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RESEARCH

Public perceptions of mangroves: a sentiment and topic analysis of global Twitter/X content

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ABSTRACT

Social media has emerged as a prominent factor in shaping public perceptions. However, significant gaps remain in our understanding of the complex interplay between social media and human-nature relationships, including for mangrove ecosystems. We assessed how mangroves have been discussed and perceived on social media by analysing 649,495 Twitter/X posts between 2010 and 2022. Using NRC and AFINN lexicons, we found a prominence of positive sentiment toward mangroves across the 13-year period. While negative sentiment was present, it was found to be co-occurring with degradation events (e.g. large dieback of mangroves in Australia in 2016). This indicates fear and anger were typically expressed for mangroves rather than of them. Topic mapping of the 100 most frequent bi-grams per year showed persistent topic structure despite fluctuations in volume. 'Ecosystem Services' was most prominent (14% of bi-gram frequencies), consisting of recreational and ecotourism terms (e.g. fishing, kayaking, boardwalks) and by coastal protection. Conversely, climate- and carbon related terms increasingly showcased policy relevant discourse. 'Restoration' was the second most frequent topic (13%) but was overwhelmingly framed as tree planting (64% of restoration bi-grams), revealing a simplified online narrative that overlooks context appropriate, holistic approaches. 'Threats' (11%) consists of tweets around widely covered events and includes sea level rise, pollution, aquaculture expansion, and general loss/destruction terms. Notably absent from top bi-grams were many provisioning and cultural services, as well as mangroves being social-ecological systems, highlighting perception gaps. Our findings demonstrate social media data can cost-effectively identify perception gaps and help inform (targeted) awareness campaigns.

KEY POLICY HIGHLIGHTS

- Twitter/X users primarily communicate about mangroves using positive sentiments and emotions, reflecting overall positive perceptions of the ecosystem.
- Mangrove communication strategies should aim to de-emphasize tree-planting as sole objective in favour of holistic conservation and restoration approaches.
- Mangrove awareness campaigns could center around the topics of climate change mitigation, local livelihoods, and cultural significance.
- Managers and decision-makers can use social media to gauge public sentiments about interventions and policies as part of their development planning.
- Popular and policy-relevant terms like *"blue carbon"* and *"nature-based solutions"* can act as bridges between science, policy, and public perceptions.

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Introduction

Social media is a powerful tool for shaping public perceptions of the natural environment, indirectly influencing the success of conservation and restoration efforts (Veríssimo et al. 2017; Dahdouh-Guebas et al. 2020). Research indicates that negatively framed messages tend to cultivate negative public perceptions of species or ecosystems (Ballejo et al. 2021), where 'perception' is understood as the way individuals view, understand, and interpret information (APA Dictionary of Psychology 2018). Conversely, there is a correlation between positive language in tweets and more favorable offline perceptions, including an

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increased willingness to engage in conservation behaviors such as philanthropy (Crespo and Cruz 2023). Social media content provides insights into human-nature interactions (Richards and Friess 2015a; Połedniková et al. 2025) or can serve as a means to study biodiversity, supplementing traditional in-the-field methods (Chowdhury et al. 2024). The use of social media data in nature conservation has grown in recent years (Correia et al. 2021). Analysis of online data from social media platforms offers cost efficiency and access to large, flexible datasets (Ladle et al. 2016). For example, it has been used to study drivers of park visitation and perceptions (Hausmann et al. 2017a), cultural ecosystem service quantification (Zhang et al. 2020), eco-tourism valuation (Spalding and Parrett 2019), and site popularity through post frequency (Tenkanen et al. 2017). Social media analyses can be more cost-effective, faster, and more accessible than in-the-field methods (Richard and Friess 2015a; Toivonen et al. 2019; Correia et al. 2021).

There is often a bias in what conservation topics gain attention, with species considered charismatic receiving a disproportionate level of attention both online and offline (Prokop et al. 2022). This bias toward charismatic species and ecosystems creates a mismatch between ecological importance, conservation urgency, and public concern (Courchamp et al. 2018). Such mismatches can, in turn, shape policies, funding allocations, and public engagement in ways that prioritize social perceptions and values over ecological need (Colléony et al. 2016). In these contexts, re-framing previously uncharismatic species or ecosystems has the potential to shift public perceptions, increase conservation engagement, and build support for more ecologically relevant policies (Mace 2014; Veríssimo et al. 2017; Albert et al. 2018; Ballejo et al. 2021).

Mangroves represent one important example of this. Mangroves play a vital role in achieving the global target of protecting 30% of nature by 2030 (United Nations 2022). Their importance extends beyond biodiversity conservation to the wide range of ecosystem goods and services they provide (Dabalà et al. 2023), including significant economic value through fisheries, coastal protection, and carbon sequestration (Donato et al. 2011; Cannicci et al. 2021; Zeng et al. 2021; Beck et al. 2022; Zu Ermgassen et al. 2025). Despite our improved understanding of the importance of mangrove forests and their ecosystem services, negative perceptions persist due to the presence of actual and perceived ecosystem disservices (Knight et al. 2017; Friess et al. 2020b; Scemama et al. 2022). Historically, mangroves were often viewed as unpleasant or dangerous habitats due to facilitating animals such as crocodiles, snakes, or tigers, and insects such as mosquitoes and sandflies, which can carry disease. Biased portrayals of mangroves have important implications for their management (Dahdouh-Guebas et al. 2020), justifying the widespread historical clearing and conversion of mangroves to other land uses (Friess et al. 2020b).

Online communication campaigns may aid in streamlining mangrove awareness, and ultimately perceptions among stakeholder groups (Shah 2024). Public awareness and participation are key to successful, long-term, implementation of conservation objectives (Frank et al. 2017; Amir et al. 2020). Moreover, involving communities enhances stewardship, fosters equity, and increases the resilience of interventions. Without a public backing, initiatives risk encountering resistance and unsustainable outcomes, particularly where projects intersect with local livelihoods, access to resources, or cultural values (De Souza Queiroz et al. 2017; Moore et al. 2022). Social media content has the potential to support improved mangrove conservation, management practices, policy development, and outcomes by positively influencing public perceptions (Wu et al. 2018; Niemiec et al. 2022).

This study aims to improve our understanding of the global perception and prevailing sentiments of mangroves on social media. Specifically, we examine how mangroves have been discussed and perceived on social media by analysing Twitter/X posts from 2010 to 2022. Using distinct lexicons, we conducted sentiment analysis to assess whether tweets reflect positive, negative, or neutral sentiments. This was combined with topic mapping to identify the most common discussion topics and shifts in emphasis over time. Through this approach, we provide insights into the dominant global narratives, public perceptions, and evolving emotional engagement with mangrove ecosystems over more than a decade of online discourse. The results can support online mangrove communication strategies towards addressing awareness gaps, and to further garner support for mangrove conservation and restoration.

Methods

Data collection

In this study we used Twitter/X as our data source. This social media platform offered a free application programming interface (API) which was available for academic research until February 2023, which allowed for large datasets to be extracted and used. While our initial intent was to launch an on-going study on mangrove tweets, the free API was only available until February 2023. This study therefore focuses on a distinct time period.

All tweets from 1 January 2010 until 31 December 2022 containing at least one of the following key terms: 'mangrove', 'mangroves', '#mangrove' or '#mangroves' were collected using the academictwitteR package in R (Barrie and Ho 2021). This resulted in the collection of more than one million (1,000,157) tweets. Links, tags (i.e. references to specific user accounts using the '@' symbol), stop words (e.g. as, and, the, …), random character strings (e.g. ':-D', 'djhsd;fdif;sjjo', …), and other non-relevant or non-classifiable information were removed from the raw data files. A total of 649,495 tweets were retained and the remaining text was converted into a comma separated value file (.csv) for further analysis.

Sentiment analysis

In the first phase of analysis, we assessed the sentiment and emotional tone of mangrove-related tweets using two widely used lexical resources: the NRC (National Research Council) and AFINN (Finn Årup Nielsen) lexicons. A lexicon is a large database of words that have been pre-assigned sentiment or emotion values. For example, words are tagged when they express positivity, negativity, or a specific emotion like joy, fear, or anger. Sentiment analysis uses these word lists to automatically score a text (in this case, tweets) based on the presence and frequency of emotionally charged words. The NRC lexicon categorizes words into eight basic emotions (e.g. trust, sadness, anticipation) and two overall sentiments (positive, negative) (Mohammad and Turney 2013). The AFINN lexicon, on the other hand, assigns each word a numeric sentiment score ranging from −5 (strongly negative) to + 5 (strongly positive) (Nielsen 2011). By applying these tools to the tweet dataset year by year, we were able to track changes in how mangroves were emotionally framed in public discourse, offering insights into how people have perceived and reacted to mangrove-related content over time.

Top 100 Bi-gram List, frequency count, and topic categorization

Text was further categorized into bi-grams – collectives of two words that most frequently appear together in the tweet text. Bi-grams are representative of commonly used terms and the assumption was made that bi-grams can, therefore, represent key mangrove concepts and topics that are communicated on Twitter/X (Joshi and Deshpande 2018). Bi-grams were chosen as opposed to other n-grams due to their conciseness and relatively limited overlap. The top 100 bi-grams and their frequency counts were calculated and analysed. From the top 100 bi-grams of each year, the most popular mangrove content (e.g. news reports further tweeted about on Twitter/X) were listed. We assume the higher a bi-gram's frequency count, the greater the occurrence of discussion on the topic.

To determine the most frequently posted mangrove topics on Twitter/X, each bi-gram was placed into a topic. Certain bi-grams were back-tracible to the original tweets by using the search function in the tweet files. The following identifiable topics emerged; 'Biodiversity', 'Carbon', 'Restoration', 'Conservation', 'Climate Change', 'Ecosystem Services', and 'Threats'. Bi-grams were coded using a mixed approach: terms with clear thematic meaning (e.g. 'climate change', 'carbon sink') were deductively assigned to corresponding categories, while less explicit bi-grams (e.g. 'satellite images', 'mangrove tunnels') were inductively interpreted by examining their use within the original tweets. If a bi-gram did not consistently belong to a tweet discussing the same topic, it received a 'NA' tag to avoid biased interpretations.

'Carbon' was used to group all bi-grams that refer to carbon. The topic 'Restoration' groups all bi-grams that reference planting, rehabilitation, restoration methods, or restoration activities of mangroves. The 'Conservation' topic consists of bi-grams of which one of the terms is conservation, protect, save, or another synonym of those terms. 'Climate Change' groups all bi-grams referring to climate change, excluding direct reference to carbon. The topic 'Biodiversity' was used to group all bi-grams referring to fauna, flora, or other ecosystems such as seagrass meadows. 'Ecosystem Services' gathers a variety of bi-grams referencing a specific service provided by mangroves, excluding carbon sequestration. Mangrove ecosystems provide humans with a wide range of benefits. In this study we considered all bi-grams belonging to tweets discussing the goods and services that mangroves provide, whether it be aesthetic value, climate adaptation, monetary value, leisure use, resource provisioning, etc. to be part of the 'Ecosystems Services' topic. Finally, 'Threats' consists of bi-grams referring to mangrove loss, degradation, and other forms of harm to mangroves such as pollution.

Results

A total of 1,000,157 mangrove tweets were posted between 1 January 2010 and 31 December 2022. After data clean-up 649,495 tweets were retained. Each year of mangrove tweets produced a mix of recurring and distinct bi-grams. While the overall presence of the topics remained consistent over time, the relative importance of each topic has been dynamic throughout our study period. This implies

that public discourse about mangroves on Twitter/X has been thematically consistent over the 13-year period, even as the number of tweets posted each year has increased (Figure 1).

Mangrove communication on Twitter/X was heavily focused on 'Ecosystem Services' with the topic averaging at 14% of bi-gram frequency counts. Over the 13-year sample period, the bi-grams belonging to this topic had a total frequency count of 37,767. Recurring bi-grams (see Supplementary Information) in 'Ecosystem Services' included: 'mangrove snapper', 'mangrove kayaking', 'mangrove tour', 'mangrove walk', and 'mangrove jack'. These bi-grams are used in tweets discussing fishing, ecotourism, and general leisure time spent in mangroves, with a total bi-gram frequency count of 16,380, or 43.4% of the topic. Coastal protection from storms and erosion was another prominent discussion point on Twitter/X within the 'Ecosystem Services' topic with a bi-gram frequency count of 6,947, or 18.4% of the topic.

Due to our chosen method, discussion points and sub-topics are based entirely on the most frequently used bi-grams. Ecosystem services that are frequently discussed, as listed in a previous paragraph, are those that are shared by most mangroves across the world. Markedly, many ecosystem services provided by mangroves were largely absent from online discussions. These include, but are not limited to, their role as nursery habitats for commercially important fish species, flood regulation, and water filtration. In addition, provisioning services such as wood and other material resources, as well as medicinal, spiritual, and cultural values associated with certain mangrove species, were rarely, if at all, mentioned.

The second most discussed topic was 'Restoration' averaging 13% of bi-grams with a total frequency count of 36,655. These tweets primarily discussed the planting and reforestation of mangroves. The bi-grams 'mangrove planting' or 'tree planting' had a total frequency count of 23,364 (63.7% of 'Restoration' bi-grams). Six out of the 13 years had 'mangrove planting', or a variation, as the bi-gram with the highest frequency count (Supplementary Information). The topic 'Threats' (11% of bi-gram frequency counts) consisted of diverse bi-grams ranging from 'oil spill', to 'rising seas', to 'shrimp farming'. More general bi-grams such as 'mangrove destruction', 'mangrove decline', and 'mangrove loss' were also common (Supplementary Information).

Notably, mangrove tweets from 2010 to 2022 largely conveyed positive sentiment following the NRC and AFINN lexicons (Figures 2 and 3). During the classification process we searched the tweets from which the bi-grams originated. We see shifts in emotive language use that correspond to the trending mangrove events (Table 1). Mangrove events can be described as something that happens to or impacts mangroves, or something that mangroves do or provide. Sentiments can portray emotive language use towards mangroves or about mangroves. For

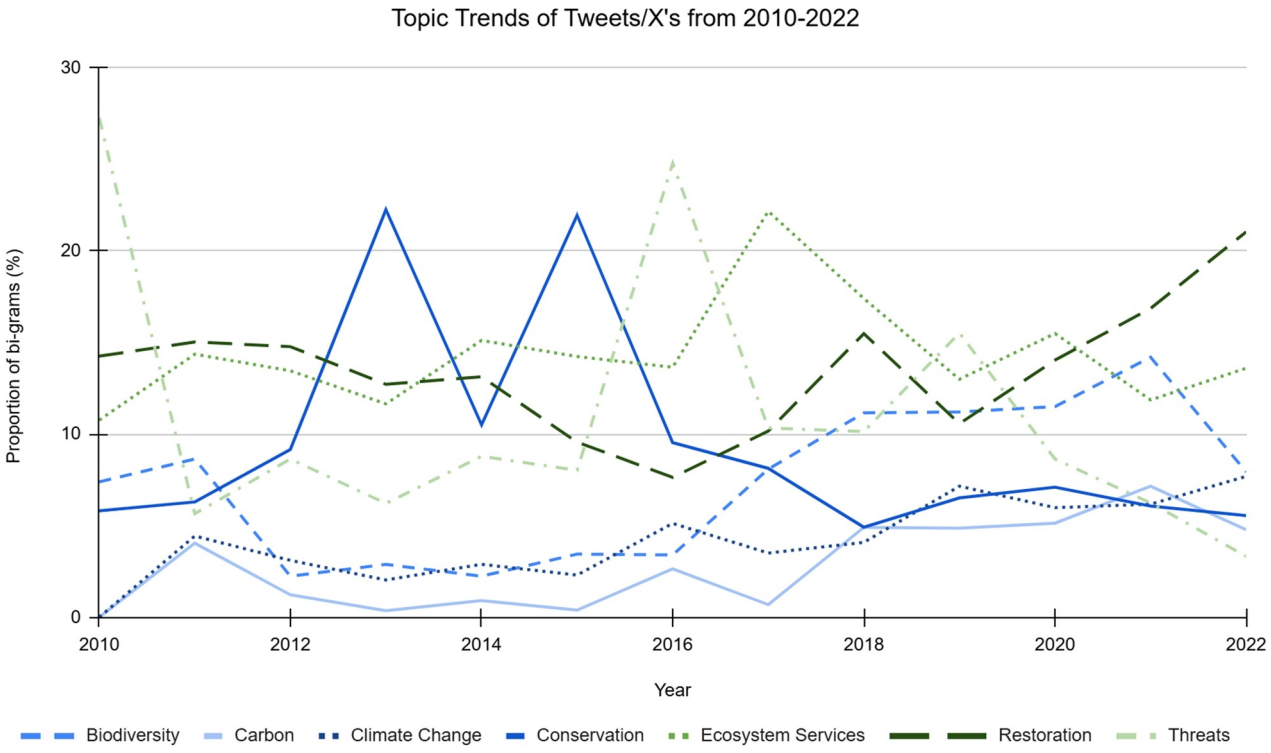

Figure 1. Topic trends of mangrove tweets/X's from 2010–2022. Each bi-grams was searched in the tweet text. The bi-grams were then classified in topics depending on the content of the tweet in which the bigrams were found. This graph depicts the proportion of bi-grams belonging to a particular topic based on the frequency counts of the bi-gram.

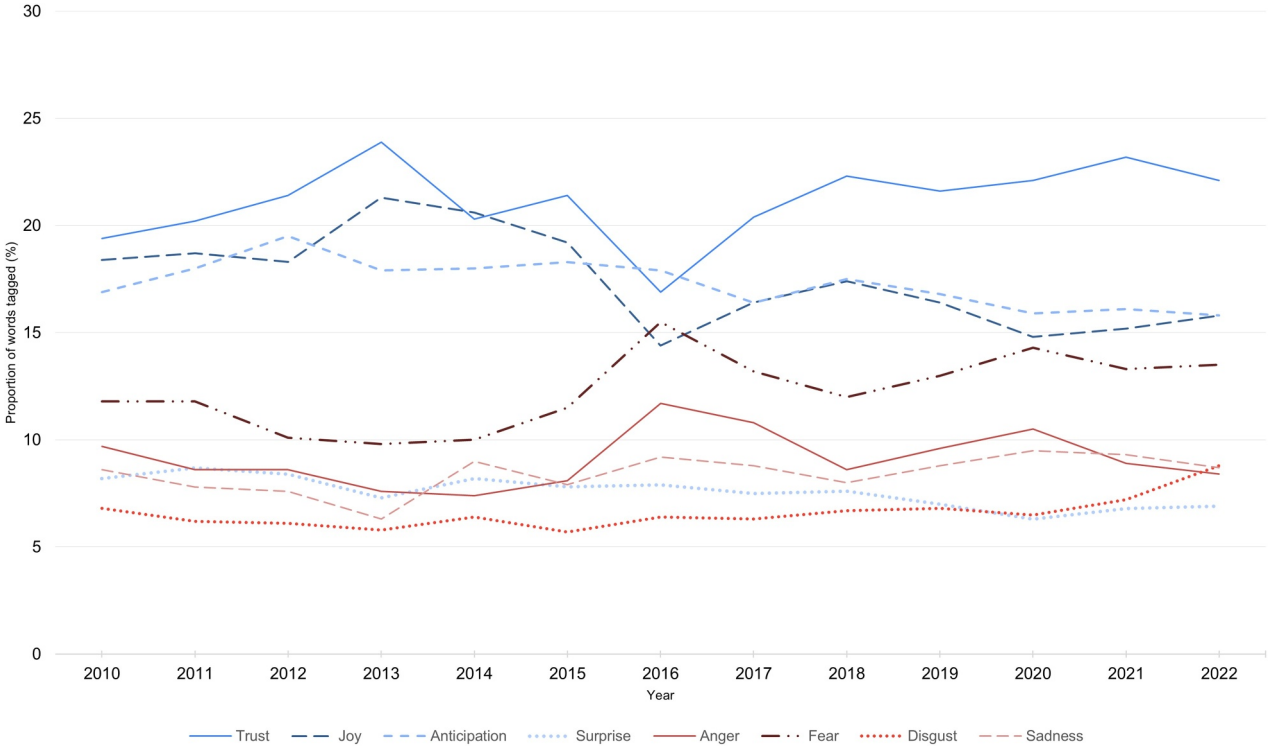

Figure 2. Emotion trends of mangrove tweets/X's from 2010–2022. Using the NRC lexicon, words used in the tweets were tagged with an emotion. This figure depicts the proportion of words tagged a certain emotion (e.g. trust) compared to the total number of words tagged for each year from 2010 to 2022.

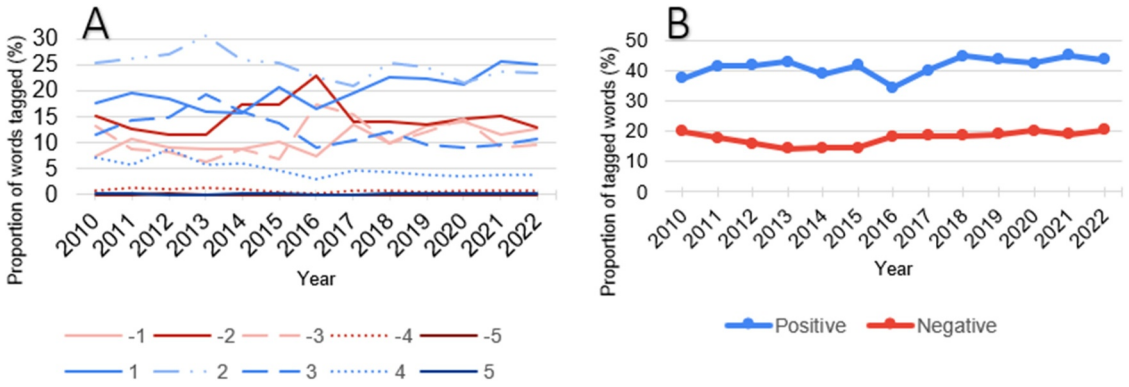

Figure 3. Sentiment trends of mangrove tweets from 2010–2022. Panel A. Using the AFINN lexicon, words used in the tweets were tagged with a sentiment score. This figure shows the proportion of words tagged a certain sentiment score compared to the total number of words tagged. The scores assigned to individual words ranges from −5 (strongly negative) to + 5 (strongly positive). Panel B. Using the NRC lexicon, words used in the tweets were tagged as either depicting positive or negative sentiment. This figure shows the proportion of words tagged positive or negative compared to the total number of words tagged.

example, mangrove degradation can be discussed using language reflecting negative sentiment and emotion such as fear. There can be a fear *of* mangroves or a fear *for* mangroves and their loss.

In this analysis we found the prevalence of negative sentiments and emotions (such as fear, anger, disgust) increased when negative events were tweeted. This portrays a general trend of language use that reflects fear *for* mangroves, or displays of anger in response to mangrove degradation, lack of protective mangrove policies, etc. When positive events occurred, such as the opening of a new mangrove park, we found an increased use of language depicting positive sentiments and emotions (such as joy, trust, anticipation). Further aligning with the trend that Twitter users expressed a positive perception of mangroves. The most noticeable dip in positive sentiment and peak in negative sentiment was in the year 2016 (Figure 3). This increased negative sentiment entails an increased use of vocabulary denoting the emotions of fear and anger about the mangrove die-off in the Gulf of Carpentaria (Australia) that took place that year (cf. Abhik et al. 2021). Simultaneously, less words denoting

Table 1. Annual trending mangrove events or news posts on Twitter/X – From Bi-gram Analysis.

Year	Trending Mangrove Events and News
2010	*Mumbai airport leads to mangrove destruction*
	Deepwater Horizon BP oil spill in Gulf of Mexico
	New Satellite data reveals true mangrove loss
	Scientists aim to create 'Red List' of endangered habitats
	Recovery of marshes begins after BP oil spill
2011	*Oil spill from MV Rak, Mumbai*
	Father of mangroves rehabilitates 30 000 hectares in Pakistan
	Man survives crocodile attack in Australia by clinging to mangroves
	Europe's shrimp/prawn demand destroying mangroves in Bangladesh
	Blue carbon stores more effective than tropical forests
2012	*Eco-tourism trending at Pasir Ris Park, Singapore*
	Shrimp farming destroys mangroves and overuses antibiotics
	Condura Skywalk Marathon: run for mangroves
	Qatar Foundation International mapping the mangroves project launch
2013	*Cristiano Ronaldo named ambassador for Benoa Bay, Bali mangroves*
	New plans for coal plant next to Bangladesh Sundarbans
	Body of man who fell out of plane found in mangroves
	Tigers in mangroves face climate change threat
	Mangroves are marching north due to warmer winters
	Haiyan's storm surge mitigated by mangroves in Philippines
2014	*Campaigners fight back against unchecked development in Bali*
	Series of oil spills in Caribbean hurt nature – photos
	UN warns devastating effects of mangrove destruction
	World's first mangrove zoo; the Sundarbans
	Oil spill in Sundarbans – tanker collision
2015	*Sri Lanka first country to protect all its mangroves*
	Oil spill in Sundarbans
	Shell to pay for oil spill in Nigeria
	Bangladesh police kill tiger poachers
	Mangroves are important in fight against coral bleaching
2016	*Rice and palm oil are threats to mangroves*
	2 potential new coal plants in Bangladesh Sundarbans
	Worst in world mangrove die-off after el nino in Gulf of Carpentaria
	Sri Lanka to protect all its mangroves
	Mexican court rules against development destroying mangroves
	Thai shrimp farmers go organic
	Hema Malini accused of destroying mangroves
2017	*Petition for Unilever to eliminate palm oil from products*
	Sri Lanka is working on mangrove forest protection plan
	Woman reveals story of mental and physical abuse at Mangrove Yoga Ashram
	Coal plant under construction Bangladesh Sundarbans
	There is a human element to mangrove management worth consideration
2018	*Navi Mumbai mangroves die after tidal water is cut off*
	Pakistan sets world record and plants 1 million mangroves
	Hurricane Irma severely damaged the Everglades
	Belize Barrier Reef Reserve removed from list of endangered UNESCO World Heritage sites
2019	*Mumbai bullet train to affect 13 ha of mangroves*
	Researching unprecedented die off Gulf Carpentaria mangroves 3 years ago
2020	*Petition to save Mada Kakinada forest from housing developments*
	New airport Manila Bay destroys mangroves
	Planting and conserving mangroves along Niger Delta to create buffer zones
	Mangroves reduce storm floods for 15 million people and prevent 65 billion in property damage annually – new study
2021	*Mangrove cover has increased in past 16 years Indus Delta*
	Rehabilitation Nilad mangrove in Manila Bay
	Destruction of mangroves by San Miguel Corporation (Manila Bay airport)
	Role of mangroves for migratory birds across Asia
	Wet Tribe campaign to call for holistic solutions to save oceans
2022	*Largest bacterium ever discovered in Caribbean mangroves*
	State of world's mangroves report by Global Mangrove Alliance
	Mangrove forest loss is slowing down
	Naturebased solutions required to combat climate change
	Bullet train Ahmedabad – Mumbai and mangrove destruction

Each year, the frequency counts of the top 100 bi-grams were collected. Each bi-gram was analyzed compared to that year's tweet file containing the full text. This table provides a list of titles of the content with active links found in the tweet data via the use of bi-gram searches. Several bi-grams, for each year, traced back to trending mangrove topics, of which the most popular are given.

the emotions of joy and trust were used in 2016 (Figure 2). Other sentiment and emotion shifts visible in Figures 2 and 3 correspond to events such as: Cristiano Ronaldo being named a mangrove ambassador in 2013, Pakistan's planting of one million mangroves in 2018, and the discovery of the world's largest bacterium in a mangrove in 2022 (cf. Volland et al. 2022), which may explain a minor spike in the emotion 'disgust' (Table 1).

Discussion

General trends in topics and sentiment

This study aimed to improve our understanding of mangrove content on social media and the prevailing sentiments. We present a comprehensive analysis of 649,495 Twitter/X posts related to mangroves, offering new insights into the public discourse surrounding

these ecosystems over a 13-year period. Despite fluctuations in tweet volume and event-driven spikes in attention, the thematic structure of mangrove-related communication has remained consistent. This indicates public interest in mangroves tends to centre around a consistent set of ideas or concerns, regardless of fluctuations in attention or tweet volume. The most frequently tweeted topics were 'Ecosystem Services', 'Restoration', and 'Threats' (Figure 1).

Literature reviews of mangrove science show similarities with discussions on Twitter/X. For example, Tasneem and Ahsan (2024) report a growing research focus on mangrove ecosystem services, conservation, and restoration, a trend also found in other recent studies (Segaran et al. 2023; Qin et al. 2025). Similarities between scientific literature and social media discourse indicates that knowledge can migrate from academic spheres into public domains and vice versa.

In contrast with the aligned topics of Twitter/X users and published mangrove research, we found discrepancies between previously held assumptions on mangrove perceptions. Studies have suggested mangroves lack public appeal or are framed negatively (Dahdouh-Guebas et al. 2020), especially historically (Friess et al. 2020b). Our analysis using AFINN and NRC lexicons indicates a clear dominance of positive sentiment and emotions in tweet language use (Figures 2 and 3). These findings suggest that sentiments towards mangroves have changed from historical perceptions related to ecosystem disservices. It also shows how Twitter/X functions not only as a platform for information exchange but also as a space where appreciation for (mangrove) ecosystems is increasingly visible. Social media communication strategies can continue to foster the already prominent positive sentiment while generating mangrove awareness where perception gaps occur. These existing positive sentiments and knowledge can be harnessed to create support for conservation action, management plans, and new policies (Veríssimo et al. 2017; Bergman et al. 2022).

The topic of 'Ecosystem Services' on Twitter/X

'Mangrove snapper' and 'mangrove jack' were two of the most common bi-grams within the 'Ecosystem Services' topic (15.1% and 9.5%, respectively). While the exact species remains unclear due to overlapping common names of fish, finding reference to recreational and commercial fish species was expected in this analysis. Mangroves are a key habitat for fisheries, supporting an estimated annual abundance of >700 billion juvenile fish and invertebrates (Zu Ermgassen et al. 2025). Unsurprisingly, mangrove fisheries are a commonly studied ecosystem service (Hamza et al. 2024). Remarkably, there was little conversation surrounding mangrove's function as nursery grounds for commercial and recreational fish. Mangroves are recognised on Twitter/X as a location to fish, not a location that feeds commercial and recreational fish populations in and out of mangroves.

Ecotourism was another ecosystem service that was a popular topic identified in this analysis. Mangrove ecotourism has been valued as a multi-billion-dollar industry, as per analysis of Tripadvisor data and other datasets (Spalding and Parrett 2019). In this study, frequencies of bi-grams were linked to recreational uses of mangroves (other than fishing) such as 'mangrove boardwalk', 'mangrove kayaking', and 'mangrove tunnel' increased over the study period (Supplementary Information). Interestingly, the COVID-19 pandemic and shut-down of international travel was correlated to a decrease in ecotourism tweets. From 2020 until 2022, bi-grams representative of mangrove ecotourism and recreational use had a total frequency count of only 677(or 1.8%).

Some regulating ecosystem services were highlighted in the topic analysis, despite them being more abstract or 'hidden' from public view compared to more tangible ecosystem services such as fisheries or ecotourism. Coastal protection, which accounted for a total of 6,947 frequency counts, refers to the ability of mangroves to act as a barrier to extreme wave events and high water levels through wave attenuation through roots and surface roughness (e.g. Jiang et al. 2025; Pelckmans et al. 2025). This ecosystem service has been well recognised to have substantial economic benefits to protected coastlines (e.g. Narayan et al. 2025), and this benefit was well recognised by social media users in this study. Another regulating service recognised by social media users in this study was the role of mangroves in climate change mitigation, through the sequestration of atmospheric carbon dioxide and its storage in anoxic soils over long time-scales (Adame et al. 2024). This ecosystem service is now well known in policy making circles (e.g. Sidik et al. 2022; Ofori et al. 2025), and the prominence of carbon- and climate-related terms in the top bi-grams (Figure 1) suggests it is an ecosystem service that has captured public attention too.

The topic of mangrove 'Restoration' on Twitter/X

The topic of 'Restoration' was the second-most prominent topic identified in this analysis, and mostly consisted of bi-grams showcasing pictures of mangrove planting activities or advocating for mangrove reforestation. Twitter/X users are posting content of tree planting in a positive context highlighting how social media can help support such restoration initiatives. However, we did not find indications of

understanding when tree-planting is appropriate as opposed to other methods. This contrasts with scientific literature and restoration best-practices which underline the importance of restoration techniques that go beyond tree-planting schemes (Lee et al. 2019). Mangrove planting, often of a single species, is widely known to have a high failure rate, as the wrong species is often planted in the wrong biophysical location (Kodikara et al. 2017; Wodehouse and Rayment 2019; Global Mangrove Alliance 2024). It is now broadly understood in academic and nature management spheres that restoration should embrace a wide range of approaches, integrating not only natural science perspectives but also insights from the social sciences, economic considerations, and cultural factors (Hagger et al. 2022; Nijamdeen et al. 2022; Tedesco et al. 2023).

The topic of mangrove 'Threats' on Twitter/X

Discussions of threats facing mangrove forests was the third most prominent topic identified in this analysis, and was particularly popular in 2010, 2016, and 2019 (Figure 1). This was often linked to high-profile events of mangrove loss in specific locations. For example, in 2010 mangroves in Mumbai, India, were being converted into an airport, and the BP Deepwater Horizon oil spill in the Gulf of Mexico, USA, had a negative impact on the limited extent of mangroves on that coastline (e.g. Mendelssohn et al. 2012). In 2016, mangroves in the Gulf of Carpentaria, Australia experienced a large vegetation dieback due to climatic oscillations (Abhik et al. 2021; Table 1), which received substantial media attention. In this year, plans for potential coal plants near the Sundarbans (Bangladesh) were also being discussed, and received substantive local attention on social media. Global news channels in 2016 were covering the impacts of rice and oil palm on mangroves in response to a study highlighting this threat in Southeast Asia (Richards and Friess 2015b). Sea level rise and mangrove destruction as a general concept were tweeted about more consistently year by year, with sea-level rise being forecasted as a key threat to mangrove survival in the future (Lovelock et al. 2015).

Positive sentiments and emotions associated with mangroves

We consistently observed the use of positive language surrounding mangroves following the AFINN and NRC lexicons (Figures 2 and 3). This is in contrast with past publications on statements in media in which mangroves were described negatively (Dahdouh-Guebas et al. 2020). Within the context of coastal ecosystems both scientific research and news media have predominantly focused on coral reefs, with mangroves, seagrass meadows, and salt marshes being characterised as 'uncharismatic' (Duarte et al. 2008). These studies used different data sources (Duarte et al. 2008; Dahdouh-Guebas et al. 2020), or took a more historical approach to understanding sentiments about mangroves, such as the use of colonial records to understand sentiments centuries ago (Friess 2016). Historically, coastal wetlands were believed to be a source of disease, e.g. malaria, due to the strange odour of decaying organic matter present in wetlands (FitzRoy 1853). This perspective has evolved into mangroves being potential breeding-grounds for mosquitoes. Since we found no mention of disservices in the top 100 bi-grams or their associated tweets, we conclude that mangrove disservices are not a prominent perception among Twitter/X users, and our results indicate that perceptions of mangroves in recent decades are now much more positive. This study reveals a more nuanced reality to mangrove communication on Twitter/X.

When negative sentiments of mangroves were observed, they were often a response to negative mangrove events (such as the previously mentioned Australian dieback in 2016) Twitter users were angry about the loss and feared for mangroves rather than being fearful of mangroves and their ecosystem disservices. Our results show consistency in advocating against mangrove degradation and destruction (Table 1). For example, news about the removal of mangroves for a bullet train in India, or to make space for an airport in Manila Bay, Philippines, was profusely tweeted.

The positive sentiments and emotions are visible in tweets describing mangrove experiences, planting success stories, the implementation of new protective mangrove policies, etc. (Table 1). A particularly popular mangrove event was in 2013 when Cristiano Ronaldo became mangrove ambassador in Bali. The news of Sri Lanka protecting all its mangroves in 2016 was overshadowed by the big die-off in the Gulf of Carpentaria. Interestingly, another shift in sentiment is visible in 2022 which, in part, corresponds to the news of the largest bacterium ever discovered. In the lexicons, the word 'bacteria' is tagged to denote the emotion disgust. However, we found that the tweets covering this news depicted overall positive sentiments and emotions. With future improvements of these lexicons, the word 'bacteria' may fall under emotions such as surprise or joy in this context. The overarching positive tone of mangrove communication on twitter indicates interest in mangroves whether it be in form of participating in eco-tourism activities, mangrove planting, or advocating to safeguard mangroves. Harnessing these sentiments and emotions to support offline actions may be feasible through conservation marketing (Wright et al. 2015; Veríssimo et al. 2017; Crespo and Cruz 2023).

Implications for mangrove communication strategies, policy, and management

Social media has become a powerful tool in conservation, shaping communication strategies, fundraising, management plans, and even policy development (Wright et al. 2015; Bergman et al. 2022). Viral campaigns, such as those against plastic pollution, have contributed to bans on single-use plastics in multiple jurisdictions (Jones 2025). Social media data have also been applied to assess visitation patterns and ecosystem service use, guiding protected area management and policy (Hausmann et al. 2017b; Tenkanen et al. 2017; Toivonen et al., 2019), with the Great Barrier Reef providing a notable example (Becken et al. 2017). Moreover, online exposure of harmful visitor behaviours has demonstrated potential to encourage behavioural change (Šmelhausová et al. 2022).

Social media sentiments support the notion that mangroves give cause to conservation optimism (*sensu* Friess et al. 2020a). Our analysis supports this view, revealing that mangroves have consistently been portrayed with positive sentiments and emotions on Twitter/X over the past decade. For example, tweets celebrating Sri Lanka's 2015 decision to protect all its mangroves were among the most widely shared. The 2022 release of the State of the World's Mangroves report by the Global Mangrove Alliance, highlighting substantial improvements in mangrove conservation worldwide, was also frequently shared (Table 1). However, gaps remain. Discussions often emphasize tree-planting as the central restoration method, despite evidence that such approaches alone are ineffective for long-term outcomes (Blum and Herr 2017). Likewise, key dimensions of mangrove social – ecological systems, such as local livelihoods and cultural values, remain underrepresented in popular discourse.

These gaps in perceptions and topics suggest directions for future awareness campaigns to broaden public perceptions. Expanding mangrove communication campaigns to include effective restoration methods, cultural ecosystem services, and the livelihood benefits of mangroves could strengthen public understanding and support. Framing mangroves as both *mitigation* (blue carbon) and *adaptation* (nature-based coastal protection) solutions simultaneously could help clarify the connection between individual ecosystem services. Popular and policy-relevant terms like *'blue carbon'* and *'nature-based solutions'* can act as bridges between science, policy, and public perceptions (Kusmanoff et al. 2020; Seddon et al. 2020). Given the rising global momentum around climate policy, stakeholders could also continue to connect mangrove conservation to international agendas such as the Paris Agreement and the Kunming – Montreal Global Biodiversity Framework.

Over the 2010–2022 period analysed in this study, Twitter/X evolved from a short-form, text-dominated microblogging site into a global, social multimedia platform. Our results can be cautiously generalised to other social media platforms, such as Instagram, Facebook, or TikTok. All large platforms similarly amplify event-driven spikes in attention, favour highly shareable content, and reflect a mix of recreational, scientific, and advocacy-oriented messaging (Ementu-Maxwell et al. 2026). However, platform-specific 'cultures' (e.g. image-based vs text-based communication) may shift the relative prominence of certain topics or sentiments. Regardless of platform, consistently positive online sentiment can be strategically leveraged to strengthen public support for conservation. Additionally, perception gaps must be intentionally addressed, as social media reliably reproduces both accurate and distorted understandings, i.e. fake news, of ecological issues and many other themes (cf. Nicolosi et al. 2025).

Study caveats – what social media cannot do (yet)

Social media data can serve as a valuable complement to traditional on-site social and ecological research but cannot capture the full complexity of stakeholder perceptions. We are unable to map which stakeholders are active posters on social media, versus those that are not. Local ecological knowledge and cultural ecosystem services, such as the spiritual value of a mangrove, are also unlikely to be broadly discussed on social media. Additionally, social norms may deter individuals from posting their perceptions. On-site stakeholder mapping and interviews, an important step in conservation planning and policy development (Nijamdeen et al. 2022; Grimm et al. 2024), cannot entirely be replaced by online (social media) methods. Furthermore, the lexicons themselves are also limited in the emotions they can track; human-nature interactions and relationships are, of course, more complex. Nonetheless, this analysis does capture the sentiment of a general public, many of which may visit, or already have visited, mangroves as the topic 'Ecosystem Services' suggests.

Conclusions

Social media is a powerful influence on public discourse, and our analysis indicates that mangroves are generally perceived positively by the broader public, challenging historical assumptions of widespread negative sentiment. Certain mangrove ecosystem services, such as ecotourism and recreational activities, and coastal protection are frequently tweeted.

However, there is the potential for misunderstandings or negative associations to still be perpetuated or revived on social media. For example, conversations around mangrove restoration on Twitter/X tend to emphasize tree-planting initiatives, often overlooking more integrated and holistic approaches. Influential users and decision-makers play a key role in shaping these narratives, intentionally or otherwise (Bergman et al. 2022; Shah 2024). Therefore, monitoring and analysing online discourse is critical (Toivonen et al. 2019). Actively highlighting the vital ecosystem functions, long-term socio-economic benefits, and conservation successes can help foster public support, counter misinformation, and continue to build the optimism needed to sustain restoration efforts. These findings highlight the potential of social media data to inform public outreach strategies, support the design of conservation and restoration efforts, and contribute to monitoring human – nature interactions, particularly in the context of ecotourism and recreational engagement with mangrove ecosystems.

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CRediT: **Layla Olefs:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing; **Mark Simpson:** Data curation, Formal analysis, Investigation, Methodology, Resources, Software; **Jean Hugé:** Conceptualization, Supervision, Writing – original draft, Writing – review & editing; **Daniel A. Friess:** Supervision, Writing – original draft, Writing – review & editing.

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