visine / explain that the air is heated by the surface and connect the drop in temperature in the troposphere with the rise in altitude – opisuje da se topli zrak (zagrijan od podloge) uzdiže, a hladan spušta / describe that warm air (heated by the surface) rises, and cold air sinks down – povezuje tlak zraka s nastankom vjetra i stabilnošću vremena, opisuje ciklonu i anticiklonu / connect air pressure with wind formation and weather stability, explain cyclones and anticyclones – opisuje planetarne vjetrove i njihova obilježja / describe planetary winds and their features – razlikuje vrste padalina i opisuje njihov nastanak / distinguish between types of precipitation and describe their formation

Ključna tema EU Strategije Bioekonomije / Key topic of the EU Bioeconomy Strategy	**Odgojno-obrazovni ishod u kurikulumu Geografije / Educational outcome from the Geography curriculum**	**Razrada odgojno-obrazovnih ishoda (odabrani sadržaji) / Elaboration of educational outcomes (selected content)**
4. Klimatske promjene – prevencija i prilagodba / Climate change – prevention and adaptation	GEO OŠ B.A.7.1. Učenik analizira prirodno-geografska obilježja Europe i objašnjava njihov utjecaj na naseljenost i gospodarske aktivnosti. / GEO Primary School B.A.7.1. Student analyze Europe's natural and geographical features and explain their impact on population density and economic activities.	– obrazlaže utjecaj klimatskih čimbenika na klimu, uspoređuje najzastupljenije tipove klime s pomoću klimatskih dijagrama te navodi i opisuje pripadajuću vegetaciju / explain the effect of climate factors on the climate, compare the most common types of climates using climate diagrams, and list and describe the associated vegetation – objašnjava utjecaj prirodno-geografskih obilježja na naseljenost i gospodarstvo Europe s pomoću tematskih karata / explain the effect of natural geographic features on Europe's population density and economy using thematic maps.
	GEO OŠ B.8.5. Učenik klasificira klimatske tipove, opisuje njihova obilježja i povezuje ih sa živim svijetom. / GEO Primary School B.8.5. Students classify climate types, describe their features, and connect them with the living world.	– analizira i izrađuje klimatske dijagrame / analyze and create climate diagrams – navodi glavne klimatske tipove prema Köppenovoj klasifikaciji / list the main climate types according to the Köppen classification – opisuje njihova obilježja s pomoću klimatskoga dijagrama / describe their features using a climate diagram – objašnjava rasprostranjenost tipova klime s pomoću geografske karte / explain the distribution of climate types using a geographic map – opisuje pripadajući živi svijet / describe the associated living world
	GEO SŠ B.1.3. Učenik objašnjava utjecaj klimatskih modifikatora na određene klimatske elemente koristeći se geografskim kartama i IKT-om. / GEO Secondary School B.1.3. Students explain the impact of climate modifiers on certain climate elements using geographic maps and ICT.	– objašnjava temperaturu zraka, tlak zraka, vjetar, vlagu u zraku, padaline i naoblaku te se koristi s njima povezanim mjernim jedinicama, uređajima i načinom mjerenja / explain air temperature, air pressure, wind, air humidity, precipitation, and cloud cover and use related measurement units, equipment, and methods – analizira podatke iz tablica i grafičkih prikaza / analyze data from tables and graphs – obrazlaže utjecaj atmosfere, geografske širine, raspodjele kopna i mora, nadmorske visine, reljefa i morskih struja na klimatske elemente / explain the influence of the atmosphere, latitude, land and sea distribution, altitude, terrain, and sea currents on climate elements – objašnjava geografsku raspodjelu temperature zraka, tlaka zraka i padalina na Zemlji s pomoću geografskih karata i IKT-a / explain the geographical distribution of air temperature, air pressure, and precipitation on Earth using geographic maps and ICT – opisuje efekt staklenika / describe the greenhouse effect
	GEO SŠ B.1.4. Učenik objašnjava uzroke i posljedice svih razina cirkulacije atmosfere s primjerima iz svijeta i Hrvatske koristeći se geografskim kartama i IKT-om. / GEO Secondary School B.1.4. Students explain the causes and consequences of atmospheric circulation at all levels with examples from the world and Croatia using geographic maps and ICT.	– objašnjava uzroke planetarne cirkulacije i objašnjava postanak planetarnih vjetrova / explain the causes of planetary circulation and the origin of planetary winds – objašnjava postanak monsunskih vjetrova / explain the origin of monsoon winds – objašnjava zračne mase i opisuje fronte / explain air masses and describe fronts – objašnjava nastanak, razvoj i obilježja ciklone i anticiklone / explain the origin, development and features of cyclones and anticyclones – opisuje obilježja i kretanje tropskih ciklona / describe the features and movement of tropical cyclones – navodi obilježja vremenskih nepogoda / list the features of natural disasters – objašnjava tercijarnu cirkulaciju / explain tertiary circulation

Ključna tema EU Strategije Bioekonomije / Key topic of the EU Bioeconomy Strategy	Odgojno-obrazovni ishod u kurikulumu Geografije / Educational outcome from the Geography curriculum	Razrada odgojno-obrazovnih ishoda (odabrani sadržaji) / Elaboration of educational outcomes (selected content)
4. Klimatske promjene – prevencija i prilagodba / Climate change – prevention and adaptation	GEO SŠ B.3.2. Učenik analizira promjene klime te argumentirano objašnjava utjecaj čovjeka na globalno zatopljenje. / GEO Secondary School B.3.2. Students analyze climate change and argue about the human impact on global warming. GEO SŠ B.3.3. Učenik analizira posljedice globalnoga zatopljenja i aktivnosti međunarodne zajednice u rješavanju toga problema. / GEO Secondary School B.3.3. Students analyze the consequences of global warming and actions of the international community to address this issue.	– navodi dokaze o promjeni klime tijekom geološke prošlosti i u instrumentalno doba / cite evidence of climate change in the geological past and in the modern measurement era – objašnjava efekt staklenika / explain the greenhouse effect – analizira podatke o glavnim stakleničkim plinovima u atmosferi i globalnoj temperaturi / analyze data on the impact of major greenhouse gases on the atmosphere and global temperature – objašnjava utjecaj čovjeka na emisiju stakleničkih plinova / explain human influence on greenhouse gas emissions – objašnjava promjenu klime kao prirodni i antropogeno uvjetovani proces / explain climate change as a natural and anthropogenically conditioned process – objašnjava utjecaj klimatskih promjena na život na Zemlji / explain the impact of climate change on life on Earth, – objašnjava aktualne prirodno-geografske promjene do kojih dolazi zbog globalnoga zatopljenja / explain the current natural changes in geography that occur due to global warming – objašnjava moguće posljedice globalnoga zatopljenja, negativne (npr. invazivne vrste, klimatske migracije stanovništva, sukobi) i pozitivne (npr. nove poljoprivredne i turističke mogućnosti) / explain possible consequences of global warming, negative (e.g. invasive species, climate migrations, conflicts) as well as positive (e.g. new agricultural and tourism opportunities) – navodi primjere međunarodne aktivnosti usmjerene smanjenju čovjekova utjecaja na klimatske promjene / cite examples of international actions aimed at reducing human impact on climate change – uspoređuje i obrazlaže različite stavove država i organizacija u svijetu oko smanjenja emisije stakleničkih plinova / compare and explain different positions of countries and organizations globally regarding the reduction of greenhouse gas emissions
5. Radna mjesta i osiguranje konkurentnosti Europe / Creating jobs and ensuring Europe's competitiveness	GEO SŠ B.2.7. Učenik analizira i uspoređuje različite pokazatelje razvijenosti na svim prostornim razinama. / GEO Secondary School B.2.7. Students analyze and compare various development indicators at all spatial levels.	– analizira strukturu gospodarstva u zavičaju, Hrvatskoj, Europi i svijetu (prema udjelu zaposlenih i dohotku prema sektorima djelatnosti) / analyze the structure of economy in their region, Croatia, Europe, and the world (based on employment and income by economy sector) – uspoređuje važnost pojedinih sektora djelatnosti / compare the significance of different economy sectors – navodi, analizira i kritički raspravlja o gospodarskim i socioekonomskim pokazateljima razvijenosti / state, analyze, and critically discuss the economic and socioeconomic indicators of development

Izvor / Source: Kurikulum nastavnoga predmeta Geografija, (2019.)

uključena je u ishod GEO SŠ C.4.1., jedan od ishoda u četvrtom razredu gimnazije. Sadržaji u razradi odgojno-obrazovnog ishoda u drugom razredu gimnazije GEO SŠ B.C.2.8. osiguravaju učenicima temeljna znanja o *održivom gospodarenju prirodnim resursima*, drugoj ključnoj temi u strategiji bioekonomije u Europskoj uniji. Za treću ključnu temu temeljna znanja osigurava odgojno-obrazovni ishod u šestom razredu osnovne škole GEO OŠ C.6.4. Nastavak geografskog obrazovanja u osnovnoj školi uvelike je usmjeren na koncept održivosti, jedan od četiri ključna koncepta nastavnog predmeta Geografija, pa se doprinos obrazovanju za treću temu prepoznaje i u drugim ishodima učenja u osnovnoj školi, npr. u osmom razredu (GEO OŠ C.A.B.8.1.) i u gimnaziji (GEO SŠ C.B.3.1.). Za četvrtu ključnu temu učenici stječu znanja i vještine postupno i kontinuirano. U šestom razredu osnovne škole stječu temeljna znanja i vještine o klimi u Hrvatskoj i na planetu Zemlji (ishod GEO OŠ B.6.5.), produbljuju spoznaje u sedmom razredu na primjeru Europe (ishod GEO OŠ B.A.7.1.) i u osmom razredu na primjerima izvaneuropskih kontinenata (ishod GEO OŠ B.8.5.). Složenije spoznaje stječu u prvom razredu gimnazije (ishodi GEO SŠ B.1.3. i GEO SŠ B.1.4.) i najsloženije u trećem razredu u odgojno-obrazovnom ishodima GEO SŠ B.3.2. i GEO SŠ B.3.3. Za petu ključnu temu iz strategije učenici stječu znanja učenjem i poučavanjem odgojno-obrazovnog ishoda koji je sastavni dio geografskog obrazovanja u drugom razredu gimnazije. Izdvojeni sadržaji ishoda učenja u predmetnom kurikulumu Geografije potvrđuju da je kurikulum dobro polazište za obrazovanje o održivosti i bioekonomiji, čime je potvrđena treća hipoteza u radu.

Dobru osnovu za integrirani pristup učenju i poučavanju o bioekonomiji pruža i *Kurikulum međupredmetne teme Održivi razvoj* (2019.). Svrha učenja i poučavanja te međupredmetne teme održivi razvoj je osposobljavanje učenika za samostalno i odgovorno odlučivanje o pitanjima važnima za njih same i za društvo u cjelini, što potvrđuje opis te međupredmetne teme u kojemu je navedeno da se primjenom „...praktičnog rada učenike potiče na ponašanja kao što su korištenje prirodnih dobara i energije, korištenje

in the fourth year of secondary school. Contents of the elaboration on the GEO Secondary School B.C.2.8 educational outcome in the second year of the 'gimnazija' secondary school ensure a basic understanding of the *sustainable management of natural resources*, another key topic of the EU Bioeconomy Strategy. Basic knowledge about the third key topic is ensured by the GEO Primary School C.6.4 educational outcome for the sixth grade of primary school. As the Geography education in subsequent grades of primary school is largely focused on the concept of sustainability as one of its four key concepts, other learning outcomes in primary school, e.g. in the eighth grade (GEO Primary School C.A.B.8.1) as well as the 'gimnazija' secondary school (GEO Secondary School C.A.B.3.1) also cover and contribute to the education on the third key topic. Students acquire knowledge and skills in the fourth key topic gradually and continuously. In the sixth grade of primary school, students acquire basic knowledge and skills regarding the climate in Croatia and on Earth (GEO Primary School B.6.5 outcome), then deepen this knowledge in the seventh grade using Europe as an example (GEO Primary School B.A.7.1 outcome), and continue to do so in the eighth grade, using examples from non-European continents (GEO Primary School B.8.5 outcome). They gain more complex knowledge in the first year of secondary school (GEO Secondary School B.1.3 and GEO Secondary School B.1.4 outcomes) and the most complex understanding follows in the third year, as part of the GEO Secondary School B.3.2 and GEO Secondary School B.3.3 educational outcomes. Students acquire knowledge about the fifth key Strategy topic through a learning and teaching outcome in the second-grade Geography for secondary schools. The selected learning outcomes from the Geography curriculum corroborate that the curriculum is a stepping stone for an education on sustainability and the bioeconomy, thus confirming the third hypothesis of this paper.

A good foundation for an integrated approach to learning and teaching about the bioeconomy is laid by the cross-subject curriculum for Sustainable Development (Kurikulum međupredmetne teme Održivi razvoj, 2019). The purpose of teaching and learning about Sustainable Development as a cross-curricular topic is to train students for independent and responsible decision-making on issues important to them and society as a whole, as con-

lokalno proizvedene hrane, racionalno postupanje s otpadom, uporaba iskorištenih materijala, aktivan rad i suradnja u zajednici". Učenjem i poučavanjem *međupredmetne teme održivi razvoj* u obveznim i izbornim predmetima, na satima razrednika, u integriranoj, projektnoj, izvanučioničkoj i terenskoj nastavi te izvannastavnim aktivnostima potiče se razvoj znanja o prirodnim sustavima, o posljedicama ljudskih aktivnosti, zatim solidarnost prema drugim ljudima, prema okolišu, vlastitom i tuđem zdravlju, cjelokupnome životnom okružju i prema budućim generacijama (Kurikulum međupredmetne teme Održivi razvoj, 2019.).

Uz dokumente obrazovne politike koji daju temelje za sadržaj učenja, važna je i osposobljenost učitelja i nastavnika geografije za nove pristupe u planiranju i vođenju poučavanja te vrednovanju ishoda učenja. Iako je pandemija COVID-19 uvelike promijenila oblike organiziranoga stručnog usavršavanja učitelja i nastavnika, može se zaključiti da je posljednjih pet godina velika pozornost posvećena upravo novim pristupima u učenju i poučavanju. Uz stručne skupove primarno namijenjene geografima, sve je više organiziranih oblika edukacije integrativnoga karaktera, primjerice *Prirodoznanstveni pristup u učenju i poučavanju o održivome razvoju* (URL 4). Teme u čijem se naslovu prepoznaju ključne riječi održivi razvoj zastupljene su i na stručnim skupovima županijske razine i drugim organiziranim i neorganiziranim oblicima stručnog usavršavanja i profesionalnog razvoja.

Kako bi se implementirali principi bioekonomije u predtercijarnom obrazovanju, buduća stručna usavršavanja trebalo bi organizirati prema međunarodnim iskustvima, uz prilagodbu hrvatskoj praksi (Kirchherr, Piscicelli, 2019.). Za očekivati je slična iskustva kao i u drugim državama, da predavači istodobno uče i poučavaju o održivosti (Brumagim, Cann, 2012.; Persons, 2012.; Wu, Shen, 2016., prema Kirchherr, Piscicelli, 2019., 3).

Dionici geografskog obrazovanja kao i obrazovanja u drugim predmetima i područjima, imaju odgovornost pridonijeti stvaranju društva temeljenoga na održivosti, a za to postoje dobri preduvjeti u Hrvatskoj.

firmed by its description, which claims that through '...practical work, students are encouraged to adopt behaviours such as using natural resources and energy, using locally produced food, rational waste management, using second-hand materials, active work and cooperation in the community.' Teaching and learning about the cross-curricular topic Sustainable Development in mandatory and elective classes, homeroom, integrated, project, extracurricular, and field courses, as well as extracurricular activities stimulates the development of knowledge related to natural systems, the consequences of human actions, solidarity with other people, care for the environment, one's own and others' health, the ecosystem, and future generations (Kurikulum međupredmetne teme Održivi razvoj, 2019).

In addition to educational policy documents that lay a foundation for learning contents, the training of geography teachers to use new approaches in planning and teaching classes and evaluating learning outcomes is also important. Although the COVID-19 pandemic has greatly affected the format of teacher professional development training, we may conclude that great attention has been paid to new approaches in learning and teaching over the last five years. In addition to professional conferences aimed primarily at geographers, there has been an increase in integrative training opportunities, such as the conference on the *Scientific Approach to Learning and Teaching about Sustainable Development* (URL 4). Topics with the keyword 'sustainable development' are also represented at academic conferences at the county-level and other structured and unstructured forms of professional training and professional development.

In order to implement bioeconomy principles in pre-tertiary education, future professional development opportunities should be built on international experiences, but also tailored to the practice in Croatia (Kirchherr, Piscicelli, 2019). We may expect effects similar to those experienced by other countries – where lecturers simultaneously teach and learn about sustainability (Brumagim, Cann, 2012; Persons, 2012; Wu, Shen, 2016, prema Kirchherr, Piscicelli, 2019, 3).

Stakeholders in geography education, as well as education in other subjects and areas, have a responsibility to help create a sustainability-based society – and Croatia has favourable conditions to make this happen.

ZAKLJUČAK

Za ublažavanje negativnih posljedica suvremenog razvoja nužni su novi pristupi u gospodarstvima na svim razinama – od lokalne do globalne. Jedan od inovativnih pristupa integriran u razvojne strategije Europske unije i Hrvatske je bioekonomija. S obzirom na obilježja, ciljeve i potencijal bioekonomije, važno je promišljati o stvaranju preduvjeta za njezinu implementaciju u suvremenom gospodarstvu kako bi se ostvarila održivost. Održivost sustava podupire primjena peterostruke spirale (*Quintuple Helix* model) u funkcioniranju ključnih elemenata gospodarskih sustava. Za ostvarivanje ciljeva ključnih tema EU Strategije bioekonomije osnovu predstavlja udio zaposlenih u bioekonomiji koji čini devet posto ukupno zaposlenih. Za prvu ključnu temu, sigurnost u opskrbi hranom, važan temelj predstavlja više od tri četvrtine zaposlenih u dva sektora bioekonomije, u poljoprivredi te u proizvodnji hrane i pića. Hrvatska je bioekonomija u začecima razvoja, još uvijek ispod prosjeka Europske unije, ali s dobrim potencijalima. Napretku i boljem ostvarivanju potencijala mogu pridonijeti razvojni smjerovi kojima Hrvatska teži, a navedeni su u strateškim dokumentima poput *Nacionalne razvojne strategije 2030*. Kako bi se ostvarile strateške smjernice, uz druge dionike, veliku će ulogu i odgovornost imati obrazovanje. Geografsko obrazovanje u osnovnim i srednjim školama utemeljeno na usvajanju planiranih odgojno-obrazovnih ishoda iz kurikuluma u suglasju je sa strateškim smjernicama *Nacionalne razvojne strategije 2030* kao i s ključnim temama EU Strategije bioekonomije i Europskog zelenog plana. Ako se cjelovitim geografskim obrazovanjem, u trajanju osam godina, postupno usvoje ishodi učenja izdvojeni u Tab. 3., ostvarit će se pretpostavke za doprinos mladih u Hrvatskoj ostvarivanju i Nacionalne razvojne strategije i Europskoga zelenog plana. Navedeno će pridonijeti daljnjoj afirmaciji geografije kao interdisciplinarne i multidisciplinarne znanosti koja ima značajnu ulogu u obrazovanju na svim razinama, od primarnog do tercijarnog obrazovanja kao i u svim oblicima učenja, od formalnog do cjeloživotnog učenja.

CONCLUSION

Mitigating negative consequences of contemporary development requires new approaches in economies at every level, from local to global. The bioeconomy is an innovative approach integrated into the development strategies of the European Union and Croatia. Taking into account the features, goals, and potentials of the bioeconomy, serious consideration should be given to laying the groundwork for its implementation in the modern economy as a way to achieve sustainability. The quintuple helix model of the functioning of key elements of economic systems supports sustainability of these systems. Employment in the bioeconomy accounts for 9% of total employment and is pivotal to meeting the objectives of key topics of the EU Bioeconomy Strategy. More than three quarters of these workers are employed in two bioeconomy sectors, agriculture and food and beverage production, laying an important foundation for the first key topic, food security. Croatian bioeconomy is in its infancy, and while still below the EU average, boasts attractive prospects. The development directions Croatia aims for, as defined in strategic documents such as the *2030 National Development Strategies*, may accelerate the progress and facilitate realization of its potential. Education will have a major role in and responsibility for achieving these strategic guidelines, alongside other stakeholders. Geography education in primary and secondary schools based on the adoption of defined educational outcomes from the curriculum is in step with the strategic guidelines of the 2030 National Development Strategy as well as the key topics of the EU Bioeconomy Strategy and European Green Deal. Steady adaptation of learning outcomes highlighted in Table 4 through comprehensive geography education over the course of eight grades may create conditions and provide opportunities for young people in Croatia to contribute to the success of both the National Development Strategy and the European Green Deal. This will help establish geography as an interdisciplinary and multidisciplinary science that plays a significant role in education at every level, from primary to tertiary education, as well as in all forms of learning, from formal to lifelong learning.

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Znanstveni doprinos Ružice Vuk je participacija u kreiranju nacrta istraživanja, odabiru metoda istraživanja, finalnom oblikovanju istraživačkih pitanja i hipoteza, pisanju dijela teksta o predtercijarnom geografskom obrazovanju u RH i bioekonomiji i zaključka te finalnom sadržajnom i tehničkom oblikovanju svih dijelova rada.

Znanstveni doprinos Biljane Vranković ogleda se u suradnji pri postavljanju metodologije, istraživačkih pitanja i hipoteza rada, participaciji u jednome dijelu teorijskog pregleda razvoja bioekonomije, u kvantitativnoj i kvalitativnoj analizi veličine bioekonomije u državama Europske unije (EU-28) te komparativnom prikazu obrazovnih ishoda iz predmetnog kurikuluma Geografije te konačnom oblikovanju rukopisa u uvodnom dijelu, metodologiji i dijelu rezultata i rasprave Promjena paradigme – s linearnog na kružno gospodarstvo, Bioekonomija u Europskoj uniji i Republici Hrvatskoj – stanje i perspektive.

Znanstveni doprinos Željke Šiljković je postavljanje temelja multidisciplinarne povezanosti geografije i bioekonomije i utvrđivanje znanstvene opravdanosti uključenosti geografije i bioekonomije u geografskome prostoru. U radu je participirala u dijelu koji se odnosi na teorijski osvrt promijenjene paradigme – s linearnog na kružno gospodarstvo te je sudjelovala u konačnom oblikovanju cijelog rada.

Ružica Vuk made her scientific contribution by participating in the drafting of the research paper, selecting research methods, designing the final research questions and hypotheses, writing the section on pre-tertiary geography education in the Republic of Croatia, the bioeconomy and the conclusion, as well as final content editing and formatting of all sections of this paper.

Biljana Vranković made her scientific contribution by collaborating on setting the methodology, research questions, and hypotheses, contributing to the theory review of the development of the bioeconomy, the quantitative and qualitative analyses of the scope of the bioeconomy in the EU member states (EU-28), and the comparative overview of educational outcomes from the Geography curriculum, as well as the final edit of the manuscript for the introduction, methodology, and part of the results and discussion section,

namely Paradigm Shift – from Linear to Circular Economy, The Bioeconomy in the European Union and the Republic of Croatia –Situation and Perspectives.

Željka Šiljković made her scientific contribution by laying the groundwork for a multidisciplinary interaction between geography and bioeconomy and evaluating the scientific justification for the inclusion of geography and bioeconomy in the geography space. She made a contribution to the section on theory review of the paradigm shift from linear to circular economy and participated in the final edit of the entire paper.