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ASSESSING CULTURAL ECOSYSTEM SERVICES OF COASTAL AREAS IN ESTONIA THROUGH SOCIAL MEDIA-BASED DATA

Master's Thesis in Geoinformatics for Urbanized Society (30 ECTS)

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Abstract

With the development of the digital world, there is an ever-increasing number of social media platforms (SMP) emerging. When geotagged photos are uploaded by social media users to such platforms, location-based user data is stored by the platform. More and more, this data is being accessed by researchers in order to explore how to enhance human well-being through improved planning, governance, and management. The study of Cultural Ecosystem Services (CES), the non-material benefits that nature brings to humans, is one area in which researchers have been using location-based social media data (SMD) to better understand how natural areas can improve life quality for society members. In Estonia, a small country with a vast coastline, the sea has played an important role in shaping the cultural identity of the people. Despite this, few studies have been conducted to study the significance of coastal ecosystems in the country. The aim of this study, thus, was to use location-based social media data from the SMP *Flickr* to evaluate the CESs provided by coastal areas in Estonia. This was achieved through quantitative (*number of photos* versus *photo-user-day*) evaluation, which allowed for the identification of hot spots in Estonian coastal zones. Through quantitative analysis, it was also possible to determine at which distance the impact of coastal zones on CESs lessened. Qualitative evaluation, involving visual content analysis, was then used to categorize photos into four CES categories, including *recreation, aesthetic pleasure, sense of identity,* and *education.* Together, this information could show which coastal areas were popular in Estonian society and provide possible explanations as to why certain areas were more popular than others, which is important for the future planning and management of Estonian coastal zones. The results showed that aesthetic pleasure and recreation were the most easily identified CESs, followed by sense of identity and education. The findings also revealed that various predictor variables such as population density, habitat accessibility, the existence of anthropic alterations, habitat uniqueness, presence of scenic areas, and seasonal conditions might have a considerable impact on the societal value placed on an ecosystem. However, while SMD can provide many insights into a society's values, many factors, such as the bias of the analyzer, the unequal representation of activities via SMP, the temporality and content variation among different SMP, the inaccuracy of location data, and so on, can all affect the validity of the results. Consequently, information from SM research should be coupled with traditional research methods like questionnaires and surveys to achieve a better understanding of the impact of CESs on coastal ecosystems. Furthermore, more research is needed to determine how to effectively normalize qualitative data from CES investigations for practical implementation by policymakers and resource managers.

Keywords: cultural ecosystem services; social media data; coastal zones; Estonia; Flickr; mapping

CERCS code: P510 (Physical geography, geomorphology, pedology, cartography, climatology)

Sotsiaalmeediaandmetele tuginev kultuuriliste ökosüsteemiteenuste hindamine Eesti rannikupiirkondades

Annotatsioon

Digitaalse maailma arengust tulenevalt on sotsiaalmeediakanalite arv üha suurenemas. Kui asukohamärgisega fotod laetakse kasutajate poolt sotsiaalmeediakanalitesse, salvestab platvorm asukohast tuleneva kasutajainfo. Aina enam saavad sellised andmed kättesaadavaks ka teadlastele, võimaldades uurida kuidas planeerimise, valitsemise ja juhtimise abil inimeste heaolu suurendada. Kultuuriliste ökosüsteemiteenuste (mitterahaline kasu, mida loodus inimestele pakub) uuringud on üks valdkondadest, kus teadlased on asukohapõhiseid sotsiaalmeedia andmeid kasutades püüdnud paremini mõista, kuidas looduslikud piirkonnad inimeste elukvaliteeti parendada saavad. Pika rannajoonega Eestis on meri mänginud inimeste kultuurilise identiteedi kujunemisel olulist rolli. Sellest hoolimata on riigis ranniku ökosüsteemide olulisuse kohta läbi viidud vähe uuringuid. Sellest tulenevalt on antud uuringu eesmärk kasutada sotsiaalmeediaplatvormi Flickr asukohapõhiseid andmeid, et hinnata Eesti rannikupiirkonna kultuurilisi ökosüsteemiteenuseid. Eesmärk saavutati kvantitatiivse (fotode arv versus fotokasutaja päev – PUD, *photo-user-day*) hindamismeetodi abil, mis võimaldas tuvastada Eesti rannikuvööndite kuumkohad. Tänu kvantitatiivsele analüüsile oli võimalik kindlaks määrata, milliselt distantsilt hakkas rannikuala mõju kultuurilistele ökosüsteemiteenustele vähenema. Andmete kategoriseerimiseks kasutati traditsioonilist sisuanalüüsi, jaotades andmed nelja kultuuriliste ökosüsteemiteenuste kategooriasse: rekreatsioon, esteetiline nauding, identiteeditaju ja haridus. Antud info võiks näidata, millised Eesti rannikupiirkonnad on teistest populaarsemad ning miks see nii on See on omakorda oluline Eesti rannikupiirkondade planeerimiseks ja juhtimiseks tulevikus. Tulemused näitavad, et kõige lihtsamini tuvastatavad kultuurilised ökosüsteemiteenused olid nauding ja rekreatsioon, millele järgnesid identiteeditaju ja haridus. Tulemused näitasid ka, et mitmed ennustavad muutujad, nagu asustustihedus, elupaikade ligipääsetavus, inimtekkeliste muutuste olemasolu, elupaikade ainulaadsus ja looduskaunite alade olemasolu, võivad ökosüsteemi ühiskondlikku väärtust oluliselt mõjutada.

Kuigi sotsiaalmeedia andmed võivad anda palju teadmisi ühiskonna väärtuste kohta, on palju tegureid (nagu näiteks analüsaatori kallutatus, tegevuste ebavõrdne esitus sotsiaalmeedias, ajaline ja sisu varieeruvus erinevates sotsiaalmeedia kanalites, asukohaandmete ebatäpsus jne), mis võivad tulemuste kehtivust mõjutada. Seega tuleks kultuuriliste ökosüsteemiteenuste mõju rannikupiirkonna ökosüsteemidele paremini mõistmiseks ühendada sotsiaalmeediauuringute raames kogutud info traditsiooniliste uurimismeetoditega (nagu küsitlus ja vaatlus) kogutud infoga. Lisaks on vaja rohkem uuringuid, kuidas tõhusalt normaliseerida kultuuriliste ökosüsteemiteenuste uuringute raames kogutud kvalitatiivseid andmeid, et poliitikakujundajad ja ressursside haldurid saaksid neid praktiliselt rakendada.

Märksõnad: kultuurilised ökosüsteemiteenused; sotsiaalmeedia andmed, rannikupiirkonnad; Eesti; Flickr; kaardistamine

CERCS kood: P510 (füüsiline geograafia, geomorfoloogia, mullateadus, kartografia, klimatoloogia)

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1. Introduction

Water is an essential component of all life on Earth. In addition to playing an important role in various ecosystem processes on Earth, coastal zones have an important impact on the development of human societies, offering food and livelihood for the ever-expanding human population, as well as offering opportunities for industry and transport development, recreation, and tourism. In fact, about one-third (~2.4 billion people) of the human population lives within a 100-kilometer distance of a coastal zone (Bolles, 2021), and this figure is anticipated to rise quickly in future years (Hugo, 2011).

The benefits that people obtain from nature are better known as Ecosystem Services (ES) (Zhang et al., 2020). By studying ES, it is possible to gain a better understanding of the inherent dependency of humans on the natural environment (Muradian & Gómez-Baggethun, 2021), as well as the relationships that make up human and environmental interactions at various sub-levels (Muradian & Gómez-Baggethun, 2021; Zhang et al., 2020). One sub-level, for example, refers specifically to the "non-material benefits that people obtain from ecosystems" (Calcagni et al., 2019; Chan et al., 2012a; Ilieva & McPhearson, 2018; MEA, 2005; Milcu et al., 2013; Wilkins et al., 2021; Zhang et al., 2020), better known as Cultural Ecosystem Services (CESs). CESs refer to the holistic contributions provided by nature towards the well-being of humans, such as "recreation and education, aesthetic experience, spiritual enrichment, inspiration, cognitive development, reflection, and a sense of place" (Fish et al., 2016; Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020). The study of CESs can have important implications for improving the life quality for society members as well as natural areas, making it fundamental to include in land-use planning, environmental management and sustainable policy making (Calcagni et al., 2019; Hammer et al., 2018). Despite this, CES have only recently begun to be studied by researchers (Ilieva & McPhearson, 2018). This is in part due to the non-material nature of CES, which makes it difficult to objectively quantify the benefits that a natural area can bring to an individual. The subjective nature of culture further complicates matters as both an individual's experiences and the society one grew up in can greatly affect their attitude towards the natural environment (Fish et al., 2016; Zhang et al., 2020). This lack of knowledge is especially apparent in the case of marine and coastal CES, as the majority of what is known about CES is focused on terrestrial ecosystems and few studies have been conducted on coastal and marine CES (Liquete et al., 2013; Martin et al., 2016). The scarcity of data and knowledge on CES obtained from coastal and marine ecosystems indicates a lack of awareness of the various meanings and values that people place on these areas and, as a consequence, the benefits provided by marine and coastal ecosystems often tend to be undervalued or inaccurate (Barbier, 2017). This could result in a bias in favor of certain commercial activities in these ecosystems, leading to user conflict or damage to coastal and marine habitats (Liquete et al., 2013; Martin et al., 2016). Given that many coastal and marine ecosystems are already under threat or disappearing as a consequence of rising anthropogenic pressures, such as increased coastal development, high tourism flows, commercial fishing, mining, and global warming (Barbier et al., 2011), recognizing and documenting the CES benefits and values associated with distinct coastal and marine ecosystems is crucial for future coastal and marine management (Barbier, 2017).

The rapid development of social media platforms (SMP) such as Facebook, Flickr, Instagram, and Twitter have greatly improved the ability of researchers to explore disciplines which previously required a great deal of time, money, and labor. In fact, social media data (SMD) is now being applied to disciplines ranging from city planning to environmental monitoring, disaster management, epidemiology, and so on. In the case of CES, in addition to traditional methods used to assess visitor experiences in natural areas such as visitor surveys, interviews, trail and road counters, and administrative data such as ticket sales (Eagles, 2014;

Newsome et al., 2013; Teles da Mota & Pickering, 2020; Veal, 2011; Wilkins et al., 2021), the content of geo-tagged tweets, photos and their related tags offer an unprecedented way to assess visitor perceptions, motivations, and values in nature (Becken et al., 2017; Cong et al., 2014; Ilieva & McPhearson, 2018; Oteros-Rozas et al., 2018; Teles da Mota & Pickering, 2020). Thus, in the era of big data, SMD guarantees a new method of expanding our previously limited knowledge on the needs, interest, and values that are held by society members (Ilieva & McPhearson, 2018).

Estonia, a coastal country with numerous lakes, bogs, and islands has a coastline of about 3,800 kilometers ("Coastal erosion in Estonia", 2021). Due to its relatively small size and low population, the majority of the country's population lives within a 100-kilometer radius of a coastal zone. In fact, according to historical documents, Estonia's coastlines have been permanently inhabited since the 13^{th} century, where traditional activities to support human settlement included fishing and seal hunting (Rivis et al., 2016). Estonia was also an important trading member of the Hanseatic League for nearly 400 years (Hanseatic, 2021; Vacht et al, 2018). The Hanseatic League dominated the economy and politics of the Baltic Sea regions and, as a result, Estonia became a prized possession and a battleground for neighboring kingdoms. The legacy of this ancient commercial route, which dates back to the 13th century, can even still be explored by visitors today (Hanseatic, 2021). Consequently, it can be said that the sea has had a significant role in shaping the cultural identity of Estonian society (Palginõmm et al., 2007; Rivis et al., 2016; Vacht et al., 2018). Nevertheless, there are few studies that examine the CES of coastal areas within the country. Thus, the aim of this study is to use geo-tagged SMD from Flickr to determine the gradient at which coastal ecosystems become less impactful on CES throughout Estonia. The study also aims to identify coastal hot spots which are highly visited but not so accessible within the country in an attempt to discern the reasons behind the popularity of such spots. Finally, the study will look at how the information obtained can be applied in future planning and management of Estonian coastal areas.

Research questions:

- At which distance do coastal ecosystems become less impactful on CES throughout Estonia?
- What hot spots of CES exist in the coastal areas and what factors make these areas more popular than others?

2. Theoretical Overview

2.1. Understanding Cultural Ecosystem Services (CES)

2.1.1. Human well-being through culture

Human well-being is a diverse and ambiguous concept. The term can be described as the state of the physical and mental health of individuals (Hammer et al., 2018), as well as a person's "ability to live a life they value" (Dawson, 2021). Various factors can affect the well-being of an individual including cultural heritage, health, income level, and access to land or natural resources (ibid). Still, it is not possible to define well-being in an absolute manner. Every community has a different idea of what well-being encompasses based off their local history and cultural norms, geography, environment, politics, and socio-economic conditions (ibid). Nevertheless, some common indicators of well-being do exist. When combining attributes such as wealth, occupation, gross domestic product (GDP), and housing with quality-of-life indicators such as employment rate, work/life balance, education level, and health status, one can gain a general understanding of how an individual or a society is faring (Ashton & Jones, 2013; Hammer et al., 2018). However, though such attributes can be informative, they are also often criticized by researchers as they only take into consideration the quantifiable aspects behind the concept of well-being (Fish et al., 2016;

Hammer et al., 2018). In reality, however, a good quality of life is made up of both material and immaterial components (ibid).

Culture, for example, is just as important a factor for well-being as other variables (MEA, 2005). Culture can be defined here as the "customary beliefs, social forms, and material traits of a racial, religious, or social group" (Merriam-Webster, 2021). In other words, culture is an individuals' perception of the world (MEA, 2005), including the intellectual, spiritual, and aesthetic dimensions of human life and development (Fish et al., 2016). In general, this is strongly dependent on the ecosystem in which a society is based (Fish et al., 2016; MEA, 2005). In the Baltic states, for example, the regulatory, recreational, and cultural significance of coastal and marine environments are a vital component to the identity of the people (Hammer et al., 2018). This is because the environment that surrounds one, including both land and sea, facilitate the experiences that occur in an area, thus shaping the cultural identity of residents in that area (Fish et al., 2016). Equally then, cultural traditions can shape the same landscapes and seascapes that created the original traditions. A society living on the coast, for instance, may turn to the sea as a source of livelihood. To aid in this endeavor, the community may choose to build a shipyard that can host many boats, creating alterations in the coastline by adding necessary infrastructure for their endeavors. What they fish for, and then sell or eat, may then determine the main diet of the community, as well as their export market. Overtime, these practices could affect the marine biodiversity in the area, however, causing it to change or decline. This may cause the people to have to shift to another source of livelihood, impacting the cultural identity and stability of the society. Thus, as demonstrated, the relations between humans and nature are in an ever-changing limbo, with direct consequences for human cultural development as well as environmental concerns. For this reason, understanding the values held by a society is critical in the pursuit of sustainability. People's values influence their direct actions, including their interactions with the natural environment (Calcagni et al., 2019; Chan et al., 2012b; Manfredo et al,.2016).

2.1.2. Cultural Ecosystem Services (CESs)

CESs can be considered as the impacts that ecosystems have on human well-being in terms of the identities they shape, the experiences they enable, and the ideals they procure in humans (Fish et al., 2016). Recreational experiences, aesthetic enjoyment, spiritual fulfillment, and cognitive development are all life-enriching contributions that ecosystems can add to human well-being (MEA, 2005). And while the practices can be ceremonial or everyday routine, they are known to invoke deep attachments in communities (Fish et al., 2016). Thus, by studying CESs, researchers can gain an understanding of the lifestyles that shape a society (Calcagni et al., 2019), as well as the values that ecosystems inspire in people and the importance of this in sustaining human well-being and improving life quality (Zhang et al., 2020). As a result, it is important that policy makers and environmental planners consider such information when making decisions regarding the sustainable land-use and ecosystem management of an area (Calcagni et al., 2019; Chan et al., 2012a; Dickinson and Hobbs, 2017; Fish et al., 2016, MEA, 2005).

This is especially true today as, within the past century, the human footprint on the world has increased tremendously. For example, as of 2015, it was predicted that there were approximately 8 billion visits per year to protected areas around the world, with more than 80% of these visits occurring in North America and Europe alone (Balmford et al., 2015). While this has a range of benefits for humans and nature, including recreation opportunities, improving physical and mental health, or enhancing people's understanding and appreciation for the natural environment - therefore possibly promoting conservation efforts (Egorova, 2021) - such high visitation rates can also lead to significant environmental and social problems (Fish et al., 2016; Newsome et al., 2013; Worboys et al., 2015). Heavy strains on the biophysical and natural resources in an area can cause environmental disturbances that can have long-term effects on an ecosystem (Egorova, 2021), thereby decreasing the ecosystems potential to provide traditional CES benefits for future generations (MEA, 2005). For this reason, it is crucial that managers and policymakers in such areas have accurate information regarding the spatial and temporal dynamics of human activities (Egorova, 2021; Teles da Mota & Pickering, 2020), including when people come, where they go, and what they do (Hadwen et al., 2007; Newsome et al., 2013; Pickering et al., 2018; Teles da Mota & Pickering, 2020; Wilkins et al., 2021). Understanding such behavior can lead to appropriate action by land managers to increase the resilience of both ecosystem and human population (Egorova, 2021).

The lack of consistency, however, between the cultural values of various societies, makes a systematic appraisal of CES challenging for decision-makers. Whereas policy often reflects one definitive interpretation by law-makers, the boundaries of culture are hazy and undefined, making it impractical to evaluate CES in the same manner (Fish et al., 2016). Thus, the main challenge for policymakers and environmental managers when evaluating CES is how to address complicated environmental and sustainability matters in a way that recognizes the inherent diversity of an area while also creating homogeneity in the evaluation method (ibid). And while this can prove difficult to achieve, an appropriate evaluation and incorporation of CES into decision-making is considered to be vital to reaching target objectives set by nations, such as the sustainable development goals (SDG) set up by the United Nations General Assembly (UNGA) for the Agenda 2030 or other sustainable target policies (Karasov et al., 2020).

In general, then, it is better to accept that CES cannot be evaluated using only one method. In fact, several frameworks already exist that look at CES through different lenses. The Ecosystem Services (ES) framework, for example, of which CES is one branch, looks mainly at the CES that are quantifiable, such as recreation and tourism (Fish et al., 2016). However, as many believe that only evaluating ES in monetary terms exacerbates the society-nature divide created by modern urban life (Muradian & Gómez-Baggethun, 2021), deepening the gap between "that which matters to people and that which is easy to measure" (Fish et al., 2016), other approaches in evaluating CES have been suggested. The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) Conceptual framework, for example, argues that ecosystem assessments should aim to understand the key ecological and social components of human-nature interaction through a wider glance than economic valuation allows (Sandra et al., 2015). This goes in line with the idea that the greater the psychological distance between humans and nature (the more we think of nature in monetary terms), the more likely that an exploitative and utilitarian relationship with nature will be developed instead of one that is symbiotic with people (Muradian & Gómez-Baggethun, 2021).

Thereupon, it is key to understand which aspects of CES are provided by an ecosystem. As previously mentioned, CES encompasses a wide range of holistic contributions, including recreation, aesthetic experience, education, spiritual enrichment, inspiration, intellectual development, reflection, and a sense of place (Fish et al., 2016; Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020). Out of these, recreation and aesthetic experience are the most studied CES type (Zhang et al., 2020), as these are the easiest to define. Recreation, for instance, aims to understand the activities visitors conduct in a specific environment (Hernandez-Morcillo et al., 2013; Thiagarajah et al., 2015; Teles da Mota & Pickering, 2020). This can include partaking in activities such as walking, hiking, biking, swimming, diving, fishing, wildlife watching, and so on. Human-made infrastructure or facilities that provide additional activities or support when in a natural area can also be considered part of recreation as they allow for activities to take place. This can refer to hiking trails or bike trails, access to swimming spots, parking lots, restroom facilities, dining, and commercial centers, etc. (Egorova, 2021). These anthropic modifications often act as a compliment to the naturalness of an area (Karasov et al., 2020), inspiring further activities and leading to more time and experiences in a natural area. Aesthetic experience, on the other hand, aims to understand what the landscape itself is offering in terms of aesthetic appeal and most frequently refers to the unique natural and geographic features of an area (Egorova, 2021). Stunning scenery and incredible views, for example, can be one reason that people choose to visit a spot, even if not partaking in any recreational activities while there. The location of viewing platforms can aid in identifying aesthetic appeal in an area, as highly frequented observation points usually indicate an area that provides an aesthetic service (Zhang et al., 2020).

Other CES have also been examined in studies, though less frequently as they are more difficult to tangibly define. Education and intellectual development, for instance, can encompass learning a new activity, learning a new skill through an activity, learning about the landscape or seascape in an area and its associated biodiversity, learning about cultural practices, history of an area, and so on (Egorova, 2021; Ruhanen, 2019; Weber & Anderson, 2010). Thus, education can be construed in either extremely narrow or extremely broad terms but overall is generally difficult to identify. The same could be said with spiritual enrichment, inspiration, reflection, and sense of place. Sense of place, for instance, refers back to the idea that ecosystems promote a certain cultural identity in an area. Those who are frequently in contact with such an ecosystem thus may feel a strong feeling of self-identity within the ecosystem. However, those who are merely visiting the area as tourists may just see a scenic area and appreciate its aesthetic value without associating the ecosystem to any feelings of identity (Fish et al., 2016).

2.2. Social media-based research and it's applications

The use of SMD for research is a relatively recent field of study (Teles da Mota & Pickering, 2020). Though there is no one way to define SM, it generally refers to content voluntarily uploaded by a user to an online platform which is meant to facilitate connection between the user and their online community (Wilkins et al., 2021). The emergence of new platforms (refer to Table 1) over the last few decades, however, has caused the magnitude of SMD to grow exponentially in a short time frame. As a result, research in the field has also seen a tremendous growth and, as of April 2022, includes around 5,250,000 publications on Google Scholar when searching for the keywords "social media data research", although this varies by site, location, and spatial scale (Teles da Mota & Pickering, 2020). The increasing accessibility to GPS-enabled devices such as smart phones, however, has led to the development of a sub-branch of social media research called "location-based social media data research". Location-based SMD research has been less studied compared to social media research in general, with only 214,000 relating articles published on Google Scholar as of April 2022. When a picture is taken on a GPS-enabled device, the exact time, date, and location coordinates of the picture are stored on the device (Wilkins et al., 2021). When uploaded to a SMP, researchers can often access the stored metadata of the image and use the associated text, photo content and geotags to ascertain useful information such as a user's patterns, preferences, and opinions (ibid). When data from millions of users is aggregated over multiple years, this can provide researchers with invaluable information regarding the temporal and spatial patterns of individuals in fields ranging from urban planning (Ghermandi & Sinclair, 2019; Hammer et al., 2018; Ilieva & McPhearson, 2018), environmental monitoring (Arts et al., 2015; Calcagni et al., 2019; Ilieva & McPhearson, 2018; Teles da Mota & Pickering, 2020; Zhang et al., 2020), health studies (Hammer et al., 2018; Ilieva & McPhearson, 2018), disaster response and management (Ghermandi & Sinclair, 2019; Ilieva & McPhearson, 2018; Kryvasheyeu et al., 2016; Yan et al., 2017), tourism (Calcagni et al., 2019; Ilieva & McPhearson, 2018; Karasov et al., 2020; Teles da Mota & Pickering, 2020; Zhang et al., 2020), and public opinion (Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020), to name a few.

Table 1. General overview of various popular social media platforms and their applications.

SOCIAL-MEDIA PLATFORM	YEAR OF CREATION	SITE/APPLICATION TYPE	MAIN DATA TYPE
TWITTER	2006	Microblog/News/Social network	Short text
FOURSQUARE	2009	Check-ins	Check-ins
PANORAMIO (DEPRECATED)	2005	Photo sharing	Photographs
FLICKR	2004	Photo hosting	Photographs
INSTAGRAM	2010	Photo sharing application with functions of social network	Photographs
FACEBOOK	2004	Social network	Photographs and text
SINA WEIBO	2009	Microblog/Social network (popular in China)	Short text
VK.COM	2006	Social network (popular in Russia)	Photographs and text
STRAVA	2009	Activity/Sport sharing	Short text

2.2.1. Urban planning

Modern applications of SM-based research in urban planning are extensive, dipping into areas of interest such as the spatial distribution of people and associated hot spots in cities, use of green areas and urban sustainable development, gentrification and need assessments of urban neighborhoods, mobility tracking, and economic development.

For one, SM posts can be used to identify highly visited locations in cities and their surrounding areas (Ilieva & McPhearson, 2018; Pettit, 2011), as well as those areas that are not often frequented by visitors (Ghermandi, 2016; Ghermandi & Sinclair, 2019; Sessions et al., 2016; Sonter et al., 2016; Tenkanen et al., 2017; Walden-Schreiner et al., 2018b). Such information can play a role in determining the overall crowdedness of a place (Garcia-Palomares et al., 2015; Ghermandi & Sinclair, 2019; Levin et al., 2015), as well as the impacts this may have on relating infrastructure. For example, areas with high visitor numbers may need more frequent fix-ups than areas that are not often frequented by visitors. Contrarily, areas that are more scarcely visited by people may need better infrastructure or accessibility in order to attract more people. By identifying the hot spots and cold spots in cities, planners can better understand the reasons behind the value of a given location and take this information into account in future developments.

Researchers have also used SMD to study urban interaction with green areas such as parks in cities. For example, both Flickr and Twitter data have been used to study statistics regarding park access and visitation in large urban metropolises such as New York City, Minneapolis, and Birmingham (Hamstead et al., 2018). In Copenhagen and NYC, Instagram data was used by researchers to evaluate how people interact with green spaces (Guerrero et al., 2016; Schwartz & Hochman, 2015) and which social activities are engaged in in such places. These studies can be used by urban planners to determine where to best establish future green areas in cities, as well as which amenities should be included in each space so as to provide the most value for its community (Ilieva & McPhearson, 2018).

In addition to determining the best locations for parks and natural areas, SMD can also be used to aid the economic development of a city by tracking the consumption practices of its inhabitants (ibid). Commercial activities relating to fitness, food, shopping, entertainment, and travel, to name a few examples, often see reoccurring patterns of activity in modern society (Hasan & Ukkusuri, 2014; Ilieva & McPhearson, 2018). SM researchers can analyze these patterns in order to provide urban planners with vital information such as where to invest in the next commercial retail center in a city, for example, or identify which neighborhoods have a need for more grocery stores or restaurant options. To illustrate, in Hangzhou, China, SM researchers used geo-located data uploaded to dianping.com, a popular consumer review website, in order to identify the most popular restaurant destinations in the city (Zhai et al., 2015). Their data showed them that a decent majority of the popular restaurants in the city were located in mixed-use, easily accessible neighborhoods (Ilieva & McPhearson, 2018). Such knowledge is important for urban planners as it shows that an establishments location and its surrounding logistics are a vital aspect to its success, which overall aids in the planning and investment in future economic improvements for an urban area.

This leads to the topic of mobility within a city. By understanding which areas are most frequented in a city, as well as which areas need more development, urban planners can then create appropriate transportation networks in order to make sure that all areas are accessible to the public as needed (ibid). This can refer to the establishment and maintenance of appropriate roads, as well as more sustainable transportation types such as pedestrian walkways, bicycle paths, bus transportation routes, and so on (Ghermandi & Sinclair, 2019; Luo et al., 2016; Sun et al., 2017; Zhang & Feick, 2016). Additionally, using SMD to create better systems for monitoring roads and traffic incidents are also already being executed. For example, researchers in Beijing have developed a method that combines the GPS trajectory from vehicles with that of geolocated Flickr data in order to better understand road attributes and continuously update road maps (Ilieva & McPhearson, 2018; Li et al., 2015). Additionally, researchers in the US have used Twitter data to effectively monitor traffic occurrences and accidents in real-time and consequently, appropriately estimate travel demand times (Yang et al., 2015).

Finally, SMD can help urban planners understand, and thus potentially anticipate and plan for, the gentrification and displacement of groups which often occurs in urban areas (Ilieva & McPhearson, 2018). Examples of studies which have already applied this include studies using geotagged Twitter posts to map the spatial and temporal division of different ethnic groups living in London (Adnan et al., 2013), studies which have examined the inadvertent social divisions that resulted from urban renewal in Johannesburg (Hoogendoorn & Gregory, 2016), and studies which used SMD to examine the socio-spatial divide that exists between the east and west part of Louisville, Kentucky in the US (Shelton et al., 2015).

2.2.2. Tourism

Similarly, SMD can also be used to identify the visitation rates of visitors (Hong et al., 2012; Ilieva & McPhearson, 2018; Wilkins et al., 2021) and distinguish between hot and cold spots of areas for tourism purposes. This can be useful for predicting future visitation rates to protected areas such as national parks, allowing for park managers to better assess park needs, such as which areas have too many visitors or, vice versa, which areas need to be more accessible or have better infrastructure to attract visitors. The connection between natural area visitation rates and nearby cities can also assist researchers in determining the importance of these natural areas to tourism relating to the city, including the benefits provided for the local economy and identity of the area (Ilieva & McPhearson, 2018). For instance, if an event occurs once a year at a specific location and attracts three times more visitors than the area usually sees, this information can tell local leaders that these types of activities are an important part of the cultural identity of the city and are valued by local and/or global communities (ibid) and should be continued in the future. In this case then, SMD can act as a valuable source of information for highlighting the types of experiences that visitors have at specific sites and the benefits obtained from such experiences, which in turn can be useful to the planning and governance of nearby urban areas (Wilkins et al., 2021).

Another manner in which SMD can be useful to tourism studies concerns the mobility patterns of visitors to popular tourist destinations. For example, researchers have aggregated geotagged Flickr photos in order to determine which routes where most frequently used by visitors to reach major tourist attractions in cities like Florence in Italy and San Francisco in the USA (Lucchese et al., 2012). Such information can be important to understand why certain routes are preferred to others and can aid in future pedestrian and public-space planning (Ilieva & McPhearson, 2018) by urban planners. At a global level, Flickr data was also used to capture intercity mobility flows (Paldino et al., 2015), whereas Twitter data was used for the same purpose albeit at a global scale (Hawelka et al., 2014). Understanding the movement between the local and foreign community in a city and its adjacent natural areas allows for planners to infer societal needs more accurately, especially for large metropolises like London or New York City (Ilieva & McPhearson, 2018) which receive millions of visitors per year.

2.2.3. Environmental monitoring and Disaster response/management

The use of SMD in various environmental studies has also been expanding within the past decade (Ghermandi & Sinclair, 2019; Ilieva & McPhearson, 2018). As already mentioned, SMD can be used as a tool to measure visitation rates to parks and protected natural areas, as well as identify hot and cold spots within these areas (Teles da Mota & Pickering, 2020; Wilkins et al., 2021). In the hands of park and recreation managers, such information could be used to predict future patterns of visitation (Wilkins et al., 2021), identify overcrowded or scarcely visited areas (Garcia-Palomares et al., 2015; Levin et al., 2015; Teles da Mota & Pickering, 2020), and provide new knowledge on which variables are drawing people to an area in order to develop unexplored sites (Ghermandi & Sinclair, 2019; Wilkins et al., 2021). Furthermore, this information could be useful in redirecting visitors from areas where wildlife is frequently disturbed, relieving pressure on those ecosystems and restoring balance to an area (Ghermandi, 2016; Sinclair et al., 2018). This is especially important in areas that allow for extractive activities such as recreational hunting or fishing (Teles da Mota & Pickering, 2020), as it is vital that protected ecosystems are not being over-exploited by human activities.

Besides identifying visitation rates, studies have also used SMD in order to investigate and map the population and spatial distribution of various flora and fauna in an area (Daume & Galaz, 2016; Dylewski et al., 2017; ElQadi et al., 2017; Lin & Cromley, 2015; Patel et al., 2017). For example, photographs uploaded online can be used to study aspects such as the geographic and temporal life cycle of a plant or animal species (Atsumi & Koizumi, 2017), or behavior in general (Dylewski et al., 2017). Studies have also been used to monitor the distribution of invasive species and causative disturbances in an area (Daume, 2016; Daume et al., 2014). Additionally, the tracking of biodiversity through SMD can be useful in terms of identifying and monitoring illegal activities such as the trade of endangered wild species (Ghermandi & Sinclair, 2019; Hinsley et al., 2016; Kitson & Nekaris, 2017) or illegal hunting of protected species (El Bizri et al., 2015).

SM studies monitoring physical and chemical properties of the environment have also gained traction in the past years, with studies ranging from topics such as air quality (Ghermandi & Sinclair, 2019; Ilieva & McPhearson, 2018) to water flow velocity (Le Boursicaud et al., 2016) to snow cover extent (Ilieva & McPhearson, 2018). For example, geotagged SM posts made to Sina Weibo (Cai et al., 2015; Wang et al., 2017a) and Twitter (Riga et al., 2015) have been used by researchers to study air pollution levels in China, the United States and Italy (Sun & Mobasheri, 2017; Wang et al., 2015; Yuan et al, 2013).

Finally, studies evaluating climate change conditions and the resulting local and global consequences is yet another emerging field of study in SM-based research (Murakami et al., 2016). This can include monitoring changes in precipitation levels that occur in an area (Zhou & Xu, 2017), the monitoring of unusual heat waves or cold waves over time (Jung & Uejio, 2017), and the resulting increase in occurrences of natural disasters that the world is facing as a result of these climate changes. The use of SM in disaster mitigation and management can aid in the effective planning, preparedness, and response of communities when natural disasters strike (Ghermandi & Sinclair, 2019; Ilieva & McPhearson, 2018). Currently, researchers are investigating how to integrate SMD into decision support systems (Shook & Turner, 2016), so as to improve the resilience of communities frequently affected by climate change and natural disasters (Deng et al., 2016; Lopez-Cuevas et al., 2017; Wang et al., 2016b), as well as improving the chances for recovery if natural disasters strike (Kryvasheyeu et al., 2016; Yan et al., 2017). Scientists have, so far, been able to use spatial data to predict flooding in cities like York, in the UK (Ilieva & McPhearson, 2018), as well as determine flooding levels by analyzing twitter data (Fohringer et al., 2015; Jongman et al., 2015). Flickr photos (Fohringer et al., 2015; Sun et al., 2016) have also been used as a tool in spatial planning of flood evacuation routes, determining best routes based off users' preferences for shelter locations (Ilieva & McPhearson, 2018; Kusumo et al., 2017). Other studies have been able to combine twitter data with remote-sensing data in order to assess post flood-related damages to infrastructure and transportation (Ilieva & McPhearson, 2018). Twitter data has also been used to model social activity during major disaster events such as earthquakes and wildfires, as well as major storm and flooding events (Kent & Capello, 2013; Kusumo et al., 2017; Wang et al., 2016b). This can be useful in helping researchers identify the spatial patterns of social activities when disasters strike. Other examples include studies that have allowed researchers to analyze tourism recovery rates in Southeast Asia after disasters have occurred using SMD from platforms such as Instagram, Flickr, and Panoramio (Ghermandi & Sinclair, 2019).

2.2.4. Health Studies

The identification and tracking of diseases, ranging from viruses to psychological well-being, have also begun to be tracked with the help of SMD. For instance, studies in the US have used Twitter data to explore the level at which one's environment influences one's food choices (Chen & Yang, 2014; Ilieva & McPhearson, 2018) by identifying the locations of fast-food restaurants (Widener et al., 2014) and comparing this to obesity rates in the country (Gore et al., 2015). Similarly, medical researchers in the US were able to use Twitter data to determine the correlation between alcohol-related tweets and alcohol-related visits to the emergency room (Ranney et al., 2016) in order to predict when surges of hospital visits would occur (Ilieva & McPhearson, 2018). Twitter data is especially valuable here as its word-specific nature allows for easier identification of public sentiment. In terms of psychological well-being, this has provided a new means for researchers to identify positive or negative patterns in mental health in urban areas, such as the tracking of happiness (Mitchell et al, 2013) or clinical depression (Yang et al., 2015; Yang & Mu, 2015) related to certain areas.

In China, researchers are using SMD to aid in studies linking high levels of pollution (e.g. air pollution) with associated illnesses (Ilieva & McPhearson, 2018). Lastly, SMD can also be used to track the spread of diseases and viruses. For example, during the outbreak of the covid-19 virus which emerged in December of 2019, the SMP Sina Weibo built a channel allowing for users who contracted the virus to seek help (Peng et al., 2020). Based on the geotagged data of the users, researchers were then able to track and monitor the spatiotemporal distribution of the virus within the city of Wuhan (ibid).

2.2.5. Public Opinion

SM can also be used to track public sentiments on important local and global issues, as well as the shifts that may occur in these sentiments over time, such as the public's perceptions on climate change (Ghermandi & Sinclair, 2019; Ilieva & McPhearson, 2018); sustainability (Cavalcante & Dante, 2016; Haider, 2016; Lee, 2017); access to important amenities such as healthy food establishments (Keeler et al., 2015; Roberts, 2017); the importance of natural areas (Ghermandi & Sinclair, 2019) and urban green zones (Kothencz et al., 2017; Lansley & Longley, 2016); the preservation of threatened biodiversity (Nekaris et al., 2013; Roberge, 2014), as well as illegal trade or hunting activities (El Bizri et al., 2015; Hinsley et al., 2016; Kitson & Nekaris, 2017; Lunstrum, 2017); environmental accidents (Cha & Stow, 2015); and environmental pollution (Chong et al., 2017; Kay et al., 2015).

For example, when evaluating people's perceptions of climate change using data from the SM platform Sina Weibo, research has shown that there is a possible divide between understanding climate change as a global consequence versus understanding the local consequences it may invoke (Liu & Zhao, 2017; Ilieva & McPhearson, 2018). Another study used data from Flickr, Panoramio, and Instagram in order to understand people's attitudes towards cities that were growing or diminishing in the US (Young et al., 2014).

2.3. Mapping CES through SM

Social media offers one solution for evaluating the CES of an ecosystem through non-monetary means. As it is assumed that taking a photograph and then uploading it to an online platform indicates some kind of importance or fondness that the photographer has for the depicted subject (Egorova, 2021), then it can also be assumed that the content that people chose to share on their personal platforms, whether via pictures, texts, or geotagged locations, can provide valuable insight into the underlaying beliefs of a user. In terms of CESs, this refers to documenting which aspects of the environment the individual views as important (Calcagni et al., 2019; Guerrero et al., 2016; Wilkins et al., 2021). A user who likes to run in a certain location may choose to share a photo of them running their favorite trail on a mountain, for example. They may also choose to share an image of a nice view from the mountain that they acquired on their run. A researcher may then use such images to conclude that this particular user values this mountain for its recreational purposes as well as the aesthetic pleasure it provides them. If multiple users upload similar images in the same location, researchers can then aggregate the images together and use the spatial distribution of the photos as a proxy to understand the general value of that particular area to humans (Egorova, 2021). This is just one way in which SM images can be used to quantify the importance of a site. It is particularly significant as it provides researchers a chance to investigate human preferences for natural areas at much larger geographic scales than was possible prior to SMD (Ilieva & McPhearson, 2018; Wilkins et al., 2021). For example, the SMP Flickr has about 90 million active users today, and sees about 1.7 million images uploaded to it on a daily basis (Ilieva & McPhearson, 2018). Researchers can then access this global data source to further their understanding of the human-nature relationship in an area by evaluating factors relating to those areas and CES, including visitation rates, motives behind visitation (including recreational activities occurring there, landscape aesthetics people find pleasing, educational purposes), and so on.

2.3.1. Quantitative Mapping

Presently, there are several approaches to how scientists can use SMD to evaluate the CESs an area provides. In relation to quantitative mapping, CESs can be difficult to quantify and therefore difficult to manage (Calcagni et al., 2019; Karasov et al., 2020). However, over the last two decades, more and more studies are recognizing that geo-tagged SM content can be used for quantitative CES evaluation studies (ibid). Currently, most quantitative mapping methods concentrate on a photo density analysis, number of photos in a geographic unit analysis, or on an economic value analysis (Zhang et al., 2020). The former, photo density analysis, refers to the number of photos taken per day within a specified geographic unit (ibid). This evaluation method, also known as photo-user-day (PUD) analysis, is a prime indicator of visitation rates to a natural area, as only one uploaded SM photo per user per day in the specified geographic unit is considered in the final data count. This is important for CES evaluation as it avoids the bias that can occur when one user uploads multiple photos within a small geographic area on the same day. Instead, a true perception is given about the value of an area to a population. For example, when PUD is high in an area, the assumption is then that the location offers multiple CES, thus leading to high CES values for the area (ibid). The number of photos taken in an area, on the other hand, refers to the total number of photos taken in a geographic unit, without distinguishing a unique user (ibid). Whilst this technique may not be good for measuring visitation rates, it is useful in evaluating the aesthetic appeal or sentiment of an area to users, for example. This conclusion assumes that in areas where there are a high total number of photos taken, the associated scenery must be very beautiful or very important to at least some individuals. The third method, an economic value analysis, refers to combining SMD with factors such as travel costs (Calcagni et al., 2019; Zhang et al., 2020), hedonic pricing (Calcagni et al., 2019), and willingness to pay (ibid). The idea is to show that people are willing to invest money and time to visit an area, and the more money and time people are spending, the more valuable that area is. This method often require additional data sources such as the home address of the user, transportation costs, travel times and distances, etc. (Zhang et al., 2020). This data, however, is not provided by SMP and thus has to be obtained through other means. All three methods offer valuable information regarding CES in an area. With such data, researchers can identify CES hot-spots to understand visitor use and the visitor experience (Calcagni et al., 2019; Guerrero et al., 2016), which is critical to the future sustainable land use, conservation, and management of an area (Calcagni et al., 2019; Guerrero et al., 2016; Hausmann et al., 2017a; Wilkins et al., 2021). Nevertheless, though a quantitative analysis of geotagged SM photos in an area can be used to evaluate important variables in CES such as visitation, recreation, aesthetic pleasure, and tourism, it does not provide further insight into other aspects of CES such as sense of place, identity, spirituality, education, sentiment, etc. (Zhang et al., 2020). For this reason, it is important to combine a quantitative analysis of data with a qualitative one.

2.3.2. Qualitative Mapping

A qualitative analysis of SMD mainly refers to image content analysis. With image content analysis, it is possible to identify numerous aspects of CES through images uploaded to SM, such as landscape aesthetics of a place (Martínez Pastur et al., 2016; Guerrero et al. 2016; Tenerelli et al. 2016); recreational purpose (Tenerelli et al. 2016; Oteros-Rozas et al., 2018); biodiversity of an area (Catana, 2016; Richards & Friess, 2015); sense of identity (Martínez Pastur et al., 2016); spirituality (Oteros-Rozas et al., 2018); sentiment, knowledge, and so on (Guerrero et al., 2016; Wilkins et al., 2021). The context of an image or a text can signify what the users' motivations are for visiting a natural area, what aspects they value out of their experience and what level of satisfaction they receive from it (Becken et al., 2017; Cong et al., 2014; Ghermandi & Sinclair, 2019; Ilieva & McPhearson, 2018; Oteros-Rozas et al., 2018; Teles da Mota & Pickering, 2020).

Photos obtained can be evaluated and processed through manual or automatic means. The former involves the researcher evaluating each picture and then categorizing it based off the groupings they have chosen (recreation, aesthetics, culture, education, etc.), while the latter refers to an automatic image recognition software, such as google cloud vision, grouping each photo based on the settings input by the researcher. Both methods have their strong and weak points. Manual evaluation, for example, takes a significantly longer time than automatic processing, and is prone to the bias of the analyzer (Zhang et al., 2020). On the other hand, manual processing can lead to more accurate categorizations of photos and provides the opportunity to assign multiple CES factors to one photo. Furthermore, the more difficult CES aspects, such as emotions, sentiment, and spirituality, are difficult to define and therefore difficult to program into a computer. With manual classification, these aspects are still difficult to identify and classify, but are much less elusive than with a computerized evaluation (Egorova, 2021). Automatic recognition software, however, have the clear upper hand in speed, saving time and manual labor for the analyzer when working with large datasets (Zhang et al., 2020). They also increase the objectivity of the study results, as categorization relies heavily on tangible objects in images, such as recreational facilities, athletic equipment, plants and animals, number of people, and so on (Egorova, 2021; Zhang et al., 2020). However, automatic classification has limitations in assigning multiple CES categories to one image and thus, can be less informative than manual classification. Manual content analysis can also lead to more accurate CES evaluations of a natural area, as now and again photos don't truly depict their geotagged locations (Zhang et al., 2020).

All in all, when SMD is aggregated, content analysis can offer perceptive information regarding the spatial distribution of a particular CES within an area (Calcagni et al., 2019). Studies previously explored, for example, include the aesthetic value of landscapes along the Lithuanian coast (Marcinkevičiūtė & Pranskūnienė, 2021; Teles da Mota & Pickering, 2020), or how the naturalness of an area determines its' attractiveness in regard to landscape aesthetics (Tenerelli et al., 2017). Other studies have focused on the influence that various biodiversity and landscape features have on recreation and tourism in particular areas (Hausmann et al., 2017a; Tenerelli et al., 2017; Willemen et al., 2015), whilst still more evaluated the reasons behind the popularity of parks in Victoria, Australia (Levin et al., 2017). In fact, though the use of geolocated SMD to study CES is a relatively new field of research, countless studies have already been conducted and SMD is increasingly being used to evaluate the CES that parks and protected areas provide society (Wilkins et al., 2021). Furthermore, with the inevitable growth of SMP and SM users around the world, the value of SMD for research relating to CESs, along with many other fields, will only continue to increase (Teles da Mota & Pickering, 2020). Nevertheless, despite rapid growth and the many advantages that SMD presents for researchers, there are still many challenges that need to be overcome within the field of SM research (Zhang et al., 2020).

2.4. Advantages to social media-based research data

Unlike in traditional social science research approaches where pictures may have been limited in quantity and quality richness, the consistent development in social media platforms, mobile systems, and smart phone technologies offers novel sources for acquiring big data for CES research questions (Ilieva & McPhearson, 2018; Zhang et al., 2020). One of the obvious advantages of using SMD for research compared to more conventional methods such as surveys, interviews, participatory GIS, and questionnaires is the cost-effectiveness of the method. SMD is known to be cheaper as it is less resource intensive than traditional methods, providing the ability to collect large amounts of data in a brief period of time with less manpower invested (Calcagni et al., 2019; Ilieva & McPhearson, 2018; Teles da Mota & Pickering, 2020; Yoshimura & Hiura, 2017; Zhang et al., 2020), especially when automated retrieval methods are employed (Antoniou et al., 2016; Soliman et al., 2017; Yan et al., 2017). In fact, in comparison to alternative methods of data collection, the volume of data collected through SMD can be up to several orders of magnitude greater (Ghermandi & Sinclair, 2019), allowing for greater perspective and scope for evaluating natural areas.

Additionally, SMD can offer a greater spatial and temporal range of data than traditional methods, providing real-time data, or close to it, on users daily, weekly, monthly, annual, or seasonal patterns of visitation to natural areas (Calcagni et al., 2019; Ghermandi & Sinclair, 2019; Gliozzo et al., 2016; Oteros-Rozas et al., 2018; Teles da Mota & Pickering, 2020). This is especially important for environmental management and planning as it allows for a more informative and adaptive style of management (Ilieva & McPhearson, 2018) that can follow users preferences over time. For example, officials can use this knowledge to identify hot and cold spots in natural areas for specific visitation periods and locations (Teles da Mota & Pickering, 2020). This information can then emphasize which areas are more disturbed by anthropogenic influences and thus require higher protection laws, or recognize the areas less visited by tourists and identify reasons for this (Garcia-Palomares et al., 2015; Ghermandi, 2016; Levin et al., 2015; Sinclair et al., 2018; Wilkins et al., 2021). Besides allowing for more informative management policies, this data can also aid in the analysis of CES (Figueroa-Alfaro and Tang, 2017), as well as aid in assessing the recreational value of a site (Becken et al., 2017; Sessions et al., 2016), monitoring changes in land-use (Arribas-Bel et al., 2015; Sitthi et al., 2016; Zhou & Zhang, 2016), understanding visitors' environmental perceptions (Jiang et al., 2016; Williams et al., 2015), and determining the biodiversity distribution in an area (Daume et al., 2014; ElQadi et al., 2017; Ghermandi & Sinclair, 2019), to name a few.

It is also said that one of the greatest benefits of SMD is the "realness" of the data, which other traditional methods of data collection cannot provide due to their intrusive nature (Calcagni et al., 2019). Nerves or mind-biases, such as the desire to want to leave a positive impression of an area when being interviewed, can create biases that could be avoided with less invasive data collection methods (Egorova, 2021). As SMD is collected in a passive manner, such a bias can be avoided as users are freely displaying their firsthand experiences/perspectives of the natural environment (Arribas-Bel et al., 2015; Calcagni et al., 2019; Ghermandi & Sinclair, 2019; Tenerelli et al. 2017). This is especially true when automated systems are being used to analyze images (Karasov et al., 2020), as this can avoid the additional biases in the analysis created from data analyzers, or when SMD is used in combination with other sources of big data, to overcome the biases that can emerge from using SMD from one particular platform (Abel et al., 2011; Ilieva & McPhearson, 2018; Jendryke et al., 2017).

Finally, the use of SMD in valuing CES of natural areas is important in that it can highlight visitor preferences for a greater section of the population (Oteros-Rozas et al., 2018; van Zanten et al., 2016). This is especially important for the global urban population as city inhabitants are shown to have much higher use of social media platforms (Guerrero et al., 2016; International Telecommunication Union, 2016) than rural inhabitants, whilst also being the first to slowly lose the opportunity to be close to nature (Dickinson and Hobbs, 2017).

2.5. Sources of bias in Social-Media based research

Despite the distinct advantages to SM-based research, there are still considerable limitations to bear in mind when using SMD for research purposes. In *"A Systematic Review: Uses and Limitations of Social Media to Inform Visitor Use Management in Parks and Protected Areas,"* Wilkens et al., (2021) list the limitations, biases, and concerns of SMD that were accounted for in numerous (58) studies (Wilkins et al., 2021). These ranged from SMD not being representative of park users, users desire to share only select content, inaccuracies in geotagging and location coordinates of SM uploads, the unknown demographics of SM users, the use of different platforms for various purposes, changing popularity in platforms and data access over time, the ethical implications of using SMD, and the difficulty linked to taking photos during particular activities or in particular conditions (ibid), among others.

Lack of Sociodemographic Information

Amongst these, the idea that SM is not entirely representative of all natural area users was the most frequently mentioned issue, with 42 out of 58 (72.4%) studies addressing this constraint (ibid). This refers mainly to the absence of sociodemographic representation through SMD (Egorova, 2021; Ilieva & McPhearson, 2018; Karasov et al., 2020; Teles da Mota & Pickering, 2020; Wilkins et al., 2021; Zhang et al., 2020), including a lack in basic information such as age, gender, education, ethnicity, income level, occupation or nationality (Allan et al. 2015; Chua et al., 2016; Heikinheimo et al., 2017; Karasov et al., 2020; Keeler et al., 2015; Martínez Pastur et al., 2016; Oteros-Rozas et al., 2018; Tenerelli et al., 2017; Willemen et al., 2015; Wood et al., 2013) of SM users. For instance, earlier studies have found that the most prevalent SM platforms are mainly dominated by younger, wealthier, and better educated users (Teles da Mota & Pickering, 2020; Zhang et al., 2020), and, especially in natural areas such as national parks, the average age of SM users is often younger than that of the general visiting population (Hausmann et al., 2017a; Hausmann et al., 2017b; Heikinheimo et al., 2017). Elderly individuals, in fact, are one of the least represented demographic groups when it comes to SM use, with the exception of and low-income individuals, who often don't have the means to use such platforms (Ilieva & McPhearson, 2018; Karasov et al., 2020; Zickuhr, 2013). Other studies show that there are high gender imbalances between SM platforms and their users, with Instagram and Pinterest attracting mainly young women with urban backgrounds (Ilieva & McPhearson, 2018; Ruths & Pfeffer, 2014), while Flickr has a much stronger male presence (Calcagni et al., 2019; Lenormand et al., 2018). Hence, even though the number of SM users and thus, SMD, continues to grow over time, it is still important to bear in mind whose data is being represented through the various platforms and how well this sample data truly stands for the population as a whole (Ghermandi & Sinclair, 2019; Ilieva & McPhearson, 2018; Zhang et al., 2020).

Unequal representation of activities

It is further important to consider that not all nature-based tourism is equally featured through SM platforms (Ghermandi & Sinclair, 2019; Ilieva & McPhearson, 2018; Teles da Mota & Pickering, 2020; Wilkins et al., 2021). According to the study conducted by Wilkens et al (2021), 16 out of 58 articles, or 27.6%, showed concerns of users only being able to share select content, and 4 articles, or 6.9%, showed concerns that some activities are much harder to photograph than others. Activities such as surfing and diving (Wood et al., 2013; Spalding et al., 2017), for example, are less likely to be featured in SM images due to the complexity of handling equipment on or in waterbodies (Teles da Mota & Pickering, 2020), as well as the general lack of mobile coverage or wi-fi networks that occurs for water ecosystems (Howarth, 2014; Ghermandi & Sinclair, 2019; Teles da Mota & Pickering, 2020). Activities such as bouldering or rock climbing (Tenerelli et al., 2016) can face similar difficulties in equipment management and mobile coverage (Teles da Mota & Pickering, 2020) and thus are also often underrepresented through SMD. Finally, it is important to remember that unequal representation of activities through SM can occur due to a visitor's familiarity with a location (Ilieva & McPhearson, 2018). The value of a place shown by newcomers can vary greatly from those shown by habitual visitors, and the distance one travels to visit a particular setting can further influence one's desire to capture and share it through an image (Dunkel, 2015; Wood et al, 2013).

Temporality of social media platforms

The instability relating to access to data and the temporality of SM platforms (Ilieva & McPhearson, 2018) are further concerns mentioned in the Wilkens et al. (2021) study. SM platforms are often owned by private companies who can choose to restrict data sharing at any point in time (Teles da Mota & Pickering, 2020; Wilkins et al., 2021) or who may entirely discontinue their services as new platforms emerge and popularity changes (Zhang et al., 2020). Panoramio, for example, a well-known geo-tagging photo sharing platform started in 2005, discontinued its services in 2016 (Teles da Mota & Pickering, 2020; Zhang et al., 2020). Current popular SM giants such as Instagram and Facebook have, on the other hand, continued their services but strengthened their public restrictions on data access since 2018 (Wilkins et al., 2021; Zhang et al., 2020), severely limiting the possibility for researchers to conduct research related to geo-tagging. Thus, the future of SMD-based research depends heavily on changes in attitude of both private and public sectors, as laws regarding data access are often regulated by companies who are directly responding to their communities' values (Teles da Mota & Pickering, 2020).

Popularity of platforms by location

Moreover, access to SM and popularity of SM platforms can vary by country as well as urban versus rural areas (Teles da Mota & Pickering, 2020). In China, for example, popular platforms such as Instagram and Facebook are not available and instead, SM users use parallel popular platforms such as Sina Weibo (Ilieva & McPhearson, 2018). This is important as it limits the ability of scholars to conduct SM-based research at a global scale (Zhang et al., 2020). The state of development of a country can additionally limit scientists' opportunities to perform global research, as most lesser-developed nations are currently only at the beginning stages of big data accumulation (Ilieva & McPhearson, 2018). Remoteness of rural areas can also play a role in the ability to use SM, with rural areas tending to have much fewer SM users than urban ones (Calcagni et al., 2019; Guerrero et al. 2016; International Telecommunication Union 2016). This can be due to less internet availability or mobile coverage (Chua et al., 2016; Ghermandi & Sinclair, 2019), as well as lower accuracy in spatial coverage and GPS signal visibility (Heikinheimo et al., 2017). A lack of data for such areas can then lead to inaccurate spatial biases (Catana, 2016; Levin et al., 2017) and misinformation regarding proper management and planning actions needed in such areas.

Ethical Implications

Perhaps most notorious in the debate against SM-based data for research purposes are the ethical challenges that arise from its use (Barocas & Nissenbaum, 2014; Calcagni et al., 2019; Ilieva & McPhearson, 2018; Teles da Mota & Pickering, 2020; Zhang et al., 2020). With traditional surveying methods such as interviews or questionnaires, individuals are aware of the data they provide and often offer researchers consent to use the information they have provided (Ilieva & McPhearson, 2018; Zhang et al., 2020). With SMD, on the other hand, consent is not typically acquired by researchers and users are generally unaware of the use of their data for any purpose other than to share content with family and friends (Schwartz & Halegoua, 2014; Zhang et al., 2020). This can lead to issues over privacy concerns, especially if researchers try to combat other SMD issues such as the lack of sociodemographic information (Ilieva & McPhearson, 2018) provided by user's accounts. The credibility of data could be greatly improved through the retrieval of user metadata from multiple sites (Boyd & Crawford, 2012; Sloan et al., 2015), but is questioned due to the possibility of acquiring sensitive information that was not meant for the public's eye (Acquisti & Gross, 2009). This would especially generate a threat in an individual's privacy if identifiable data was then further shared with third-parties or with researchers who are unfamiliar with ethical normalities in such research fields (Ilieva & McPhearson, 2018).

Inaccuracy of Location Data

An additional pitfall to consider regarding SMD is the accuracy of the geotag (Calcagni et al., 2019; Oteros-Rozas et al., 2018), as location coordinates may not always be reliable (Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020). This can be for a plethora of reasons including erroneous manual addition of place tagging (Ilieva & McPhearson, 2018) or unintentional disruptions in signal when uploading a post (Zhang et al., 2020). For this reason, it is difficult to categorize SMD alone as a precise representation of human activity and CES value in time and space and any patterns discovered should be substantiated with additional sources of information (Hauff & Houben, 2012). Another strategy would be to use buffers when working with SMD so as to use approximate rather than precise locations when evaluating a site (Guerrero et al., 2016; Ilieva & McPhearson, 2018).

Content variation amongst platforms

It is important to note that content posted by users can vary significantly depending on the SM platform and that each platform attracts its own unique users (Ghermandi & Sinclair, 2019). For instance, previous studies show that Flickr is much better at capturing CESs than the now-disabled SM platform Panoramio (Oteros-Rozas et al., 2018) and includes more photos of landscape and biodiversity than Instagram (Tenkanen et al., 2017). Another study surveyed national park visitors and found that those who used Instagram as their main SM platform were generally younger than the users of other SM such as Flickr (Ghermandi & Sinclair, 2019; Heikinheimo et al., 2017). Finally, the popularity of the platform and its users ultimately also depends on the location of a site and thus policymakers and environmental managers must be aware of which SM platform portrays the most relevant information for their particular need (Teles da Mota & Pickering, 2020).

Other possible biases

The introduction of bias into a study can be done through several means and thus is important to keep in mind when carrying out SMD-based research. Firstly, bias can be introduced from the data analyzer, as there is a tendency to want to see and create patterns that may not actually exist (Calcagni et al., 2019; Wood et al., 2013). Generally, the aim of a researcher or research team is to carry out a study in as objective a way as possible. This can be achieved by using a team of analyzers with different backgrounds or confirming the results of a study through multiple research teams, for example. In the case of SMD, however, this is rarely possible as data is often limited in accessibility to different research groups (Ilieva & McPhearson, 2018). Thus, when interpreting data in a study, it is important to note that the perception and responses given to one by a certain environment are entirely subjective and that the emotions and value of a natural area are highly influenced by an individual's own cultural and historical background (Egorova, 2021; Muradian & Gómez-Baggethun, 2021). Moreover, the use of different languages (Hong et al., 2012; Ilieva & McPhearson, 2018), linguistic idiosyncrasies, as well as metaphors and sarcasm (Widener & Li, 2014) can further complicate the interpretation of SM images and tags. The limitations this can pose for a researcher or research team is critical to keep in mind when considering SM-based research, as it can lead to a one-directional interpretation or misinterpretation of data (Calcagni et al., 2019; Derungs & Purves, 2016; Oteros-Rozas et al., 2018).

An additional pitfall that researchers may encounter in SM-based research is multiple SM accounts for one user (Zoomers et al., 2016) or multiple users for one account (Kay et al., 2015; Liu & Zhao, 2017). This can be problematic during the analysis because, if not identified or controlled by researchers, it can lead to a bias in data accumulation for a particular site location (Dunkel, 2015) from highly active SM users, overshadowing the less active users (Ghermandi & Sinclair, 2019; Ilieva & McPhearson, 2018). Additional issues that should be deliberated include posts shared by non-human accounts (Ilieva & McPhearson, 2018) or automated services (Palomino et al., 2016), as well as posts spread deliberately to deceive people (Cong et al., 2014; Ghermandi & Sinclair, 2019).

Additionally, as already mentioned, locations which have higher quantities of data points for research may often be interpreted as being more attractive and valuable to the public (Ilieva & McPhearson, 2018). This is not always the case, however, as certain locations may have many data points originating from one SM user (Dunkel, 2015), some sites are not as easily accessible or well-connected to a mobile network, and the number of photos taken by a local of an area can differ severely by the number of pictures a tourist may take (Dunkel, 2015; Ilieva & McPhearson, 2018; Wood et al., 2013). The latter is especially important to consider as often, tourists tend to upload pictures at highly popular sites or share images that draw attention to themselves and their environment in a positive manner (Calcagni et al., 2019; Ghermandi & Sinclair, 2019).

The heterogenous nature of SMD, referring to the spread of mixed messages about certain subjects, can also lead to biased studies if not properly monitored (Ghermandi & Sinclair, 2019), as people's stated sentiments can often differ from their true opinions in a desire to become more socially accepted (Bacallao-Pino, 2014; Goodspeed, 2013) or people may deliberately aim to spread misinformation for various reasons (Ghermandi & Sinclair, 2019). This is especially true regarding textual SMD (Ilieva & McPhearson, 2018).

Lastly, the time frame that events occur in can introduce another source of bias into SM studies, especially those that occur as a one-time event such as natural disasters or celebrations such as weddings, anniversaries and birthdays, as well as seasonal events such as festivals, outdoor markets, summer activities, etc. (Ilieva & McPhearson, 2018). Hence, the specific time of the day, week, month, season, or even year can fully influence the relationship determined between a certain place and the meaning it evokes in an individual as a consequence (Godbey et al., 2005), as well as affect the size of the data gathered during the sampling period (Widener & Li, 2014). This is an important factor to recognize when using SMD for long-term planning of natural areas (Ilieva & McPhearson, 2018).

Lack of quality assurance of data

As demonstrated, there are many biases which can be introduced into a study using SMD. One of the main reasons for this is a lack in quality assurance of data, as the field is relatively still novel, and as a consequence, data is not always obtained using the best possible measures (Daume, 2016; Kent & Capello, 2013; Muller et al., 2015). For example, spatial bias can occur as an outcome of gaps in data (Catana 2016; Levin et al., 2017), or due to inaccuracy of geotagging (Calcagni et al., 2019; Kirilenko et al., 2015; Leibovici et al., 2017; Oteros-Rozas et al, 2018; Senaratne et al., 2017; Tenerelli et al., 2016). This can be countered with richer data sources but, unfortunately, large data quantities are usually only obtainable for highly populated areas such as popular tourist spots, whereas more remote locations often suffer from poor data or lack of data (Jongman et al., 2015; Richards & Friess, 2015; Tenkanen et al., 2017; Wood et al., 2013; Zhou & Xu, 2017). Additionally, as already mentioned, the time frame within which data is gathered, as well as the propensity of certain users to upload multiple posts, the activity pursued, and the value a tourist versus a local will give to a site can all have an effect on the quality of the data gathered for a study if not carefully monitored.

3. Data

The study focuses on the coastal areas of Estonia. The Estonian coastal areas, in the context of this study, included all shorelines of the Baltic Sea, lake Peipus, and lake Võrtsjärv. These two lakes are the largest in Estonia and have significantly long coastlines, and thus were decided to be included in the study analysis.

Data for the study was a CSV file of geotagged photos within a 20km (10km terrestrial and 10km marine) buffer zone of the Estonian coastal borders, uploaded to the social media platform Flickr. The original file included 69,623 photos. The data was originally extracted from Flickr by Oleksandr Karasov. The data includes relevant information such as the user id, latitude, and longitude coordinates of the photo, as well as the server number of the photo, a description of the image and keywords relating to it, the date and time the image was taken, the number of count views, likes, and comments each photo is given, and the URL at which the photo can be viewed (see Annex 1).

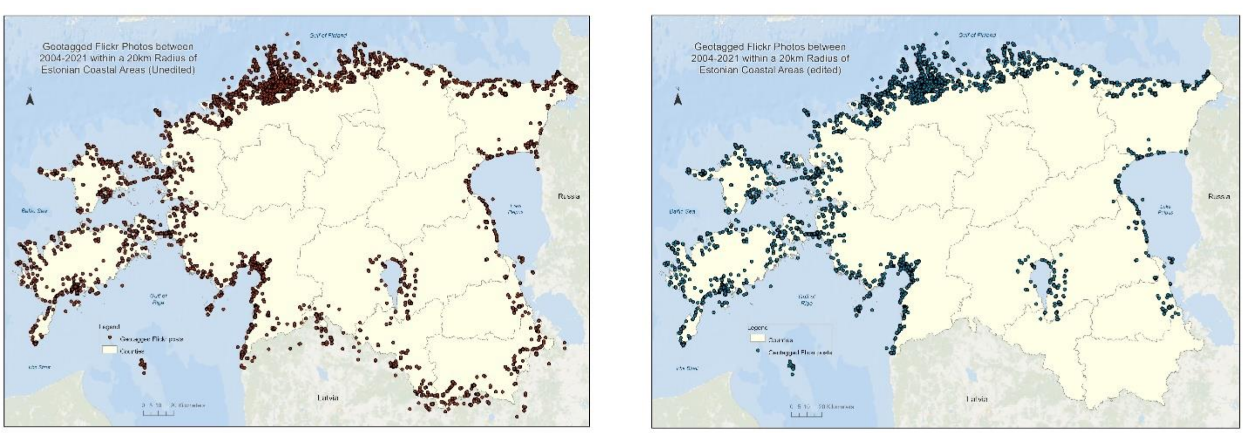
The platform Flickr was chosen because, although declining in popularity, the platform has over a decade of voluntarily uploaded information from users (Wilkins et al., 2021), with far fewer data access restrictions than the current top platforms such as Instagram and Facebook, which have discontinued providing location-based information to third-parties (Ghermandi & Sinclair, 2019; Karasov et al., 2020; Tenkanen et al., 2017; Teles da Mota & Pickering, 2020). The platform was established in 2002 and has grown to have tens of billions of images online and more than 100 million users as of 2021 (Flickr, 2021). The absence of strict privacy regulations of the uploaded images implies that researchers can download metadata that includes information such as what time and at which location an image was taken, the name of the user who uploaded the image, and the text associated with the image through the use of an API (Teles da Mota & Pickering, 2020). Moreover, several studies identified Flickr as a more relevant platform to capture CESs due to the content of photographs and users associated with the platform (Oteros- Rozas et al., 2018). Images uploaded to Flickr often relate more to passive recreation such as nature observation, sightseeing (Hausmann et al., 2018; Teles da Mota & Pickering, 2020; Ilieva & McPhearson, 2018), and biodiversity (Ghermandi & Sinclair, 2019), whereas images of active tourism such as hiking or biking are more often displayed through platforms such as Instagram (Angradi et al., 2018; Ghermandi & Sinclair, 2019; Hausmann et al., 2018; Teles da Mota & Pickering, 2020; Tenkanen et al., 2017). For example, a paper that compared the images taken at Kruger National Park in Africa found that the majority of photos uploaded to Flickr by users included images of wildlife, whilst the photos uploaded to Instagram from the same location were more of people and personal photographs (Hausmann et al., 2018; Teles da Mota & Pickering, 2020). Finally, Flickr is known for more high-quality professional images (Tenkanen et al., 2017; Teles da Mota & Pickering, 2020) compared to platforms such as Instagram and Facebook, which are considered as everyday use platform and thus often have less selective content.

In addition, the boundaries of Estonia were used. This was downloaded from the geoportal of the Republic of Estonia Land Board (https://geoportaal.maaamet.ee/). Generalized Estonian Topographic data was also used and downloaded from the geoportal of the Republic of Estonia Land Board. Lastly, the Estonian official 1x1km grid, used for population statistics, was also used. This was downloaded from the Spatial Data Catalogue of Estonia (https://metadata.geoportaal.ee/geonetwork/srv/api/records/stat_grid).

4. Methodology

The full analysis (refer to Figure 2) was carried out using ArcGIS Pro 2.6 and MS Excel. The CSV file was converted into point layer based on XY coordinates and reprojected into the Estonian National coordinate reference system in ArcMap 10.7. Next, the point data was cleaned by eliminating all points not related to Estonian coastal areas, namely point data along the terrestrial Estonian-Russian border and Estonian-Latvian border. After this step, the dataset consisted of 65,821 points with geo-tagged photos (Figure 1).

Figure 1. The location of geotagged social media photos uploaded to the SMP Flickr within a 20km (10km land and 10km sea) distance of the Estonian border. Left: Original complete data set of images acquired from Flickr. Right: Pre-processed data set, with photos along the Estonian-Latvian and Estonian-Russian land borders removed.



The quantitative analysis included two main phases. The first phase was to create several buffer zones along the coastline in order to identify at which distance photos became irrelevant to the coastal environment. As the initial data included photos posted within 10km of either side of the coast, the buffer zones first chosen were 500m, 1km, 2km, 5km, and 10km. After establishing the initial buffer zones, however, it was decided that many of the photos past 1000m became irrelevant for the study. This was determined by scanning through the downloaded images and identifying whether coastal ecosystems were present in the photos outside of the 1000m buffer zone. This is in line with research that shows that landscapes are perceived at an average maximum distance of 1000m, after which objects become less clear to perceive visually (Piek et al., 2011). Thus, a buffer of 1000m corresponded exactly to the landscape scale. As a result, all of the photos exceeding a 2000m radius (1000m towards sea and 1000m towards land) of the coastline were eliminated from the study. However, an issue still remained regarding coastal cities such as Tallinn, Pärnu, and Haapsalu. These cities, with their downtown areas well within 1000m of the coast, still retained many points irrelevant to coastal ecosystems. Thus, in coastal city areas, the buffer considered in the study was reduced from 1000m inland to 200m inland. Points were removed manually through the tool *Select by polygon* in ArcGIS. The marine side buffer, however, was kept at 1000m as all water-related activities were considered vital to analyze in the study. Thus, in total, 15,420 images remained in the study.

The second phase of the quantitative analysis involved running the *Optimized Hot Spot Analysis* tool. Hotspot analysis identifies where clusters of high values (hot spots) and clusters of low values (cold spots) are located. A hot spot indicates that multiple 1km grid cells with a high number of photos are located close together, whereas a cold spot indicates an area where multiple 1km grid cells with few photos are located together. Areas with no photos at all are not represented on the map and can therefore be interpreted as the least visited locations. Photos were analyzed based off Photo-User-Days (PUD) (Zhang et al., 2020). This step, however, required additional data processing. PUD is a unique combination of the date a photo was taken combined with the owner ID. Thus, it was necessary to export the already pre-processed data into MS Excel and create a new column that combined both of these attributes. Duplicates were removed so as to limit the bias created when one user uploads multiple photos at the same location (Wilkins et al., 2021; Zhang et al., 2020). The file was then exported and added back to the map. This left 3,300 unique photo combinations that could then be used for the PUD analysis. However, it is important to measure PUD per some geographic unit (Zhang et al., 2020). Therefore, a 1x1 km grid (used for official Estonian population statistics), was used for this step. The tool *Summarize Within* was used to count how many photos were present per grid square using the pre-processed PUD photos. Lastly, the *Optimized Hot Spot Analysis* tool was run. The final addition to the quantitative analysis included an evaluation of photo count per population density. First, a spatial join was created between the pre-processed data points and population density data. Then, a new field was added to the attribute table. The field was calculated by dividing the pre-processed number of photo points within a 1x1km grid square by the population density within the same grid square.

In addition to quantitative analysis, exploratory analysis was performed. As the majority of CES studies (about 90%) use traditional visual content analysis methods to categorize activities in images into different types of CES (Wilkins et al., 2021), this consisted mainly of identifying the coastal locations most frequented by visitors and then looking at image content to understand the possible motivations behind visitation rates. To better capture the full variety of CES-related activities present in each location, a preliminary visual content analysis including all of the pre-processed data points (15,420 images) was conducted. Data points intersecting with hotspots identified in the previous step were manually selected using the tool *select by lasso* and then exported into new layers. Manual selection was preferred over automatic selection so that each hotspot could be uniquely identified for further analysis. A new field, *coast*, was added to the attribute table of the data points and using the image url present, each image was manually checked to identify whether the image related to coastal ecosystems. If the image related to coastal ecosystems, a 1 would be given to the new field. If not, a 0 would be assigned. Annex 2 demonstrates the keywords identified as relevant or irrelevant to Estonian coastal ecosystems. All irrelevant photos were then eliminated from the study, leaving the final data count with 7, 231 images.

The next step of the analysis included manually assessing and classifying the content of each image into the appropriate CES-related category. The categories chosen for this study included recreation, aesthetic pleasure, identity, and education, as they have more material carrier than CES activities related to other categories such as reflection, existence, or spiritual value, for example (Zhang et al., 2020). In order to limit bias, however, it was first necessary to define each category. For the purpose of this study, the chosen definition of recreation was "activities or experiences carried on within leisure, usually chosen voluntarily by the participant - either because of satisfaction, pleasure or creative enrichment derived, or because [they] perceive certain personal or social values to be gained from them" (Kraus, 1978). With this in mind, and the knowledge that it was not possible to directly engage with the user of the photo to question their true motivations in the image, an image would be classified as recreation if engagement in an activity was shown, or amenities pictured in an image were directly meant to facilitate recreational activities (restaurants, boat harbors, parking lots, etc.). Aesthetic pleasure was defined as "the pleasure people derive from processing the object for its own sake, as a source of immediate experiential pleasure in itself, and not essentially for its utility in producing something else that is either useful or pleasurable" (Berghman & Hekkert, 2017). Thus, to classify an image as relating to aesthetic pleasure, it was necessary to ask whether the photo was displaying an attraction solely for its own sake, no matter if the attraction was natural or man-made. Though there are numerous types of identity, sense of identity here was defined as a "phenomena where people identify themselves with a certain scale of region with its people, culture, traditions, landscape, etc. The bigger the area represented on the map, the bigger the role of symbolic aspects of the environment" (Shao et al., 2017).
Furthermore, "Identity of a place is also viewed in relation to the historical heritage and the traditional characteristics of the region" (Ilieva & McPhearson, 2018; Shao et al., 2017). Therefore, to classify an image as relating to sense of identity, it was necessary to determine whether the image content had a specific relation to the local, regional, or national identity of the area or Estonia as a whole. Lastly, for the purpose of this study, education and intellectual development was defined as "the transmission of the values and accumulated knowledge of a society" (Thomas et al., 2021). However, as it is difficult to judge whether an experience is transmitting any sort of values amongst a group, only photos depicting direct messages that an experience is meant for educational purposes was considered as educational (such as field trips and group excursions).

Once each category was defined, the final step was to determine how an image could be classified as relating to or unrelating to the respective category. This was done by investigating the content of the pre-processed images and, once again, breaking each category further into subcategories and keywords. Table 2 depicts the breakdown of the various categories, subcategories, and keywords used to classify an image. Each image was then viewed manually and classified based off the CES categories present in the photo. Text associated with the image (image caption or description) was sometimes also used as an additional means of classifying the activity occurring, though not frequently as most images did not have any associated text describing them. Images could either have one or multiple of the CES categories present. Once every image was classified, *select by attribute* was used to select and export the images relating to each category. At this point, maps using graduated symbology were created to present which areas had the highest and lowest number of photos relating to the chosen CES aspect.

Table 2. Categories, sub-categories, and main keywords used to categorize Flickr images representing CES services related to coastal ecosystems in Estonia.

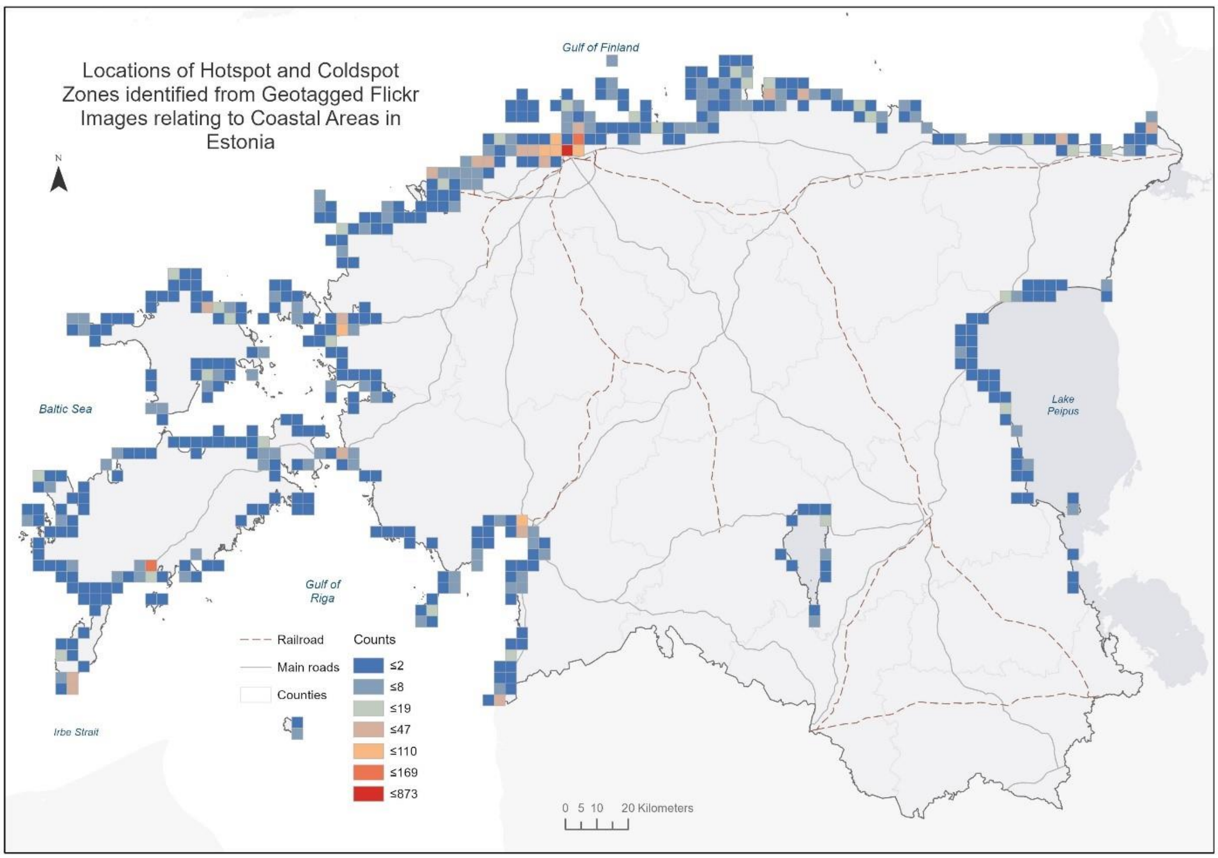
CES CATEGORY	SUB-CATEGORY	KEYWORDS
RECREATION	Activities	Swimming, walking, running, biking, fishing, sailing, kitesurfing, paragliding, motorcycling, playing, building
	Facilities	Trails, recreation centers, parking lots, seaside cafes/restaurants/hotels, viewing platforms, benches, tables on beaches, changing rooms, sports
	Attractions	Lighthouses, museums, cliffs, castles, windmills, nat. geo shot frame
AESTHETIC PLEASURE	Natural attractions	Coastline, beach, water, sun rise, sunset, northern lights, cliffs, flowers
	Human-made attractions	Piers, viewing platforms, beach art
SENSE OF IDENTITY	Sense of Identity	Flags
	Local culture	Residential houses along coast, fish for sale, northern lights, port
	Historical attractions	Castles, windmills, lighthouses, museums
EDUCATION & INTELLECTUAL DEVELOPMENT	Man-made	Museums, historic landmarks (windmills, monuments, statues, castles, lighthouses), signs in parks, art
	Natural	Biodiversity (animals, plants)
	Institutions	Cruise line

Figure 2. Description of workflow.

5. Results

The location of the hotspots detected in Estonia can be seen in Figure 3. The majority of the hotspots along the northern boundary of Estonia were located within the vicinity of the capital city of Tallinn. Other hotspot areas were also mainly located near main city areas, such as those around Haapsalu, Pärnu, and Kuressaare. However, several hotspots were also located in national park areas, such as Lahemaa National Park in the north of Estonia, Matsalu National Park in the west of Estonia, and Vilsandi National Park, in the west of Saaremaa Island. Hotspots were also detected around lake Peipus and lake Võrtsjärv, as well as in border crossing areas of Estonia-Latvia and Estonia-Russia.

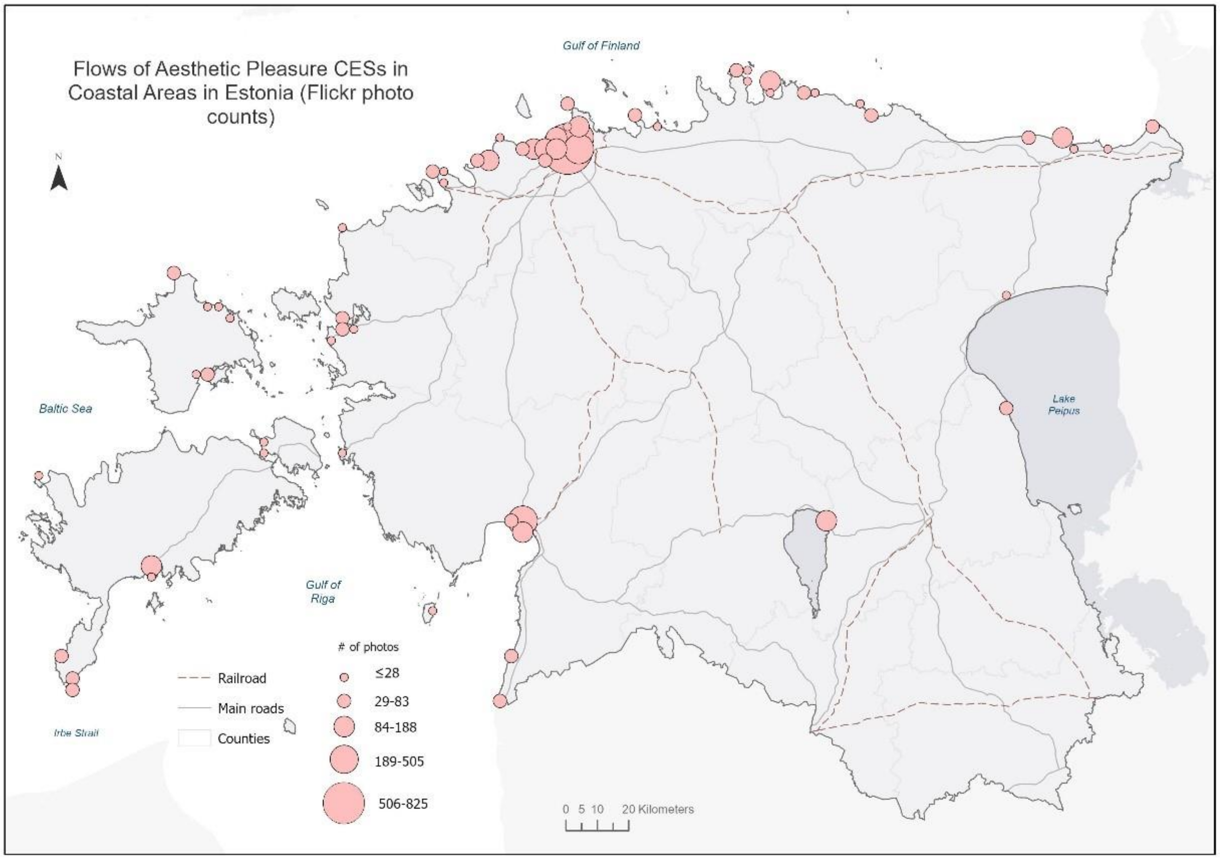
Figure 3. Location of hot and cold spots relating to geotagged SM photos of Estonian coastal areas.



The rest of the study was carried out using only hotspot areas with greater than 19 counts. Counts represents the number of photos within the hotspot areas. Within these hotspot areas, 3,336 photos were classified as displaying recreational value, 4,784 photos were classified as displaying aesthetic appeal, 2,732 photos were classified as displaying a sense of identity, and 157 photos were classified as displaying educational development.

All CES groups considered were well-represented by the images analyzed, with the exception of education. Aesthetic pleasure was the most recognized group of CESs (refer to Figure 4), as it was identified in every hotspot location and over 66% of the photos examined were categorized as displaying aesthetic appeal. The highest presence of photos displaying aesthetic appeal was found within the vicinity of the Tallinn metropolis, with 825 geotagged photos categorized as "aesthetically pleasing." Similarly, the second highest number of photos, up to 505 geotagged photos, were also found within the Tallinn metropolis area, as well as in the main city area of Pärnu. 11 locations were identified as displaying aesthetic appeal within at least 188 geotagged photos within the Tallinn city area, as well as in the Pärnu city area, Kuressaare city area, lake Võrtsjärv area, near Lahemaa National Park, and near Toila-Oru Park. 22 areas displayed aesthetic appeal within at least 83 photos, and 25 areas displayed appeal within at least 28 photos. Content determined as aesthetically appealing could be seen in Table 2. Examples of images classified as aesthetically appealing can be seen below Figure 4, and additional images can be found in *Annex 3.*

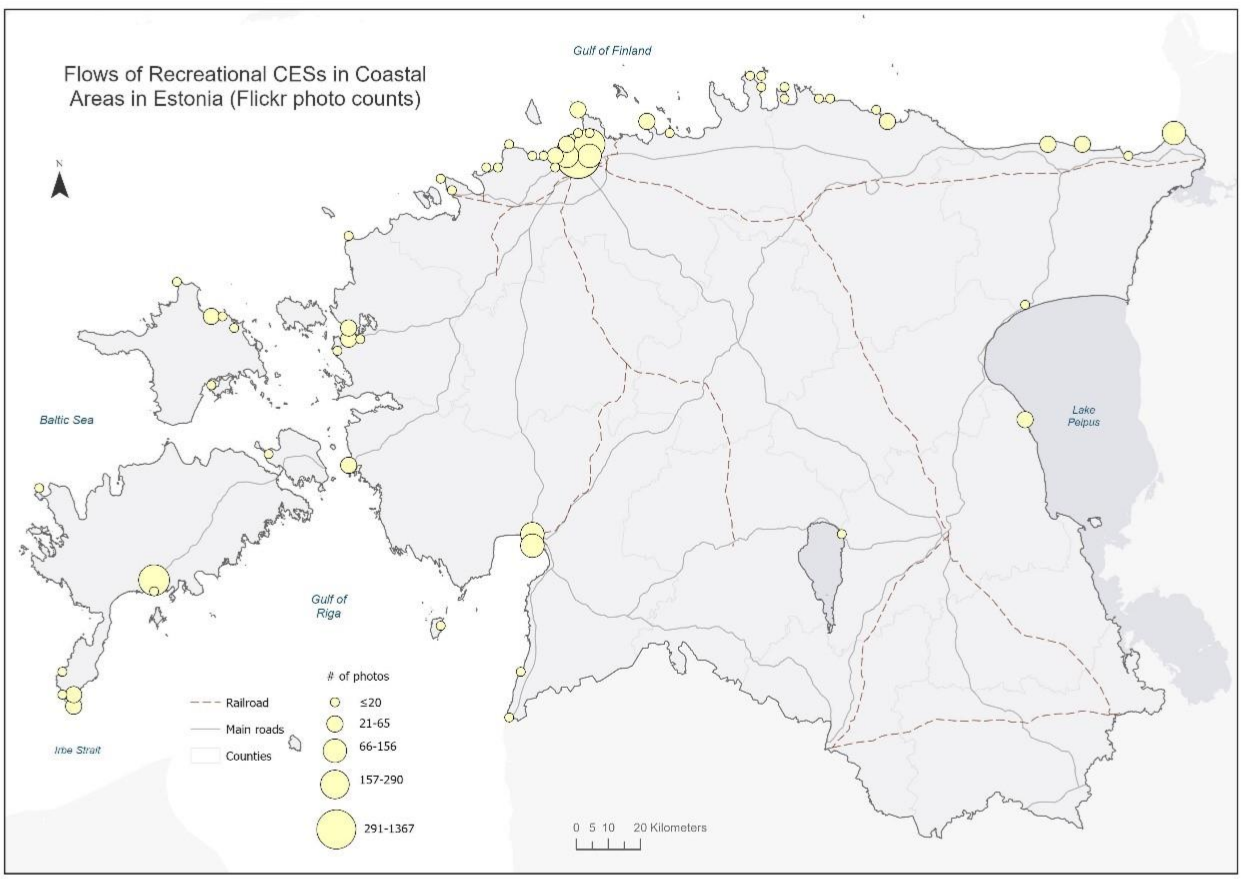
Figure 4. Flows of Aesthetic CESs as classified via geotagged Flickr images uploaded in coastal hotspots of Estonia.



Examples of photos from flows of aesthetic CESs.

Recreation followed aesthetic appeal as the second most recognized CES provided in coastal hotspot areas, with recreational activity being present in each hotspot zone and 46% of images displaying a connection to recreational activity (refer to Figure 5). The largest hotspot was also found within the Tallinn metropolis area, with 1,367 geotagged photos displaying recreational activity. A majority of activities depicted within this hotspot zone were connected to the many cruise and ferry ships that pass by and the recreational activities associated with them. However, outside of the Tallinn metropolis, recreational activity identification decreased dramatically. The second largest hotspots, occurring within the Tallinn metropolis and Kuressaare main city area, displayed recreational activity in 157-290 geotagged photos. 4 hotspot zones, with 66-156 photos displaying recreational activity, were also found within the Tallinn metropolis area and Pärnu main city area. 1 was found near to the Estonian-Russian border, at the beach of Narva-Jõesuu. The latter was largely in part due to a beach volleyball tournament that occurs there during the summer months, as well as beach concerts. 14 hotspot zones were identified as having 21- 65 photos depicting recreational activity, and 37 hotspot zones were identified with 20 or less geotagged photos depicting recreational activity. The content classified as recreation can be seen in Table 2 and example images of recreation can be seen below Figure 5, as well as in *Annex 3*.

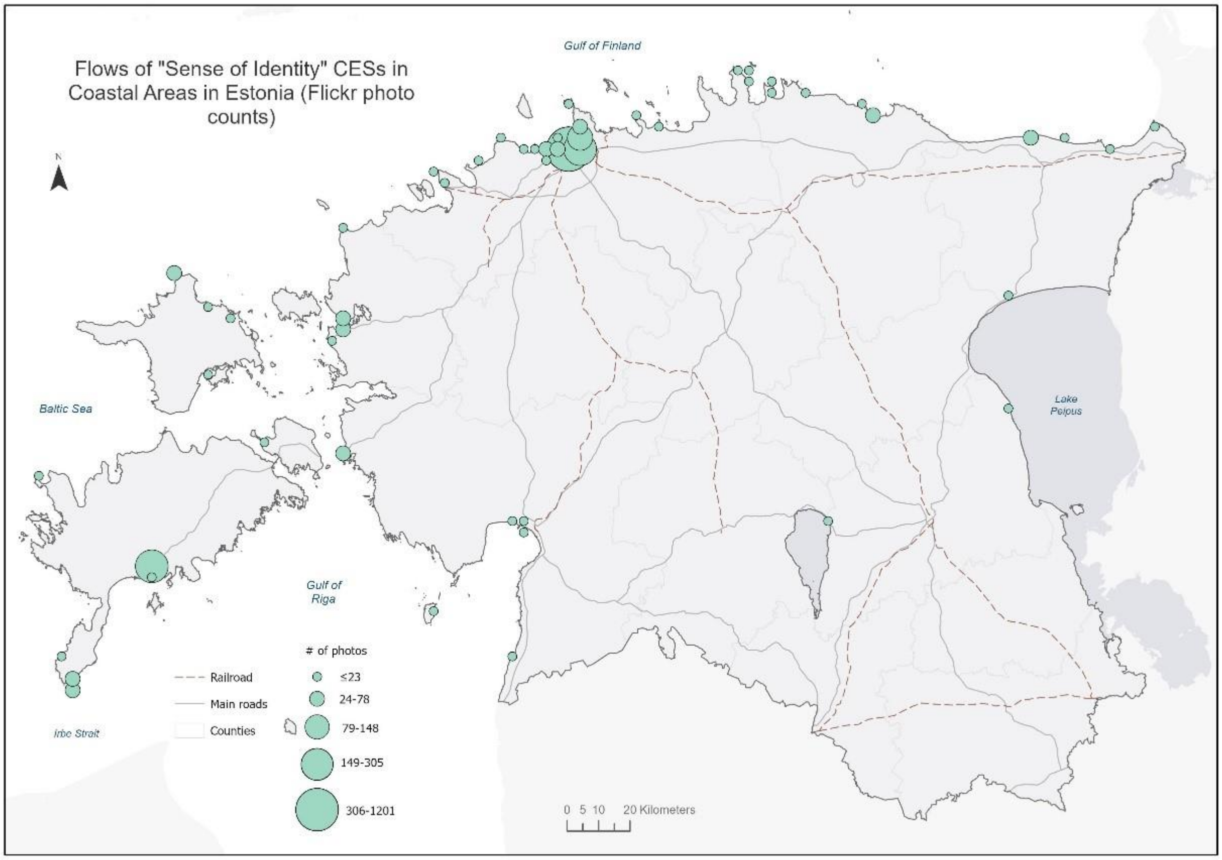
Figure 5. Flows of Recreational CESs as classified via geotagged Flickr images uploaded in coastal hotspots of Estonia.



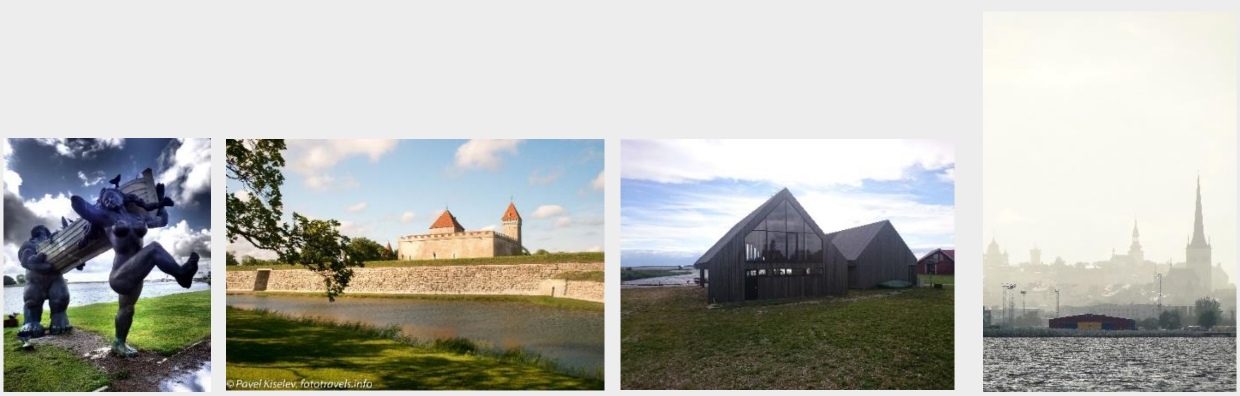
Examples of photos from flows of recreational CESs.

Sense of identity (refer to Figure 6) was detected in 37.8% of all images within coastal hotspot zones. Again, the Tallinn metropolis area demonstrated the highest presence of this CES, with 1,201 geotagged photos displaying a relation to identity. This was mainly in relation to the identity of Tallinn as a port city, and the many images that depicted the port, as well as ferry and cruise lines. Images taken of the Tallinn city skyline, picturing the Estonian flag, or of significant landmarks such as the Tallinn "Linnahall" - an old, multi-purpose, soviet amphitheater, and the Tallinn Maritime Museum were also considered as "identity". The second largest hotspot zones displaying "sense of identity" were also located within the Tallinn metropolitan area, as well as within the Kuressaare main city area. These hotspot zones had between 149-305 photos categorized under "sense of identity". Another hotspot zone, also within the Tallinn metropolitan area, had between 79-148 photos classified as "sense of identity". 11 hotspot zones had between 24-78 photos relating to sense of identity and 38 hotspot zones were identified as having 23 or less photos relating to sense of identity. Sense of identity was detected in most but not all hotspot zones. Additional content classified as "sense of identity" can be seen in Table 2 and images related to identity can be seen below Figure 6, as well as in *Annex 3*.

Figure 6. Flows of "Sense of Identity" CESs as classified via geotagged Flickr images uploaded in coastal hotspots of Estonia.

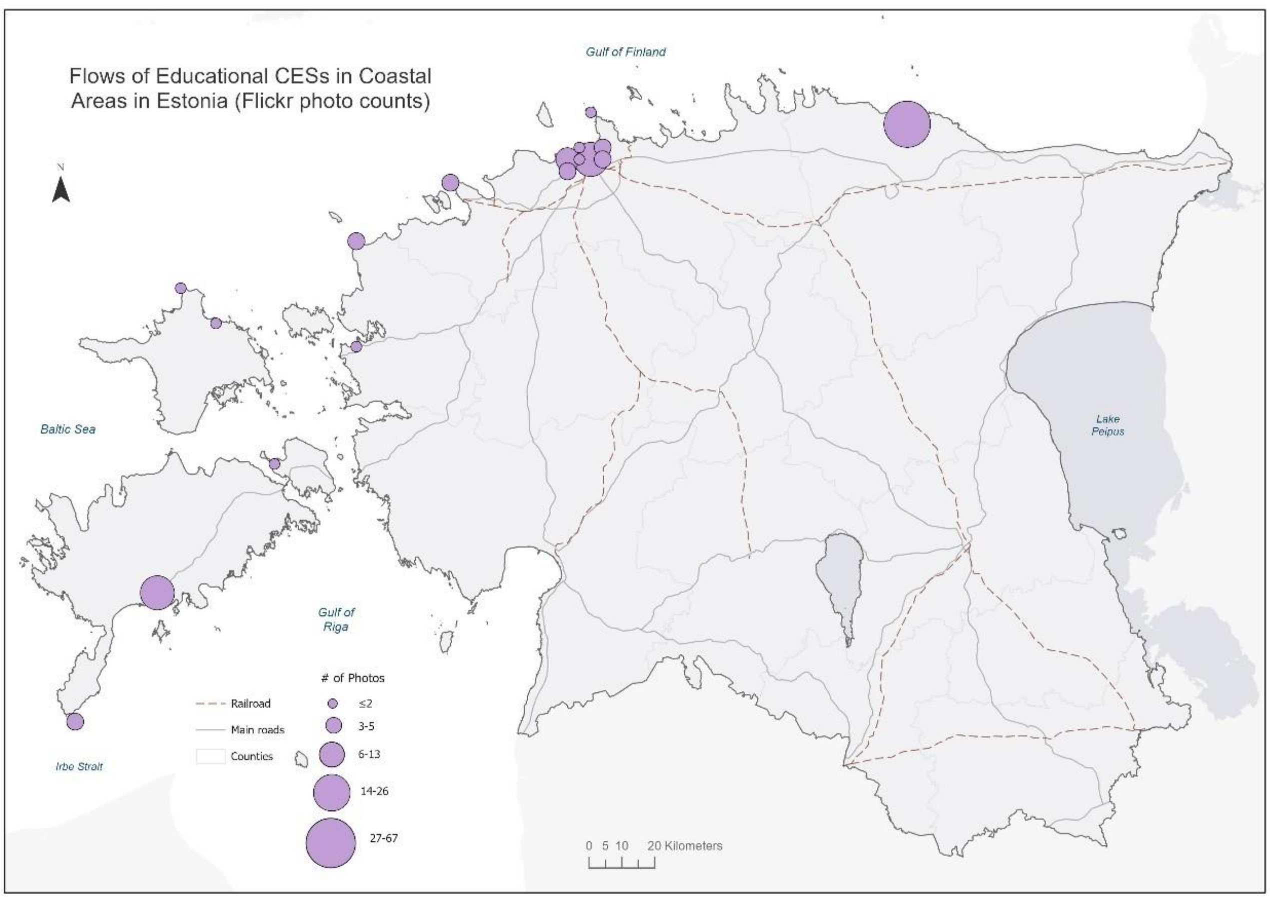


Examples of photos from flows of "sense of identity" CESs.



Education was the least recognized CES, with only 2.17% of all images in hotspot zones depicting a connection to education (refer to Figure 7). This was mainly in part due to the difficulty in classifying an activity as educational, without clear indications that the activity was, indeed, educational. Only 17 hotspot areas were classified as relating to education, of which the largest one, with 67 photos, was located near the small town of Toolse, along the north-eastern coast of Estonia. This was in part due to the associated text that accompanied the images of the Toolse Castle, which described the history of the castle. As many images did not have accompanying text to convene whether a landmark was simply being admired or was serving educational purposes, this text was considered as proof that this landmark was being visited for an educational reason. The next largest hotspot zones were located within the Tallinn metropolis and Kuressaare vicinities, with 14-26 images classified as "educational". As Tallinn is known for its many historical landmarks and museums, this result was to be expected. Additionally, Kuressaare also hosts a medieval castle popular to both locals and visitors and therefore this result was also to be expected. 1 hotspot zone with 6-13 images was identified as educational, also within the Tallinn city area. 6 hotspot zones with 3-5 images were identified as educational: 3 within the Tallinn city area, 2 along the northwestern coast of Estonia, and one on the island of Saaremaa. Finally, 7 hotspot zones with 2 images or less were identified as relating to education. These were found within the Tallinn city area, along the western coast near Haapsalu, as well as on the larger islands of Hiiumaa and Saaremaa. Categories identified under education include wildlife biodiversity such as bird watching, as well as educational signs in park areas. A full description of what was considered as "educational" can also be seen in Table 2, and example images can be found below Figure 7 and in *Annex 3*.

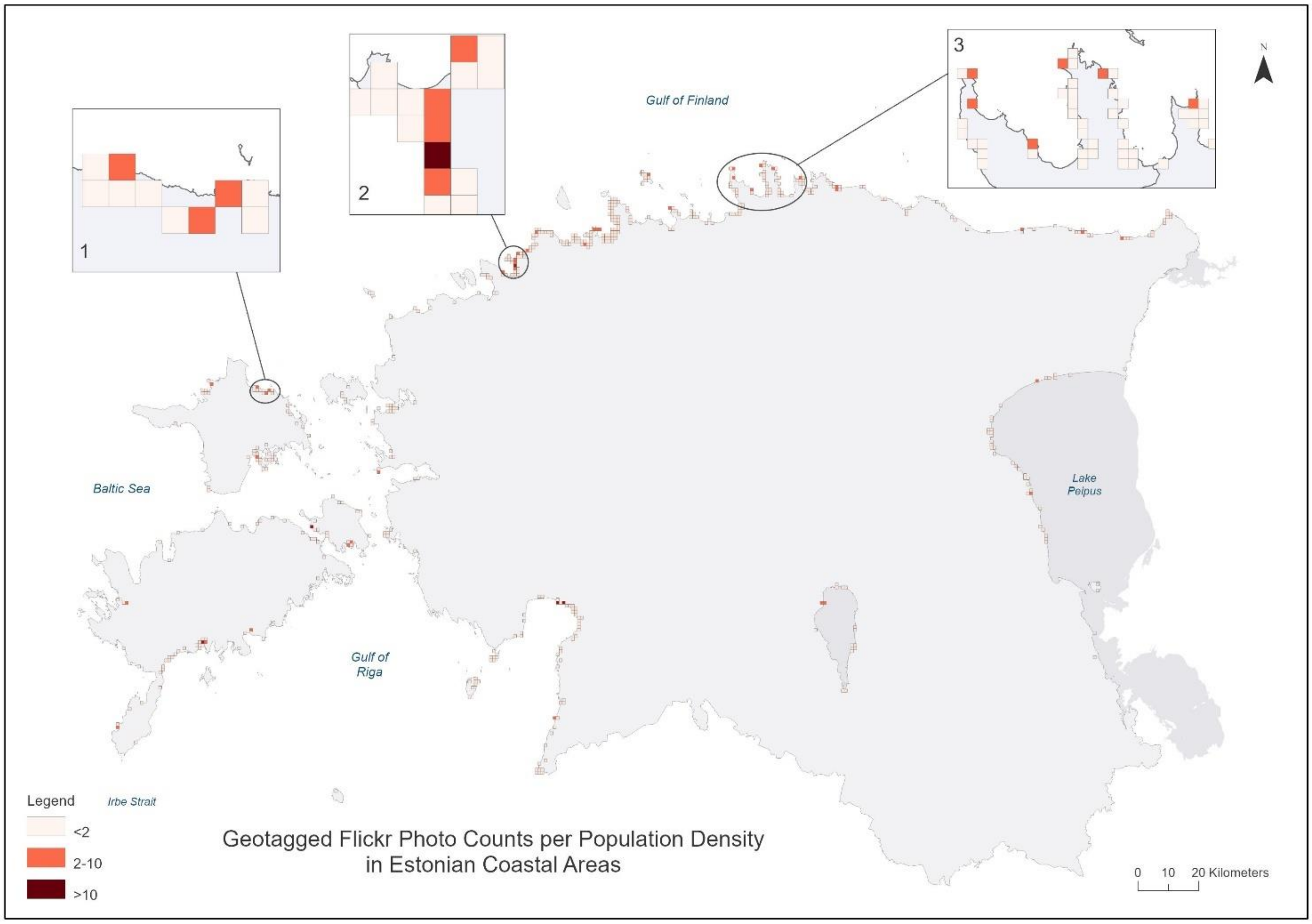
Figure 7. Flows of Education CESs as classified via geotagged Flickr images uploaded in coastal hotspots of Estonia.



Examples of photos from flows of educational CESs.

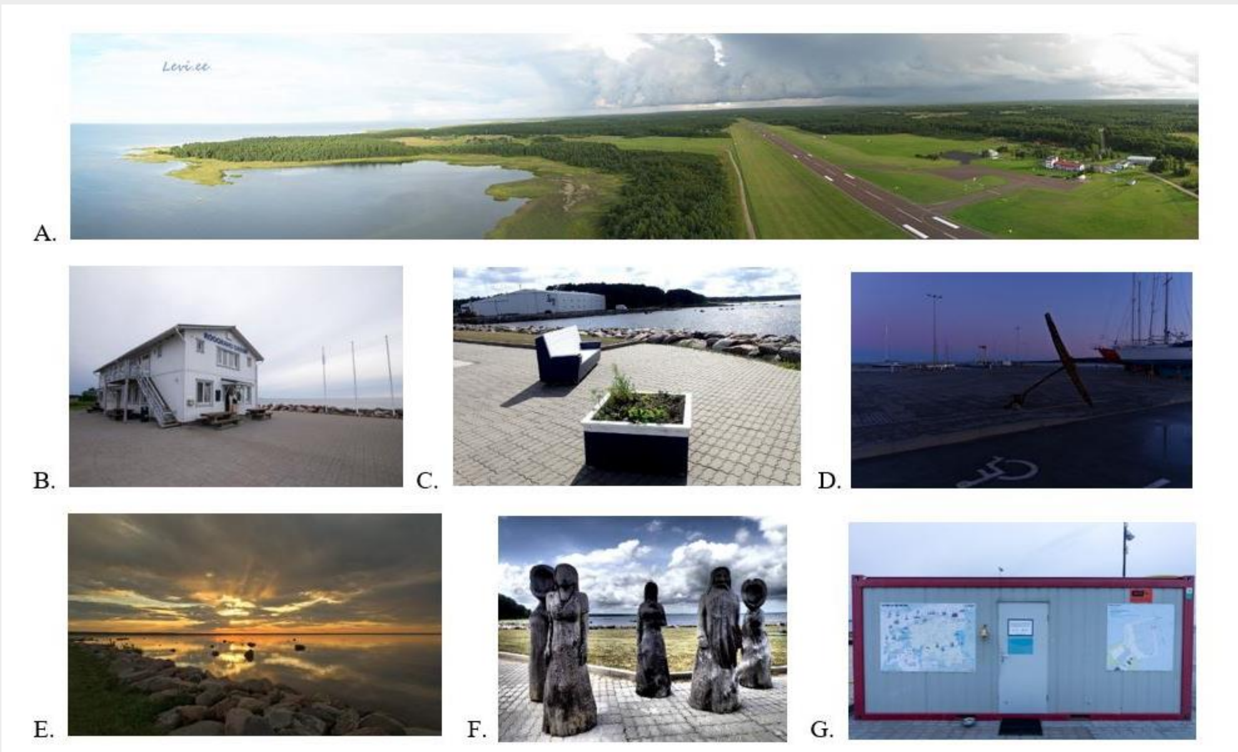
Lastly, the study looked at the number of geotagged Flickr photo counts per population density in Estonian coastal areas. The purpose of this was to identify which areas of the coastline had a high number of photos compared to population density and investigate the reasons for their popularity. Figure 8 depicts the location of these areas. Many of the locations were within main city areas. However, some of the locations were outside of main cities. To determine the motivations behind their popularity, three areas with aggregated hotspot zones were chosen for further evaluation. Inset zone 1, located on the island of Hiiumaa, for example, depicted a variety of recreational activities possible within the area, as well as facilities to support these activities. Inset zone 2, home to Laulasmaa nature reserve and Kloogaranna rand beach, is known for hiking trails as well as a beautiful and secluded beach. Its relatively short distance to Tallinn and its ease of access via public transport make it a perfect spot for a day trip, seen by the many photos depicting coastal scenery. Many images also depicted an aerial view of forest and coast. Thus, this location can be said to have high aesthetic pleasure value. The third inset zone emphasized was located within Lahemaa National Park. The national park is the largest national park in Estonia and contains a variety of landscapes. Also located within close proximity to Tallinn, it can be easily reached by public or private transport by both visitors and locals. The high recreational and aesthetic value of the park can be seen through the variety of activities depicted in the photos, ranging from coastal landscapes, recreational facilities such as cafes and harbors, as well as historical landmarks (lighthouses, war memorials, submarine base).

Figure 8. Inset maps depicting geotagged Flickr photo counts per population density in Estonian coastal areas. Images depicting the content of photos uploaded within each inset zone, along with an explanation of image content, can be seen below.



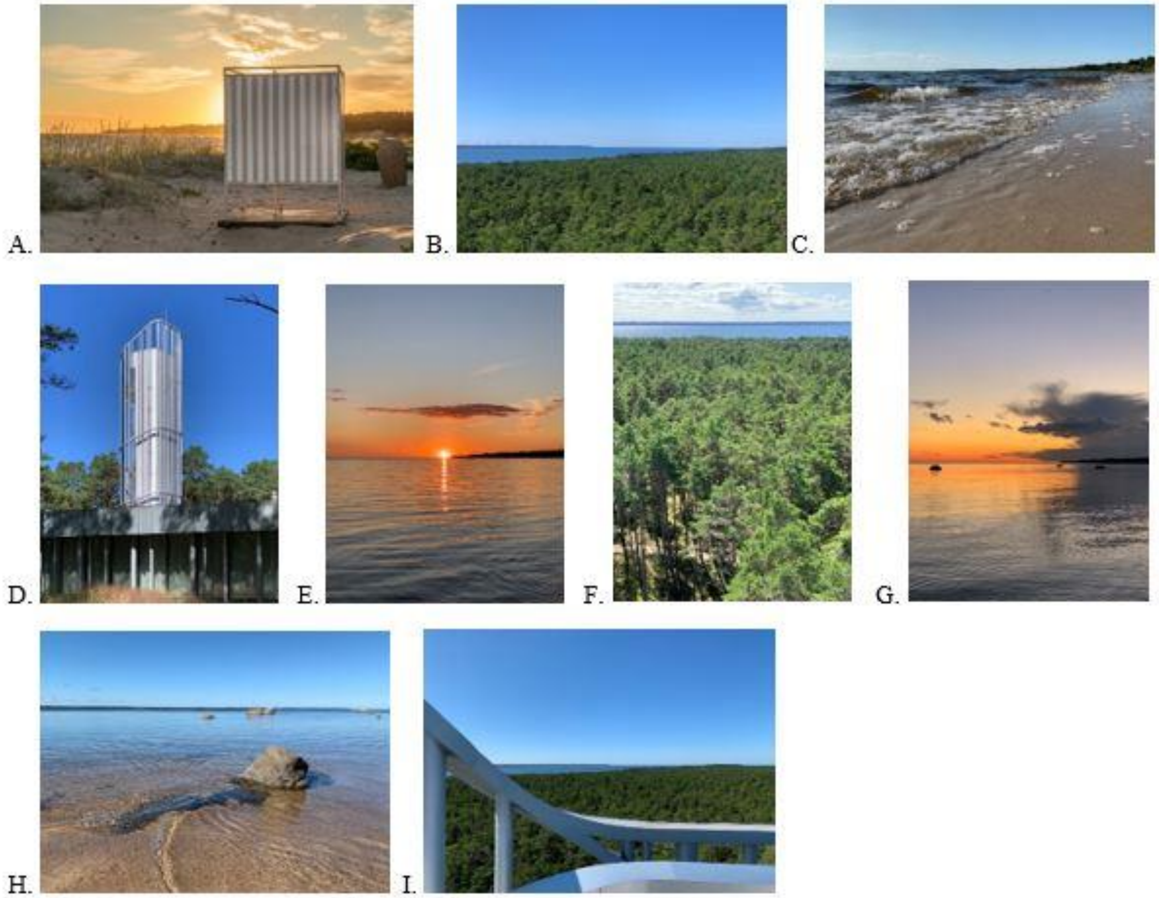
Inset 1:

Inset 1, located in the north of the island of Hiiumaa, depicts images relating to an airfield space (A), a café (B) located within a marina (C, D, G), several statues located next to the shoreline, and areas for observing the surrounding landscape. The lack of residential housing indicates that population, however, is low in the area and thus, most visitors are drawn to the area to participate in the variety of activities possible. This is clearly visible in the photos uploaded within the area as many of the photos depict activities relating to recreation and aesthetic pleasure, which makes the area popular with visitors.



Inset 2:

Inset 2, located to the west of Tallinn, is home to Laulasmaa nature reserve, Kloogaranna rand beach, as well as attractions such as the Kõltsu manorand. The area is easily accessible by public transport from Tallinn, but far enough away to avoid the large crowds that can occur at beaches located closer to the city. In fact, the beach is known for its beauty, cleanliness, and lack of crowds (C, E, G, H). Furthermore, though it is pleasantly undeveloped, facilities such as changing rooms (A) and cafes exist, and new boardwalks have been put in place within recent years. Additionally, a popular viewing tower (B, D, F, I) exists that allows viewers to overlook both the forest and the sea simultaneously. Thus, this location can be said to have high recreation and aesthetic CES flows, as seen from the content of the images uploaded within the area.



Inset 3:

Inset 3 depicts images from various locations around Lahemaa National Park. The park is the largest national park in Estonia, and one of the largest in Europe in general. The area is located conveniently close to Tallinn and is accessible via private or public transportation. This makes it perfect for day trips for both visitors and locals. A variety of landscapes exist there, including sandy and rocky beaches, forest, bogs, etc. Its high recreational and aesthetic value can be detected from the photo content, shown through randomly selected geolocated images uploaded to Flickr within the area (below). Images depicting coastal scenery (I, K, L, M, N), lighthouses (F), seaside cafes (G), a war memorial dedicated to the ships that fell in 1941 (B, C), an old submarine base - Hara Allveelavade Sadam (A, E, H, J), and the area around Viinistu Harbour (D), were just among a few of the various activities found within the vicinity of the national park.

A.

B.

C.

D.

E.

F.

G.

H.

I.

J.

K.

L.

M.

N.


6. Discussion

It is clear from the results that the key hotspots of CES flows are concentrated around main city areas in Estonia, such as Tallinn, Kuressaare, Pärnu, and Haapsalu. This is to be expected, as a higher population density in city areas implies that there are more people within those cities and therefore more possibilities for pictures to be taken and uploaded to SMP (Hausmann et al., 2017). Indeed, the highest flows of recreation, aesthetic pleasure, and sense of identity were identified in the hotspot zone correlated with the largest number of photos uploaded within the area. Specifically, 3,662 geotagged photos relating to coastal ecosystems were uploaded within the vicinity of the Tallinn metropolis, and between 600-1000 photos were uploaded in the surrounding hotspot zones of the Tallinn metropolis. Other main cities such as Kuressaare, Pärnu, and Haapsalu only saw between 450-800 photos uploaded within hotspot zones. Outside of main city areas, photo uploads ranged between 1-400 photos.

Tallinn, the largest city in Estonia, hosts a population of 451,776 residents (Tallinn, 2022) as of 2022. Besides its local population, however, the city also acts as an important hub for both local and international tourists. In fact, according to mobile positioning data provided by the Bank of Estonia, out of the 6.12 million foreign tourists who visited Estonia in 2017, 74% of them visited Tallinn alone (Positium LBS, 2018). And while the airport in Tallinn greeted 2.64 million people that same year, Tallinn's Old City Harbor saw more than 10.5 million passengers passing through its port (Statistics Estonia, 2018). A majority of these tourists (83%) came via the Tallinn-Helsinki ferry route, 10% travelled via the Tallinn-Stockholm ferry route, and 1% travelled via the Tallinn-St. Petersburg ferry route (ibid). 6% of all travelers came from cruise ships travelling the Baltic Sea, with Tallinn being the third most frequented destination by cruise lines in the Baltic that year (ibid). Thus, Tallinn's harbor undoubtedly plays an important role in the identity of the city. This was made clear by the large number of geotagged photos depicting cruise ships, ferry lines, and the harbor within the largest hotspot zone in Tallinn, as well as in some of the hotspot zones nearby. As cruise ships and ferry lines can have both recreational values, as well as play a role in the identity of the city as a port, all photos relating to these topics were considered as providing both recreational CESs and "sense of identity" CESs. Several photos also depicted courses occurring on ships, as well as workrooms depicting navigation charts, control systems, etc. These were then considered as educational categories and thus contribute to the second largest hotspot of educational CESs in Tallinn. Other photos taken from cruise ships and ferries often involved the skyline of the city of Tallinn, as well as images of the sea. These were normally then categorized as "aesthetic pleasure" CESs, "sense of identity", or sometimes both.

In addition to the cruise and ferry lines related to Tallinn's Harbor, the city of Tallinn also has numerous attractions within a short distance of its coastline. For example, Tallinn's "Linnahall", a multipurpose amphitheater built in the 80's, is a popular hangout spot and viewpoint of the Tallinn city harbor. Patarei prison, along with the Estonian Maritime Museum "Lennusadam" located adjacent to it, are also highly visited recreation points in the city. Walking trails connecting the prison to the museum also provide a vantage point to admire both attractions, whilst also providing an excellent view of the sea. Port Noblessner, a novel seaside promenade and residential area with chic apartments, restaurants, cafes, shops, and a yacht harbor, is also within the area. Accordingly, this space offers a plethora of recreational activities, aesthetically pleasing views, "sense of identity" of the city of Tallinn and Estonia in general, and a multitude of educational opportunities. These attractions, as well as the beaches in the area and the above-mentioned cruise and ferry lines, account for the majority of the photo content uploaded within the largest hotspot zone in Tallinn, leading to the highest identification of recreation, aesthetic pleasure, and sense of identity CESs in Estonia.

Outside of the main city of Tallinn but still within the surrounding areas are many boat harbors and beaches (Pirita beach and Stroomi beach, for example), as well as volleyball courts, the open-air ethnographic museum, sauna park, exercise parks, and general seaside promenades. As a result, the surrounding area of the city of Tallinn had many hotspot zones which also showed high flows of CESs relating to all 4 categories. Here it is important to keep in mind that many factors impact the ability of an ecosystem to provide CESs. The accessibility of the landscape, measured by the distance and density of roads to trails, for example, or roads to cities is repeatedly noted among studies to be the most important factor influencing CES (Thiagarajah et al. 2015; Willemen et al. 2015), This is because areas that are easily accessible can receive all types of visitors, and often act as the first documented (through photographs, for example) stopping point for visitors (Zhang et al., 2020). This is further confirmed by study results claiming that CES decrease as distances to urban areas increase, along with a decline in CESs in areas that lack human modification (ibid). The city of Tallinn is well-connected to its surrounding neighborhoods, with frequent public transport. Thus, the location of these hotspot zones close to the city could play a significant role in the high flows of CESs represented in the extended areas of the Tallinn metropolis.

The role that proximity to urban areas plays on location of hotspot zones was also detectable outside of Tallinn. Pärnu and Kuressaare, for example, both also had several hotspot zones detected adjacent to one another in terms of recreational CESs, aesthetic pleasure CESs, and sense of identity CESs. An additional factor that can affect CESs are seasonal conditions. Seasonal conditions can heavily influence CESs as certain areas may become more or less accessible based off time of year and weather patterns (Egorova, 2021). This trend could be detected in Pärnu, Estonia's fourth largest city. Known as the "summer capital" of Estonia, this resort town is known for its many spas, white sandy beaches, and numerous parks. During its peak holiday season, between May-September, the city comes alive offering visitors' concerts, festivals, and numerous nightclubs in addition to daily beach activities (VisitParnu, 2022). Indeed, in 2017, 714,000 domestic and foreign tourists visited the city during the summer season (2019 PÄRNU OUTDOOR MEDIA, 2019.) As a result, it is not surprising that the city and its surrounding areas saw high flows of recreational CESs relating to summer activities. The visual content analysis of the photos uploaded within this hotspot zone revealed numerous recreational activities, including kitesurfing, volleyball games and football matches, people swimming in the sea and tanning on the beach, and children playing on the numerous playgrounds within the area. Other activities presented included beach concerts, fishing, and people engaging in picnics on the benches and tables located in the beach area. Piers and walking areas also appeared to provide nice vantage points of which to admire the sea and surrounding landscapes, as well as spectacular sunrises and sunsets. This contributed to the flows of aesthetic pleasure CESs identified in the area. The city of Pärnu also hosts a relatively large port. Though mostly cargo traffic passes through it, a ferry line to the island of Kihnu and occasionally to the island of Ruhnu also operates (ibid). Several photos depicting the ferry line and cargo traffic were identified in the hotspot zones. Finally, within Pärnu county, the ferry line passing from Virtsu (mainland Estonia) to Kuivastu (the island of Saaremaa) was also pictured multiple times. As previously determined, ferries provide both a recreational service, as well as play a part in the local identity of a place. For this reason, flows of recreation and sense of identity CESs were well-represented near the town of Virtsu.

The smaller town of Haapsalu is, similar to Pärnu, known as a popular summer holiday destination and also enjoys a long spa tradition (Haapsalu, 2022). Less than a two-hour drive from Tallinn, the small town hosts many international festivals, a castle, and many fine restaurants in addition to spas and beaches (ibid). Recreational activities observed in the photos uploaded within this hotspot zone include images of cyclers riding their bikes along the beach promenade, kite surfers and paragliders, sailors, and fishermen. A small marina hosts yachts, and facilities, such as piers, benches along the promenade, and a bandstand pavilion act as excellent spots to watch the seascape, the sun rise, or the sunset. Thus, again, CES flows of recreation and aesthetic pleasure were highly identified within the hotspot zones in and around the vicinity of the main city area. Additionally, sense of identity was also high in Haapsalu, as many photos contained images of the elegant wooden architecture located alongside the coastal promenade. Haapsalu Resort Hall, for example, frequently appeared in image content. Finally, few educational CESs were also present in the area, mainly referring to bird watching activities occurring.

Kuressaare is the main city and central hub of daily activity on the island of Saaremaa. This medieval town is known for a charming city center and hosts one of the best-preserved medieval fortresses in Estonia (Kuressaare, 2022). Indeed, the vast majority of photo content depicted within this hotspot zone was in relation to the fortress. As the fortress is both a form of entertainment and represents the identity of the city, recreation and identity were the most observed CESs within this area. Aesthetic pleasure, however, was also frequently identified, as the castle, overlooking the seaside, provides many points of which to observe the surrounding scenery. Signs displaying information about the castle and its history were seen as educational, therefore educational CESs were also identified within the area. Other attractions within the hotspot zones included boats within the harbor area, windmills, lighthouses, statues along the seaside, and people swimming in the sea. Fish drying in the sun were also displayed in several photos and were categorized as a part of the identity of the region. To the south of the island, the Mõntu Sadam AS marina and the Sõrve Lighthouse frequently appeared in the images. The lighthouse especially attracts many visitors, as it provides not only entertainment, but also acts as a viewpoint from which to see the surrounding landscapes. A café and museum detailing the history of the attraction are also present for visitors to enjoy. Consequently, this hotspot too offered the highest flows of CESs related to aesthetic pleasure and identity, followed by recreation, and finally education. To the north of the island, off the tip of the Tagamõisa peninsula, Undva Pank is a scenic spot providing visitors with pristine beaches, walking trails, and a rocky bank filled with human-made rock towers. Aesthetic pleasure was the most identified CES within this zone, as a majority of the photos depicted the rocky towers made by visitors. Sense of identity and recreation were similarly identified, as the formations were human-made and clearly only possible to make within this area of Estonia. Finally, in the northeast of the island, multiple CESs were identified at Koguva Jahisadam. This picturesque old harbor hosts a boutique bed and breakfast, a restaurant, a fishing museum, and has a nice pier. Again, aesthetic pleasure and sense of identity were the most detected CESs, with recreation as a close third (mainly from walking along the beach), and few photos depicting educational activities.

Hotspot zones were also identified on the smaller island of Hiiumaa. Aesthetic pleasure was identified within 6 hotspot zones on the island, followed by recreation in 5 hotspot zones, sense of identity in 4 zones, and education in 2 zones. In the northern part of the island, Tahkuna lighthouse was most frequently pictured in the photos. This zone showed high flows of aesthetic pleasure, as the lighthouse offered a nice viewpoint to admire the surrounding scenery. Photos of the lighthouse itself with the surrounding coastline also fell under aesthetic pleasure in most case scenarios. Photos of bird diversity were seen as both recreational and educational CESs, and thus both of these CESs were present in the hotspot zone. Finally, as a lighthouse is important to the identity of an area, sense of identity also was present here. To the east of the island, 3 hotspot zones were identified. These were related to the ports Kärdla Sadam, Roograhu Sadam, and Suursadam. Many photos showed images of various boats and yachts, as well as related facilities such as boat repair shops. In addition to the ports, recreational facilities, seaside cafes, social gatherings on the beach, individuals skipping stones all contributed to the recreational CESs provided by the area. Sunrises, sunsets, and seaside statues, were also depicted in the photos within these three zones, contributing then to the aesthetic pleasure provided by the area. Finally, in the south of the island, hotspot zones were identified relating to the Orjaku Sadam port. Content of photos included coastal views, sunrises, and sunsets, as well as boats, bird watching, and coastal trails. The port had the highest flows relating to aesthetic pleasure, recreation, and sense of identity. Education was not identified in the area.

Only two hotspot zones were identified near Lake Peipus, and one hotspot zone was identified near Lake Võrtsjärv. The first hotspot zone identified near lake Peipus related to the Rannapungerja Lighthouse. Besides the lighthouse, photo content within this zone included beach and coastal views, as well as flowers, and several sailboats. Thus, aesthetic pleasure, sense of identity and recreation were all identified within the zone. The second hotspot zone related to Kallaste liivakivipaljand, a scenic spot featuring a red sandstone landscape. In addition to the landscape being unique in Estonia, the site also has excellent viewpoints overlooking the lake. In addition to the scenery, photos uploaded within this site featured recreational activities such as swimming and walking along the beach, boats, and many seashells. Thus, aesthetic pleasure and recreational services were the most identified CESs within the area, followed by sense of identity. Educational CESs were not identified within either hotspot zone near the lake. As for Lake Võrtsjärv, the area with the highest number of photos was near Jõesuu vaatetorn, an observation deck providing scenic views of the surrounding area, adjacent to a long stretch of beach. Most frequently pictured here were sunrises and sunsets, and several photos showed the aurora borealis. A famous bridge, as well as the national geographic shot frames located around Estonia, were also found within the vicinity of the area. Finally, a sauna house was also present within the photo content. As a result, aesthetic pleasure was the highest identified CES found within this area, followed by sense of identity and recreation. Again, no educational CESs were depicted from the photos in the area.

Multiple hotspots were also detected in areas outside of main cities and their surrounding areas. In the north of Estonia, for example, hotspots were detected within the area comprising Lahemaa National Park, the largest national park in Estonia. Within 70km of Tallinn, Lahemaa is a perfect day-trip destination for nature lovers, featuring everything from sandy beaches to bogs, walking trails, forests, and rivers. It is no surprise then that recreation, aesthetic pleasure, and sense of identity were all identifiable in various hotspot zones within the park boundaries. For example, recreational activities included walking, hiking, kitesurfing, biking on the beach, bird watching and fishing. Facilities that aided in such activities included changing facilities, cabins, boats, walking trails, observation platforms, and a lighthouse. Aesthetic pleasure was depicted in many photos, showing skies with sunrises and sunsets, landscape views, beaches, and coastlines. Once again, aesthetic pleasure was depicted in the most photos, with recreation and sense of identity following. Education was not identified within the area.

Other hotspot zones detected along the northern coast of Estonia included the area around Hele Park in Narva-Jõesuus, the small town of Sillamäe, Oru Park near Toila, and Valaste waterfall, the highest waterfall in Estonia (Valaste, 2022). With the exception again of education, these areas showed flows of aesthetic CESs, recreational CESs, and sense of identity CESs. However, the most surprising result in northern Estonia may have come from the location with the highest flow of educational CESs. The Toolse fortress is a historical landmark popular with visitors in the area. As mentioned previously, the reason why it was deemed as an educational experience when other castles were not is because of the associated text that accompanied the images depicting the castle. Most photos used in this study lacked associated text. Text, however, can play an important role in determining the motivation behind an individual's visit to a particular location. In the case of the Toolse fortress, the accompanying text described the history of the castle and the area. For this reason, the motivation behind the users' visit was deemed educational and all photos relating were categorized similarly. Additionally, the fortress provided stunning views of the surrounding scenery, and is an excellent spot for watching the sunrise or sunset, as many photos within the area showed. A boat and beach rocks were also part of the scenery in the area. Thus, aesthetic pleasure, recreation, and sense of identity were also all identified within the area.

As other literature has described, the results of this study prove once again that recreation and aesthetic pleasure are the easiest CESs to define, and therefore are also the most studied CESs (Zhang et al., 2020).

This study identified activities such as walking, hiking, swimming, kitesurfing, paragliding, fishing, sailing, cycling, bird watching, and so on within coastal hotspots in Estonia. In addition, recreational facilities such as walking trails, promenades, historical landmarks and museums, along with ferry and cruise ships, cafes, and parking lots were considered as support facilities that allowed for recreational activities to take place (Egorova, 2021). The large number of photos identified depicting such content then supports the idea that human-made modifications compliment natural areas and inspire more activities and experiences within the location (Karasov et al., 2020). The many observation platforms, along with lighthouses and castles, act not only as recreation points, but often also provide scenic views to visitors. The location of such infrastructure aids in identifying the aesthetical appeal of an area. Thus, these observation points indicated that an area was providing an aesthetic service to its visitors (Zhang et al., 2020). In addition to observation points, photos also depicted various landscapes, seascapes, sunrises, sunsets, and occasionally the aurora borealis, aiming to show the unique features of the area, and thus its aesthetic appeal. Other CESs, such as sense of identity and education, have been less frequently studied previously as they are more difficult to define (Egorova, 2021; Zhang et al., 2020). Sense of identity, for example, often refers to the idea that an ecosystem inspires a certain cultural identity in an area. If one lives within this area or has been exposed to it frequently, they may indeed feel a sense of identity related to it (Fish et al., 2016). However, visitors may feel no sense of identity at all and may just admire the ecosystem for its aesthetic appeal (ibid). In the context of this study, however, sense of identity was considered as the identity of Estonia, which was represented through tangible objects such as flags, historical landmarks (castles, lighthouse, amphitheaters, piers), cultural traditions (saunas, smoking fish), and residential housing. Thus, in this study, sense of identity was more frequently identified than educational CESs. Identifying education was a challenging task, as education often implies acquiring new knowledge, whether through a new skill or an activity (Egorova, 2021; Ruhanen, 2019). This is difficult to ascertain from a photo with pure visual content analysis, however, and thus education was the least found CES within the numerous coastal hotspot zones in Estonia. Excluding bird watching as a form of both recreational and educational activity, as many studies consider wildlife to be biodiversity and thus by default presence of birds was labeled as educational, only when clear signs were presented that educational development was taking place, whether through signs, field trips, etc., was the category of education assigned to a photo. For this reason, educational CESs were drastically lower than all other CESs provided in areas.

As was mentioned previously though, while manual evaluation can lead to more accurate categorization than automatic processing, it does tend to lean towards the bias of the analyzer (Zhang et al., 2020). Thus, it is important to keep in mind that the results obtained from the study are fluid, and in the eyes of another analyzer, may be interpreted differently. However, for the purpose of this study, the four CESs evaluated were defined and assessed as is described. The benefit of manual classification, however, is that multiple CES categories could be assigned to one image. Indeed, a majority of the images depicted multiple CESs, and thanks to manual classification, it was possible to get a better understanding of all the CESs offered in the various hotspots. This gives a more realistic image of what an area offers society and, consequently, why an area is visited more than others.

The study of CES can help to inform and support decision makers in regional planning and development to provide better living environments. The city of Tallinn, for example, provides a great illustration of how CESs can improve a city's living environment in a short timeframe. The coastline, which was largely inaccessible to the public during Soviet times due to military activities and the belief that many would use the seaside as a way to flee the communist regime, now acts as an important multipurpose public space used by both locals and visitors. Improvements in recent years regarding coastal recreation and educational opportunities have led to the development of good quality public beaches, as well as bird watching observation towers, and access to multiple hiking and educational trails near the city (Vacht et al., 2018).

As a result of such improvements, a 2013 satisfaction survey found that 94% of Tallinn's residents were satisfied with the state of its coastal areas, compared to 76% in 2006 (ibid). Further additions made to the value of the Estonian coastline include a platform created by the Estonian Environmental Agency and Tallinn University in 2014 which outlines digital discovery trails around Estonia (Discovery, 2022). The platform provides users with educational activities that allow them to explore the country's natural environment independently, with several routes running along the coast of Tallinn (ibid). The Beta Promenade, a 1.7km coastal path established in 2016 connecting Tallinn's Fishing Harbor to the port neighborhood of Noblessner Harbor (Peehk, 2016), is an additionally example of an improvement made to the Estonian coastline. What was previously an isolated and disconnected section of Tallinn's coastline is now a popular area among visitors for recreational activities such as walking, jogging, and biking, while also offering unlimited views and access to the sea (Vacht et al., 2018). Such additions have resulted in a noticeable improvement in both the living environment in Tallinn and the use of the city's public seaside spaces. (Peehk, 2016).

Similarly, the results of this study can be used to determine which parts of Estonia's coastline are important to visitors and why. This data can then be used to identify and develop other coastal areas in Estonia with the same potential value for society members. Additionally, the data collected can be used to identify visitors' preferences for nature-based experiences and human activities in coastal areas (Hausmann et al., 2017b). The study could, for example, be used to determine the demand for recreational opportunities in coastal areas, or which anthropic modifications are valued over others. This knowledge can be used to improve existing coastal hotspot zones, or it can be used by land and marine managers in the future development plans of less-frequented coastal areas. This would help to relieve pressure from highly-frequented coastal environments while increasing the appeal of underdeveloped ones. This can lead to an improvement in the general attraction of the country's coastal areas, subsequently boosting the country's living environment, as seen in the case in Tallinn.

The results of this study can also contribute to the gap in knowledge of marine/coastal CESs. As mentioned previously, while research of CESs is growing, the majority of the research focuses specifically on terrestrial CESs, with less than 9% of studies on average focusing on marine/coastal environments (Townsend et al., 2018). This is concerning because increased human activities in coastal areas have raised the magnitude of coastal degradation throughout time (Lotze et al., 2006), with one-third of coastal regions presently at high risk of degradation (Townsend et al., 2018). This gap in knowledge is largely due to the difficulties in studying marine/coastal environments (ibid). The lack of spatial data that exists concerning these ecosystems then makes it difficult for environmental managers and policymakers to identify and protect areas which are already over-exploited by humans (Liquete et al., 2013). This is especially true for Estonia, as an investigation aiming to identify gaps in ecosystem services research in the Baltic Sea Region found that, out of 57 publications on marine and coastal ecosystem services in the Baltic Sea region selected for review, no publications were found from Estonia (Kuhn et al., 2021). Thus, the results of this study can be used to expand the currently limited knowledge of CESs in modern-day Estonia. Future studies can then utilize this information to monitor how CESs provided by coastal habitats in Estonia will change over time, as well as to understand which coastal ecosystems are impacted by human activity and how they are affected.

In general, however, a lack of research exists regarding the practical applications of qualitative CES data and their value for coastal and marine area management (Martin et al., 2016). In fact, a review of 24 publications on coastal and marine CES determined that studies tend to speculate about the usefulness of CES data in informing and supporting decision makers, but do not provide any concrete suggestions or examples of additional measures that should be taken by marine and coastal area managers (ibid). This can be attributed to the lack of standardized approaches in presenting and interpreting qualitative data on CES, which creates obstacles for effective policy implementation (ibid). For this reason, further research should be carried out to determine which indicators are most effective for measuring and tracking changes in CESs over time, as well as how to incorporate these indicators into coastal and marine resource managers' decisions. Only then will it be possible to understand how CESs in coastal ecosystems are changing over time and how this is affecting the related ecosystems.

7. Conclusion

The developing world of SM offers researchers a unique and complementary approach to traditional evaluation methods for increasing our understanding of modern-day society. SMD is now being applied in a variety of fields, including urban planning, environmental governance and disaster management, tourism, health studies, and ecosystem service evaluation, among others. CESs, one subfield of ecosystem services, refers to the non-material benefits that nature provides humans (Calcagni et al., 2019; Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020). These non-material benefits can include aspects such as recreation, aesthetic pleasure, spiritual enrichment, education, inspiration, cognitive development, and a sense of identity (Fish et al., 2016; Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020). The study of CESs can have significant implications for improving the quality of life for members of society as well as natural areas, making it critical to include in land-use planning, environmental management, and sustainable policy making (Calcagni et al., 2019; Hammer et al., 2018). Due to the inherent difficulties researchers face in quantifying CESs, such as the subjective nature of culture and the novelty of the field, however, relatively few studies have been conducted on CESs. This is especially true for marine and coastal habitats (Martin et al., 2016), as the bulk of CES studies have focused on terrestrial environments and only 9% of literature has a marine focus (Townsend et al., 2018). This lack of knowledge is especially concerning as, in addition to the important roles that coastal ecosystems play in various ecosystem processes, coastal zones contain more than a third of the world's population (Barbier, 2017). As a consequence, anthropogenic influences, such as coastal development, population growth, and pollution, have seen an increase in coastal areas within the last few decades, causing the degradation and destruction of many coastal habitats (Barbier, 2017; Martin et al., 2016).

Estonia, a small country with an expansive coastline, has seen increased coastal land use and a rapid expansion in coastal areas since their independence in the 1990's (Palginõmm et al., 2007). As a result, the pressure on Estonia's coastal habitats has increased. Despite this, there is minimal research in Estonia on CESs originating from distinct coastal environments. This gap in knowledge indicates a lack of awareness of the various meanings and values that people ascribe to coastal ecosystems (Martin et al., 2016), which can lead to conflicts of interest among users (Palginõmm et al., 2007). As a result, the goal of this study was to improve the current state of quantitative and qualitative knowledge on CESs supplied by Estonian coastal locations using geo-tagged SMD from the SMP Flickr. This was done by examining the research questions:

- At which distance do coastal ecosystems become less impactful on CES throughout Estonia?
- What hot spots of CES exist in the coastal areas and what factors make these areas more popular than others?

The study found that a distance of 1km was the threshold at which coastal ecosystems become less impactful on coastal CESs in Estonia. This was found by creating several buffer zones and then scanning the geo-tagged photographs for coastal scenery via visual content analysis. This result is in line with the research conducted by Jacobs and Way (1968), which identified that landscapes are perceived at a maximum distance of 1000m before becoming unclear (Piek et al., 2011). However, in major city areas, a buffer zone of 1000m still included many photos unrelated to coastal ecosystems. Thus, in major cities, the inland buffer was reduced to 200m to exclude unrelated content.

The study then sought to identify coastal hotspot zones in Estonia and the factors that may contribute to their popularity. This was done via hot spot analysis. The results showed that a majority of hotspot zones were found within the vicinity of larger cities in Estonia, such as Tallinn, Haapsalu, Pärnu, and Kuressaare, or in national park areas such as Lahemaa. Few hotspots were found near to lake Peipus and lake Võrtsjärv, as well as in international border crossing areas between Estonia-Latvia and Estonia-Russia. The popularity of these zones was then assessed by determining which CESs were prevalent in the selected hotspots. The key CESs studied were recreation, aesthetic pleasure, sense of identity, and education. Visual content analysis, the most common way of identifying CESs, was used to categorize each photo based on the CESs it contained. The study found that in coastal hotspot zones, aesthetic pleasure was the most recognized CES, followed by recreational services, sense of identity and education. This was mainly due to the large number of photos depicting images of coastal scenery, as well as recreational activities such as walking, biking, and swimming. Facilities mean to aid in aesthetic pleasure and recreational activities, such as observation decks, marinas, footpaths, lighthouses, and cafes, were also frequently observed in images. Less tangible aspects of CESs, such as sense of identity and education, are generally more difficult to define and, consequently, were less observed in images. In accordance with the literature on CESs, the results of this study verified that a number of predictor variables, including population density, habitat accessibility, human alterations, habitat uniqueness, presence of scenic areas and seasonality, can have a considerable impact on the value a society sets on an environment. This was confirmed as the majority of high CES flows were discovered around major cities and their surrounding areas, in areas with significant human-made attractions or modifications (trails, lighthouses, castles), or in areas with unusual scenery (cliffs, waterfalls).

The knowledge obtained from CES studies of Estonia’s coastal ecosystems can provide valuable insights for the continuous development of its coastal areas. The results of this study, for example, can help environmental managers and policymakers determine which areas of Estonia's coastline are valued by visitors, as well as the reasons behind this. The information gathered can be used to identify the demand for activities in specific coastal habitats, (Hausmann et al., 2017b), or identify which human alterations are valued above others. This information can then be used to find and develop new coastal regions in Estonia with similar qualities, as well as to improve already established hotspot locations. Furthermore, the findings of this study can be used to identify the meanings and values that people place on various coastal habitats, allowing us to gain a better understanding of human-nature interactions in coastal areas. Finally, researchers may also be able to use data from this study to track coastal changes, which is an important area of study as many coastal habitats are currently endangered.

In conclusion, SMD can provide many insights into the CESs provided by an ecosystem. The content that people chose to share via their SMP often demonstrates the values and beliefs of users, and when multiple users upload similar content within the same area, researchers can then aggregate this information and use it to understand the importance of an ecosystem to society (Egorova, 2021). However, it is important to remember that while SMD can offer insights into the CESs provided by an ecosystem, there are also a number of concerns regarding the validity of the results. These can include the bias of the analyzer, the unequal representation of activities, the temporality and content variation amongst different SMP, the popularity of certain platforms compared to others, and the inaccuracy of location data, to name a few. Thus, to gain a more complete understanding of the impact of CESs on coastal ecosystems, SMD should be integrated with traditional research methods such as questionnaires and surveys. Finally, more research on CESs is needed to better our understanding of how to successfully standardize data collected from CES studies so that governments and resource managers may improve ecosystems for all.

8. Summary

“Assessing Cultural Ecosystem Services of Coastal Areas in Estonia Through Social Media-Based Data”

In the age of Big Data, the ever-expanding world of social media (SM) offers researchers a novel and supplementary approach to traditional evaluation methods to increase our modern-day knowledge of society. The use of social media data (SMD) is now being applied to disciplines ranging from urban planning, environmental governance, tourism, health studies, public opinion, disaster planning and management, and ecosystem service (ES) evaluation, to name a few. One branch of ES refers specifically to the non-material benefits that nature provides humans, better known as cultural ecosystem services (CESs) (Calcagni et al., 2019; Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020). These non-material benefits refer to holistic contributions to human well-being such as recreation, aesthetic pleasure, spiritual enrichment, education, inspiration, cognitive development, and a sense of identity (Fish et al., 2016; Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020). However, the novelty of the discipline, as well as the innate challenges researchers face in quantifying CESs due to the subjective nature of culture, have resulted in relatively few studies of CESs being conducted. This is particularly true for marine and coastal environments, as compared to terrestrial environments (Martin et al., 2016). With the increasing use of social media platforms (SMPs) such as Flickr, however, researchers can use SMD to expand their understanding of CESs. Thus, the aim of this study was to show how geo-located photographs uploaded to Flickr could be utilized to determine the distance at which coastal habitats become less significant on CESs, as well as to discover coastal hotspots in Estonia and the motivations behind their popularity.

All Baltic Sea coastlines in Estonia, as well as the coastlines of Lake Peipus, and lake Võrtsjärv, were included in the study. Data for the study included a CSV file of 69,623 geotagged photos located within a 20km (10km sea and 10km land) distance of the Estonian coastline, uploaded to the SMP Flickr. Additionally, the study included the boundaries of Estonia and Generalized Estonian Topographic data, obtained from the geoportal of the Republic of Estonia Land Board. Finally, the official Estonian 1x1km grid for population statistics was used, obtained from the Spatial Data Catalogue of Estonia. The analysis was carried out in ArcGIS Pro 2.6 and MS Excel and included both a quantitative and exploratory analysis. After creating several buffer zones along the coastline, images were scanned for presence of coastal ecosystems. It was determined that the coastal environment became irrelevant in photos further than 1km from the coastline. In the case of main cities, the buffer zone was reduced to 200m (inland). After all irrelevant images were removed, a hotspot analysis, based off Photo-User-Days (PUD), was conducted to determine the location of hot and cold spot zones in coastal areas. An exploratory analysis was then run in which visual content analysis was used to evaluate the CESs present in the coastal hotspot zones in order to determine the motivations behind the popularity of these areas. Four cultural services, including recreation, aesthetic pleasure, sense of identity, and education were focused on. Aesthetic pleasure included land and coastal scenery, as well as skylines and facilities meant to aid people in admiring the surrounding sites, such as observation towers. Recreation included activities such as walking, biking, swimming, and bird watching, among others, as well as facilities such as walking trails, cafes, marinas, museums, lighthouses, etc. Sense of identity was assessed through tangible objects such as Estonian flags, historical landmarks (castles, lighthouses), cultural traditions (sauna, smoked fish), and residential housing. Education was depicted through activities such as bird watching, as well as through signs and group excursions. Aesthetic pleasure and recreation tend to be easier to define, and thus are more likely to be identified in photos compared to sense of identity and education.

Indeed, the results showed that aesthetic pleasure, as well as recreational services were the most identifiable CESs in coastal hotspot zones, followed by sense of identity and education. Additionally, the results showed that several predictor variables exist that can affect an ecosystem and the CESs it offers. Population density (Hausmann et al. 2017), accessibility of the habitat (Thiagarajah et al. 2015; Willemen et al. 2015), presence of anthropic modifications (Gliozzo et al. 2016; Karasov et al., 2020), uniqueness of the habitat (Guerrero et al. 2016), and presence of scenic areas (Tenerelli et al. 2016), are all factors which tend to significantly affect how an ecosystem is valued by society. This was confirmed in the study, as key flows of CESs were concentrated around main cities, such as Tallinn, Kuressaare, Pärnu, and Haapsalu, or in areas easily accessible from main cities such as Lahemaa National Park. Areas with human modifications (castles, lighthouses, observation towers, ports, walking trails) also observed high flows of CESs, as well as areas where unique scenery (cliffs, waterfalls) existed. Furthermore, seasonal conditions can also have an effect on CESs, as areas can become more or less accessible depending on weather and time of year (Egorova, 2021). This was true in the case of the "summer cities" in Estonia, such as Pärnu and Haapsalu, which had a large number of photos depicting beach activities. The results of this study can be used to determine the significance that people place on certain coastal ecosystems in Estonia, as well as help land managers understand what people are looking for when they visit such areas. This information can be used to plan future coastal improvements in Estonia, enhancing people's access to coastal regions and CESs while also safeguarding coastal environments by alleviating pressure from excessive visitors in coastal hotspots.

The study of CES can have significant implications for improving the quality of life for members of society as well as natural areas, making it critical to include in land-use planning, environmental management, and sustainable policy making (Calcagni et al., 2019; Hammer et al., 2018). SMD provides researchers a unique and complementary method to evaluate the CESs provided by an ecosystem. The content that people choose to share through their SMP often reflects their values and beliefs, and when multiple users upload similar content within the same area, researchers can aggregate this information and use it to understand the importance of an ecosystem to society (Egorova, 2021). However, it is also important to remember that while SMD can offer insights into the CESs provided by an ecosystem, there are also a number of concerns regarding the validity of the results. These can include the bias of the analyzer, the unequal representation of activities, the temporality and content variation amongst different SMP, the popularity of certain platforms compared to others, and the inaccuracy of location data, to name a few. It is feasible to acquire a more well-rounded and holistic picture of the value a region serves society, however, by integrating SMD with traditional research methodologies. Nevertheless, more research on CESs is needed in order to better understand how to effectively use the data gathered to improve ecosystems for everyone.

Kokkuvõte

Sotsiaalmeediaandmetele tuginev kultuuriliste ökosüsteemiteenuste hindamine Eesti rannikupiirkondades

Suurandmete ajastul pakub üha laienev sotsiaalmeedia maailm teadlastele traditsioonilistele hindamismeetoditele lisaks uuenduslikku lähenemist, et suurendada meie teadmisi kaasaegsest ühiskonnast. Sotsiaalmeediaandmeid kasutatakse nüüd valdkondades, mis ulatuvad linnaplaneerimisest, keskkonnajuhtimisest, turismist, terviseuuringutest, avalikust arvamusest, katastroofide ohjamise ning ökosüsteemiteenuste hindamiseni.

Üks ökosüsteemiteenuste haru viitab konkreetselt mittemateriaalsetele hüvedele, mida loodus inimestele pakub ja mida tuntakse paremini kultuurilise ökosüsteemi teenustena (Calcagni et al., 2019; Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020). Need mittemateriaalsed hüved viitavad terviklikult inimese heaolusse panustamisele, hõlmates rekreatsiooni, esteetilist naudingut, vaimset rikastamist, haridust, inspiratsiooni, kognitiivset arengut ja identiteeditunnet. (Fish et al., 2016; Ilieva & McPhearson, 2018; Wilkins et al., 2021; Zhang et al., 2020). Selle distsipliini uudsus, aga ka loomulikud väljakutsed, millega teadlased kultuuriliste ökosüsteemi teenuste kvantifitseerimisel kultuuri subjektiivsest olemusest tulenevalt silmitsi seisavad, on põhjus, miks kultuuriliste ökosüsteemi teenuste kohta on läbi viidud suhteliselt vähe uuringuid. See kehtib eriti mere- ja rannikukeskkonna uuringute kohta, võrreldes maismaakeskkonnaga (Martin et al., 2016). Suurenenud sotsiaalmeediakanalite, nagu näiteks Flickr, kasutamine võimaldab teadlastel sotsiaalmeedia andmeid kasutades suurendada teadmisi kultuurilistest ökosüsteemi teenustest. Sellest tulenevalt oli antud uuringu eesmärk näidata, kuidas Flickrisse üles laetud asukohamärgisega fotosid saab kasutada selleks, et määrata kindlaks vahemaa, kust alates rannikuelupaigad muutuvad kultuuriliste ökosüsteemiteenuste kontekstis vähem oluliseks ja avastada Eesti rannikualade populaarseimad paigad ning motivatsioon nende külastamiseks.

Uuringusse kaasati kogu Eesti Läänemere rannikupiirkond, aga ka Peipsi järve ja Võrtsjärve rannajoon. Uuringu andmestik koosnes CSV andmefailist, mis koondas rannajoonest 20 km kaugusel (10 km mere ja 10 km maa poole) jäädvustatud ja sotsiaalmeediakanali Flickr kaudu üles laetud 69 623 asukohamärgisega fotot. Lisaks hõlmas uuring Eesti piiride ja Eesti üldistatud topograafilisi andmeid, mis saadi Eesti Vabariigi Maa-ameti geoportaalist. Lõpetuseks kasutati Eesti ruumiandmete kataloogist saadud ametlikku Eesti 1x1km rahvastikustatistika ruudustikku. Analüüs viidi läbi kasutades ArcGIS Pro 2.6 tarkvara ja MS Excelit ning hõlmas nii kvantitatiivset kui ka uurimuslikku analüüsi. Pärast rannajoonele mitme puhvertsooni loomist otsiti piltidelt märke ranniku ökosüsteemide olemasolu tuvastamiseks. Tehti kindlaks, et rannajoonest kaugemal kui 1 km asuvatel fotodel muutus rannikukeskkond ebaoluliseks. Sisemaal asuvate linnade puhul vähendati puhvertsooni 200 meetrini. Kui ebaolulised pildid olid eemaldatud, viidi rannaalade kuum- ja külmkohtade kaardistamiseks läbi PUD (photo-user-day) meetodil analüüs.

Sellele järgnes piirkondade populaarsuse põhjuste teada saamiseks läbi piltide visuaalne sisuanalüüs rannikualade kultuuriliste ökosüsteemiteenuste hindamiseks. Keskenduti neljale kultuuriliste ökosüsteemiteenuste kategooriale – rekreatsioonile, esteetilisele naudingule, identiteeditajule ja haridusele. Esteetiline nauding hõlmas maa- ja rannikualade maastikku, aga ka horisondijoont ja rajatisi, nagu vaatetornid, mis võimaldavad inimestel ümbritsevaid kohti imetleda. Rekreatsiooni kategooria kätkes muuhulgas selliseid tegevusi nagu kõndimine, jalgrattasõit, ujumine ja linnuvaatlus, aga ka rajatisi nagu jalutusrajad, kohvikud, jahisadamad, muuseumid, tuletornid jne. Identiteeditunnet hinnati läbi käegakatsutavate objektide nagu Eesti lipud, ajaloolised vaatamisväärsused (kindlused, tuletornid), kultuuritraditsioonid (saun, suitsukala) ja elamud. Haridust kujutati selliste tegevuste kaudu nagu linnuvaatlus ja rühmaekskursioonid, aga ka siltidel. Esteetilist naudingut ja rekreatsiooni oli fotodel lihtsam määratleda ning seetõttu on need tõenäolisemalt tuvastatavad, võrreldes identiteeditunde ja haridusega.

Tulemused näitavad, et rannaalade kuumkohtades olid esteetiline nauding ja rekreatsioon kultuurilistest ökosüsteemiteenustest kõige paremini identifitseeritavad, neile järgnesid identiteeditunne ja haridus. Lisaks näitasid tulemused, et eksisteerib mitu ennustavat muutujat, mis võivad mõjutada ökosüsteemi ja selle pakutavaid kultuurilisi ökosüsteemiteenuseid. Asustustihedus (Hausmann jt 2017), elupaiga ligipääsetavus (Thiagarajan et al. 2015; Willemen jt 2015), antroopsete modifikatsioonide esinemine (Gliozzo jt 2016; Karasov jt, 2020), elupaiga unikaalsus (Guerrero jt 2016) ja looduskaunite alade olemasolu (Tenerelli et al. 2016) on tegurid, mis kipuvad oluliselt mõjutama seda, kuidas ühiskond ökosüsteemi väärtustab. Sellele saadi kinnitus ka uuringus, kui peamised kultuuriliste ökosüsteemiteenuste vood koondusid linnade (Tallinn, Kuressaare, Pärnu, Haapsalu) või lihtsasti suurematest linnadest ligipääsetavate alade (nagu Lahemaa rahvuspark) ümbrusesse. Palju leidus kultuuriliste ökosüsteemiteenuste voogusid inimeste poolt muudetud aladel (kindlused, majakad, vaatetornid, sadamad, jalutusrajad) ja ainulaadsete maastikega (kaljud, kosed) piirkondades. Lisaks võivad kultuuriliste ökosüsteemiteenuste tarbimist mõjutada hooajast tulenevad tingimused, kui piirkonda ligipääsu mõjutavad rohkemal või vähemal määral aastaajale omased ilmastikutingimused (Egorova, 2021). See leidis tõestuse Eesti „suvelinnades“ Pärnus ja Haapsalus, kus kujutati piltidel hulgaliselt rannas toimunud tegevusi. Selle uuringu tulemusi saab kasutada, et kindlaks teha, kui oluliseks peavad inimesed teatud Eesti rannikuökosüsteeme, samuti aidata piirkonna halduritel mõista, mida inimesed selliseid alasid külastades otsivad. Infot saab rakendada ka Eesti rannikuala planeerimiseks tulevikus, et parandada inimeste juurdepääsu rannikupiirkondadele ja kultuurilistele ökosüsteemiteenustele, kaitstes samal ajal rannikukeskkonda ja leevendades liigset külastajate survet rannikualadele.

Kultuuriliste ökosüsteemiteenuste uuringul võib olla märkimisväärne mõju nii ühiskonnaliikmete elukvaliteedi kui ka loodusalade parandamisele, mistõttu on seda oluline rakendada maakasutuse planeerimisel, keskkonnajuhtimisel ja säästva poliitika kujundamisel (Calcagni et al., 2019; Hammer et al., 2018). Sotsiaalmeedia andmed pakuvad teadlastele ainulaadse ja tasuta võimaluse hinnata kultuurilisi ökosüsteemiteenuseid, mida ökosüsteem pakub. Sisu, mida inimesed oma sotsiaalmeediakanalite kaudu jagavad, peegeldab sageli nende väärtusi ja tõekspidamisi ning kui mitmed kasutajad laadivad üles samas piirkonnas sarnast sisu, saavad teadlased selle teabe koondada ja kasutada seda mõistmaks ökosüsteemi tähtsust ühiskonnale (Egorova, 2021). Oluline on meeles pidada, et kuigi sotsiaalmeedia andmed võivad anda ülevaate ökosüsteemi pakutavatest kultuurilistest ökosüsteemiteenustest, võib tulemuste paikapidavuses esineda ka mitmeid probleeme. Probleemide hulka võivad kuuluda näiteks analüsaatori kallutatus, tegevuste ebavõrdne esitus, ajaline ja sisu varieeruvus erinevates sotsiaalmeediakanalites, teatud platvormide populaarsus võrreldes teistega ja asukohaandmete ebatäpsus.

Sotsiaalmeedia andmete integreerimisel traditsiooniliste uurimismetoodikatega on võimalik saada laialdasem ja terviklikum pilt väärtustest, mida piirkond pakub. Sellegipoolest on kultuurilisi ökosüsteemiteenuseid vaja rohkem uurida, et paremini mõista, kuidas kogutud andmeid tõhusalt kasutada ja ökosüsteemi olukorda kõigi jaoks parandada.

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Annexes

Annex 1. Example of pre-processed data.

Example of the CSV file containing data of geotagged photos from Flickr within a 20km (10km terrestrial and 10km marine) buffer zone of the Estonian coastal borders.

D *	Field1	·license	id	owner	secret	server	farm	title	ispubli	isfrien	isfamily	dateupload	lastupdate	datetaken	date
	0	0	455612144	36698961@N00	ce60aa0958	192	1	Lauluväljak talvel	<Null>	<Null>	<Null>	2007-04-11T18:24:23...	2013-01-19T21:08:11...	2004-02-24T00:00:00...	
	1	0	455624050	36698961@N00	3ec92a760b	184	1	Lauluväljakul	<Null>	<Null>	<Null>	2007-04-11T18:35:26...	2013-01-19T21:08:37...	2004-02-24T00:00:00...	
	2	0	454335692	7746450@N08	0e1715b2cc	183	1	Whadya want buddy?	<Null>	<Null>	<Null>	2007-04-10T19:07:35...	2007-04-25T19:53:48...	2004-04-04T00:00:00...	
	3	0	237058745	36698961@N00	298d315d2a	97	1	Vaade Tallinnale Tabasa...	<Null>	<Null>	<Null>	2006-09-07T19:54:37...	2008-05-19T15:40:44...	2004-04-18T00:00:00...	
	4	0	1248599092	8343832@N08	ce355514bb	1148	2	Tallinn, Song Festival G...	<Null>	<Null>	<Null>	2007-08-27T11:01:37...	2008-09-14T20:18:30...	2004-04-29T00:00:00...	
	5	0	8056269935	87930045@N05	87e98eafeb	8311	9	Viimsi - Punamütsike	<Null>	<Null>	<Null>	2012-10-05T11:01:09...	2021-07-17T08:39:04...	2004-05-08T00:00:00...	
	6	0	4699635364	26603935@N03	9a215108cb	4008	5	Tallin, Oleviste Church	<Null>	<Null>	<Null>	2010-06-14T10:57:36...	2012-01-24T12:39:12...	2010-05-30T00:00:00...	
	7	0	4699633884	26603935@N03	0953a3e83a	4005	5	Tallin, view from Olevis...	<Null>	<Null>	<Null>	2010-06-14T10:56:48...	2012-01-24T12:40:17...	2010-05-30T00:00:00...	
	8	0	4699682610	26603935@N03	5c6e59a55c	4011	5	Tallin, restaurant Tristan...	<Null>	<Null>	<Null>	2010-06-14T11:25:05...	2012-01-24T12:22:56...	2010-05-30T00:00:00...	
	9	0	4665413963	77095568@N00	4874d6d9e3	1290	2	Dead End on New Filtri...	<Null>	<Null>	<Null>	2010-06-03T09:43:57...	2017-07-10T01:16:41...	2010-05-30T00:00:00...	
	10	0	6660238069	99251983@N00	c6dc3d2ef8	7158	8	Tallinn, Estônia	<Null>	<Null>	<Null>	2012-01-08T16:27:22...	2012-01-08T19:42:32...	2012-01-07T00:00:00...	
	11	0	452802550	36698961@N00	dbfa6ba6c0	198	1	Päikeseloojang Tabasal...	<Null>	<Null>	<Null>	2007-04-09T19:17:28...	2013-02-03T17:19:38...	2004-05-15T00:00:00...	
	12	0	2211187381	36698961@N00	aaef21b4f8	2133	3	Lagedi mõis	<Null>	<Null>	<Null>	2008-01-22T10:12:03...	2013-01-10T16:48:55...	2004-06-03T00:00:00...	
	13	0	2211189909	36698961@N00	d2e05da404	2146	3	Vana sild Lagedi mõisa...	<Null>	<Null>	<Null>	2008-01-22T10:14:29...	2013-01-10T16:49:33...	2004-06-03T00:00:00...	
	14	0	2211177033	36698961@N00	dcf3362967	2224	3	Saha kabeli "pööningu...	<Null>	<Null>	<Null>	2008-01-22T10:02:36...	2013-01-10T16:49:39...	2004-06-03T00:00:00...	
	15	0	2149027469	11197122@N00	913ba9dd1a	2280	3	Tallinn street	<Null>	<Null>	<Null>	2007-12-30T19:15:40...	2008-07-05T12:32:37...	2004-06-06T00:00:00...	
	16	0	2149098755	11197122@N00	e257f42574	2254	3	Danish kings garden	<Null>	<Null>	<Null>	2007-12-30T19:43:14...	2008-03-09T13:18:16...	2004-06-06T00:00:00...	

vidth_c	url_l	height_l	width_l	url_o	height_o	width_o	description	longitude	latitude	geometry	within	license_name	license_url	Shape *
800	https://live.staticflickr.c...	768	1024	https://live.staticflickr.c...	1704	2272	<a href="http://loc.a...	24.809446	59.444453	c(24.809446, 59.44445...	1	All Rights Reserved	<Null>	Point
800	https://live.staticflickr.c...	768	1024	https://live.staticflickr.c...	1704	2272	<a href="http://loc.a...	24.809639	59.444442	c(24.809639, 59.44444...	1	All Rights Reserved	<Null>	Point
800	https://live.staticflickr.c...	682	1024	<Null>	<Null>	<Null>	<Null>	24.814499	59.435736	c(24.814499, 59.43573...	1	All Rights Reserved	<Null>	Point
800	https://live.staticflickr.c...	768	1024	https://live.staticflickr.c...	1704	2272	<a href="http://loc.a...	24.538897	59.438393	c(24.538897, 59.43839...	1	All Rights Reserved	<Null>	Point
<Null>	<Null>	<Null>	<Null>	https://live.staticflickr.c...	446	654	<Null>	24.804468	59.443962	c(24.804468, 59.44396...	1	All Rights Reserved	<Null>	Point
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533	https://live.staticflickr.c...	1024	683	https://live.staticflickr.c...	2800	1867	The church itself dates...	24.747991	59.441289	c(24.747991, 59.44128...	1	All Rights Reserved	<Null>	Point
800	https://live.staticflickr.c...	683	1024	https://live.staticflickr.c...	1867	2800	The church itself dates...	24.747991	59.441289	c(24.747991, 59.44128...	1	All Rights Reserved	<Null>	Point
533	https://live.staticflickr.c...	1024	683	https://live.staticflickr.c...	2800	1867	<Null>	24.745631	59.437372	c(24.745631, 59.43737...	1	All Rights Reserved	<Null>	Point
800	https://live.staticflickr.c...	576	1024	<Null>	<Null>	<Null>	<Null>	24.757022	59.419711	c(24.757022, 59.41971...	1	All Rights Reserved	<Null>	Point
800	https://live.staticflickr.c...	682	1024	<Null>	<Null>	<Null>	Viru Gate	24.749429	59.436767	c(24.749429, 59.43676...	1	All Rights Reserved	<Null>	Point
800	https://live.staticflickr.c...	768	1024	https://live.staticflickr.c...	1704	2272	<Null>	24.520969	59.443722	c(24.520969, 59.44372...	1	All Rights Reserved	<Null>	Point
800	https://live.staticflickr.c...	768	1024	https://live.staticflickr.c...	1704	2272	<a href="http://ww...	24.941899	59.41787	c(24.941899, 59.41787)	1	All Rights Reserved	<Null>	Point
800	https://live.staticflickr.c...	768	1024	https://live.staticflickr.c...	1704	2272	<a href="http://loc.a...	24.941787	59.417845	c(24.941787, 59.41784...	1	All Rights Reserved	<Null>	Point
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Annex 2. Keywords identified from visual content analysis of data.

Keywords identified relevant or irrelevant to Estonian coastal ecosystems in preliminary visual content analysis of photos uploaded to the SMP Flickr.

Location Identity:	Yes:	No:
Pärnu_Selection_1	Rocks, coastline, wildlife (birds), waterfront	Estonian/Latvian border crossing, country flags, food, rest stops, residential houses
Kuressare_Selection_3	Swimming, beach, castle, boats, harbor, windmill, fish, lighthouse, statues	Food, drinks, graffiti, house pets, supermarkets, Kuressaare city center, residential houses, cars, marathon, car show, indoor concert
Saar_sel_1	Lighthouse, boats, kitesurfing, facilities, viewpoints, wildlife (birds), coastline, beach, recreational activities, historical landmarks (bunker)	People eating, food
Saar_sel_2	Trail along coast, recreational activities (motorcycling), coastline, wildlife (birds), windmill	Forest
Saar_sel_3	Coastline, beach, boats, harbor, facilities (seaside café), lighthouse, sunrise, sunset, events (concert on beach)	Airport
Saar_sel_4	Lighthouse, viewpoints, recreation activities (walking)	None
Saar_sel_5	Sunrise, sunset, recreational activities (hiking), seaside facilities, boats	Residential houses, house pets (cats, dogs), windmill, cultural museum, apple trees, road
Hiumaa_sel_1	Coastal views, boats, sunrise, sunsets, recreational facilities, wildlife (birds), coastal trail, coastal plants	Residential houses
Hiumaa_sel_2	Viewpoints, coastline, ferry, recreational facilities, boats	Abandoned buildings, pond
Hiumaa_sel_3	Coastline, recreational facilities (seaside cafes)	Airport, airplanes, open fields, beer, forest, large rocks
Hiumaa_sel_4	Sunrise, sunset, beach, picnics on beach, skipping stones, boats, marina, social gatherings on beach, yacht repair shop, seaside facilities, statues	Cars, piano, winter sport, stream, graffiti, cafes, singers, forest bonfire, bikers, road signs, church, food, snow
Hiumaa_sel_5	Viewpoints, lighthouse, coastline, wildlife (birds), monuments, rocks	Airplane ruins, military vehicles (tank)

Pärnu_sel_2	Ferry, boats, coastline, facilities, recreation activities (walking on beach)	Skateboarding, wind turbines, factories
Pärnu_sel_3	Boat, ferry, fishing, facilities (parking lot)	Thrift shop, sunflowers, house pets (dogs), cars, people
Pärnu_sel_4	House by the sea, wildlife (birds, plants), sunrise, sunset, viewpoint, pier, seaside café, seaside benches, coastline	Shed, residential houses, cars
Pärnu_sel_5	Concert on the beach, kitesurfing, volleyball, football, sunrise, sunset, seaside café, facilities, fishermen, hotel, benches and playgrounds on beach, sculptures, swimming, tanning, ships, wildlife (birds, seaweed), walking, playing, viewpoint, beach art, pier, walking platforms	Snow
Haap_sel_1	Seaside facilities, shipyard, pier, fishermen, seaside promenade, benches, wildlife (birds), boats, statues, coastline, sunrise, sunset, bikers on beach	Train station, baby, town buildings, church, castle, forest, flowers, residential houses, food, house pets, school performances, walking trails in city, graffiti, coffee
Haap_sel_2	Kitesurfing, paragliding, ferry, cruise ship, boats, wildlife, sculptures	Children, apartment complexes
Haap_sel_3	Sailboats, coastline, beach, forest trail along coast, educational signs, wildlife (birds, mollusks), boats, coastal views, shipyard for fishing boats	Forest
Vil_sel_1	Sunrise, sunset, bridge, aurora over water, natgeo shot frame, road along coast, viewing platform, sauna house	Stars, full moon
Peipsi_sel_1	Skipping stones, small cliffs, coastline, rocks, educational activities (fieldtrip), seashells, swimming, wildlife (birds), boats, boat dock	People, bus stop, cemetery, flowers, sky, residential houses
Peipsi_sel_2	Sand, flowers on beach, sailing, lighthouse	Sky, spoon, house pets (dogs), art, road signs, fence, shoes, pinecone seeds, forest
Ida_sel_1	Picnics on the beach, hotels, pier, walking trail along coast, playground on beach, boats, children playing in sand, bikers on beach, professional beach	Singer, fence, residential street with houses, café, dog, construction site, billiards, fire, church, park, food, cars, karate school

	volleyball tournament, sunrise, sunset, swimming, food festival on beach, benches, facilities, sandcastles, lighthouse, tanning, fish, market	
Ida_sel_2	City with beach view, benches, factory on coast, sunrise, sunset, wildlife (birds), coastline, rocks, viewpoint, flowers	People, abandoned buildings, football team/game, rubble, sports competition, marathon runners, residential housing, church, exercise, forest bike rides
Ida_sel_3	Coastal plants	Portrait photographs, fireworks
Ida_sel_4	Boat, wildlife (birds), viewpoint, campsite, swimming, walking on the beach, sailboats, fish, beach, parasailing, lighthouse, benches, Oru Park, sunrise, sunset, pavilion	People, helicopter, door, forest, flowers, park, sculpture, sky, church, cemetery, sauna, stream, winter sports, trees, statues, botanical garden, houses, deer
Ida_sel_5	Coastline, cliff, pier, walking path along coast, ice waterfall, viewing platform, beach, walking, waterfall, seaside café	Snow and ice on trees, pond, residential house
Laane_sel_1	Castle, sunrise, sunset, viewpoint, boat, castle ruins, rocks	Telephone wires
Laane_sel_2	Sunrise, sunset, wildlife (birds), beach	Horses, wildlife (birds), forest
Laane_sel_3	Fishing nets, rocks, ships, coastline, lighthouse, kitesurfing, beach, sunrise, sunset, changing facilities, bridge, cabins, boats	Residential houses, swing, forest, flowers, road signs, fruit at market, bread, roof, stream
Laane_sel_4	Coast, rocks, recreational activities (hiking, walking), beach, sunrise, sunset, Eru Bay, walking trails, seaweed, coastal vegetation	Night sky
Laane_sel_5	Boat, beach, birds, viewing platform, statues, navigation charts, maritime museum, houses along coast, full moon above water	Residential houses, festival, patio, swings, musicians, mountain, bridge, waterfall, dog, hookah, cloudy, cabin, ice cream, forest, rocks in forest
Harju_sel_1	Beach, boats, lighthouse, shoreline, statues, fishing poles	Festival, food, cabin, shed, tower, chair, picnic, houses, road, driving
Harju_sel_2	Coast, rocks, birds, frogs, bikers on the beach, sunrise, sunset, dragon fly, flowers, walking on beach, lighthouse	Folk festival, village houses, swing, cows, bikers, deer

Harju_sel_3	Boats, coastal paintings, beach, swimmers, tanning, beach café, picnic on beach	Pond, forest
Harju_sel_4	Beach, rocks, boat, dog walking on beach, lighthouse, viewing platform, sunrise, sunset, birds, coastal plants, boat harbor, boat party, beach picnic	Puppy
Harju_sel_5	Coastline, ship, sunrise, sunset, rocks, walk on the beach, cruise ship, field trip, coastal trial, promenade, flowers, beach picnic, café, educational excursion, cottages, wading in sea, benches	Flower fields, forest, spider webs, cemetery, abandoned buildings, residential housing, basketball court, rocks, sculptures, meadow, forest bunker, t-shirt
Harju_sel_6	Castle, lighthouse, viewing platform, boat fixing area	Junkyard, church, ruins, graffiti, bus stop, car lot, snowy streets, apartment complexes, snow-covered forest, building ruins, wind turbines, cars, military vehicles, trash bins, street mural, abandoned buildings, train station, cafes, fences, crest
Harju_sel_7	Cliffs, lighthouse, viewing platform, walking trial, coast, castle ruins, sailing, coastal road, ship, birds, wind turbines, paragliding, ice	Error
Harju_sel_8	Small cliffs, beach in snow, rocks, house on peninsula, sunrise, sunset, coastline, beach, seaweed	Cabin in the woods, drinks, rusty car, sowing machine, abandoned van, forest, mill
Harju_sel_9	Beach, rocks, sunrise, sunset, lightning storm over water, aurora over water, boats, walking on beach, snow on beach	Snow, house, river
Harju_sel_10	Beach, boat, ice on sea, walking on the beach, snowy beach, Turisalu Cliff, educational signs, birds, parking lot, viewpoint, parasailing, sandcastles on beach, wedding	Road, stream, flowers, snow, error, snail, hill
Harju_sel_11	Houses along coast, rocks, coastal trial, sunrise, sunset, rainbow over water, ice on sea, northern lights over water, birds, cliffs, ships, viewpoint	Residential housing, snow path, forest, flowers, food, tennis players, tennis club, error

Harju_sel_12	Sunrise, sunset, cliff, rocks, ship, beach, birds, residential housing, boats, children on beach, peninsula, toys for sand, benches, changing facilities, harbor, café, football field	Sunset over field, butterfly, café, flowers, house, abandoned building, festival, error
Harju_sel_13	Beach, swimming, tanning, walking, Tallinn old town view from beach, coastal apartments, sunrise, sunset, windmill, cultural museum, path along coast	Sticks, apartment complexes, selfies, Old Town Tallinn, sports shop, forest flowers, pizza, house pets, shopping center parking lot, leaf, people, bowling, conference, TedTalk
Harju_sel_14	Snow/ice covered sea, sunrise, sunset, beach, houses along coastline, swing, cruise ships, family beach outings, rocks, birds, volleyball court and players, benches, tables, boats, trail along coast, café, swimming, restaurants, tulips	Forest, buildings, restaurants, airplanes, musicians, folk festival, night club, car shop, snow, church, tennis lesson, error, guns, military training, babies, aquapark, spring flowers
Harju_sel_15	Pet walking on beach, Tallinn city view, windmill, picnic benches, trail along coast, boats, beaches, cruise ships, houses along beach, open air museum, dried fish, bridge, cruise ship control room, navigation education course, steps into sea for swimming, train tracks along coast	Field, dogs, playground. Open air museum, windmills, train station, snow, shoes, buildings, church, horse-drawn carriage, pigs, crafts, candles, cars, bus, train, canned goods, piano, spinning needle, biking in forest, houses, sheep, chairs, tablecloths
Harju_sel_16	Sauna park, running/biking/walking/playing on beach, football, volleyball courts, seashells, piers, dogs on beach, sunrise, sunset, playground, harbor, ships, snow-covered beach, sand art, cruise ships, navy academy, birds, trail near beach, night concert on beach, changing facilities, cafes, swimming/tanning, Tallinn city view, recreational facilities, apartment complexes, wedding, kitesurfing, benches	Horses, babies, dogs, abandoned building, street signs, fashion show (Erki Moeshow), costumes, grass, buses, trams, selfies, Tallinn old town, old factory, leaves, flowers, bar, street art, market, apartment complexes, museums, selfies, newspapers, rubble in office, church, error, fields, trails through fields, pipes
Harju_sel_17	Beach, sunrise, sunset, rocks, biking on the beach, coastal trial, dogs, birds, ice on sea, flowers on beach, pier, view point, walking trial, changing facilities, cruise ship, ferry,	Path, frozen bench, dog in snow, berries, grass, bonfire, stream, leaves, lady bug, plants, fireworks, screws, snow path, cow, street art, residential housing, aurora lights, error

	swingset, walking, tanning, sailboats, exercise area, park sign, rainbow over water, tv tower, hotel	
Harju_sel_18	Beach, swimming, Tallinn city and sea viewpoint, sculpture, dog on beach, navy museum, cruise ship, ferry, factories, restaurants by the coast, old concert hall (linnahall), port, birds, tv tower, sunrise, sunset, icicles above water, street art, anchor, pier, boat in snow, coastal neighborhood, sunbathing chairs, friends, couples, souvenir shop, sailing, fishermen, picnic on beach, boats, biking on beach, airplane show, navy academy, walks on the beach, submarine, canons, Estonian maritime museum, sailing, jet skiing, interior of ships, engine rooms, bonfire on beach, fish, kayaking, speed boats,	Party, friends, selfies, Tallinn old town, Tallinn city, butterfly, patio, café, sculpture, barbed wire, hostel, medicine, doctor's office, abandoned buildings, street art, storage room, prison, prison cell, city park, sunset, streets in Tallinn, guns, old factories, museums, error, auditorium, flowers, military vehicles, cars, bars, tram, fireworks, ice, buses, church, meetings, office space, children's toys, city map, supermarket, snow field, musician, helicopter, concert, amusement park, Ferris wheel, hiking, trash, festival, market, airplane show, fashion show, spider web, game room, Estonian flag, clouds, military academy, Helsinki, chicken costume, advertisement, food, autumn leaves, swing, dandelions, hot air balloon, boar, market, race car, candy, laptop, stairs, chimney, balconies, Estonian History photography exhibition, tour group, police cars, chair, truck, electric car, microscope, choir, motorcycles, signs, street lamp, Patarei prison, beer, toilet, vinyl record, forest, robot workshop, rock climbing, stuffed toys, hill, Linnahall, memorial, footprint, art fair, startup festival, apple tree, cat, dog, DJ, demonstration, family dinner, liquor shop, ping pong tables,
Harju_sel_19	Statues, Tallinn city view, trial along coast, bikers, memorial, monuments, beach, walking/rollerblading/playing on beach, benches, cafes, sunrise, sunset, Tallinn Old Town view, birds, beach in	Tallinn city center, monuments, abandoned buildings, police car, selfies, street art, facial portraits, tea, doors, cars, houses, festival, sidewalk, gate, driving, cake, error, horse-drawn carriage, lamp, trash can, motorcyclists,

	snow, old concert hall area, ship, wadding, rocks, dogs, sailboats, cruise ship, ferry, helicopter, seaweed, Estonian history museum, street art on beach, marathon runners,	ice, church, water fountain, concert, market, museums, airplanes, lawn, sculpture park, art museum, flowers, karaoke, piano, book, money, cartoons, soda pop, menu, car show, dentist, old computer,
Harju_sel_20	Beach, Pirita marina, sunset, sunrise, yachts, sea, frozen sea, Tallinn skyline, car show, rocks, cruise/ferry ships, coastline, playground, birds, ice, sailboats, waves, pier, jet ski, hotel, café, walking, sailing, kitesurfing, sky, swimming, 1980 Olympics monument	Spa, oldtown, selfies, portrait photos, dogs, residential housing, flowers, trucks, cats, music, bar, forest, frozen berries, snow, children

Annex 3. Additional examples of images categorized into respective CES categories.

Examples of geotagged photos relating to coastal ecosystems in Estonia and their categorization into respective CES categories.

Recreation:

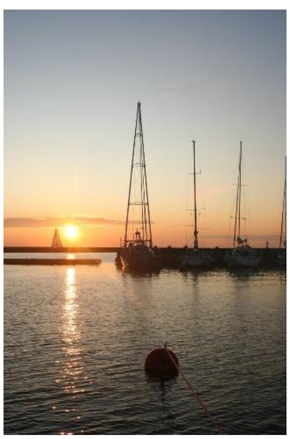
Aesthetic Pleasure:





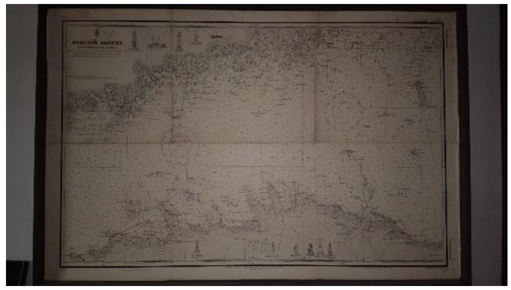






Sense of Identity:

Education:



Images displaying all four CESs - recreation, aesthetic pleasure, sense of identity, and education:

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