International conference

Earth as a Human-Environmental System: Challenges and Dynamics

BOOK OF ABSTRACTS

Institute of Geography and Spatial Management

Jagiellonian University in Kraków

6–8 May 2024, Kraków, Poland

Honorary patronage
of the Rector of the Jagiellonian University

Prof. Jacek Popiel

JAGIELLONIAN UNIVERSITY
IN KRAKOW

www.uj.edu.pl

Patronage of the Polish Geographical Society

https://www.ptgeo.org.pl

Conference Partner
**International Geographical Union Commission on Tourism,
Leisure and Global Change**

https://www.igutourism.org

Organizer

Institute of Geography
and Spatial Management,
Jagiellonian University,
Kraków, Poland

Venue

Campus of the 600th Anniversary
of the Jagiellonian University Revival,
Kraków, Poland,
7 Gronostajowa St.

Honorary committee

Prof. Urszula Myga-Piątek, President of Polish Geographical Society
Prof. Marek Degórski, President of the Committee of Geographical Sciences
        of the Polish Academy of Sciences
Prof. Maciej Jędrusik, President of the Conference of Polish Geographical Units

Scientific committee

Prof. Stefan Brönnimann, University of Bern, Switzerland
Prof. Bolesław Domański, Jagiellonian University, Kraków, Poland
Dr. Elżbieta Gorczyca, Assoc. Prof., Jagiellonian University, Kraków, Poland
Prof. Dagmar Haase, Helmholtz Centre for Environmental Research, Leipzig,
        and Humboldt-Universität zu Berlin, Germany
Prof. Jacek Kozak, Jagiellonian University, Kraków, Poland
Dr. Mirosław Mika, Assoc. Prof., Jagiellonian University, Kraków, Poland
Dr. Estela Nadal-Romero, El Instituto Pirenaico de Ecología, IPE-CSIC, Zaragoza, Spain
Prof. Maciej Pietrzak, Jan Amos Komeński State University of Applied Sciences,
        Leszno, Poland
Prof. Chiara Rabbiosi, University of Padova, Italy
Dr. Izabela Sołjan, Assoc. Prof., Jagiellonian University, Kraków, Poland
Prof. Zbigniew Ustrnul, Jagiellonian University, Kraków, Poland
Dr. Krzysztof Widawski, Assoc. Prof., University of Wrocław, Poland
Prof. Wiesław Ziaja, Jagiellonian University, Kraków, Poland

Organizing Committee

Dr. Anita Bokwa, Assoc. Prof.
Dr. Joanna Hibner
Dr. Justyna Liro
Dr. Małgorzata Luc, Assoc. Prof.
Katarzyna Rotter-Jarzębińska, M.Sc.
Grzegorz Smułek, M.Sc.
Elżbieta Jagłowska, M.Sc. and Maciej Pilch, M.Sc. Eng. (Jagiellonian University Centre
        for Communications and Marketing - Conferences)

Inspiration

The conference aims to stimulate new ideas and foster collaborations in the field of geography and related research areas. The meeting brings together scientists to discuss the diverse research areas that are relevant and linked to contemporary and perspective future geographical studies.

In 2024, Institute of Geography and Spatial Management celebrates **175th anniversary of its establishment as the second chair of geography in Europe**, after the one in the University of Berlin. In 1849, Professor Wincenty Pol organized this first Polish geographical university unit. Geographical studies were initiated in the University of Kraków (today: Jagiellonian University) already in the 15th century, as the university was established in 1364. The jubilee is a good opportunity to determine the issues relevant for future sustainable human-environmental interactions which are rooted both in the previous geographical studies and past environmental changes.

Wincenty Pol (1807–1872)
Founder of the Institute of Geography and Spatial Management, Jagiellonian University

Timing and location of the sessions: Overview

6.05.2024, Jagiellonian University – Campus, 7 Gronostajowa St.				
Lecture room: Main Aula	10:30-12:00 – Plenary keynote session 1			
	12:30-14:00 – Plenary keynote session 2			
Time Slots	Lecture rooms			
	1.21	1.23	1.25	1.26
1. 15:00–16:30	Session 1.1	Session 3.1	Session 4.1	Session 2
19:00	Conference Gala Dinner			
7.05.2024, Jagiellonian University – Campus, 7 Gronostajowa St.				
2. 10:00–11:30	Session 1.2	Session 3.2	Session 4.2	Session 5.1
3. 12:00–13:30	Session 1.3	Session 3.3	Session 4.3	Session 5.2
4. 14:30–16:00	Session 1.4	Session 3.4	Session 4.4	
8.05.2024, Jagiellonian University – Collegium Novum, 24 Gołębia St.				
Lecture room: Aula	10:00–12:00 – Special session: 175 years of geographical studies in Kraków			
	12:00–12:30 – Jubilee toast, presentation of the 3D map of Scotland and coffee break			
	12:30–14:00 – Closing panel session: conclusions from thematic sessions and future perspectives of geographical research			
9.05.2024, Conference trips				

The book of abstracts is available as a pdf file only. Please notice that the abstacts are divided into thematic sessions, and within each session, they are further arranged by the first author's name, in alphabetical order.

Contents

Session 2.
Soils in the Anthropocene: Hazards,challengesand opportunities

Session 2.
Soils in the Anthropocene: Hazards, challenges and opportunities

Session 3.
Dynamic land use changes: opportunity for rewilding?

Session 2.
Soils in the Anthropocene:
Hazards, challenges and opportunities

Session 3.
Dynamic land use changes:
opportunity for rewilding?

Session 4.
Climate change: Detection and impacts

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Urban circular development and post-war green recovery: connections between concepts

Anna Avdiushchenko

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

email: anna.avdiushchenko@uj.edu.pl

The last decade of the XXI century brought a series of challenges provoked by the COVID-19 pandemic and the Russian invasion of Ukraine. Both global threats caused significant distress to citizens worldwide, prompting geopolitical, economic, infrastructural, health, energy, food and humanitarian crises (Rawtani et al., 2022). In that context, the issue of post-pandemic recovery was broadly discussed and introduced, besides other global concerns such as climate crises and the emergency for shifting to low-carbon development. At the same time, the war in Ukraine influenced the exacerbation of other regional tensions and conflicts in the Balkan and Caucasus regions (Strategic Comments, 2022; Network for Strategic Analysis, 2023). Since 2022, post-war recovery matters have become an extremely attractive and relevant study area for researchers and practitioners.

Recent research shows that urban areas are the main engines for sustainable, just and diverse development. The urban circular development approach proposed by Willimas (2021) seems to be one of the possible options for accelerating such a type of development in the context of post-war green recovery. The present paper examines theoretical background for finding and developing conceptual connections between both above mentioned approaches. There were investigated the issues related to interrelation between circular and sustainable urban development, urban systems transition and transformation processes, the possible role of circular city approach for accelerating post-war green recovery. The research outcomes are focused on presenting hierarchy and connections between theories related to urban circularity in context of post-war green recovery. Future research directions could be devoted to developing Urban Circular Development Framework for Post-War Green Recovery.

Dynamics of land use in small towns in Poland: A Case Study of Bodzentyn and Połaniec

Ewa Bubula, Paulina Pisarczyk, Ewa Grabska-Szwagrzyk

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: ewa.bubula@student.uj.edu.pl

Urban ecosystems, predominantly inhabited by humans, are unique and largely artificial environments that encompass various ecosystem types such as forests, lakes, rivers, and agricultural areas, all significantly influenced by human activities. Although small towns exhibit different patterns than large cities and metropolises, they play crucial role in regional economies, and also face distinct challenges and transformations. Well-being and sustainability are crucial to their inhabitants, including factors like spatial order and a friendly, unpolluted environment.

In this study, we employed very high-resolution aerial imagery to examine how land use has changed over the last two decades in the towns of Bodzentyn and Połaniec. These two towns, with populations of 2,135 and 7,606, respectively, are situated in the Świętokrzyskie Voivodeship in south-central Poland. We employed orthoimagery available since the beginning of the 2000s, utilizing an automatic classification process. By comparing the results, we identified interesting patterns and trends in land use over the last 20 years.

Our findings reveal a noticeable increase in built-up areas, especially with new parking lots and the conversion of previously green spaces into concrete market squares. We also observed large parking lots associated with companies selling trucks, indicating changes in economic activities. Improved roads and the emergence of new buildings are other signs of the evolving landscape, possibly influenced by support from the European Union. On the other hand, the process of agricultural land abandonment, leading to an increase in tree cover, was common, particularly in Połaniec.

This presentation aims to illustrate the complex changes occurring in small towns, emphasizing the importance of understanding how land is used, especially when confronted with challenges like depopulation. Insights from our research can serve as a valuable resource for making informed decisions and planning for the future. It is crucial to recognize both the positive changes and the difficulties that accompany these transformations in the studied towns.

"Walk and talk" about nature in nature. A qualitative approach to analyse conflicts and trade-offs in urban green spaces

Marta Derek[1], Sylwia Kulczyk[1], Tomasz Grzyb[1], Edyta Woźniak[2]

[1] *University of Warsaw, Faculty of Geography and Regional Studies,
Poland*
[2] *Polish Academy of Sciences, Space Research Centre,
Poland*

Contact person email: m.derek@uw.edu.pl

Urban green spaces (UGS) are, almost by definition, multifunctional landscapes. As a part of urban social-ecological system, they are widely recognized as a major factor affecting health and quality of life in urban environments (WHO, 2016). There are, however, many different conflicts and trade-offs among different cultural ecosystem services provided by UGS, and, consequently, among different planning perspectives and land uses of UGS. In this presentation we aim to analyse them using a walking interview method. This method is extremely useful in sustainable and inclusive planning, as practitioners increasingly need to pay attention to how people value and use the spaces in which they live (Evans, Jones 2011). In this way, it can guide landscape ecology towards more people-oriented science.

In our research we used the walking interview method to study cultural ecosystem services, as well as disservices, conflicts and trade-offs, in five urban green spaces of Warsaw, Poland, each representing different landscape characteristics. For each area, we performed five walking interviews with different local stakeholders. This was supported by qualitative GIS techniques. This approach helped us to identify and map different conflicts and trade-offs found in each urban green area. The results delivered outcomes that can contribute to sustainable land use planning and enhance the understanding of people–landscape relationships in the urban environments.

Green urban areas – places for building resilient communities or places where conflicts burn out?

Katarzyna Gorczyca [1], Anna Sławik [2], Jacek Strojny [3] , Łukasz Fiedeń [1],
Magdalena Miśkowiec [1], Agnieszka Świgost Kapocsi [1]

[1] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management,
Poland*
[2] *Jagiellonian University in Kraków; Institute of Economics, Finance and Management,
Poland*
[3] *University of Technology, Department of Project Management, Rzeszów,
Poland*

Contact person email: k.gorczyca@uj.edu.pl

Conflicts that emerge in cities between different groups of stakeholders often have their origins in the lack of access to certain goods or services, and this increasingly applies to the accessibility of green urban areas[GUA]. However, little is known about the extent to which stakeholder conflicts and grassroots actions drive the development of resilient urban communities. This paper aims to explore the impact of grassroots community initiatives on the development of urban land use and conflicts that induce local government decisions pertaining to the creation of GUA. The study of the conflict is placed within the Space-Time-Stakeholder framework. Detailed analyses have been presented for a case study of two Polish cities, Kraków and Rzeszów. The research methods are comprised of planning document analysis, qualitative in-depth interviews and the analysis of stakeholders. Our research shows that the protection of GUA occurs as a result of a grassroots battle amongst various stakeholders and is often enforced by appropriate legal instruments for environmental protection. This demonstrates the weakness of urban planning in post-socialist cities, where the voice of residents pointing out the importance of maintaining a GUA as an important place for rest and recreation is overlooked until a serious conflict arises.

Social ecosystem services provided by urban green spaces – experiences from Krakow

Julia Gorzelany, Tomasz Noszczyk, Anita Kukulska-Kozieł, Józef Hernik

University of Agriculture in Kraków,
Department of Land Management and Landscape Architecture,
Poland

Contact person email: tomasz.noszczyk@urk.edu.pl

Ecosystem services are all benefits provided by nature. Among them, social ecosystem services can be distinguished, which include, for example, reducing the urban heat island effect, the well-being of residents or improving their health. With this in mind, a survey was conducted to identify Krakow residents' perceptions of the role of urban green spaces and the social ecosystem services they provide. Surveys were obtained from 1,250 respondents. The results indicate that urban green spaces are popular with the Krakow community. Based on the survey, it can also be indicated that residents consider green spaces important for their mental and physical health. More than 75% of respondents felt that visiting urban green spaces is very important or important for reducing stress levels. Respondents also indicated that existing green spaces should be retrofitted with additional lighting, benches for relaxation and trash garbage cans. The survey results provide empirical evidence that can influence green space management.

Capitals and biggest cities – different ways to measure distance between countries

Łukasz Gręda

University of Warsaw , Faculty of Geography and Regional Science, Poland

email: *l.greda@uw.edu.pl*

Distance is a highly important parameter used in many models to analyze the flows between objects. It is a key element to estimate the importance of different factors which influence trade, migrations, or diffusion of innovations. Yet it is not clear how to measure it. The aim of this presentation is to present different ways of measuring distance and to describe new method based on distribution of major cities.

In literature there are two popular ways to assess the distance between countries/regions. The first one is calculating the distance between capitals, and the second between the biggest cities. According to differ definitions there are between 34 to 38 countries where this issue occurs. In case of smaller ones like Malta or Belgium the difference is barely noticeable. However, for example in Brazil the distance between Rio de Janeiro and Brasilia is more than 900 km, which may disturb the analysis. Situation is even more complicated if there are more than one dominating cities. If we analyze the trade of the United States across the Pacific Ocean, should we then use the distance from New York, or perhaps Los Angeles would be better?

One way to answer this issue is to go beyond old ways of measuring the distance based on capital or the biggest city. I ought to construct new method which considers distribution of countries' major cities. Thanks to this new measurement of distance, analysis of flows between countries may better reflect reality. In this presentation we will see the differences between two most common ways of measuring distance. Then I will present a way of measuring the new method. Finally, usefulness of this new statistic would be tested in gravity model of trade.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Systematic mapping on modelling systemic changes in urban growth models – prelimary results

Katarzyna Krasnodębska, Przemysław Śleszyński, Andrzej Affek

Institute of Geography and Spatial Organization, Polish Academy of Sciences, Poland

Contact person email: kgoch@twarda.pan.pl

Urban systems are complex systems, linking social, ecological and technological components at multiple scales and levels, where a rapid disturbance or a gradual evolution can lead to fundamental changes in system's structure. Although the non-stationary nature of urban systems affects the reliability of the urban growth projections, the number of applications that take into account the non-stationary nature of the complex urban environment is limited. Our research intends to analyse the current state of knowledge on the implementation of the non-stationary nature of socio-ecological-technological systems in models representing urban systems, including their trends, dynamics and thematic domains. We undertake a systematic mapping of studies combining four main strands of research: the systemic component, the urban environment, the connotation of change in the environment and the modelling component, denoting the conceptualisation of change in the urban system. We collect a database of 56 eligible research papers, categorised into seven main thematic groups: 1. Land-use change; 2. Planning and policies for sustainable development; 3. Climate change; 4. Resilience; 5. Infrastructure; 6. System's approach; and 7. Global scale models. The mapping products include the spatial distribution and temporal trends of the studies, as well as an overview of approaches to incorporating system change into the modelling framework. Preliminary results of the survey indicate a predominant presence of studies classified under the thematic group 'Land Use Change', with the notion of fundamental change in system behaviour or structure most commonly associated with demographic processes or with climate change.

Integration of immigrants with local society in Berlin

Anna Kropyvnytska, Maksymilian Łepek, Mateusz Mirlak, Arleta Pająk,
Marta Skupińska, Arkadiusz Wróbel, Jadwiga Gałka

Contact person email: anna.kropyvnytska@student.uj.edu.pl

Berlin is one of Europe`s most culturally diverse cities and possibly worldwide. At the end of August 2023, a group of students undertook a project related to migrations to the capital of Germany and the perception of this phenomenon by the host population from the perspective of immigrants. In social media forums and the realm of geopolitics, it is often stated that Germany is the most welcoming country for migrants, and Berlin itself is one of the most ethnically and culturally diverse cities in Europe; hence the choice of this city for the project. The research was conducted among various national groups in the form of interviews. The main respondents were individuals of Polish, Ukrainian, and Middle Eastern descent (with few exceptions). Ten interviews were conducted for each of these groups. Through this data collection method, several key issues related to migration to Berlin were identified. The main topics examined included: reasons for migration, issues related to the immigrant identity of the respondents, perception by the host population (Germans), matters related to religiosity and perception of religion, and their political views and personal reflections on immigration. Based on the analysis of these issues, it is possible to gain a broader perspective on Germany as a host country. The research was conducted thanks to funding obtained from the "Program Strategiczna Inicjatywa Doskonałości w Uniwersytecie Jagiellońskim" as a part of the „Zespołowa aktywność naukowa studentów" action. Financial support was also provided by the "Fundacja Studentów i Absolwentów UJ Bratniak". The project is supervised by Dr. Jadwiga Gałka.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Ecosystem Services-Based Planning and Management of Multifamily Residential Areas: Bridging Practitioners' Approaches and Residents' Preferences

Sylwia Kulczyk, Piotr Matczak, Iwona Zwierzchowska, Michał Litwiński,
Krzysztof Mączka, Alina Gerlée [1], Marta Derek

[1] *University of Warsaw, Faculty of Geography and Regional Studies,
Poland*

Contact person email: a.gerlee@uw.edu.pl

This study addresses the often-overlooked realm of planning and managing greenery in multifamily residential areas—a critical yet understudied facet of urban ecosystems. We aim to uncover parallels between practitioners' approaches, residents' preferences, and the spatial attributes of residential areas that influence the supply of ecosystem services (ES). In particular, we focus on cultural ecosystem services (CES), the most directly experienced by urban inhabitants. Employing a multi-method approach encompassing a workshop for practitioners, a discrete choice experiment (DCE)-based survey of urban residents, and mapping of greenery attributes in Poznań (Poland), our study underscores the importance of shaping conditions that facilitate bundled regulating and cultural ES. Practitioners recognize the pivotal role of greenery in ES production, with temperature and humidity as the most important ES. This resonates with residents' preferences for predominantly green neighborhoods, dominated by trees. Mismatches between practitioners and residents emerge concerning the maintenance of greenery and recreational facilities. Ultimately, we identify four distinct types of multifamily residential areas, each reflecting varying degrees of resident preferences. These findings offer valuable insights for future development of multifamily residential areas, considering both residents' preferences and the imperative for ES provision.

Session 1.
Urban ecosystem: Services and conflicts

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Different perspectives on the identification of urban thermal hotspots and coolspots, using the example of Prague

Veronika Kvetonova [1], Michal Lehnert, Jiri Panek, Jan Geletic, Petr Simacek

*Palacky University Olomouc, Department of Geography,
Czech Republic*

Contact person email: veronika.kvetonova@upol.cz

The manifestation of climate change and rapid urbanization require more efficient solutions in urban planning. The thermal environment in urban areas has been recently the subject of numerous studies; however, the "human factor" of thermal comfort and related heat stress often remains overlooked. On that account, we present findings and experiences from our thermal walk and participatory-based cognitive thermal mapping campaigns that allow us to identify urban thermal hotspots and locations that provide relief from the heat during hot summer days – "thermal coolspots". Presented methods help to reveal several hotspots, including specific crossroads, open public spaces, arterial streets with a lack of greenery, unshaded northern parts of streets, and streets with inappropriate tree spacing, all of which contribute to heat stress of urban pedestrians. Simultaneously, our results emphasize the importance of green spaces, even those covering just a few hectares within neighbourhoods. By combining these human-oriented approaches with established "classical" methods in urban climate research–such as land surface temperature analyses, field measurements, and numerical modeling–we can provide valuable information for researchers and urban planners.

Session 1.

Urban ecosystem: Services and conflicts

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Just transition – theory and practice.
An example of an unfinished nuclear power plant in Żarnowiec, Poland

Agata Lewandowska, Justyna Chodkowska-Miszczuk, Jagoda Ulewicz

Nicolaus Copernicus University in Toruń, Doctoral School of Social Sciences, Poland

Contact person email: a.lewandowska@doktorant.umk.pl

The immense threat of climate change is shaping today's world. It is also influencing different levels of policies, including the European Union's. The proof of that is the European Green Deal - a blueprint for Europe's zero net emission future. An important element of this document is the concept of just energy transition. However, the implementation of leaving no one behind policy might be challenging, especially in rural areas where a lot of green investments are located. Energy transition is becoming a reality which makes it even more important to consider its pros and cons, especially in relation to places and people who will be most affected by it. Our research focuses on the downfalls of low-emission energy investments. Based on the literature review and the analysis of the case study of the unfinished nuclear power plant 'Żarnowiec' (pomorskie voivodship, Poland) we explored different dimensions of justice in the process of energy transition. The interviews with former inhabitants of the area, where the power plant was supposed to be located, provided an insight into their perspective on large-scale energy investments and its impacts on the local community, environment and cultural landscape. Respondents shared their thoughts on the issue of the resettlement and lost opportunities for the development of tourism near Żarnowieckie Lake. They also stated that one of the most important matter for them was to keep the community together - they did not want the money as a retribution for displacement. They rather had their village recreated elsewhere to keep former relationships and the sense of belonging. Analysis of the case of the 'Żarnowiec' nuclear power plant and performing interviews with people affected by the investment allowed us to form conclusions about designing the energy transition process. Our research showed how crucial it is to include the locals in planning energy investments. The case discussed in the study is an example that the effects and differences in costs of energy decisions are not the result of individual choices of locals but rather the result of inequalities occurring in geographical space, i.e., an element beyond their control.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Exploring Cultural Ecosystem Services and Disservices in Urban Green Spaces

Agnieszka Nowak-Olejnik [1], Jarosław Działek [1], Joanna Hibner [1], Justyna Liro [1],
Rafał Madej [1], Martin Sudmanns [2], Dagmar Haase [3,4]

[1] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland*
[2] *University of Salzburg, Salzburg, Department of Geoinformatics – Z_GIS, Austria*
[3] *Humboldt-University Berlin, Institute of Geography, Germany*
[4] *Helmholtz Centre for Environmental Research — UFZ,
Department of Computational Landscape Ecology, Germany*

Contact person email: ag.nowak@uj.edu.pl

Cultural ecosystem services (CES), the contributions that ecosystems make to human well-being in terms of identities, experiences and capabilities, shape landscape planning policy to a huge extent. Furthermore, disservices (EDS), understood as sources of harm to people from human-ecosystem relationships, are also important factors for managing green spaces. The proper management of urban green spaces is crucial for the well-being of the urban population. Our analysis focused on the occurrence of the benefits and disbenefits associated with CES. The specific objectives included: (1) identifying the bundles of benefits and disbenefits; (2) exploring the co-occurrence of specific benefits and/or disbenefits; (3) linking benefits and disbenefits with particular spatial and landscape characteristics; (4) exploring the seasonality of the derived benefits and disbenefits. We conducted a map-based online questionnaire among visitors of two urban green spaces in Kraków, Poland (Wolski Forest and Jordan Park). Respondents were asked to map places visited and assign them benefits and disbenefits using indicator statements. Doing so, we found three bundles of benefits (connection to nature, social bonding in nature and responsibility) and five to seven bundles of disbenefits. The experiences (e.g., strengthening social bonds) tend to be more concentred whereas the identities (e.g., reflection) are more blurred spatially due to their individual character. The relationship between benefits/disbenefits and landscape features was rather weak and more visible in the case of experiences and capabilities. Respondents perceived more human-related disbenefits, which were geographically concentrated to a greater extent, especially in the vicinity of tourist attractions. The ecosystem-related disbenefits were less geographically concentrated. Our study revealed differences in perceiving disbenefits among different seasons. Respondents visiting study areas during warm seasons complained about overcrowding, insects and allergies, whereas those who visited study areas in the winter season particularly complained about darkness and snow covering the paths. These are important implications for enhancing the provision of benefits and reducing disbenefits while visiting green spaces. These findings have vital implications for enhancing benefits provision and reducing disbenefits during visits to green spaces.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Complex socio-ecological framework development of the revitalisation of post-industrial urban peripheries' intangible and tangible heritage

Gergely Papp

*Padon Alapitvany Foundation,
Hungary*

email: gergely.papp@pad.network

In the majority of European countries, there is a large amount of brownfields located on the periphery of regional post-industrial medium-sized cities. These are usually in close to socially vulnerable, segregated neighbourhoods. Our research supports both regional and European analyses, which show that the socially most vulnerable communities are also the ones most exposed to the harmful effects of climate change, environmental degradation and unequal ecosystem services distribution/provision.

The heritage of post-industrial urban peripheries' neighborhoods' working-class and heavy industry past is a key element in these cities' identity. However, these contemporary urban identity constructions exclude the deprived population and local SMEs- who still partly perpetuate the area's cultural heritage- as well as the neglected built and unmaintained natural environment and their organic interactions. Both local society - primarily the underprivileged Roma population – and the natural environment – the vegetation of unused brownfield sites, the existing circumstances of the natural environment and the increasing environmental hazards- are perceived by the urban majority population as dangerous, deteriorating and negligible phenomenon. At the same time, organic interactions between local society, built and natural environment are ignored by the urban majority. However, these interactions add new layers to the existing heritage.

The aim of our applied multidisciplinary and participatory research is to explore these layers of contemporary living heritage, to establish a common knowledge among local and other relevant stakeholders and professionals. The long-term aim is to build a development framework on this shared knowledge for the conservation and upscaling of the natural and built environment, which can also form the basis of small-scale pilots. Our ongoing socio-ecological design framework development intends to support the socially just climate adaptation of urban peripheries.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Hexageodesign Game
– an educational hierarchical game about public space

Małgorzata Pietrzak, Małgorzata Luc

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: *malgorzata.pietrzak@uj.edu.pl*

The innovative educational game, HEXAGEODESIGN GAME, focusing on raising awareness of sustainable development in settlement areas through an interactive approach to spatial urban planning. Its presentation during the conference can emphasize the value of a tool for effective knowledge transfer, a tool for supporting learning processes and developing diverse skills through interaction. In addition to the game, the authors will present preliminary results of research on its use in didactics.

The introduction focuses on current issues of urban and rural landscapes' degradation, which leads to the disappearance of spatial order and, consequently, disharmony. In this context, the need for education of sustainable development of settlement areas seems all the more important, and the idea of using an educational game acquires importance, enabling the development of cognitive and social skills and practical application of acquired knowledge.

HEXAGEODESIGN GAME, like other educational games, poses tasks that require players to solve problems, think logically and creatively, develop planning skills. At the same time, it raises awareness of responsibility in urban planning, develops communication and cooperation skills, and educates on the positive effects of urbanization, in line with sustainable development. The overarching problem that the game seeks to teach how to solve is the improvement of public spaces and the involvement of the community in the process, because, as Danish architect Jan Gehl noted, design decisions can affect whether people meet and interact with each other.

The game's hierarchical layout is designed to strengthen the ability to assess the spatial order of areas with diverse characteristics, as the arrangement of cards represents the rules for creating public space, according to a scale of importance. Players jointly prioritize the rules (divided into three categories), trying to reach an agreement on the organization of space. The game ends when all the cards are placed on the board.

The prototype of the HEXAGEODESIGN GAME was developed based on a game used in previous educational projects aimed at high school students, and then used in classes with students. The results of participatory research indicate the development of analytical thinking skills, communication, negotiation and social awareness in players.

The presenters suggest running the game through a three-stage process, including guided field observation, playing the game in groups, and spatial planning of "smart" settlement areas. This approach allows the game to be effectively enriched with research and field elements, opening new perspectives for the education of sustainable development of urban and rural landscapes. The principles for the creation of public space were taken from the work of Jan Ghel, which was enriched with information from the "Public Life Data Protocol" developed by Gehl Institute and expanded with goals taken from the 2030 Agenda for Sustainable Development and sustainable landscape research.

Thermal-sensitive city users and the microclimate of human habitats. Thermal comfort, safety and urban fabric planning in the selected Polish cities

Klaudia Plac

University of Economics, Katowice, Department of Strategic and Regional Studies, Poland

email: klaudia.plac@uekat.pl

The article describes the results of a pilot field study conducted during the summer months of 2023 in selected spaces serving recreational or temporary relaxation purposes in the cities of the Upper Silesian Conurbation. Special attention was given to spaces serving residents sensitive to both shortwave and longwave radiation, especially children, the elderly, and individuals with specific health conditions. The cross-sectional study combines elements of urban planning science and practice, as well as urban climatology, bioclimatology, and knowledge of the biological functioning of the human body. The author focuses on issues such as the thermal accessibility of the place, the safety of using spaces dedicated to sensitive user groups, and shaping urban spaces in terms of the behavioral and health characteristics of residents. The conclusions point to the necessity of addressing and applying a cross-sectional approach in the national scientific discourse, as well as defining design standards for spaces dedicated to sensitive urban users.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Urban protected areas within a complex social-ecological system: Navigating conflict determinants through spatial indicator clustering and analysis of residents' perceptions

Marcin Rechciński, Joanna Tusznio, Małgorzata Grodzińska-Jurczak

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: marcin.rechcinski@uj.edu.pl

Traditionally, urban protected areas (PAs) are remnants of less disturbed ecosystems that provide a bundle of services to local residents, with the multifunctionality being challenged by a) the small size of these PAs, reducing their resilience and potential to maintain the flow of ecosystem services, and b) a high potential for land-use conflicts related to intense recreational and settlement pressures. From another, more practical perspective, in the case of just one Polish region – Lesser Poland – urban areas encompass all legal forms of nature conservation, covering different sizes, conservation regimes, management systems, and networks of stakeholders. This may question the common assumption that the determinants of PA conflicts in urban areas are significantly different from those in rural settings.

Our presentation outlines the results of two studies of PA conflicts in Lesser Poland. First, using 187 relevant indicators from public statistics, we identified 14 clusters of municipalities with similar determinants of PA conflict. While three clusters were exclusively urban, cities or towns were present in all clusters, including those related to tourism, small-scale entrepreneurship, and urban sprawl.

In the second study, we surveyed a representative sample of 555 residents from the socio-ecological systems of all PAs (both urban and rural) in the region to investigate public perceptions of various PA conflict determinants. Awareness of PA conflicts was significantly related to characteristics that ambiguously corresponded to the urban-rural dichotomy. For example, one of strong predictor of reporting PA conflicts was a perceived high number of incoming visitors, which was more common among metropolitan and suburban residents. Similarly, those who perceived their local nature as a source of income for residents were more likely to report the conflicts, but this was less the case for urban dwellers. Low-regime PAs were better recognised by urban respondents, most likely due to the relatively more important role of such areas in a context of overall local wilderness perceived as less abundant. Low-regime urban and suburban PAs were also seen as beneficial to some local stakeholders (anglers), in contrast to the results obtained for all PAs, perceived as mainly of benefit to non-local actors. Interestingly, the most positive attitudes towards PAs were shown by residents of the urban sprawl cluster. Apparently, in such transitional areas, PAs can act simultaneously as a) a subject of public appreciation that drives people to change their place of residence and b) an unavoidable source of the resulting land-use conflicts.

Overall, the multi-faceted design of our study has helped us to reach beyond standard urban-rural and conflict-services dichotomies. Our presentation will help to navigate through all the intricacies we have explored.

Implementation of electromobility in public transport in the context of sustainable urban development and climate change challenges. The case of Poland

Jakub Taczanowski, Arkadiusz Kołoś, Łukasz Fiedeń, Robert Guzik,
Adam Parol, Krzysztof Gwosdz, Jakub Łodziński

*Jagiellonian University in Kraków, Institute of Geography and Spatial Management,
Poland*

Contact person email: jakub.taczanowski@uj.edu.pl

Delivering effective and environmentally friendly municipal transport is one of the main challenges for the future of towns and cities. On the one hand, urban areas and the share of world's urban population are constantly growing. On the other, transport is among the most important sources of environmental pollution, including greenhouse gas emission. Electric public transport can be a crucial tool to address these challenges as it offers high transport capacity and low environmental impact. The paper presents the progress in implementation of electromobility in public transport in Poland. This country is an interesting case because it has a well-developed system of traditional networks of electric public transport including trams, trolleybuses and urban rail and many of its towns and cities have been rather quick in adopting modern battery electric buses. What is more, Poland is also one of the main urban electric bus manufacturers in Europe with a strong position of railway and tram rolling stock producers, too. Nevertheless, implementing electromobility in municipal transport is a long and complicated process which is strongly differentiated between Polish towns and cities. In the first years of adopting battery electromobility we have observed different approaches of decision-makers ranging from very conservative cities which have been reluctant to introduce electric buses – often basing on their long tram systems (e.g. Wrocław or Łodź) – to courageous innovators who have launched large-scale programs of electric bus purchase – not rarely accompanied by massive acquisition of new tram and urban rail carriages (e.g. Warsaw and Cracow). A very interesting case are small towns like Miechów or Ząbkowice Śląskie which by buying the first electric buses have also decided to introduce urban transport – for the first time in their history. Another case which is worth noting is Olsztyn – the first and so far only Central-European city which has reintroduced tram transport after having dismantled its historical network fifty years before. Generally, the adoption of electromobility is closely related to high level of socio-economic development and favourable urban and technological features of town or city and can be seen as part of its policy oriented towards making the given urban area more sustainable and attractive.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Urban land use change in Europe; linking Green space connectivity and biodiversity

Hossein Talebi Khiavi, Jan Ferane, Robert Pazur

Slovak Academy of Sciences , Institute of Geography, Slovakia

Contact person email: hossein.talebikhiavi@gmail.com

The changes in land use affecting agriculture, forests, natural areas, and cities, put more stress on biodiversity and can lead to significant natural disasters. With urban areas as hotspots of the land-use changes, predictions indicate a notable rise in urban development across Europe by 2050. Thoughtful planning of urban land use and green spaces can improve lives, minimize environmental impact, and enhance urban services to cope with climate change. Having current information on land use changes in Europe, especially in cities, helps decisions and manage the land-use changes to lessen their negative effects on natural resources and biodiversity.

Open data policies enhanced our abilities to assess the temporal patterns of urban landscapes integrating spatial patterns with specific topics such as biodiversity.

Proposed study identifies the development of the urban areas and its hinterland across Europe in the periods of 2006–2018 with specific focus on urban greening. We utilized the Urban atlas dataset that Provides detailed land cover and land use data in 319, 785, and 788 Functional Urban Areas (FUA) respectively for 2006, 2012 and 2018.

We particularly focused on the green areas that we coupled with the Landsat based vegetations specially on the normalized difference vegetation index (NDVI), and Vegetation Phenology Parameters (VPP).

We identified a large variety of the greening patterns in the European cities and their surroundings. Coupling the land-use changes in the cities together with the greening pattern, we found that even the most greening areas were changed into the impervious surfaces

This study brings important insights into the effects of expanding urban areas on the urban greening areas.

Application of the 3-30-300 rule in Czech cities

Matej Wagner, Veronika Kvetonova, Michal Lehnert

*Palacky University Olomouc, Department of Geography,
Czech Republic*

Contact person email: matej.wagner01@upol.cz

More than half of the human population lives in cities while this share is continuously increasing and people are losing touch with nature. Present urbanization together with other global challenges call for efficient solutions for enhancing the life quality and wellbeing of urban inhabitants. Contemporary research emphasizes the importance of green infrastructure in urban areas not only for improving local climate but also for physical, social, and mental health of urban dwellers. Recently introduced 3-30-300 rule for assessment of urban green spaces aims to be standard for the evaluation of equal access to urban greenery in cities around the globe. With help of deep learning and data from remote sensing methods, the rule is expected to be applicable in towns of a few thousand inhabitants as well as cities of several million people. Moreover, only free public data are used and thus this method is appropriate not only for developed countries but also for developing ones. As one of the results of the analysis, information about the inner structure of the city can be obtained and the local policy-makers can target an improvement at specific locations. Furthermore, in case we use data from Copernicus, we can apply the rule to all European cities. Since the 3-30-300 rule can be used as one of the main tools for urban planning in a near future, the aim of this pilot study is to test feasibility and discuss rationality of implementation of the rule in Czech cities.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

When green meets compactness. In search for good practices of and challenges for implementing a green compact city idea in four Polish cities

Agata Warchalska-Troll [1], Paweł Pistelok, Anna Zielonka

[1] *Urban and Regional Policy Observatory, Institute of Urban and Regional Development, Poland*

Contact person email: atroll@irmir.pl

In the age of ever growing cities but also climate change challenges, compact urban stuctures seem a desired pattern for cities' development. However, urban dwellers usually tend to appeal for more greenery and more space, especially in their closest neighbourhood. A fragile balance between a city that is compact enough to save non-built up areas for nature around it, and green enough to provide its users as much healthy and comfortable living conditions as possible, remains often difficult to meet. In our study we take as a principle that satisfying proportions of these two features can be achieved when urban green areas are treated as equally important public spaces as squares and streets, and thus are saturated with wisely planned urban furniture, but also when plants are introduced to 'concrete by definition' spaces. Based on four in-depth case studies (Łęczna, Chorzów, Włocławek and Kutno) we identify how good examples of such coexistence are sometimes achieved almost by accident and how this balance can be easily missed, also despite large funds invested in design, renovation or maintenance of a given part of a city. Here, we argue that multifunctionality and interchangeability of functions of public spaces are key terms for green compact cities' implementation, guaranteeing that the full environmental and social potential of green spaces is used. In our methodological design we apply remote sensing analyses (including a combined NDVI+NDWI index as well as classified impervious areas derived from Sentinel-2 data) with field studies covering a detailed inventory of selected spaces in downtowns, interviews with local stakeholders as well as broad queries including press discourse. According to this interdisciplinary approach we also demonstrate that the 'concretosis' phenomenon- a widely discussed in the Polish media- is in fact very complex and can (and should) be considered at various spatial scales.

SESSION 1.

URBAN ECOSYSTEM: SERVICES AND CONFLICTS

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Susceptibility to piping erosion in Europe

Anita Bernatek-Jakiel[1], Matthias Vanmaercke[2], Jean Poesen[2,3],
Anna Biernacka[1], Pasquale Borrelli[4], Anastasiia Derii[1], Joanna Hałys[1],
Joseph Holden[5], Gergely Jakab[6], Michał Jakiel[1], Panos Panagos[7], Dawid Piątek[1],
Taco H. Regensburg[5], Jan Rodzik[3], Estela Nadal-Romero[8], Mateusz Stolarczyk[1],
Els Verachtert[9], Patryk Wacławczyk[1], Wojciech Zgłobicki[3]

[1] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland*
[2] *KU Leuven Division of Geography and Tourism, Belgium*
[3] *UMCS, Institute of Earth and Environmental Sciences, Poland*
[4] *Roma Tre University, Roma, Italy*
[5] *University of Leeds, School of Geography, United Kingdom*
[6] *Eötvös Loránd University, Hungary*
[7] *European Commission, Joint Research Centre (JRC), Italy*
[8] *Instituto Pirenaico de Ecología, Consejo Superior de Investigaciones Científicas (IPE-CSIC), Spain*
[9] *Flemish Institute for Technological Research, Belgium*

Contact person email: anita.bernatek@uj.edu.pl

Soil erosion is a significant global environmental issue that poses a threat to land, freshwater, and oceans. Subsurface erosion by soil palters the conditions for controlling measures aimed at mitigating soil degradation. However, it remains one of the most overlooked soil erosion processes, with limited documentation of its global and regional recognition. The objective of this project is to construct a piping erosion susceptibility map of Europe. The map allows to identify locations affected by this process, where specific erosion control measures should be taken. Firstly, we compiled a database of soil piping-related features, i.e. pipe roof collapses (PCs) and pipe outlets in the European Union and the United Kingdom. The database consists of 6841 piping-related features: 6171 PCs and 670 outlets, among which the location of 88% features is known at a resolution of 25 m. Then, this database is used to model the susceptibility of soils to piping erosion at the European scale. We applied the logistic regression model using the scikit-learn library in Python. The following environmental factors are tested: topography (such as slope and height difference), pedology (content of silt, clay, sand, and coarse fragments), land use and land cover, and climate (such as effective precipitation). Our preliminary result clearly shows that it is feasible to accurately identify the European hotspots susceptible to piping erosion, based on a combination of land use, topographic and soil variables (AUC >0.75). The presented map is an important step towards incorporating subsurface soil erosion into regional and global soil erosion models. This research is part of a project "Building excellence in research of human-environmental systems with geospatial and Earth observation technologies" funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 952327. The research has been supported by a grant from the Priority Research Area Anthropocene under the Strategic Programme Excellence Initiative at the Jagiellonian University.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Mapping sensivity to land degradation in a small catchment using a modified MEDALUS method (Polish Carpathians)

Anna Bucała-Hrabia[1], Rafał Kroczak[2], Tomasz Bryndal[2]

[1] *Polish Academy of Sciences, Institute of Geography and Spatial Organisation, Poland*
[2] *University of the National Education Comission, Institute of Biology and Earth Sciences, Poland*

Contact person email: abucala@zg.pan.krakow.pl

Land degradation is a major global problem that can lead to overexploitation of land resources, loss of ecosystem productivity, shifts in vegetation composition and loss of livelihoods. The research objective is to determine the spatial sensitivity of land to degradation in the Rzepianka catchment (Polish Carpathians) using the Mediterranean Desertification and Land Use (MEDALUS) model. The Rzepianka catchment covers an area of 25 km^2. It is located in the Ciężkowickie Foothills (Polish Western Carpathians). Land degradation was assessed using high resolution (1 m) data. This included the analysis of 13 quantitative parameters, four main quality indicators, i.e. Climate Quality Index (CQI), Soil Quality Index (SQI), Vegetation Quality Index (VQI) and Management Quality Index (MQI), which were calculated for the entire study area. The Environmentally Sensitive Areas Index (ESAI) was then derived. According to the ESAI results, only 6.0% of the study area was identified as critical, 63.08% as sensitive, 17.6% as potentially affected by degradation and 15.9% as non affected by degradation. In addition, a comparison of areas identified as sensitive to land degradation by the MEDALUS model with areas of surface topographic change detected by the Digital Elevation Difference model (DoD, generated by ALS-LIDAR in 2011 and 2022) showed a low spatial correlation. These results open the way for a discussion on the applicability of the MEDALUS model in small mountainous areas.

Session 2. Soils in the Anthropocene: Hazards, challenges and opportunities

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Soil dynamics in an urban forest as a result of parent material and land use

Milica Kašanin-Grubin[1], Nevena Antić[1], Snežana Štrbac[1], Sanja Stojadinović[1], Vukašin Rončević[1], Nikola Živanović[2]

[1] *Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Njegoševa 12, 11000 Belgrade, Serbia,*
[2] *Faculty of Forestry, University of Belgrade, Kneza Višeslava 1, 11000 Belgrade, Serbia;*

Contact person email: milica.kasanin@ihtm.bg.ac.rs

Urban forests are defined as areas that include everything from individual street trees and urban green spaces to suburban forests. These areas contribute to the green infrastructure, i.e., natural or engineered ecological systems that conserve ecosystem values and functions. However, urban forests face significant pressure including difficult growing conditions, insufficient resources for proper care, pollution, encroachment from development, and generally incomplete public understanding of the benefits they provide. The direct negative impact between climate change and anthropogenic pressure in urban forests is particularly reflected in soil degradation, and this problem requires special attention. The purpose of this research is examining how the parent material and land use affect physico-chemical and mechanical characteristics of the urban forest soil with the final goal of defining soil degradation indicators. Total of 53 soils samples from the urban forest at the Fruska gora Mt. near Belgrade, Serbia, were analyzed for the following properties: pH, electrical conductivity, oxido-redox potential, content of organic carbon, concentration of available cations, aggregate size and stability. The soils were developed on five bedrock types: serpentinite, marl, trachyte, shale, loess and two land use types: forest and meadow. The correlation between the obtained parameters was tested with two-way ANOVA and principal component analyses (PCA). All of the obtained results indicated that the soil physico-chemical properties depended on the geological setting and that rock composition has to be taken into consideration during land management.

Influence of vegetation on soil organic matter composition and spectroscopic properties in the subalpine zone of the Bieszczady Mountains (Eastern Carpathians)

Patrycja Kramarczuk [1, 2], Wojciech Szymański [1]

[1] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland*
[2] *Jagiellonian University in Kraków, Doctoral School of Exact and Natural Sciences, Poland*

Contact person email: *patrycja.kramarczuk@doctoral.uj.edu.pl*

The type of vegetation covering the soil plays a crucial role in determining the content and quality (chemical composition) of soil organic matter (SOM), as well as the rate of its decomposition. Mountainous areas globally often exhibit a mosaic of shrubs and grasslands, serving as significant reservoirs of SOM with largely unknown chemical compositions due to their harsh climatic conditions.

The main aims of this study were to determine the content of soil organic carbon (SOC), total nitrogen (TN), water-extractable organic carbon (WEOC), water-extractable total nitrogen (WETN) and the spectroscopic properties of SOM and water-extractable organic matter (WEOM) in the topsoil horizons under Vaccinium shrubs and tall-grass vegetation in the Bieszczady Mountains (Eastern Carpathians).

The litter (O) horizons of soils under Vaccinium shrubs were characterized by significantly higher SOC and TN content as well as higher WEOC concentration compared to O horizons in soils under tall-grass vegetation. The mean C/N ratio for the O and A horizons of soils covered with Vaccinium shrubs was significantly higher in comparison with O and A horizons of soils under tall-grass vegetation Similarly, the mean WEOC/WETN ratio was significantly higher for the O and A horizons of soils covered with Vaccinium shrubs in comparison with soils under tall-grass vegetation. Despite significant differences in the spectroscopic properties of the above- and belowground parts of shrubs and tall-grasses, the spectroscopic properties of SOM and WEOM obtained from the O and A horizons of soils covered with these different types of subalpine vegetation are generally similar. Most likely this is related to the homogenization of SOM through decomposition under similar environmental conditions.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Organic carbon in Mollisols of the world – a review

Beata Labaz [1], Alfred E. Hartemink [2], Yakun Zhang [2], Annalisa Stevenson [2], Cezary Kabała [1]

[1] *Wroclaw University of Environmental and Life Sciences, Institute of Soil Science, Plant Nutrition and Environmental Protection, Wroclaw, Poland*
[2] *University of Wisconsin-Madison, Department of Soil Science, FD Hole Soils Lab, Madison,USA.*

Contact person email: beata.labaz@upwr.edu.pl

Mollisols represent 7% of agricultural land and they are considered to be one of the most fertile soils in the world. The aim of the study was the comparison of soil organic carbon (SOC) concentrations and pools of Mollisols for the globe, the USA and Poland, and review how differences are caused by climate, land use, and key environmental factors. Globally, the mean thickness of the A horizon in Mollisols is 50 cm. At 0-30 cm the mean SOC concentration is 2.3%, SOC pool is 84 t ha-1, and clay content calculated at 0-50 cm soil depth is 21%. Mollisols in the USA have an A horizon thickness of 36 cm and have a mean clay content of 27% (0-50 cm). SOC concentrations are 2.0 and 1.7% and SOC pools are 85 and 116 t ha-1 at 0-30 and 0-50 cm soil depth, respectively. Mollisols in Poland have SOC concentrations of 1.8 and 1.5% at 0-30 and 0-50 cm soil depth, respectively, and lower clay content (17%) at 0-50 cm depth. The SOC pool at 0-30 cm depth is 74 t ha-1 whereas it is 106 t ha-1 at 0-50 cm. At the global scale, the highest SOC concentrations and pools are in Mollisols from Eastern Europe (including Ukraine and Western Russia) and Asia, while the lowest SOC pools are found in Mollisols from South America. The Mollisols in Western and Central Europe and North America have similar SOC pools, although Mollisols in North America have higher SOC concentrations and lower A horizon thickness. Globally, the mean pH value of Mollisols is 7.1, and the pH is slightly lower in Mollisols of the USA (6.9±0.9). The SOC concentrations and pools are strongly and positively correlated with clay content. Soil moisture and temperature regimes determine SOC accumulations and pools in Mollisols, and higher SOC concentrations and pools are in Mollisols with frigid and frigid-cryic soil temperature regimes as well as aquic, xeric, and aridic soil moisture regimes. Mollisols under grassland have the largest SOC pools compared to those cultivated or under forest. The important environmental factors on SOC accumulation in Mollisols worldwide are soil texture, land use, and soil temperature regime. The study indicated that the quantification of SOC pools up to 50 cm soil depth is insufficient and measurements should be included to 100 cm soil depth. Secondary carbonates (of pedogenic origin) as well as carbonates associated with calcareous parent materials (of lithogenic origin) are an important source of soil inorganic carbon (SIC), which contributes to the total carbon pool in Mollisols. Further studies of the carbon content in Mollisols of the world should be expanded to estimate the total and inorganic carbon pools.

Tracking macroplastic fragmentation across world biomes

Maciej Liro[1], Anna Zielonka[2]

[1] *Polish Academy of Sciences, Institute of Nature Conservation, Poland*
[2] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland*

Contact person email: maciej.liro@gmail.com

Microplastics can enter the natural environment as primary pollutants (e.g., as by-products of cosmetics) or as secondary pollutants (particles produced during the fragmentation of macroplastics). The long-lasting presence and global distribution of macroplastic waste pose serious risks of its fragmentation in various terrestrial environments. However, the potential for this process remains largely unexplored across different world biomes, and it is mostly unknown where hotspots of secondary microplastic formation occur. To identify potential hotspots of secondary microplastic formation across different world biomes, we combined information on the availability of macroplastics (global mismanaged plastic waste emissions) with data on the occurrence and intensity of physical and biochemical factors that accelerate its fragmentation. Our analysis indicated that high-energy mountain rivers draining areas with high emissions of macroplastic waste (e.g., in Asia and South America), as well as beach environments in surrounding regions, can act as hotspots for secondary microplastic formation due to both physical factors (e.g., water movement, wind action) and biochemical factors (e.g., sunlight). The maps and conceptual models we have developed can guide future efforts to track hotspots of secondary microplastic formation at regional and local scales.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Rivers as macroplastic fragmenters

Maciej Liro[1], Anna Zielonka[2], Tim H. M. van Emmerik[3]

[1] *Polish Academy of Sciences, Institute of Nature Conservation,
Poland*
[2] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management,
Poland*
[3] *Wageningen University, Hydrology and Environmental Hydraulics Group,
The Netherlands*

Contact person email: maciej.liro@gmail.com

The breakdown of plastic and the subsequent production of secondary microplastics remain unexplored in riverine environments. However, it is known that these micro-particles pose threats to both biota and human health and are challenging to remove from the environment. To provide a basis for future experimental exploration of this fundamental knowledge gap in our recent conceptual model we outlined potential pathways and rates of macroplastic fragmentation in rivers. We conceptualized riverine macroplastic fragmentation as a process modulated by two types of controls: intrinsic (resulting from plastic item properties) and extrinsic (resulting from river hydromorphology and climate). Based on our model we identified intrinsic properties of macroplastic items that make them particularly prone to fragmentation (e.g., film shape, low mechanical resistance of polymer, high degree of previous plastic degradation) and suggested the river types where this process is most effective (e.g., high-energy, coarse-bed mountain rivers). Plastic fragmentation and degradation processes have barely been studied and quantified under field conditions. We anticipate that our theoretical framework will serve as a guide for planning future field experiments able to quantify the plastic footprint of most common macroplastic items polluting rivers.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Assessing the effect of windthrows on soil organic carbon storage in different soil types – a case study in the Tatra Mountains, Southern Poland

Łukasz Musielok, Marek Drewnik, Mateusz Stolarczyk, Wojciech Szymański

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: l.musielok@uj.edu.pl

Storage of soil organic carbon (SOC) is crucial for the overall health and functionality of ecosystems. SOC influences nutrient cycling, supports biodiversity, mitigates climate change, and enhances soil stability and structure reducing the risk of erosion. Environmental disturbances, often induced by human activity, directly and indirectly affect SOC storage. An example of such disturbances are windthrows, which in many areas of Central Europe are linked to past tree species conversion transforming natural mixed forests into spruce monocultures and contributing to the current weakening of their overall condition. As a consequence, forests become more susceptible to strong winds. Windthrows impact both the external conditions for the formation of SOC pools, including biomass production and decomposition, and intrinsic soil transformations. However, the direction and outcomes of any environmental disturbance on SOC storage may depend largely on soil type. Mountains, characterized by high local geodiversity and susceptibility to global changes, serve as field laboratories for analyzing the effects of environmental disturbances on SOC storage. The study aimed to assess the impact of windthrows on the storage of SOC in the context of the local diversity of soil types. The impact of tree uprooting events on SOC concentration was assessed based on 340 soil profiles of the forest zone of the Tatra Mountains classified as Podzols and Cambisols (the latter developed both from calcareous or acid rocks). More than 50% of the analyzed soils were affected by the windthrows and on average showed a slightly lower SOC content recorded in O, A, and B horizons compared to undisturbed soil profiles. However, the effects of windthrows on SOC content varied significantly depending on soil type. Podzols, which generally stored much more SOC in the study area than Cambisols, also showed significantly greater SOC losses due to the impact of windthrows. The most pronounced differences in SOC content in windthrow-affected and undisturbed soils were observed in the B horizons, which indicates the loss of the most stable SOC pool (deep SOC) from Podzols as a result of this environmental disturbance. The research was supported by funds from Polish State Forests transferred to the Tatra National Park and grants from the Priority Research Area Anthropocene and the Faculty of Geography and Geology under the Strategic Programme Excellence Initiative at Jagiellonian University.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

How does ski infrastructure change soil erosion processes on hillslope?

Dawid Piątek, Anita Bernatek-Jakiel

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: dawid.piatek@uj.edu.pl

The rise in popularity of ski tourism has led to an increase in the number of ski resorts. This research aims to examine the impact of ski infrastructure on soil erosion processes in a small catchment in the Gubałowskie Foothills (southern Poland). The study presents landscape changes before and after the construction of a ski station in 2007. The analysis includes studying changes in flow accumulation, slope morphometry, and drainage ditches in the test area. To gather data, repeated DEMs derived from LiDAR survey and detailed geodetic measurements were used, along with field-based geomorphological mapping. The findings reveal that the ski infrastructure has not only directly altered the hillslope by earthworks like flattening and constructing escarpments (up to 3 m high), but it has also changed patterns of erosion and accumulation. In the test area, the drainage ditch was poorly designed, resulting in it being filled with material (0.1–0.5 m) and the formation of two new outlets. The escarpment of the ski run analyzed has been reduced by 0.5 m. Additionally, an alluvial fan (0.1 to 0.22 m thick) has formed on the flattened surface below the escarpment, where the drainage ditch outlets are located. This fan is eroded by subsurface flow, creating a piping system. The gully below the alluvial fan has moved upslope due to accelerated subsurface erosion. This study provides insights into hillslope adjustments and processes in response to the changes brought about by ski infrastructure. The results can contribute to more effective land management in regions that have been impacted by ski infrastructure.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Global riverine macroplastic hotspots

Anna Zielonka[1], Maciej Liro[2]

[1] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland*
[2] *Polish Academy of Sciences, Institute of Nature Conservation, Poland*

Contact person email: anna.zielonka@doctoral.uj.edu.pl

Mountain rivers in densely populated areas have recently been reported as substantially polluted by macroplastics. Macroplastics entering mountain river channels can easily become fragmented due to the specific conditions present, such as the high energy of flow and specific morphology. produced microplastic (and related risks) can not only affect mountain rivers but can also be transported downstream to lowland rivers and oceans. Information on the local, regional and global hotspots of macroplastic pollution within mountain river catchments is thus crucial for planning future mitigation actions. We have combined global databases of river network characteristics GLORIC and mismanaged plastic waste emission (MPW) to quantify amount of plastic discharged from global mountain rivers [t yr^{-1}]. The highest amount of mismanaged plastic waste was detected in mountain river catchments in the Himalayas and Andes. Mountain river catchments in Europe, especially in northern Europe, and Australia are significantly less polluted, with maximum values three times lower than those in Asia and South America. We identified catchments where high levels of mismanaged plastic waste emission coincide with occurrences of extreme rainfall, particularly in the Southeast Asia region, as potential hotspots of microplastic production and downstream transport during extreme events. The data obtained provide a unique source of information for regional and local mitigation of plastic pollution in mountain rivers worldwide.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Římov Catchment: A Chronicle of Land-Use Transformations and Their Hydrologic Impacts

Adam Babuljak, Raquel Nogueira Rizzotto Falcão, Josef Krása, Tomáš Dostál

CTU Prague, Faculty of Civil Engineering,
Czech Republic

Contact person email: *adam.babuljak@fsv.cvut.cz*

Rural depopulation, a widespread trend in Northern and Eastern Europe and the Mediterranean region, has multifaceted causes and consequences. From the forced abandonment of post-war Europe to the economically motivated migration to urban centers, depopulation has shaped landscapes and ecosystems. In some cases, it has led to the intensification of agriculture and large-scale monocultures, while in others, it has promoted ecosystem restoration, reforestation and the enhancement of biodiversity. The Římov Reservoir catchment in South Bohemia showcases a dynamic evolution of land use shaped by history, politics, and culture. The traditional, diverse 19th-century agricultural landscape underwent a series of changes after WWII. This process was set in motion by the displacement of the Germans, who formed the majority of the local population, and their partial replacement by people from the inland or Eastern European countries. This was followed by the complete displacement in the border zone including the demolition of local villages and the emergence of collectivisation and concentration of the population from farms to villages in the inland after the rise of the communist regime. After the fall of the communist regime and the transition from a planned economy to a market economy, there was another wave of farmland abandonment at the end of the 20th century. Many original owners, having regained their property (after four decades of national ownership), often unaccustomed to farming, opted not to return to the agricultural way of life as it made more economic sense to move to the economic centres than to cultivate less fertile land in a remote part of the country. What was once a diverse agricultural landscape, later unified by the communists into large monocultural units, has been transformed in recent decades into a series of forests, pastures and small municipalities that are developing and growing in popularity thanks to their location in the heart of a quiet and beautiful corner of the country. All these changes have a direct impact on many natural processes, some of which, such as rainfall-runoff process and sediment dynamics, can be modelled using modern computational tools with land use as one of the input parameters. CTU Prague scientists use models (HEC-HMS, WATEM/SEDEM) and historical maps to understand how land use changes affected the watershed's hydrology and sediment dynamics. The main motivation is not only to understand the extent of the impact of such changes in a real catchment with dynamic land use development on rainfall-runoff and erosion processes, but also to predict future impacts of societal trends on these processes in the pursuit of sustainable landscape management facing the challenges of the 21st century.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Human-environmental relation as a component of identification and assessment of areas susceptible to changes in land use and land cover

Katarzyna Cegielska, Anita Kukulska-Kozieł, Józef Hernik

University of Agriculture in Kraków,
Department of Land Management and Landscape Architecture,
Poland

Contact person email: katarzyna.cegielska@urk.edu.pl

The role and sustainability of green spaces are particularly important in peri-urban areas, where in Poland, in many cases, sprawl is the main type of development. This, in turn, makes them environmentally and culturally susceptible to changes. Keen demand for residential areas threatens the sustainability of the peri-urban landscape. The balance between anthropogenic and investment-free areas is proving to be in danger. The proper, balanced Human-Environmental relationship is disturbed. This study focuses particular attention on suburban green spaces. The fast-paced anthropogenic pressure and suburbanisation in peri-urban areas lead to the question of how long green spaces in these zones will remain unchanged. It is the primary goal of this article to estimate the sustainability of these areas. The authors developed Green Neighbourhood Sustainability Index (GNSI), with which one can assess the sustainability of the landscape and green spaces using spatial data and GIS technology. The case study included the suburban zone of the city of Krakow. In most cases the investigated peri-urban areas exhibit a gradual and smooth transition from the most ecologically relevant land cover types to those most anthropogenic, leading to a well-balanced neighbourhood of natural areas. There were also such green spaces which are not clustered but occur as individual spots surrounded by mainly anthropogenic land. They are at risk of conversion. Their sustainability is not guaranteed. They are in danger of being absorbed by surrounding built-up areas. It was found that arable land is the most vulnerable to conversion.

Session 3.
Dynamic land use changes: opportunity for rewilding?

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Renaturalization and wolf habitat

Roman Gula [1], Katarzyna Bojarska, Dominik Kaim, Jacek Kozak, Mahsa Shahbandeh & Joanna Toczydłowska

[1] *Polish Academy of Sciences, Museum and Institute of Zoology, Poland*

Contact person email: rgula@miiz.eu

In the beginning of 1970s, the majority of >100 wolves that survived the state-organized eradication campaign (1955–1974) in Poland lived in the eastern part of the Polish Carpathians. The area depopulated due to historical events following World War 2, was subsequently renaturalized, rewilded, and became a mainstay of Polish populations of large carnivores. A few wolves survived eradication in western Poland, part of Germany before World War 2. That region was also depopulated as a result of the war and depopulation had a profound long-lasting effect on the landscape of that area, making the wolf habitat structure of western Poland more coherent than traditionally recognized as the rural eastern part of the country. Reaching population minimum in the early 1970s, the population of wolves recovered since then, and over the last 5 decades wolves recolonized Poland. At present, they occur in over 20% of the country and their numbers are estimated for 2000–3000. The recovery process was parallel to the renaturalization of former arable land caused mainly by a gradual transformation of agriculture that startedin the mid-1970s. Although renaturalization was not the sole cause of wolf recovery, it altered the landscape in a way likely advantageous for wolves and other wildlife. At the beginning of the millennium, wolves began to recolonize the Holy Cross region of the central part of Poland, which has poor soil conditions, and small-scale self-subsidiary farming began to vanish in the 1970s. In this area, the natural reforestation of private farmland since 1970s has increased the forestation by almost 100%, reducing the isolation of existing state-owned forests. This process improved the cohesion of wolf habitat on the scale of single pack territory but also subpopulation scale. It allows wolf families to establish and control territories in the areas previously fragmented by arable lands, but also easy dispersal of young wolves accelerating recolonization. After 20 years of recolonization, 10–15 wolf packs successfully breed in the Holy Cross region every year, despite human density of 127 person/km^2 and substantial road infrastructure. The subpopulation is a leafy source population for other regions in Poland and Europe, as seen in data of young individuals dispersing outside of the area.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Road-side delivery of household waste to fluvial systems – the case of Kamienica Gorczańska catchment (Polish Carpathians)

Wojciech Haska, Maciej Liro, Paweł Mikuś, Elżbieta Gorczyca

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: wojtelhaska@wp.pl

The issue of road waste emissions into the environment has been discussed in many works by various researchers. Individual works focused on determining the regularities in the number, type and spatial distribution of waste occurring along roads. However, no one has examined the impact of these emissions on river fluvial systems. The authors of the following work observed that the road network is the main source of household waste delivery to river beds. To precisely investigate the scale of this phenomenon, field research was carried out in the Kamienica Gorczańska catchment area in the Gorce Mountains, in the Polish part of the Carpathian chain. Waste delivery sources related to the road network were divided into those two types: point delivery and dispersed delivery. As a result of the fieldworks, 103 measurement sites were established, where 29 illegal dumping sites and 1,759 individual waste particles were collected within 74 research plots. Both the point delivery sites in the form of illegal dumping sites and the dispersed supply measured in oblong plots along roads are characterized by certain spatial regularities. It has been observed that the amount of waste lying along roads is influenced by land use, distance from buildings, vegetation as well as the road surface and its type. The greatest amount of waste was observed in areas with lush vegetation in forest areas at a distance of no more than 100 m from the nearest buildings. Dirt roads leading directly to river beds were also indicated as the main source of waste, where they occur in the largest quantities. The above results provide new information about the main factors determining the delivery of waste to mountain river systems and could be an important source of information for relevant institutions dealing with the problem of environmental litter and waste management.

The Shift of the Upper Treeline in the Ďumbier Tatras on Historical Maps and Current Aerial Photographs

Tomáš Hrdý

*Matej Bel University, Department of Biology, Ecology and Environment,
Banská Bystrica, Slovakia*

email: thrdy@umb.sk

The Ďumbier Tatras form the western part of the Low Tatras. In the past, this territory was significantly transformed by human activity into extensive pastures for the purpose of grazing livestock and logging for mining purposes. In recent decades, we can see the gradual overgrowth of these grasslands due to changes in their current use. The shift of the upper limit of the forest and the change of the habitat significantly affects the population of two endemics, the High Tatras chamois *(Rupicapra rupicapra tatrica*) and the High Tatras marmot (*Marmota marmota latirostris*). On the basis of historical maps from three military mapping and contemporary aerial photographs, we analyze the change in the area of grass-heraceous ecosystems from the 18th century to the present.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

River landscape in Banská Bystrica (Slovakia) at the beginning of the 18th century

Pavel Hronček[1], Bohuslava Hrončeková Gregorová[1], Tomáš Hrdý[2]

[1] *Matej Bel University in Banská Bystrica, Department of Geography and Geology, Slovakia*
[2] *Matej Bel University in Banská Bystrica, Department of Biology, Ecology and Environment, Slovakia*

Contact person email: thrdy@umb.sk

The Hron river, which drains the central part of the Western Carpathians, was in the past one of the most intensively used watercourses in Slovakia. Until the beginning of the 20th century, rafting developed intensively on the Hron and a huge amount of firewood was floated down the river. From the earliest settlement of the area, rafts were used to transport wood, wood product and, from the second half of the 19th century, rails to the Hungarian capital, Pest. For the purpose of intensive use of the Hron river, its riverbed was water-managed. In Banská Bystrica, as the center of historical mining and metallurgy, the riverbed was modified along its entire length, and canals for rafts were built near the water rakes for extracting driftwood. The aim of the article is to digitally reconstruct the anthropogenically modified and constructed riverbed of the Hron river at the beginning of the 18th century, in the period before the first good quality map documents, based on historical-geographical research.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Decline in the wildland-urban interface as opportunity for rewilding

Dominik Kaim [1], Michał Jakiel, Piotr Szubert, Volker Radeloff

[1] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland*

Contact person email: dominik.kaim@uj.edu.pl

The wildland-urban interface (WUI) is an area, where housing is close to natural vegetation, which might have negative consequences for humans and the environment, e.g. due to the risk of fire ignition, invasive species spread or human-wildlife interactions. WUI is a global phenomenon showing an increase in many areas, where it already exists. However, it also happens that some of the areas witness WUI decline over time, although is not common. It means that the changes in land use that occurred are usually caused either by settlement decline, or forest cover decrease. In the Polish Carpathians, where we observed a gradual forest cover increase since the mid-19th century, the areas, where WUI decline was observed, were located in the Eastern part of the mountains, where the resettlement of inhabitants after WWII took place. The disappearance of the local population and the forest cover increase created an opportunity for rewilding. This is the area, which was occupied by large carnivores including brown bear and wolf. In this paper we analyse under which conditions the WUI decline happened over time, what is the scale of the phenomenon and how it change the landscape. Our results show that the share of past WUI was much higher in the areas used permanently by bears and wolves than in the areas used by these species only sporadically. On the other hand, the density of damages caused by these species is also relatively high there. More broadly, it shows that ongoing depopulation in rural areas in many parts of Europe may create a space for future large carnivore recovery, however, it has to be planned carefully, because existing settlements still may offer an attractive arrangement for the most opportunistic carnivores.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

The impact of land use change on river water quality, an example from the Polish Western Carpathians

Małgorzata Kijowska-Strugała, Witold Bochenek,
Sabina Wójcik, Tomasz Szydłowski

*Polish Academy of Sciences, Institute of Geography and Spatial Organization,
Research Station in Szymbark,
Poland*

Contact person email: mkijowska@zg.pan.krakow.pl

One of the most important factors affecting water quality is land cover and land use change (LULC). Research on LULC has been carried out in the Bystrzanka catchment (13 km^2), located in the Polish Western Carpathians. Significant changes in LULC have occurred here over the last 50 years, with a decrease in arable land and an increase in grassland and forest. The reasons for these changes include the political transformation in 1989, the transition from a centrally planned economy to a free market economy. Studies on the water quality of the Bystrzanka stream were carried out between 1995 and 2022, including both physico-chemical measurements and ionic composition. Samples were taken every week. Electrical conductivity (EC) and pH were measured *in situ* at daily intervals. The annual mean pH and EC show a statistically significant decreasing trend over the study period. The pH decreased by almost 1 unit over the study period towards a neutral value. EC decreased from about 30 to 25 mS· m^{-1}. The chemical composition of the water during the study period was dominated by autochthonous ions released as a result of the leaching of the slope cover and the bedrock of the Tertiary formations: HCO^{3-} and Ca^{2+}. Mean annual water mineralisation showed a statistically significant negative correlation with runoff. Biogenic ions, which are of allochthonous origin, are associated with water pollution by municipal and agricultural wastewater. Both total biogenic concentrations and their contribution to total dissolved ions in water show a statistically significant decreasing trend. This trend is due to LULC changes and a shift away from root and cereal crops, a reduction in mineral fertilisation and the partial canalisation of farms in the Bystrzanka catchment area. Recognising the links between land use impacts and river water quality is crucial in catchment management studies.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

GeoSen: map applications with an artificial intelligence (AI) component – prototype application

Karol Król, Tomasz Salata, Józef Hernik,
Anita Kukulska-Kozieł, Katarzyna Cegielska

University of Agriculture in Kraków,
Department of Land Management and Landscape Architecture,
Poland

Contact person email: k.krol@urk.edu.pl

The subject of the presentation are a map applications equipped with an artificial intelligence (AI) component developed as part of the scientific project titled Artificial Intelligence and Geodata for Local Community Sensitisation to Sustainable Spatial Development (GeoSen). The project GeoSen is set to support modern spatial planning processes with artificial intelligence on the local (municipal) and regional levels. The combination of artificial intelligence and remote-sensing systems will facilitate continuing registration, pattern recognition, and tracking of structural changes and changes in land cover and land use. The system will also identify urban-rural relationships in spatial management. The technology will handle large datasets and monitor land-use and land-cover changes automatically and continuously.

Session 3. Dynamic land use changes: opportunity for rewilding?

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Multitemporal satellite data
as a potential for mapping mountain vegetation

Adriana Marcinkowska-Ochtyra, Adrian Ochtyra, Krzysztof Gryguc

*University of Warsaw, Faculty of Geography and Regional Studies,
Poland*

Contact person email: adriana.marcinkowska@uw.edu.pl

The impact of climate change is visible in many environments around the world. One of them are mountain areas, where, for instance, changes of the treeline or shrubs encroachment into grasslands can be observed. Mountain vegetation, including rare endemic or endangered species is unique and systematic monitoring is a key element of its protection. Field mapping is a part of geographer's work, but for large or difficult to explore areas, is laborious and time consuming. As a result, it is not feasible to develop frequently updated maps of mountain vegetation covering large areas based solely on field data. Hence, satellite imagery, characterized by great objectivity and spatial coverage, as well as frequent revisit time, are increasingly used in monitoring works. To achieve the most accurate results, proper preprocessing of images is crucial, especially when planning to rely on data from different time periods.

The Sentinel-2 satellite mission by the European Space Agency provides high temporal resolution data (every 5 days since 2017) with 10-20 meters pixel, offering substantial support for both scientific research and practical applications, including the identification of mountainous vegetation. This work presents a whole data processing workflow, from acquisition of scenes from available terms of data acquisition (vegetative period in 2018 and 2019), through initial preprocessing to the generation of a cloud-free multi-temporal mosaic in Google Earth Engine platform. Such a dataset was subjected to the classification of eight major types of mountain vegetation in the Polish and Czech parts of the Karkonosze Mountains, which was performed in RStudio with Support Vector Machine algorithm. The following classes were identified: subalpine and alpine grasslands, deciduous shrubs vegetation, bogs and fens, subalpine tall-forbs, rocks and scree vegetation, heathlands, subalpine dwarf pine scrubs and forests. Special attention was given to the grasslands class.

As reference data, field-acquired polygons were utilized, supplemented by high-spatial-resolution images to aid in determining vegetation classes in the area. Various classification scenarios were tested, and the most significant variables for classification were discussed, emphasizing key identification periods for grasslands. The achieved F1 accuracies for this class, depending on the scenario, ranged around 80%.

Presented research is based on the first case study presented within Module 2 of an open E-learning course on Time Series Analysis in Remote Sensing for Understanding Human-Environment Interactions (E-TRAINEE, Erasmus+Strategic partnership, ID 2020-1-CZ01-KA203-078308) developed within collaboration of four research groups from Charles University, Heidelberg University, University of Innsbruck, and University of Warsaw.

Functional mix on a city scale – the example of Warsaw

Maciej Misztal

*University of Warsaw, Urban LAB,
Poland*

email: mm.misztal@uw.edu.pl

The functional mix is one of the foundations of creating a city that is friendly to residents. Mixing functions allows to reduce the distances necessary to meet various needs in the city. Due to its specificity, the functional mix is analyzed in the literature mainly on the scale of districts or neighborhoods. However, according to the author, examining the functional mix on the scale of the entire city may show the studied phenomenon in a new light. The following article presents a new method of studying the functional mix based on the use of spatial data. The results show that it is possible to create a functional mix map showing the intensity and spatial structure of the studied phenomenon on a city scale. Thanks to this, it is possible, among other things, to identify problem areas that require thorough analysis. Research Goals: (G1) To examine the functional mix on a city scale and assess its implications for creating a resident-friendly environment. (G2) To develop a new method utilizing spatial data to study the intensity and spatial structure of the functional mix phenomenon. (G3) To identify problem areas in the city that require indepth analysis and intervention based on the functional mix map. Hypotheses: The functional mix on the scale of the entire city will reveal new insights and perspectives on the studied phenomenon compared to district or neighborhood-level analysis. The new method of studying the functional mix using spatial data will provide a more accurate and comprehensive understanding of the intensity and spatial structure of the phenomenon, enabling effective planning and intervention strategies for creating a resident-friendly environment. By setting these research goals and hypotheses, the study aims to contribute to the knowledge and understanding of the functional mix and its implications for urban planning and design on a city-wide level.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Method for assessing landscape changes caused by deep mining of hard coal in mining areas on the example of Jastrzębska Spółka Węglowa (Poland)

Urszula Myga-Piątek, Anna Żemła-Siesicka, Bartłomiej Szypuła, Agnieszka Piechota

*University of Silesia, Faculty of Natural Sciences,
Poland*

Contact person emal: anna.zemla-siesicka@us.edu.pl

Intensive hard coal mining activities within Jastrzębska Spółka Węglowa is still carried out in the areas of the counties of Mikołów, Pszczyna, Wodzisław, Rybnik and the city of Jastrzębie Zdrój (Śląskie Voivodeship, southern Poland). Acquiring a mining concession always requires environmental decision for an environmental impact assessment report obtained from the Regional Directorate for Environmental Protection. One of its integral part is the landscape impact assessment (LIA), prepared, as the rest of the report, for two investment variants and for the cumulative impact of the investment. The LIA procedure is not legally established in Poland, the content or level of detail required in the report is not determined by the law. Nevertheless, there are some procedures that have been developed and successfully applied, mainly for land-based investments as wind farms or large-scale structures (e.g. Wróżyński et al., 2019; Badora, 2016). However, no guidelines for the LIA of the underground mining effects have been developed so far.

In the conducted research, the changes of the landscape caused by the modification of topographic conditions resulting of land subsidence due to underground coal mining were assessed. The study required the elaboration of a method which in an objective manner, based on quantitative data, would indicate the more favourable choice of the exploitation variant. As a basis of the method, the landscape audit procedure (Journal of Laws, 2019) was adopted, adjusted to the scale of the study. The main sources of The data were the resources of the Head Office of Geodesy and Cartography (Orthophotmap, Topographic Objects Database), the National Institute of Cultural Heritage and the Polish Geological Institute and, the most important, data on the scale of land subsidence obtained from the operators of the mines. The study covered a mining area, legally understood as "the space covered by the anticipated detrimental effects of the mining works of a mining plant" (Geological and Mining Law, 2011), which means the zone of the predicted negative impact of the mining plant on the landscape and natural environment. Both horizontal and vertical landscape analyses were conducted. The assessment was carried out in several stages: 1) verification, including refinement of the audit landscape typology; 2) delimitation of landscape units - based on uniformity of background, functional-visual connections and landforms; 3) preparation of a digital surface model with expected subsidences; 4) characterisation of the identified landscapes (natural and cultural features and visual resources); 5) identification of the elements of visual exposition (such as linear views, viewpoints, landscape dominants); 6) identification of landscape functions; 7) development of a scale of landscape change intensity; 8) assessment of the degree of change in each of the identified units, for two variants; 9) indication of the more favourable investment variant.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Satellite imagery for monitoring changes in natural environment

Adrian Ochtyra, Adriana Marcinkowska-Ochtyra,
Krzysztof Gryguc, Edwin Raczko

University of Warsaw, Department of Geoinformatics, Cartography and Remote Sensing, Poland

Contact person email: adrian.ochtyra@uw.edu.pl

Open access to Earth Observation (EO) data collected over decades is an undisputed advantage for the application of such data in geographical research. Optical satellite data, which enables the analysis of large areas across the entire globe at regular time intervals, such as Landsat for over 50 years, provides information about the environmental condition and its dynamics. In remote sensing literature, numerous examples can be found of studies investigating changes in the natural environment. Authors continually develop newer algorithms, varying in complexity, to address this evolving field. Majority of them require several tunable parameters or can detect only one type of change in a specific environment. The aim of this study was to present the performance of threshold- and trend-based vegetation change monitoring algorithm (TVCMA) that can detect both abrupt and gradual changes in vegetation. As a study site Polish and Slovak Tatra Mountains which are unique and ecologically significant were selected. The strong winds and bark beetle outbreaks are the primary causes of vegetation disturbances in this area. An annual time series of data from 1984 to 2022 was used as the input. The long time span necessitated the use of scenes from several Landsat scanners: Thematic Mapper (TM), Enhanced Thematic Mapper Plus (ETM+), Operational Land Imager (OLI) and Operational Land Imager 2 (OLI-2). Atmospherically and topographically corrected data from May to September each year were subjected to clouds/shadows masking and based on the closest pixels to 213 day-of-year (DOY) time series composite was created. With such yearly composites prepared, Tasseled Cap transformation bands and spectral indices were calculated in order to select the most sensitive variable for change detection. TVCMA was applied to them and various threshold values. Based on reference data points best model selection was performed. Accuracy assessment shows overall accuracy around 95% and over 80% detected disturbance events. Final step allowed for creation of disturbance maps for each year presenting detected events in the Tatra Mountains. Presented research is based on the third case study presented within Module 2 of an open E-learning course on Time Series Analysis in Remote Sensing for Understanding Human-Environment Interactions (E-TRAINEE, Erasmus+ Strategic partnership, ID 2020-1-CZ01-KA203-078308) developed within collaboration of four research groups from Charles University, Heidelberg University, University of Innsbruck, and University of Warsaw.

Hotspots of land cover change in national parks and their buffer zones in the last 20 years in Slovakia

Zuzana Pazurova, Šimon Opravil, Robert Pazur

Slovak Academy of Sciences, Institute of Geography, Department of Geoinformatics, Slovakia

Contact person email: zuzandam@gmail.com

Natural protected areas are under increasing threats from climate change and intense human pressure globally. As they have a crucial role in biodiversity conservation and the maintenance of ecosystem services, it is important to assess the impacts of human activities on their functioning. The aim of the study is to identify the hotspots of land cover changes in the national parks in Slovakia and their buffer zones between the years 2000 and 2020. In total nine national parks, we used the Global Land Cover and Land Use Change dataset for 2000 and 2020 to evaluate the land transitions, categorized as urbanization, agricultural intensification and extensification, afforestation, deforestation, and forest disturbance. Results show, that national parks are significantly affected by forest disturbances, especially the High Tatras and Low Tatras national parks, where the rate of forest disturbance was 6–9 higher in comparison with the rest of the national parks. The buffer zones were exposed to forest disturbance, agricultural extensification and urbanization locally. The highest rate of urbanization in buffer zones was identified again in the High Tatras and Low Tatras national parks, which is connected with the building of new tourism and leisure opportunities and the increase of new housing in the vicinity of towns. The localization of hotspots of land cover change highlighted the important issues in national parks and their surroundings. As the frequency of forest disturbances is on the rise and urbanization is likely to grow in the future, the national parks and their buffer zones need a special landscape policy to reflect the actual threats on the health of ecosystems.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Land cover dynamics in Połaniec town over the last two decades seen from aerial imagery

Paulina Pisarczyk, Ewa Bubula, Ewa Grabska-Szwagrzyk

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: *paula.pisarczyk@student.uj.edu.pl*

In the last few decades in Poland, significant socio-economic changes have taken place, primarily attributed to joining the European Union. Notable processes occurring in rural towns include the increase in built-up areas and new infrastructure, and, on the other hand, the decline in agricultural activities due to socioeconomic and environmental factors. The abandonment of agricultural lands has led to forest succession on previously cultivated areas. These processes have an impact on land cover and land use changes, which can be monitored using remote sensing data. This presentation will discuss the changes in land cover in Połaniec town over the past two decades, exploring the potential impact of these changes on the town's ecological, spatial, and social structure. Połaniec, situated in Świętokrzyskie Voivodeship in south-central Poland, serves as an intriguing case study. A significant portion of previously agricultural lands has transformed into tree-covered areas in recent decades. While specific to Połaniec, this example mirrors a broader trend observed in numerous Polish regions undergoing the process of forest succession. Moreover, the population of Połaniec has decreased in recent years from 8,683 inhabitants in 2000 to 7,606 in 2021. The analysis of land cover changes was based on aerial orthoimagery from the years 2001–2022, processed using automatic classification. The results illustrated the pace of these changes, with a notable increase in forest cover, particularly in recent years. This increase is observed predominantly on parcels close to previously forested areas. While the rise in forest cover is often viewed as having negative social and economic impacts and posing a threat to semi-natural habitats, other implications include managing CO_2 emissions in Poland and the potential opportunity for rewilding and restoration of non-agricultural habitats. This research is part of the project *Assessment of transformations in vitality, vulnerability and versatility of rural towns*. It is supported by and carried out within the framework of the research activities of the 3VRUT Project and benefits from the financial support of the EIG CONCERT-Japan program 7th Joint Call ICT for Resilient, Safe and Secure Society (2021-2024).

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Application of machine learning algorithms and satellite imagery in identifying land cover changes

Tomasz Salata

University of Agriculture in Krakow,
Faculty of Environmental Engineering and Land Surveying,
Poland

email: tomasz.salata@urk.edu.pl

The changes in land cover observed by the scientific world are identified using various techniques and methods. In this study, a machine learning method was used to automatically classify land cover based on satellite imagery. The Landsat and Sentinel satellites were used for this purpose, but due to the higher spatial resolution of the imagery, Sentinel-2 was chosen. An experiment was performed to check how different training data sets can affect the results of algorithms, and a qualitative and quantitative evaluation of the results obtained. The area of interest is the issue of the quality of classification of data from satellite imagery in the field of land cover. The relationship was identified on the basis of two sets of training fields, differing from each other by a certain group of interpretatively uncertain objects. Two types of data were used to solve the problem: original data from the 10 m Sentinel 2 satellite and data processed with Geomatic's Super Resolution algorithm, the resolution of which was quadrupled with adaptive edge detection. This allowed them to obtain high-quality imagery and perform a quality analysis of the land cover classification on fairly accurate material. The satellite imagery analysis method was based on the creation of a training set and the training of artificial intelligence (AI) using synchronized data from a specific timestamp, followed by iterative repetition of the land cover classification process on imagery from year to year. The effects of the approach to training a model with different sets of inputs are clear, but not spectacular. Particular differences could be observed in regions with fragmented result classification. Areas with larger surface areas remained independent of the input factor. On the basis of the experiments carried out, the weaknesses of this method were also discovered, i.e. cases of completely wrong classification. It can be concluded that in the case of areas with fragmented and changing land cover structure, properly prepared training data is a key element in the process of classifying satellite images using machine learning. It is a process that can be established a priori and as a result bring the expected results. The spatial resolution of the analyzed satellite imagery is of secondary importance.

Session 3.

Dynamic land use changes: opportunity for rewilding?

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

The impact of contemporary hard coal exploitation on the development of subsidence basins in the Upper Silesian Coal Basin

Maksymilian Solarski

University of Silesia, Institute of Social and Economic Geography and Spatial Management, Poland

email: maksymilian.solarski@us.edu.pl

The aim of the research was to determine the extent to which contemporary deep mining of hard coal affects the development of subsidence basins in the Polish part of the Upper Silesian Coal Basin. The research covered an area of 2,558.2 km^2. LIDAR models from 2011 and 2021 were used in the study. Using simple raster algebra, the number, area and volume of subsidence basins that developed in the examined decade were determined. The research shows that in the years 2011–2021, 87 basins were created in the analyzed area, the total area of which was 202.6 km^2, which constituted 7.9% of the research area. The area of the basins ranged from 0.13 to 22.7 km^2, with an average of 2.3 km^2. However, the size of the average land depression was a maximum of 2.1 meters (Pawłowice II), with an average of 0.8 meters. The resulting subsidence basins cause mining damage in urban areas, which results in the deterioration of the technical condition of buildings and transport infrastructure, and in extreme cases, they cause the displacement of people from endangered areas.

Session 3.

Dynamic land use changes: opportunity for rewilding?

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Towards a new landscape typology for the analysis of rural abandonment in Europe

Anton Van Rompaey, Lisa-Marie Hemerijckx

KU Leuven, Geography and Tourism Research Group, Belgium

emails: *anton.vanrompaey@kuleuven.be,*
lisamarie.hemerijckx@kuleuven.be

Rural abandonment represents a significant phenomenon in peripheral regions across Europe, encompassing areas distant from urban centers, mountainous regions, and remote islands. Historically, abandonment of rural landscapes dates back to the early 19th century, initially associated with the onset of a forest transition. However, this process gained momentum following World War II, as urban centers experienced rapid economic growth, leading to the neglect of traditional countryside areas. Moreover, the accession of new member states to the European Union, coupled with increased competition in a unified market, further exacerbated rural abandonment in these regions. Traditionally, scholars have analyzed this phenomenon in a binary manner, distinguishing between abandoned and non-abandoned areas. However, the reality is far more intricate, as farmland can be left unused while populations remain in the same location, or villages may become depopulated while agricultural land remains in use. To address this complexity, this paper proposes a novel analytical framework that considers rural abandonment along two axes: population and land cover. By examining these dimensions, the paper aims to identify potential abandonment clusters. Additionally, it outlines how these clusters can be mapped and discusses the unique sustainable development challenges associated with each cluster. By adopting this new approach, policymakers and researchers can gain a more comprehensive understanding of rural abandonment dynamics, thus facilitating the design of targeted interventions and policies to mitigate its adverse effects on local communities and landscapes.

Session 3.

Dynamic land use changes: opportunity for rewilding?

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Natural rewilding of the Sørkappland (Spitsbergen) coastal landscape

Wiesław Ziaja

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

email: *wieslaw.ziaja@uj.edu.pl*

It would be seemed that such a remote and difficult to access area as the southern Spitsbergen peninsula (± 1500 km^2) should be completely wild. However, different resources of its environment were quite intensively exploited, especially in coastal areas. This exploitation started with a very intensive whaling from the beginning of the 17th century to the 1660s. Remains of whaling stations from this period are visible in the landscape of the western coast until today, although already very blurred. After extermination of Greenland whale, the Pomor (Russian) hunting activity had begun and continued until the middle of the 19th century. Remains of their small settlements are absorbed by nature but still visible on the western, southern and eastern coasts. Pomor hunters had been replaced mainly by Norwegian trappers in the second half of the 19th century. Their activity boomed from the end of the 19th century to AD 1973 when was stopped due to establishing the South Spitsbergen National Park. Remains of this activity are still well visible in the landscape, in form of ruins and two old trapper huts which have survived until today. A big environmental and lanscape change had resulted from a complete extermination of wild reindeer by trappers in Sørkappland. Hence, the coastal tundra had become dense and flowering in various colors (various plant species) with a lot of bird nests (of at least several species) due to the lack lack of grazing and trampling by reindeer (which was observed back in the 1980s). Today, after 50 years of the hunting ban and regeneration of reindeer population since the 1990s, tundra is in a much worse condition with compacted soil and reindeer droppings instead of flowers and bird nests (apart from skua's ones). This is a real rewilding of tundra, harmful for its biodiversity due to no predators eating reindeer (apart from polar bears who are just learning to hunt reindeer after recession of sea ice around the peninsula). The only attempt of mining activity in Sørkappland was made in AD 1920–2025 when three buildings and coal mining shaft were built just on the sea coast in the NE Sørkappland. 270 tons of coal were taken out. This was the biggest human interference in the Sørkappland landscape. However, this activity was abandoned due to heavy sea ice conditions at the end of the 1920s. Afterwards, these objects have completely disappeared in result of sea transgression and slope erosion there. The site of the geological exploration well (for petroleum and gas) in the central-eastern Sørkappland coast from AD 1987-89 has been also flooded by the sea afterwards. To sum up, the Sørkappland coast is today the wildest since the beginning of the 17th century, especially because it is not inhabited (without any wintering) for 50 years.

Urban Growth's Implications on Land Surface Temperature in a Medium-Sized European City based on LCZ classification

Aleksandra Zwolska, Marek Półrolniczak, Leszek Kolendowicz

Adam Mickiewicz University in Poznań, Department of Meteorology and Climatology, Poland

Contact person email: alezwo@amu.edu.pl

The study determined the influence of changes in land use and land cover (LULC) on land surface temperature (LST) over a 33-year period based on a medium-sized European city (Poznań, Poland). The LST was estimated from Landsat 5, 8 and Terra (MOD11A2v6) satellites. The local estimation of climate patterns was based on the Local Climate Zones (LCZ) classification utilised with the methodology proposed by the World Urban Database and Access Portal Tools (WUDAPT). Moreover, the Copernicus' imperviousness density product (IMD) was used. Between 2006-2018 the area with IMD of 41-100% increased by 6.95 km², 0-20% decreased by 7.03 km². The contribution of built-up LCZs increased by 7.4% (19.21 km²) between 1988 and 2021 reaching 13% (34 km²) within open mid-rise LCZ. Due to urbanisation and reforestation, low plants LCZ shrunk by 12.7%. For every 10% increase in IMD, LST increases by up to 0.14 °C. Between 1988 and 2021 the LSTm in specific LCZs rose from 1.52 °C up to 2.97 °C. As per LST models LCZ change from natural to built-up led up to 1.19 °C LST rise. The increase of the LSTm was registered even when the LCZ remained unchanged.

Long-term variability of air masses temperature in Kraków (1961–2023)

Zuzanna Bielec-Bąkowska

University of Silesia in Katowice, Institute of Earth Sciences, Poland

email: zuzanna.bielec-bakowska@us.edu.pl

In a changing climate, changes in air temperature are the most noticeable. They concern not only their average or extreme values but also the frequency of occurrence of selected thermal characteristics. Research on the described changes also involves searching for their causes, one of which is changes in atmospheric circulation. For this reason, this study attempted to determine temperature changes in southern Poland due to changes in the thermal characteristics of individual air masses flowing over the area. For this purpose, the daily values of minimum, average and maximum air temperature at the Kraków-Balice synoptic station were used (for the period 1961–2023), as well as types of atmospheric circulation and air masses from the daily *Calendar of Atmospheric Circulation Types for southern Poland* (from the period 1951–2023) compiled by T. Niedźwiedź.

On this basis, long-term and annual changes in the frequency of occurrence of particular types of air masses, annual and seasonal changes in the directions of their inflow and their thermal characteristics were determined. It was found that the most significant influence on the decrease in air temperature is caused by the inflow of arctic air masses (PA) (mainly in the warm half of the year) and continental polar air masses (cP; in the cold half), which have been recorded slightly less frequently in recent years. At the same time, the air temperature increases most during the inflow of tropical air masses (T) (especially in spring) and during the increasingly frequently recorded polar maritime warm air masses (mPw) (most strongly in winter).

A more detailed analysis of the long-term variability of the temperature of individual air masses shows that its increase was most significant in tropical air masses (T). It concerned almost all months of the year and was noticeable in both average and extreme temperature values. The smallest thermal changes were recorded in the continental polar air masses (cP), only concerned with the summer months.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Quantitative evaluation of the impact of land form and urban structure on UHI intensity spatial pattern in Kraków

Anita Bokwa [1], Mateusz Durka [1], P. Sekuła [2]

[1] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland*
[2] *Institute of Meteorology and Water Management, National Research Institute, Poland*

Contact person email: anita.bokwa@uj.edu.pl

The spatial pattern of urban heat island (UHI) intensity in Kraków, Poland is complicated as it depends on both: land forms and land cover/land use. The location of the city in a concave land form is linked to the occurrence of cold air pool formation and frequent air temperature inversions. Therefore, UHI intensity has to be determined with the application of RMUHI concept. UHI intensity has been determined with the application of point measurements and generation of continuous spatial pattern is a methodological challenge. The air temperature measurements were carried in the network of points located in the city and its vicinities in the years 2009–2021. Air temperature inversion occurrence was determined with the application of the measurements at a 100-meter mast. Those data together with land use/land cover data (e.g. mean building height, green areas share) and relief data (for source areas of particular measurement points) were used to determine quantitatively the significance of particular factors in controlling UHI intensity. The statistical methods used included multiple regression, Random Forest method and Artificial Neural Networks.

The complex role of trees as the most popular heat wave mitigation measure in Czech cities

Jan Geletic, Pavel Krc, Jaroslav Resler, Martin Bures,
Hynek Reznicek, Michal Belda

*Czech Academy of Sciences, Institute of Computer Science,
Czech Republic*

Contact person email: geletic@cs.cas.cz

Generally, trees are widely considered the most effective heat wave mitigation measure in cities. Most of their positive effects are well described and analyzed in detail. Despite that, their effect on their surroundings is not homogeneous. Trees in urban canyons significantly affect the energy balance of horizontal and vertical surfaces. Moreover, they decrease wind velocity and block night-time radiative cooling of horizontal surfaces. The role of trees in the urban canyon is more complex – they can decrease surface temperature (ST) or mean radiant temperature (MRT) by about tens °C, same as related biometeorological indices, e.g. universal thermal climate index (UTCI) or physiological equivalent temperature (PET); maximum decrease can be as high as 10–15 °C. All these decreases are located close to trees, with only a slight effect on their surroundings. Moreover, they strongly vary during the day. New studies based on large-eddy simulation principles proved that there are more dependencies than expected; e.g. that newly planted trees on the north sides of buildings have only a minor effect on MRT, UTCI and PET. There is also a strong dependency between UTCI reduction and building height or distance between tree and building. Finally, the effect of trees is often modeled with optimal soil moisture and health conditions mainly due to a lack of data about trees in urban environments. The modern urban planning tools supported by scientific simulations could support a ‚smart city' concept.

Co-creation for climate action – experience with implementing NBS's

Patryk Kaczmarek, Paweł Churski, Katarzyna Fagiewicz, Tomasz Herodowicz, Piotr Lupa, Joanna Morawska, Andrzej Mizgajski

Adam Mickiewicz University in Poznań, Poland

Contact person email: kaczy@amu.edu.pl

Climate change is a complex phenomenon that affects communities in different places around the globe in different ways, further deepening the divergence of development. Urban areas are increasingly exposed to the impacts of climate change, like the frequent occurrences of extreme events, e.g., heatwaves, strong winds, and flash floods. This picture shows how necessary it is to implement robust and effective solutions to better adapt cities to the effects of changing climate. One of the desired directions is the development of green infrastructure that plays a crucial role as a city-wide backbone while its diverse parts are fundamental for local nature-based solutions delivering multiple benefits to nature, society, and the economy.

The ongoing global transition towards the sustainability calls for a place-based, action-orientated research and transdisciplinary collaborations of actors leading to new solutions and innovations. In TeRRIFICA project (Territorial Responsible Researach & Innovation Fostering Innovative Climate Action, H2020 2019 – 2023) we have adopted a quadruple helix approach for developing solutions related to climate change adaptation and mitigation in six European pilot regions. This approach complements the existing models of regional cooperation with "bottom-up" insights from civil society and supports the creation of social innovation. The co-creation is implemented within a Living Lab methodology, accompanied by a crowd mapping tool, with the aim to develop, test and evaluate concrete pilot actions focused on mitigation of and adapting to climate change issues. Our main goal was to find ways to utilize the complementary resources of various actors and to find joint approaches to problems that affect them all.

The article aims to present the co-creation process based on the author's assumptions, which led to the selection and implementation of specific actions aimed at a more significant use of nature-based solutions to mitigate and adapt to climate change. The actions taken led to the creation of a demonstration climate garden at the Collegium Geographicum of the University of Adam Mickiewicz in Poznań. The implemented project is based on two assumptions: 1) proposing educational activities addressed to residents (including children and adolescents, as well as adults), raising awareness of the essence and consequences of climate change, and promoting the Faculty's scientific activity in the context of achieving the sustainable development goals; 2) involving residents and other university stakeholders in practical activities to adapt and counteract climate change and respond to the challenges of sustainable development. The Demonstration Climate Garden is an example of good climate practice consistent with the implementation of the assumptions of the Adaptation Plan to Climate Change of the Poznań Metropolis (APtoCCPM) and the "Programme of Directional Actions for the Green University".

Changing probabilities of days with snowfall and rainfall in the Atlantic Arctic under the climate warming

Ewa Łupikasza

University of Silesia in Katowice, Institute of Earth Sciences, Poland

email: ewa.lupikasza@us.edu.pl

Snowfall and rainfall are both crucial for environmental processes in the Arctic ecosystems and for life. The phase precipitation occurs in affects glacial mass balance, radiation balance and food availability for Arctic species. Accelerated warming in the Arctic leads, among others, to significant changes in the occurrence of snowfall and rainfall, as evidenced in Łupikasza and Cielecka (2019) based on the data for 1976-2017. Since 2017, the Arctic has experienced further warming, which intensified existing trends and induced further changes in snowfall and rainfall occurrences. This study presents updated results on the reaction of snowfall and rainfall to the warming in the Atlantic sector of the Arctic based on the research period extended to 2023. The study uses data on air temperature and precipitation phase from six synoptic stations, Ny Alesund (NA), Svalbard Airport (SA), Hornsund (HRN), Høpen (HOP), Bjørnøya (BRN) and Jan Mayen (JM). The stations represent a latitudinal belt 7° wide with a prominent air temperature gradient and various rates of warming. Trends in air temperature and probability of days with solid (snowfall), mixed and liquid (rainfall) precipitation are presented for various periods depending on data availability at the particular stations and for the common period of 1979-2023.

Snowfall and rainfall were sensitive to warming to various degrees, depending on the phase, mean climate features, month, and local conditions. The air temperature trends for the extended period indicated further warming, most rapid at SA and HOP. Despite dramatic warming, no significant increase in air temperature was found in March or in March and April until 2017. However, during the next five years, this part of the year with no significant warming shortened at NA, SA and HRN. Positive trends in the probability of rainfall found at all stations in September strengthened at NA and SA. The rate of increase in the probability of rainfall at other stations and in other months (mainly October and November) remained the same. At HOP, trends in the annual probability of rainfalls become significant after 2017. Mixed precipitation trends were various depending on the period of the year, thus producing insignificant trends in the annual probability of mixed phase. However, additional decreases appeared after 2017 at two stations located most to the south, JM and BRN, which translated into significantly rarer occurrence of days with mixed phase on the annual scale. Since 2017, the biggest acceleration has concerned negative trends in the snowfall probability, particularly at SA and HOR. Moreover, snowy days occurrence significantly decreased between January and April at SA, HRN and HOP. In HOP, in the coldest part of the year, March, the probability of snowfall increased.

Climate trends and climate change scenarios in Slovakia until 2100

Marián Melo, Martin Gera, Samuel Radič

Comenius University Bratislava, Faculty of Mathematics, Physics and Informatics, Slovakia

Contact person email: melo@fmph.uniba.sk

The regular systematic meteorological measurements began in Slovakia in the middle of the 19th century. Meteorological observations were recorded at some places in Slovakia in earlier times, though only for short periods and after some time they died out completely (e.g. Felbiger and his meteorological observations in Bratislava in the period 1783–1785). Many pre-instrumental weather records for Slovakia can also be obtained from various documentary data (e.g. daily weather records in the Diarium of the Jesuit order at Trenčín from 1701 to 1710).

The temperature series based on the measurements show an increasing trend at all meteorological stations in Slovakia. For the meteorological station Hurbanovo, located in the Danubian lowland, in the period of meteorological measurements from 1881 to 2020 average annual air temperature increased from 9.3°C in the oldest 30-year period 1881–1910 to 10.0°C in the period 1951-1980 and to 11.2°C in the latest 30-year period 1991-2020.

Based on the model outputs, climate change scenarios for selected stations in Slovakia were prepared up to the year 2100. These scenarios relate to air temperature, atmospheric precipitation totals and relative air humidity, presented in daily or monthly step. For Hurbanovo Observatory, the duration of some typical air temperature spells (T ≤ 0ºC, T ≥ 5ºC, T ≥ 10 ºC, T ≥ 15°C, T ≥ 20ºC, T ≥ 25ºC) have been evaluated for the period 2071–2100 (based on the MPI and KNMI regional climate models outputs), compared to the periods 1951–1980 and 1971–2000. The temperature scenarios for Slovakia show a general increase throughout the year by the end of the century. Meanwhile, the monthly precipitation scenarios for Slovakia demonstrate an increase in precipitation totals during winter and a decrease in precipitation totals during summer. The results of the average annual relative humidity in Hurbanovo show a gradual slight decrease in different periods between 1901 and 2020 and, according to MPI and KNMI climate models, a further slight decrease at the end of this century.

By using climate change scenarios, we can assess potential shifts in climatic regions in Slovakia according to the Köppen-Geiger classification between the periods 1991–2020 and 2071–2100. The climate change scenario (based on the MPI model) indicates shift in climatic areas (Cfb, Dfb, Dfc and ET) towards the north and higher altitudes. A new climatic zone, Cfa, may even appear in Slovakia.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Czech and Central-European extreme weather events since 1961

Miloslav Müller, Marek Kašpar

*Charles University,
Czech Republic*

Contact person email: muller@ufa.cas.cz

Extreme weather events can be defined as events when a given phenomenon affects a large area with high intensity. Considering this definition, we present six types of extreme weather events in the Czech Republic, namely heat waves, cold waves, air temperature drops, windstorms, heavy precipitation events, and heavy snowfalls. For this we use daily data from the Czech Hydrometeorological Institute's station network since 1961. To these data we apply the weather extremity index, an index based on a spatial evaluation of return periods of relevant meteorological elements at individual stations. Each event is thus also characterized by its areal extent and duration.

Extreme events of each type are briefly presented in terms of their causal meteorological conditions, using the method of anomalies of selected variables describing the atmospheric circulation during these events. As these events were usually not limited to the Czech territory, we discuss their extremity within the wider area of Central Europe as well. Especially in the case of extreme precipitation events, we also present their connection to extreme flood events.

Session 4.
Climate change: Detection and impacts

Vulnerability of mountain forest ecosystem of the Ukrainian Carpathians: application of the DPSIR framework

Oksana Pelyukh

*Ukrainian National Forestry University,
Ukraine*
email: pelyukh.o@nltu.edu.ua

Mountain forest ecosystems have strong causal relationships and connections with social systems that need to be understood for managing these ecosystems. Reviewing the complex and multifaceted phenomenon of Norway spruce (Picea Abies (L.). Karst.) tree decline in the Ukrainian Carpathians solely through the lens of forestry leads to a misunderstanding of the exacerbating factors of this destructive process and to „narrow-disciplinary," non-systemic decisions, resulting in the neglect of the interests of certain stakeholders and hindering their involvement in problem-solving. The synergy of these factors significantly reduces the effectiveness of forestry-based decisions. An analysis of the interaction between society and mountain forest eco-systems in the Ukrainian Carpathians, conducted using the DPSIR framework- Driving forces- Pressures- State- Impacts- Responses, has allowed for a comprehensive under-standing of the causes (natural, socio-economic, and institutional) and consequences of increased pressure on mountain forest ecosystems, thereby providing the informa-tional basis for developing preventive and mitigating measures against eco-destructive impacts. The formalized representation of this interaction in the form of a DPSIR model enhances understanding of the problem and facilitates the identification of conflicts and synergies in stakeholder positions for its resolution. The constructed DPSIR model is conceptual in nature, revealing drivers of eco-destructive processes and suggest-ing a systematic approach to their resolution in the mountain forest ecosystem of the Ukrainian Carpathians, with potential for applying the developed model to similar mountainous territories to minimize global change driver interactions.

Hottest days of summer 2023 in Kraków – what they tell us about interconnections between Biotope Area Factor, Land Surface Temperature, and Surface Urban Heat Island

Marta Róg

*AGH University of Kraków,
Faculty of Geo-Data Science, Geodesy, and Environmental Engineering,
Poland
email: martarog@agh.edu.pl*

Urban environments, and consequently people who live, work or study in cities, are particularly affected by the ongoing climate change. Surface Urban Heat Island (SUHI), measured with Land Surface Temperature (LST), is clearly visible in areas lacking green spaces. The presentation will discuss the results of the analysis of interconnections between Biotope Area Factor (BAF), LST, and SUHI. The study was conducted for 4 hottest days of summer 2023, in the selected region of Kraków. First, I will talk about data collection from various spatial data sources and methodology used for obtaining a detailed land cover map with Biotope Area Factor (BAF) and LST information. Then, the results of a statistical analysis exploring the relationship between BAF and LST will be presented, along with the consideration of SUHI spots and their connection with BAF. Finally, I will discuss the results with reference to other factors, such as demographic data, or types of human activities within the selected study area.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Changes in the duration of snow cover extent in Central Europe (1951–2022)

Julia Salaja, Polina Danchenkova

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: julia.salaja@student.uj.edu.pl

The aim of this research was to identify spatial variability of snow cover in Central European region. Main focus was paid to the duration of the snow cover extent with the special attention to the mountainous regions. Gridded data from ERA5-Land dataset with the daily resolution were used as a basis to conduct the research. Additionally, some available station data were also used to verify gridded values. All analyses were done for the period of 72 years. All basic snow cover characteristics have been considered. Results have been visualized on adequate maps and figures. To determine the trends and correlation, Man-Kendall test was used. The most extreme snow cover seasons were analyzed in a more detailed way. Despite the vast area considered in the main part of the research, the cross section on the parallel 20°E and meridian 50°N was provided. Finally snow cover duration changes have been compared to the seasonal air temperature conditions. The results obtained have been compared with other regions of Europe.

Session 4. Climate change: Detection and impacts

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Urban heat island in the Górnośląsko-Zagłębiowska Metropolis: modelling the intensity and spatial extent of the phenomenon

Jakub Słotwiński

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

email: jakub.slotwinski@student.uj.edu.pl

More than half of the world's population live now in urban areas and according to the UN, the rate of urbanisation is set to achieve 68% by 2050. The intense development of cities and urban infrastructure, characterised by large shares of impervious surfaces, contributes to the occurrence of the urban heat island (UHI) effect, which should be defined as the increase in temperature in cities in relation to their surrounding non-urban areas. Górnośląsko-Zagłębiowska Metropolis (GZM) is a metropolitan union of 41 municipalities in southern Poland, inhabited in 2020 by about 2 230 000 people and covering the area of 2 553 km^2. With population density of about 863 people/km^2 GZM, industrial by nature and of an unusual spatial layout, is Poland most heavily urbanised area. In this study, the atmospheric urban heat island (AUHI) during the warm season (April–September) is investigated employing a dual approach, aiming at describing its intensity and delimiting the spatial extent of the phenomenon. First, data from an urban network comprising 12 stations was collected and analysed for the time periods of 2012–2022 and 2023 separately. Preliminary data analysis allowed the UHI intensity index to be defined as the difference between measurements conducted at respective stations and the Katowice-Pyrzowice airport station, acting as the reference station. Second, a series of mobile measurements was conducted within GZM, alongside pre-defined routes and in favourable weather conditions. In total, 8 traverses were completed over 2 routes covering diverse urban backgrounds, all during night hours. The UHI intensity index was defined as the difference between measurements collected in respective trackpoints and parts of the routes defined as non-urban. The collected data was analysed in relation to the Local Climate Zones classification. Initial findings confirmed that the UHI effect depends strongly on the distance from the nearest city centre, which determines also the type and density of buildings.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Air temperature impact on springtime tree phenology in Poland based on satellite data

Agnieszka Sulikowska, Ewa Grabska-Szwagrzyk, Agnieszka Wypych

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: agn.sulikowska@uj.edu.pl

Recent advancements in satellite phenology research demonstrate its effectiveness as a robust tool for monitoring terrestrial vegetation and its responses to climate drivers. Satellite data provides insights distinct from ground-based observations, yet both sources complement each other well. Utilizing new-generation satellites with high spatial and temporal resolutions facilitates a deeper understanding of climate-phenology relationships. These satellite-derived indices prove especially valuable in regions with scarce ground-based observations.

Air temperature plays a crucial role in driving various plant developmental processes, among which the initiation of spring activity is the most prominent. However, drawing ultimate conclusions regarding this relationship remains challenging as quantitative estimates strongly diverge. Recent observations indicate that climate warming has altered plant phenology across many European regions. Investigating these complex connections is crucial, given that changes in plant phenology affect fundamental ecosystem functions, including water, carbon, and energy fluxes, as well as interactions between plants and animals, ultimately shaping ecosystem productivity.a

The main aim of this study is to evaluate the impact of air temperature conditions on the onset of spring activity among deciduous trees in Poland spanning the years 2018-2023. Phenology data used in the study include both ground observations of leaf unfolding for silver birch (Betula pendula) and satellite-derived estimates of start-of-season (SOS) for birch, common beech (Fagus sylvatica), and two species of oak (Quercus). These selected species represent some of the most abundant deciduous tree species in Poland. Ground-based data were sourced from the Institute of Meteorology and Water Management – National Research Institute, while the satellite-based SOS metric was derived from Sentinel-2 imagery. The SOS metric was based on EVI (Enhanced Vegetation Index) derivatives, but other indices were also tested.

Temperature conditions during six individual seasons were assessed using in-situ measurements as well as the E-OBS (v27.0e) gridded dataset, and the relationship between air temperature and the start of the season was studied using the Growing Degree Days (GDD) index for 0°C and 5°C base temperatures.

This preliminary study showed large inter-annual variability in deciduous tree phenology – the estimated start of the season varied between studied seasons by

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

more than 20 days. For instance, in 2018, characterized by extremely warm April and May, an advanced start of the season was observed. Conversely, in 2021, a delayed start of the season was noted as a consequence of cold temperatures during these months. The results also proved the usefulness of Sentinel-2 data in monitoring the phenology of individual tree species, while indicating that satellite-based estimators pertain to a slightly different phenological phase than ground-based observations. The study provided insights into the links between temperature conditions and the spring phenology of deciduous trees, showing that responses to climate drivers are species-dependent and complex. The relationship remains evident, as, for instance, in 2018, characterized by extremely warm April and May, an advanced start of the season was observed. Conversely, in 2021, a delayed start of the season was noted as a consequence of cold temperatures during these months. However, quantitatively describing these relationships remains a challenge.

Correlation between increasing average temperature and increasing sultry days in one of the hottest places in Slovakia

Kristina Szaboova

*Slovak Hydrometeorological Institute,
Slovakia*

email: kristina.szaboova@shmu.sk

Sultriness is formed by the interaction of several weather factors. It is the state of the atmosphere when the water vapor pressure exceeds 18.7 hPa. This condition has adverse physiological effects on plants, animals and especially on the human body. For this reason, in this research, emphasis was placed on the time evolution of sultriness at the meteorological station Hurbanovo in the Slovak Republic. The paper will examine the 40-year period (1981 – 2020). The study is a continuation of the work of Štefan Kveták, who examined the previous 30-year period (1951 – 1980). We hypothesized that the number of sultry days is also increasing due to climate change. The basis of the whole assumption was hourly data from meteorological stations in the database of the Slovak Hydrometeorological Institute. As the scientific goals of the project, we preferred the categorization of sultriness according to various criteria, the evaluation of their frequency and time trends of occurrence, and we compared their development with the previous period.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Atmospheric circulation classifications for Central Europe – inventory approach

Zbigniew Ustrnul [1], Jan Řehoř, Agnieszka Wypych

[1] *Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland*

Contact person email: zbigniew.ustrnul@uj.edu.pl

Atmospheric circulation plays a fundamental role in shaping the climate of Central Europe. This area is particularly diverse climatically due to its transitional nature, influenced by both the Atlantic and the vast continental area of Eurasia. Precise assessment of the occurrence of circulation types sometimes poses problems and is also a scientific challenge. It is therefore not surprising that many classifications of circulation types have been developed for this part of Europe, both traditional (manual) and modern (automatic, objective) ones. The work presents an overview of them, paying attention to their methodological assumptions and the resulting differences that can be found in various synoptic situations. These differences are illustrated by several examples, including the use of long-term series of circulation types. The traditional classifications of Niedźwiedź, CHMU, Pecely and the well-known Grosswetterlagen classification were considered here. Simultaneously the automatic classifications developed by Lityński, Ustrnul and Řehoř were also taken into account independently.

Session 4.
Climate change: Detection and impacts

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Are heatwaves and drought more likely to occur simultaneously with warming?

Joanna Wibig

University of Łódź, Department of Meteorology and Climatology, Poland

email: *joanna.wibig@geo.uni.lodz.pl*

Heat waves and droughts are two the most frequent weather extremes in Poland, both excerbated by the ongoing global warming. Very often they occur simulateously. The aim of this presentation is identification of cases of simultaneous occurence of these extreme situations, examination of their spatial extent, frequency of occurrence and long-term variability. Reasons of their occurrence are also analysed. On the basis of data from the period 1966-2023 from 48 stations in Poland the warm days defined as a days with maximum temperature exceeding 90 percentile of daily maximum temperature. Threshold values are calculated separately for all stations and days of the year based on data from reference period 1971-2000 in 15 day moving window centred on days under consideration. Moisture conditions are assessed based on sum of precipitation in 15 days preceding day under consideration and then a technic similar to temperature is applied. Next periods both dry and warm are distinguished and their interannual course and long-term trend are established.

Factors causing trends are analysed, Among them most important seem to be snow cover long-term changes and atmospheric circulation.

**Session 4.
Climate change: Detection and impacts**

Adventure tourism development in Slovakia (on the example of hunting tourism and via ferrata´s climbing)

Vladimir Cech, Jana Vaskova, Radoslav Klamar

*University of Presov,
Slovakia*

Contact person email: vladimir.cech@unipo.sk

There are tourists for whom the „classic" form of leisure and recreation is not enough. They are looking for active forms of recreation, sports activities, which are often characterized by a certain degree of health and life risk and which require special skills and equipment. For these forms of tourism, the term adventure tourism was used, which represents a dynamically developing industry especially in recent decades. Normally, it is divided into two categories: soft and hard. Soft includes activities with a lower level of risk that require minimal commitment and initial skills; under the supervision of a guide (horse riding, hunting and fishing tourism, kayaking, etc.). The hard category includes activities with a high level of risk that require intensive commitment and advanced skills (climbing, base jumping, caving, via ferratas, etc.). Adventure tourism is also divided according to the environment in which it is carried out- sports activities in water, in the air, on land and underground, respectively for outdoor and indoor activities. From the point of view of natural conditions, the territory of the Slovak Republic is suitable for carrying out several activities of adventure tourism. In the field of soft adventure tourism, hunting tourism is relatively widespread, which also brings a significant economic benefit. In the hard category, the construction of secured climbing routes, known from the Alps region under the name via ferrata, has been developing rapidly in the last 10 years. The presented contribution offers a basic overview and analysis of hunting tourism and via ferrata´s climbing as two forms of adventure tourism in Slovakia.

Saving the indigenous – how to preserve Huaorani culture and cope with climate change

Julia Glibowska, Tomasz Wites

University of Warsaw, Faculty of Geography and Regional Studies, Poland

Contact person email: j.glibowska@student.uw.edu.pl

Huaorani are an indigenous population primarily residing in eastern Ecuador in the Oriente region (provinces of Napo, Orellana, and Pastaza). Since 1958, when the first peaceful contact occurred between the Huaorani and the "culture of the Western world," many aspects of this minority's life have undergone changes. One such change is the initiation and engagement in tourism activities, which serve as an alternative source of income to the oil extraction industry. Despite the support extended to indigenous communities, including the Huaorani, by oil companies through the provision of employment opportunities and the construction of transportation, educational, and medical infrastructure, several catastrophic consequences of such extraction are observed. These consequences range from water pollution and reductions in the populations of flora and fauna species to the abandonment of traditional cultural practices. The presentation aims to present and elucidate how tourism, using the example of the Huaorani in Ecuador, can influence the preservation of cultural heritage and serve as a significant argument in combating extractive activities and their negative impacts on both the environment and communities. Employment in the tourism sector among the Huaorani often entails working as guides in the Yasuní National Park, which can only be accessed with a licensed guide. Within the framework of tours, visitors can stay in a Huaorani settlement for several days and experience life within the community. Such an experience not only generates economic benefits but also serves as an incentive to continue practicing traditional activities (hunting, crafts), learning the Huaorani language (Huao Terero), and mitigating Huaorani emigration from Amazonian communities. From a global perspective, the indirect impact on environmental conservation may seem significant due to the increased awareness among a wide range of visitors regarding the threats to the primary forest arising from the expansive activities of Western civilization.

Exploring visitor spatial behavior trends in protected and recreational areas – a research concept

Joanna Hibner

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

email: *joanna.hibner@uj.edu.pl*

Visitors' spatial behaviour is determined by two important factors which affect the whole decision-making process of visitors. The first factor refers to motivations for undertaking recreational activities. The knowledge of visitors' motivations plays a pivotal role in the visitors management process in protected and recreational areas (Konu, Kajala 2012). The second factor that significantly influences the visitors' decision-making process is perception. It is worth emphasising that perception is linked with evaluation of a specific object, landscape or area, and therefore influences visitors' opinions and their level of satisfaction with the undertaken activity (Krzymowska Kostrowicka 1999). Thus, it is also an important element in the process of visitors management in protected areas. There are many research studies on both visitors motivations and landscape perception (e.g. Arriaza et al. 2004; Needham et al. 2010; Konu, Kajala 2012; Kulczyk 2013; Rid et al. 2014) and their importance in the context of protected area management. However, limited attention has been given to so-called 'undesirable' elements, which, if present, negatively affect the visitors experience acquired during each trip and thus determine further tourist activity. The purpose of this presentation will be to illustrate, on the basis of previous research, which 'undesirable' elements have the greatest impact on the negative visitors experience. The main objective of this presentation will be to present a research concept on the impact of 'undesirable' factors on visitors' spatial behavior in protected areas. The research will include: surveys of tourists, in selected protected areas, taking into account the visual simulation method and field observation of tourists' spatial behaviour. Details will be presented during the presentation.

Restructuring of rural cultural spaces in tourism development: A case study of reviving the Star Worshipping Festival in Zhangbi Ancient Fortress

Chao Lei

University of Leicester, Department of Geography,
United Kingdom

email: clol3@leicester.ac.uk

Festivals and local special events have increasingly made an important contribution to regional and urban economic development through tourism. However, the question of the revival of traditional folk festivals resulting in rural restructuring through an interpretation of tourism also requires more attention. This research conceptualized rural cultural spaces by expanding Halfacree's (2006) three-fold conceptual model of rural space and selected Zhangbi Ancient Fortress, a typical Chinese Traditional Village in Shanxi Province, as its empirical case study. Through in-depth interviews and participant observation, the research explored how the revival of the Star Worshipping Festival, which had been suppressed for nearly half a century, can contribute to the restructuring of rural cultural spaces from three facets, namely material, symbolic, and lived cultural space. The findings showed that by publically reviving the Star Worshipping Festival of Zhangbi Ancient Fortress, the local tourism company played a key role in legitimizing Ancient Fortress culture as the formal representation of symbolic cultural space and selectively conducting renovation practices of material cultural space. However, the revival of the festival was in contrast to the long-standing festival memories of local villagers, who developed initiatives to question the rationality of the festival through their daily life experiences and practices based on their own lived cultural space. The research serves as a reference for approaches to conserving intangible cultural heritage in the Chinese Traditional Villages during tourism development.

THE INTERDEPENDENCIES OF RELIGIOUS TOURISTS' ATTRIBUTES IN THE LIGHT OF CONTEMPORARY SOCIO-CULTURAL CHANGES

Justyna Liro

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

email: justyna.liro@uj.edu.pl

The social-cultural changes in the 20th and 21st centuries and changes in religiousness have significantly caused the ways of travel. The attributes of religious tourists are becoming increasingly complex and diverse, which may also influence the development of other travel forms and economic benefits, and also create challenges for the management of pilgrimage centres. However, interdependencies of motivation, perception of place, experiences and tourist satisfaction have not been studied so far. The poster presents the results of surveys (n = 1545) carried out in popular pilgrimage centres in Poland. The presented analysis of the interdependencies of visitors' attributes and proposed conceptual models: (a) the conditions of religious tourism, and (b) paths of religious tourists' attributes solely provide an opportunity to understand the complexity and multifacetedness of religious tourism in the changing world and to determine its development directions and destinations.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

The relations of the religiosity components and participation in religious and spiritual tourism of young adults – Generation Z

Justyna Liro, Anna Zielonka, Magdalena Kubal-Czerwińska,
Elżbieta Bilska-Wodecka, Izabela Sołjan, Aneta Pawłowska-Legwand

Jagiellonian University in Kraków, Institute of Geography and Spatial Management, Poland

Contact person email: justyna.liro@uj.edu.pl

Due to historical and social conditions, and among other, the social-cultural changes in the 20th and 21st centuries, and despite secular processes – the religious and spiritual motives are still one of the common reasons for traveling. Unquestionably, religious tourism is undergoing changes today, especially adapting to the changing, and multivalent reality, especially in relation to the expectations and needs of participants. Poland is still one of the most religious countries in Europe – with the majority of citizens (71%, 2021) declaring as Catholics. However, the secularization processes strongly present in Europe (since the mid-20th century) have also been become more over the last two decades. The recent studies have highlighted the changes – slow decline in declaring as Catholics (from 96% in 1992 to 71% 1992 in 2021), and rapid decline in practicing (from 67% in 1992 to 28.3% in 2021, *Census*, 2021). Noteworthy, the greatest declines have been noticed among young adults, not only on mentioned national scale, but also globally (*Pew Research Center*, 2018). The main aim is to present: a. the components of religiosity (*believing, belonging, behaving*, adopted from Davie&Wilson, 2020), b. attributes related to religious and spiritual tourism, c. interdependence of a.-b., d. differentiation of the studied variables in relation to the socio-demographic characteristics, and finally in the context of the socio-cultural changes, based on survey research of respondents born between 1995 and 2007 (young adults, Generation Z, n=510).

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental
System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

The Great Polish Map of Scotland – is this model really carthometric?

Małgorzata Luc, Krzysztof Grabarek, Bartłomiej Ślawski, Julia Zwolińska,
Bartosz Zarzecki, Jerzy Walaszek

*Jagiellonian University in Krakow, Institute of Geography and Spatial Management,
Poland*

Contact person email: malgorzata.luc@uj.edu.pl

In the vicinity of Edinburgh, Scotland, about 30 kilometres to the south lies the small village of Eddleston, and in it lies a unique historical site, evidence of the many historical and cultural links between Poland and Scotland- The Great Polish Map of Scotland (GPMS). This is the outdoor concrete scale model of Scotland based at Barony Castle Hotel. This B category listed object (Buildings of special architectural or historic interest which are major examples of a particular period, style or building type) was built between 1974 and 1979 on the initiative of Krakow-born Jan Tomasik, a former sergeant in the 1st (Polish) Armoured Division during the WWII. It was mainly the work of a small group of geographers from the Institute of Geography at Jagiellonian University of Krakow, Poland, led by the cartographer prof. dr. hab. Kazimierz Trafas. W They build the 50 metres by 40 metres model. This is the largest 3 dimensional terrain relief model in the world. In 2017 Historic Environment Scotland made an accurate 3D laser scans and photogrammetry data of the Great Polish Map of Scotland. After many years, and in view of the few materials that have survived from the construction of the map, it is interesting for a geographer to ask the questions- is the model really cartometric?; does it reflect the actual relief and how much?; does it have errors, and if so, what are they due to? A team of master's students in geography with a specialty in GIS tried to find the answer to these questions. They used accurate 3D laser scans and SRTM data and compared them. They then selected few areas for more detailed analysis, based on the 1:10.000 scale topographic maps the constructors originally used. The selected areas were digitized and compared with the GPMS model. Lidar data was used to develop several relief models using various methods, which were then printed on 3D printers. The poster presents the history of GPMS and the methods used to analyse it and the results of this research. It also shows the map's qualities, accuracy and importance for Polish culture and science. Above all, it provides answers to the questions posed earlier.

Institute of Geography and Spatial Management, Jagiellonian University
International conference "Earth as a Human-Environmental System: Challenges and Dynamics"
6–8 May 2024, Kraków, Poland

Tourist experience of the national parks in Poland

Adela Malak

Jagiellonian University in Kraków, Doctoral School in the Social Sciences, Poland

email: adela.malak@doctoral.uj.edu.pl

Recognizing individual experiences plays a key role for management implications and value co-creation strategies for protected areas. This is especially important in Polish national parks, which have the highest conservation regime compared to other protected areas. The tourism experience is central to interdisciplinary tourism studies, which are also linked to geography. The goal of the study was to explore how visitors construct their experiences of the national park, as a specific geographical space, throughout tourist activities. The research was conducted in selected national parks in southern Poland. Based on the in-depth interviews with tourists, the study examines their individual experiences, human-nature connections, and nature bond through undertaken tourist activity. I also investigate what tourists experience apart from contact with nature in the national park area. The study focuses on five components of tourist experience indicated and developed by Pearce (and Mohammadi, 2021): sensory, affective, cognitive, behavioral and relationships. I explore what tourists' experiences in national parks mean to them, how are they talk about such experiences, how the five components shape visitors' experiences, and which components are salient in their statements. The role of modern technology or lack of it was also examined. Preliminary research on tourists' experiences suggests that the sensory component of the tourist experience in natural environment is essential. Moreover, visitors' experience of the national park is linked to its *genius loci*, defined concept of nostalgia and "tourist biography" of the person. Tourists' motivations and needs also appeared as crucial for the lived tourist experiences. The results of the visitor experience research could be useful in managing and co-creating experiences to enhance eligible behavior in a fragile area of national parks, not only in Poland.

COMPARISON OF TOURISM POTENTIAL OF ZOO WROCLAW AND WARSAW ZOOLOGICAL GARDEN

Weronika Michalska

University of Warsaw, Faculty of Geography and Regional Studies, Poland

email: *wc.michalska@uw.edu.pl*

The contemporary role of zoos, apart from protecting animals, also concerns education, popularization and raising ecological awareness, as well as conducting scientific research and providing entertainment to tourists and residents. Over 4 million tourists visit zoos in Poland every year. They are perfect places for walks and spending free time in the bosom of nature, understood as the main element of aesthetics here. The proximity of animals, numerous species of trees, bushes and other small plants makes visitors stay much more pleasant. The diversity and appropriate adaptation of plant species should be satisfying not only for tourists, but above all for the animals staying in the zoo. However, it is not only the wealth of nature that determines the tourist potential of zoos. In the geographical (spatial) aspect, the importance of tourism potential can also be extended to include tourist capacity and optimal periods of using tourist attractions (Wyrzykowski 2010). The tourist attractiveness of a given zoo is determined by three factors- the rank of tourist attractions, the degree of transport accessibility and the state of tourist development. These are the so-called structural resources (Rogalewski 2008). Functional resources also play an important role, including various entities and factors directly or indirectly involved in the development of tourism in a given area, e.g. economic, political, ecological or technological. Tourist values are understood as specific features and elements of the natural environment and manifestations of human activity that are the subject of tourists' interests. In the case of zoos, the author classified them according to the degree of human interference in their creation (Leiper 1990, Lijewski et al. 1998, Śniadek & Zajadacz 2009), seasonality and motives for undertaking a tourist trip. Therefore, the aim of this presentation will be to compare the tourism potential of two Polish zoos. ZOO Wroclaw - the largest in terms of the number of animals and the most frequently visited zoo in Poland (over 1.7 million in 2022) - and the Warsaw Zoological Garden (nearly 1 million tourists in 2022) were selected for the study. Both facilities belong to the European Association of Zoos and Aquaria, which brings together the most modern zoos in Europe that meet global standards for the protection of wild animals. The speech will discuss the importance of zoos in the tourism of a given area and the tourist attractions offered by both facilities, relating to tourist values, transport accessibility and the degree of development of tourist infrastructure. Afterwards, based on the analyses of strategic documents regarding the development of tourism in the area of zoos, reports and participant observations, the tourism potential of both facilities will be assessed and compared. An attempt will also be made to identify examples of opportunities to increase the tourist potential of both zoos.

Photo M. Baścik

175 LAT INSTYTUTU GEOGRAFII
I GOSPODARKI PRZESTRZENNEJ
UNIWERSYTETU JAGIELLOŃSKIEGO

1849–2024

Photo K. Toboła