"Mahseer on the internet": A Conservation Culturomics Study of the Emotion and Attitude of the People towards Mahseer, a Flagship Megafish

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Certificate of Examination

This is to certify that the dissertation titled "**Mahseer on the internet**": **A Conservation Culturomics Study of the Emotion and Attitude of the People towards Mahseer, a Flagship Mega fish**" submitted by Ms. Anima Angelina Lakra (Reg. No. MS16101) for the partial fulfilment of BS-MS dual degree programme of the Institute, has been examined by the thesis committee duly appointed by the Institute. The committee finds the work done by the candidate satisfactory and recommends that the report is accepted.

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Dated: April 09,2021

Declaration

The work presented in this dissertation has been carried out by me under the guidance of Dr. Manjari Jain (Internal Supervisor) Indian Institute of Science Education and Research Mohali and Dr. V.V. Binoy (External Supervisor) National Institute of Advanced Studies, Bangalore. The work has not been submitted in part or in full for a degree, a diploma, or a fellowship to any other university or institute. Whenever contributions of others are involved, every effort is made to indicate this clearly, with due acknowledgement of collaborative research and discussions. This thesis is a bonafide record of original work done by me and all sources listed within have been detailed in the bibliography.

Angelina

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In my capacity as the supervisor of the candidate's project work, I certify that the above statements by the candidate are true to the best of my knowledge.

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Abstract

Mahseer is an iconic and magnificent fish species and is often referred to as 'the tiger of the freshwater'. For a long time, these fish have been a cultural symbol of economic, recreational, and conservation importance across their range, depicted and worshipped as gods by many communities. However, in recent years, these species have faced a catastrophic decline in population size mainly due to anthropogenic pressure. Therefore, the conservation of these iconic species not only requires the help of biologists and ecologists but also, the support of the public, since their perception, interest, and emotion towards these species can function as a determinant of conservation intervention programmes. With the dramatic growth of the internet and popularisation of the Information Communication Technology (ICT) around the world, nature-related content on the digital world is expanding. If systematically processed, such information may be of high value for a large-scale evaluation of species or ecosystems and hence the conservation This line of research known as conservation culturomics is getting popularity all over the world. The current study analysed the trend of search conducted on the internet (Web, Image, News, YouTube), articles published (media attention) and scientific literature published on three species of Mahseers namely Golden Mahseer, Humpback Mahseer, and Deccan Mahseer. The sentiment analysis of comments received by the posts on Mahseer appeared on various social media was also carried out.

Our results reveal spatial and temporal variation in interest in different Mahseer species across the last 10 years within India and across the world, with higher interest from countries like India and Bhutan, and states like Himachal Pradesh, where Mahseers are abundant. Analysis of public interest, perception, attitude, and emotions towards the species demonstrated that the general public was more inclined towards Golden Mahseer and Humpback Mahseer as they were the most frequent search queries across 10 years. However, the overall interest in Mahseer

in online media decreased as indicated by the number of articles published by the media sector. Our survey of scientific literature illustrated that research publications regarding Golden Mahseer, Humpback Mahseer, and Deccan Mahseer focused on their conservation as the populations of these species are declining at a faster rate. We also found a strong correlation between social media data volume and online news volume concerning the extinction of the Humpback Mahseer, while other events regarding the other species only appeared in either social media or online news. Lastly, the sentiments of the public on social media demonstrated that there is a neutral sentiment of the people towards Mahseer. Hence, public interest in different locations and at different times varies across online platforms, and may be related to current events. Collection of such Culturomics data is rare in conservation studies, and can help nature conservation practitioners respond to cultural trends and revive their societal significance.

Introduction

Human populations have increased global demands on natural resources, putting many species in jeopardy. Developing effective schemes to conserve the natural population of any organism is a complex process requiring an approach integrating biological aspects of the species, data on the properties of their habitat and various people interacting with them directly or indirectly. However traditionally the conservation programmes are highly dependent on the biological and environmental information and rarely considers the human dimensions of the conservation problems. Many recent studies have shown that conservation strategies involving only traditional methods such as diversity study, taxonomy, ecology, behaviour, population biology, ecology etc. of the focal species and ecosystem study have not provided satisfactory outcomes (Ostrum, 2010). While understanding population ecology and genetics of the species focused by the conservation programmes is important for managing their natural population, perceptions and attitudes towards these animals kept the people dependent on the species for their livelihood sharing, or sharing habitat with them is a major contributor to the success of conservation programs. Conservation scientists have historically emphasized the importance of considering the information on importance integrating the mind-set and cultural practices of various stakeholders while designing plans for conservation of a species or ecosystem (Ladle et al. 2019). Local biodiversity conservation was found to be more successful when the utility value and gain to communities are obvious (Gurung and Seeland, 2008) and community-oriented conservation programs have evolved over the last two decades as an alternative to conventional practices based on legal, theoretical, and pragmatic considerations (Horwich and Lyon, 2007). Promotion of this conceptual change and public engagement in natural resource management and biodiversity conservation were high priorities from the United Nations Conference on Environment and Development (UNCED) in 1992 (UN 1992).

An individual's interest in conservation and pro-environmental behaviour is influenced by their awareness of ecosystem, concerns and pro-environmental values and behaviours of local human communities on natural resources are often the determining factors in whether local species conservation projects succeed or fail (White, 2011). Anticipating people's reactions to conservation concerns and approaches, identifying more socially appropriate management actions, advising communication and other attitude-behaviour change techniques, and recognizing the context for and addressing social tension among various population segments and user groups are all examples of contributions from such an approach to the conservation (Bennett, 2017). Individual values, perceptions, opinions, standards, and habits have been studied using a variety of approaches ranging from quantitative surveys to more qualitative strategies such as interviews and focus groups (Bennett, 2017). Non-cognitive (e.g., emotions) and wider cultural and societal-level (e.g., urbanization, institutions) effects on human behaviour are among the promising new directions in this field (Manfredo et al, 2014, Bennett et al. 2017). Similarly, Greving, (2020) suggests that emotional responses like sympathy for suffering, hurt, or endangered wildlife are important factors for animal conservation. For instance, a study conducted by this group looked at how different wildlife photos influenced compassion, attitudes toward Citizen Science (CS) projects, and intentions to participate in CS. Their findings revealed that images of distressed raccoons and foxes elicited feelings of sympathy, which in turn influenced attitudes toward CS projects and intentions to engage in them. Since compassion was also shown to improve behavioural intentions to relieve distress, compassion could be an important factor in growing citizen participation in wildlife conservation.

A huge gap exists between conservation biologists and the people on the ground who are in day-to-day contact with these focal species. Involvement of people from various sectors in conservation decision making and discussions have shown to be extremely helpful, for instance

(Olsson et al. 2004) explains that some habitats can only be maintained by human management activities, while many conservation programs do not allow for such interventions. However, the rapid accumulation of a wide range of digital data forms (Castells, 1996) and popularisation of the tools of Information Communication Technology is evolving as a tool for understanding the emotion and sentiments of the public towards animal species and ecosystems. The Internet, which provides unparalleled amounts of diverse and easily accessible data via web pages, social media, and other data platforms, is at the heart of this revolution. According to Jaric (2020) these kinds of data are increasingly generated and processed in the digital world, and they are an inextricable part of modern life. It also opens up new research possibilities that the scientific community is only now starting to consider. He reiterates that the data generated can be useful to answer essential ecological questions and examine ecological processes at a variety of spatiotemporal scales and in a variety of settings.

Words represent concepts, places, or objects in a symbolic direction (Carlston, 2013). Therefore, information about their cultural salience or visibility is provided by the frequency with which words and phrases are used in a language (Correia et al. 2016), yielding insights into human cultures and how they transform. Culturomics and iEcology are two new research fields that mine digital data produced by people in their daily lives with low sampling costs and a wide spatiotemporal reach to derive new and unique insights. Culturomics approaches are being used to research contemporary conservation issues (Ladle, 2016) through the perspective of human–nature interactions. Culturomics focuses on the study of human culture through the quantitative analysis of vast bodies of digital data (Michel, 2011) while the ecological information that can be obtained from these human-nature experiences in the digital world is used for iEcology. iEcology data primarily yields correlative insights similar to other large-scale ecological explorations including much of macroecology (Gaston and Blackburn, 2000).

An area of conservation research which presents unique challenges is freshwater diversity. A diverse fish fauna inhabits global freshwater resources, with nearly 16,000 species (47 percent of all fishes and 25% of all vertebrates) and about 250 new species described each year (Villamil et al., 2015; Arthington et al. 2016; Eschmeyer and Fong 2016). However, this diversity is concentrated in a small region (less than 1% of the Earth's surface) that is heavily exploited and adjusted for social needs (Dudgeon et al. 2006; Vörösmarty et al. 2010; Closs et al. 2016). Recent research suggests that, despite covering a region nearly as vast as Greenland, inland and marine/coastal wetlands have continued to decline rapidly, with 35 percent declines since 1970, three times the global forest loss rate (Finlayson et al. 2018). Most large rivers are now fitted with dams (Poff and Schmidt, 2016), and rivers are commonly used to dump large amounts of sewage and industrial waste (Keller et al. 2014). Freshwater fishes are among the most endangered taxa as a result of these stressors. More than 20% of the 7,588 freshwater fish species evaluated for the IUCN Red List are endangered, with 69 species already declared "extinct" or "extinct in the wild" (Darwall and Freyhof, 2016).

The current state of study, surveillance, and intervention is inadequate to address the threats that aquatic ecosystems face and their consequences for humans. Restricted accessibility and poor species detectability make aquatic research difficult (Katsanevakis et. al, 2016, Hussey, 2015). Importantly, in aquatic ecosystems, environmental effects often occur faster than they can be actively controlled and understood (Stedman, 2019). Furthermore, conducting high-quality social science research to understand human beliefs, attitudes, activities, and information about aquatic ecosystems takes time and money, and it frequently lags behind fast ecological changes or occurs at scales that do not correspond to local ecological change (Bragagnolo, 2016).

An important freshwater mega fish indigenous to India and other parts of South Asia is the Mahseer. Mahseers (Order Cypriniformes; Family Cyprinidae) are rheophilic (flow-loving) cyprinids (Order Cypriniformes; Family Cyprinidae) renowned for their sport and table value around the world (Nautiyal, 2014). India is home to 15 out of the 47 species of Mahseer that exist in the world (IUCN fish diversity). Mahseer translates as Mahi – fish, and sher – tiger, and is therefore often referred to as tiger among fish (WWF India). These fish are a sportsman's delight, apart from their cultural and religious prominence they are preserved in 'temple sanctuaries' throughout India. They are very robust and resilient, making them one of the toughest fighting freshwater sports fish (Pinder,2020). Recreational angling may also produce substantial revenue for the protection of Mahseer (Everard and Kataria, 2011). Involving local people in the benefits associated with angling, wildlife, and cultural tourism by the Western Ramganga River in Uttarakhand State was found to be important. This provides local incentives for river conservation and could be the most successful way to avoid disruptive over-exploitation in impoverished rural communities. The recognition of this value and its recirculation to local people will serve as the foundation for a "paying for ecosystem services" (PES) market that benefits river ecosystems, local people, tour operators, and visiting anglers, as long as local people profit more than through the killing of fish for non-renewable consumption or sale (Everard and Kataria, 2011). As a flagship species, the presence of Mahseer is a symbol of a healthy riverine ecosystem and is therefore significant (Wildlife Association of South India). This fish has experienced significant population loss in much of its distribution area, and is now considered endangered due to pollution, habitat degradation, and overfishing (WASI, India, 2018). Mahseers are fragile and extremely sensitive to changes in water conditions, as evident from the reported decrease in their size (length), size composition (predominance of young individuals), and reduced catch share over the last century (Pinder et al. 2019).

Restricted accessibility and poor detectability of organisms impede studies in aquatic environments (Collier et al. 2016, Schipper et al. 2008). As both complementary and specific sources of knowledge, culturomics, and iEcology can make important contributions to aquatic sciences and conservation (Šmejkal, 2020). Aquatic systems' persistent data and analysis deficits call for the creation of innovative research methods. They are also far less expensive than field sampling and social surveys because culturomics and iEcology take advantage of the available data (Jaric, 2020).

Therefore, in the present study, we used online tools such as Google trends that compare the frequency of top Google Search queries across regions and languages. It generates an impartial sample of anonymized, categorized, and aggregates Google search data to help measure interest in a particular topic in the search from all over the world, down to city-level geography. It can produce data for up to 12 years, which is useful for analyzing current ecological thought patterns (Redondo et al. 2016). Mediacloud is a tool for studying media ecosystems. The system assists researchers in tracking the spread of news, media frames, and tone of coverage of various narratives by analyzing millions of online stories. (From the MIT Media Lab). Lastly, Sentistrength (JAVA version) a sentiment analysis tool is a software that analyzes text data to help quickly understand how customers feel and what their emotions are about the content you produced.

- ❖ Characterize temporal and spatial variation of public interest in various Mahseer species in the last 10 years using internet search data.

- ❖ Understanding how these endangered species were projected by the media.

- ❖ Exploring the focus of the scientific literature published on Mahseers.

- ❖ Understanding the sentiment towards this species through social media analysis.

Public interest and Popularity of the species

To ensure sustained support for conservation efforts, it is important to understand public perceptions of biodiversity. However, observations across larger spatial scales remain scarce, primarily due to a lack of appropriate evaluation methods (Correia, 2016). Some studies assess species popularity and public interest towards biodiversity using culturomics methods. For example, the study by (Correia et al. 2016) used an internet saliency measure to determine the national and international popularity of four Brazilian bird taxa and assessed the extent of this visibility that can be explained by factors such as familiarity, aesthetic appeal, and conservation interest. Their findings suggest that familiarity (the number of people living within a species' range) is the most important factor driving internet saliency in Brazil, whereas aesthetic attractiveness (body size) is the best explanation for variation in international saliency. Endemism and survival status of species had minor, but mostly negative, effects on both internet saliency metrics (Correia et al. 2016). Culturomics can also be used to track public interest in natural features and environmental concerns in general. For example, (McCallum and Bury, 2013) used Google Insights for Search (GIFS), a precursor to Google Trends, to determine the importance of 19 environmental words between 2001 and 2009. Throughout the 9-year research, they discovered a global decline in the usage of words like "biodiversity" and "wildlife." With the same objective, (Wilde and Pope, 2013) assessed the public interest in recreational fishing using Google Insights for Search in 50 countries for the words "fishing" and "angling". From 2004 to 2011, normalized fishing search volume trends ranged from a

72.6 percent decrease in Russia to a 133.7 percent rise in the United States (Hungary). In 40 (80%) of the countries surveyed, the normalized fishing search volume has decreased. The decline has been disproportionately high in English-speaking countries, but it has also been large in Central and South American, as well as European countries.

Spatiotemporal trends

The potential of iEcology and culturomics has been illustrated in many recent studies. The most popular uses of such approaches have been to investigate species occurrences and patterns in space and time. For instance, the study by (Ghimire, 2020) investigated Spatio-temporal variation in vulture-related information on Facebook, where researchers used photographs of vultures collected in Nepal. A total of 518 photographs were taken, including photos of all nine species found in Nepal, with the Himalayan Griffon being the most common and the Indian Vulture being the most limited. At least one vulture species was photographed in 59 districts across Nepal, with Kaski capturing the most photos and Nawalparasi coming in second and third. Another similar study by (Proulx, 2013) investigated the timing of biological processes over a latitudinal gradient, such as the seasonal recurrence of pollen release or mosquito outbreaks with the help of Google Trends. They also mapped the regional extent of Google Trends results for 5 invasive species in the United States and discovered invasion patterns that match their coarse-grained distribution at state levels. Similarly, (Mittermeier, 2019) explored the seasonal trends of interest in nature across many species and cultures, by analyzing 2.33 billion page views to articles for 31,751 species across 245 languages using data from Wikipedia, and demonstrated that how and when people communicate with plants and animals online is influenced by seasonality. Seasonality is substantially more prevalent in pages for plants and animals than it is in a random sample of Wikipedia articles, with over 25% of species

in the data set exhibiting a seasonal trend in at least one of their language-edition pages (Mittermeier, 2019).

Sentiment, attitude, and emotions

Culturomics techniques can also help assess the sentiments, attitudes, and emotions of the public by providing a means to quantify the polarity of attitudes expressed within various media. This was explained by the study done by (Fink, 2020) which measured online sentiment towards rhinoceros using natural language processing techniques, based on social media and online news data. Rhinos are iconic species that are particularly endangered by the illegal wildlife trade. They concluded that tragic events, such as the death of the last male northern white rhinoceros in Sudan in March 2018, elicited the strongest responses concentrated in western countries outside rhinoceros range states. Likewise, for mitigating the devastating impact of the infectious amphibian disease chytridiomycosis in the Pyrenean Mountains, a touristic area, information on human attitudes was assessed. (Loyau, 2016) investigated whether attitudes toward amphibians affected support for future conservation actions by conducting a questionnaire survey in mountain areas (n = 418) and on the internet (n = 868). Positive sentiment toward amphibians (reported liking amphibians) and knowledge of amphibian decline and/or disease were the most important factors correlating with support for conservation measures, according to their findings; this relationship was particularly true for those who replied to the internet questionnaire.

Ecosystem and habitat dynamics

Changes in the ecosystem and habitat dynamics in response to rising anthropogenic influences have also been studied using culturomics methods. For example, (Frenne et al. 2018) assessed Videos from the Tour of Flanders cycling race, which have been used to map phenological changes in vegetation in response to climate change for over 35 years. Images of corals and

tweets about corals have both been used to assess the condition and patterns of coral reefs in numerous areas that have been impacted by human activity (Haas et al. 2015). Photo reviews, tweets, and news stories have also been used to investigate aspects of invasion dynamics and overfishing (Francis et al. 2019). Similarly, such approaches may be used to monitor behavioral changes in animals in response to anthropogenic impacts. For example, the study by (Sullivan, 2019) where the endangered Hawaiian monk seal was studied to determine the animal's occurrence, behaviour, and survival threats. Monk seals have recently re-established a small but increasing population in the human-populated main Hawaiian Islands, raising questions about human-seal interactions. They looked at Instagram posts with the hashtag #Monkseal and, found that a large percentage of them showed the animal being disturbed by anthropogenic activities by a significant number of people living within 3 meters of the seal. Lastly, (Pinder et al. 2014) explains that recreational fishing and the angling community have frequently been cited as playing a vital role in conserving Mahseer. Since there is a lack of scientific evidence and tracking fish stocks in large monsoonal rivers is difficult, attempts to establish long-term trends in their populations have concentrated on sport fishing capture records. The catch per unit effort (CPUE – by number and weight) as a measure of relative fish abundance and the size structure of catches were determined using data collected between 1998 and 2012 from Galibore, a former fishing camp on the River Cauvery in Karnataka, India. Between 1998 and 2012, 6161 Mahseers, ranging in size from 1 to 104 lbs (0.45–46.8 kg), were captured and released using 23 620 hours of fishing effort. Over time, the number of CPUE increased dramatically, while the number of CPUE by weight decreased, indicating high population recruitment and a change in population size structure. This indicates a strong response to the catch and release policy and a decrease in illegal fishing, showing that conservation policies that concentrate on both the positive and negative aspects of exploitation can be effective in achieving positive outcomes. These results from angler capture data provide information about

the Mahseer population that would be difficult to obtain by any other means (Pinder et al. 2014).

Framing of policies and issues

The solutions considered acceptable are determined by how a problem is understood, and the way an issue is framed affects policymakers and activists' acceptance of the solution. Corey, (2019) analyzed words used in digitized texts to determine the chronological order in which scientists, the public, and policymakers participate in the conservation process for three major conservation issues, acid rain in North America, global DDT pollution, and ivory overexploitation of African elephants. Through their analyses of the order of severity of the three problems, they highlighted the fact that there are many paths to conservation success, and scientists, the general public, and policymakers must all work together to ensure the success of conservation efforts. Case studies on how recreational fishing has aided Mahseer conservation in India will aid in the development of future fisheries management policies in Asia. PES markets' potential focused on the recirculation of revenue from recreational anglers to local people has been recognized as a potentially important conservation mechanism in Uttarakhand (Pinder et al. 2019). The incentivized community policing of illicit and harmful fishing has resulted from C&R fisheries' longer-term profits exceeding the immediate-term market value of harvested fish (Everard and Kataria, 2011; Pinder and Raghavan, 2013) described the position of recreational fisheries on the Cauvery River in Karnataka as positive in general, with local NGOs managing fisheries sustainably and providing alternative employment as guides and guards to fishermen who previously used illegal fishing tactics. Angler capture data has been used to track Mahseer size and weight changes (Pinder et al. 2015; Bower et al. 2017) used a proactive strategy to involve stakeholders in priority-setting activities, and discovered

that a social-ecological systems approach was warranted in researching Mahseer recreational

fisheries in both Karnataka and Uttarakhand.

Study design

Why Mahseer

The potential of culturomics and iEcology applications has been harnessed by scientists focusing on terrestrial species. However, extending these to the aquatic realm by offering a short outline of these emerging methods and highlighting key areas where culturomics and iEcology are most likely to have the greatest effect, such as protected area management, fisheries, flagship species identification, detection, and distribution of endangered, unique, and alien species, and ecosystem status assessment (Jaric, 2020). Mahseers are 'flagship' and 'umbrella' focal species, which are top predators, potentially acting as key agents in trophic cascades (Caro, 2010). Most previous studies have focused on aspects of their physiology and conservation. Following the traditional methods of conserving the species by artificial propagation and a national stock augmentation program has resulted in a dramatic expansion of *Deccan Mahseer's* natural biogeographic range, with large numbers of fingerlings distributed to every state in India. However, the species such as Golden Mahseer (*Tor putitora*) and Humpback Mahseer (*Tor ramadevii*) have been recently classified as Endangered due to continued population decline (Raghavan, 2013). Therefore, there is an urgent need to consider alternative approaches involving human dimensions such as people's opinions and perceptions while designing the conservation policy of this threatened species, since people are more likely to protect species and places with which they are acquainted and which provide them with something valuable (Ladle et.al. 2019). Such attitudes and perceptions of the public could be analyzed using culturomics tools to improve policy measures for better conservation outcomes.

Three species of Mahseer were chosen for this study:

Golden Mahseer (*Tor putitora*) One of the most fascinating" flagship" freshwater fish species of the Indian subcontinent, (Everard and Kataria, 2011; Gupta et al. 2014). Golden Mahseer is found primarily in the Himalayan rivers. This mega fish is also known as 'king Mahseer', 'mighty Mahseer', and 'The tiger of the freshwater'. Because of its large size, attractive golden color, and large body scales, it is a popular game fish species and is therefore assessed as Endangered (Gupta et al. 2014), considered ''elusive and intelligent" and therefore, an angler's delight (Gupta et al. 2014).

Figure 1 Golden Mahseer (Photograph by Ongordy under CC BY-SA 4.0 Licence)

Deccan Mahseer (*Tor khudree*): Also known as Blue finned Mahseer and currently found across peninsular India, especially in westward-flowing river systems that originate in the southern Western Ghats (Menon 1992; Jayaram 1995, 2005). Because of the overall population loss, blue finned Mahseer has been classified as Endangered (Raghavan, 2013). Blue finned

Mahseer, however, is now considered non-indigenous in river Cauvery and, in some cases, invasive and harmful to native marine biodiversity outside of the Krishna drainage (Pinder 2015; Pinder et al. 2015).

Figure 2 Deccan Mahseer. (Photograph provided by Cognition and Scicomm Lab)

Humpback Mahseer (*Tor ramadevii*), The other common name used for denoting this fish is 'orange finned Mahseer' This species is endemic to the River Cauvery catchment in South India (Pinder et al. 2018), but it is believed to have once been widely distributed along the Cauvery and its major tributaries (Thomas, 1873). However, it is now recognized as the most imperiled of all *Tor species* and the only species to be assessed as Critically Endangered (Pinder et al. 2018).

Figure 3 Humpback Mahseer (Photograph by Dr. A. J. T. Johnsingh under CC BY 3.0 License)

Analysis of the search for Mahseer on the internet

Recently the Google Trend has emerged as an efficient system to study the search conducted by the people on various topics on the internet (Jiang, et al. 2016). The keywords chosen for the present study were the names of the focal species "Mahseer", "Golden Mahseer", "Deccan Mahseer", "Blue finned Mahseer", "Humpback Mahseer", "Orange finned Mahseer". The trend in search over 10 years (from 09.09.2010 to 09.30.2020) was collected keeping geographical areas 'Worldwide' and 'India'. The data was collected following this protocol from Web, Image, News, components of Google Trend, and the video-sharing website hosted by Google, YouTube. Google Trends reports relative rather than absolute search volumes on a 0-100 scale for any given period (known as Relative Search Volume; RSV), it yields the search volume relative to the highest point in popularity (100) of that term over the whole period under

consideration Redondo et al. (2016). Google Trends provides the opportunity to compare the trend between searches happening using specific keywords. A quick exploration of the literature on Mahseers and raising search queries associated with the keywords used in the internet analysis has revealed the importance of studying the relationship between the terms such as angling, spawning, and overfishing, along with 'Mahseer'. Hence the data on these terms were collected and correlation analysis was conducted.

The dates on which the peaks of search (the trendline crossing the 100% RSV) were detected and were subjected to further analysis by searching on the internet by giving the keyword and that specific date to know the incident fueled high levels of search.

How media projected information on Mahseer

Media cloud is a platform hosted by the Massachusetts Institute of Technology USA for analyzing media content published in digital format all over the world (https://mediacloud.org/about). Here also the keywords used in the internet analysis were entered in the double quotation marks form in the tools "Explorer" which creates an instant analysis of how digital news media covers the topic of interest. Where we can see the attention to the issue, the language used, and the people and places mentioned. "Source Manager" views the print, broadcast, and digital news collections and sees what media sources this platform has, and suggests additional sources about the research topic. tools of Mediacloud. These tools analyze the contents published by various media on digital platforms relevant to the search query. A word cloud of the top words that are frequently used with the search query was also generated.

Has the focus of scientific research on the Mahseer changed over the years?

research publications related to the Mahseer species that came out in the last "10 years" were extracted from the two scientific databases/search engines SCOPUS and Google Scholar. The search queries and the keywords were entered in double quotation marks so that only those research articles appear which are relevant to the query. The keywords were extracted from each scientific publication and a word cloud was generated for each focal species.

Social media analysis: Sentiment towards Mahseer

To know the polarity of attitudes of the general public towards the Mahseer species expressed within various social media (Facebook, Twitter, Instagram, and YouTube) posts related to the focal species and comments it received were extracted. From Twitter, tweets regarding the species, name of the account holder, number of retweets, date, and time, were collected. The data collected from Facebook and Instagram includes the date, time, and caption of the post, comments, and likes received by post. From YouTube, the date, URL of the video, comments on the video, likes, and the total number of videos were extracted. The comments received by the posts were analyzed using Sentistrength (JAVA version). Sentistrength measures the strength of the sentiment towards a post by assigning scores ranging from -4 to +4 (Thelwall, 2010). All posts were collected from each of the social media platforms either manually or using Python 3.7.3. (Myself and Mr. Akash Singh, VIT Vellore).

Analysis of the search for Mahseer on the internet

Although people were searching with the term 'Mahseer' on the Internet worldwide from 2010 onwards the frequency increased in the last couple of years only. On the web search, the golden Mahseer was getting very good attention during the period considered for the analysis. However, humpback Mahseer and blue finned Mahseer were searched regularly after 2019 only. The image search followed the pattern of web search. Analysis of the search on YouTube provided no results for bluefin Mahseer (Fig. 4-6). However golden Mahseer had been searched from 2017 onwards frequently and humpback Mahseer gave only one spike during 2019 April. The 'news search' gave a response to only the keyword Mahseer and a noticeable relative search volume was found during 2018-2019. While none of the search categories gave the RSV on orange finned Mahseer and deccan Mahseer.
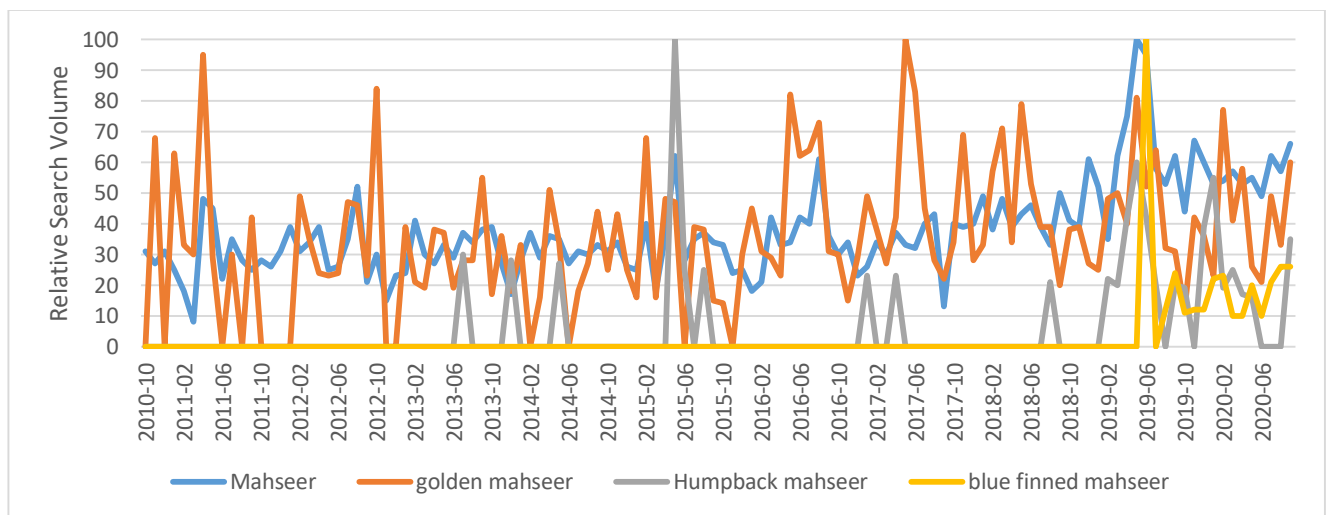
Figure 4. Relative Search Volume of the different Mahseer species in Web searches from 2010-2020 (Worldwide).
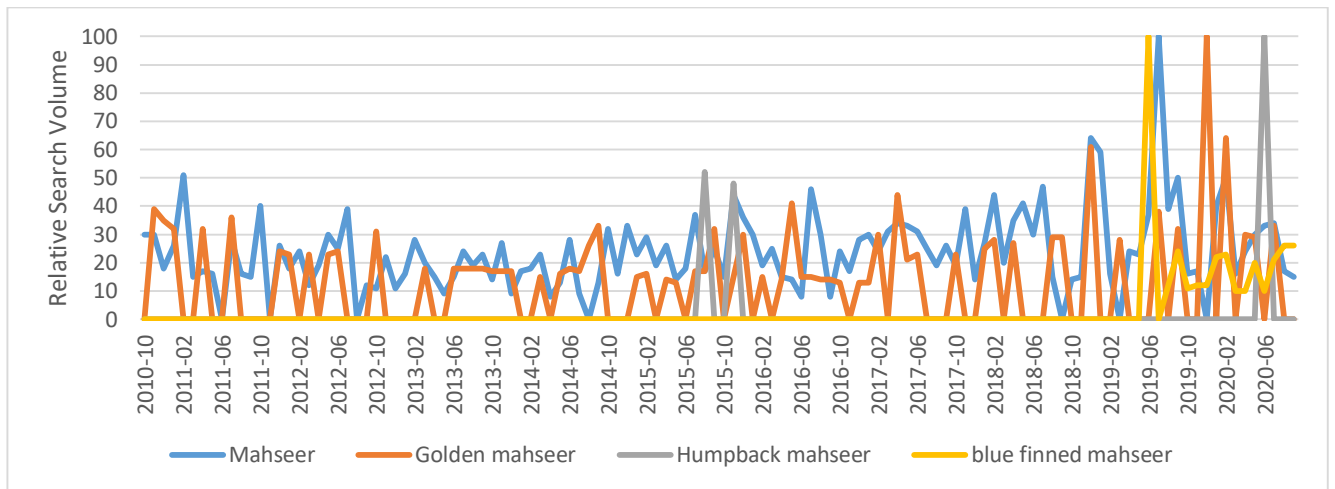
Figure 5. Relative Search Volume of the different Mahseer species in Image searches from

2010-2020 (Worldwide)
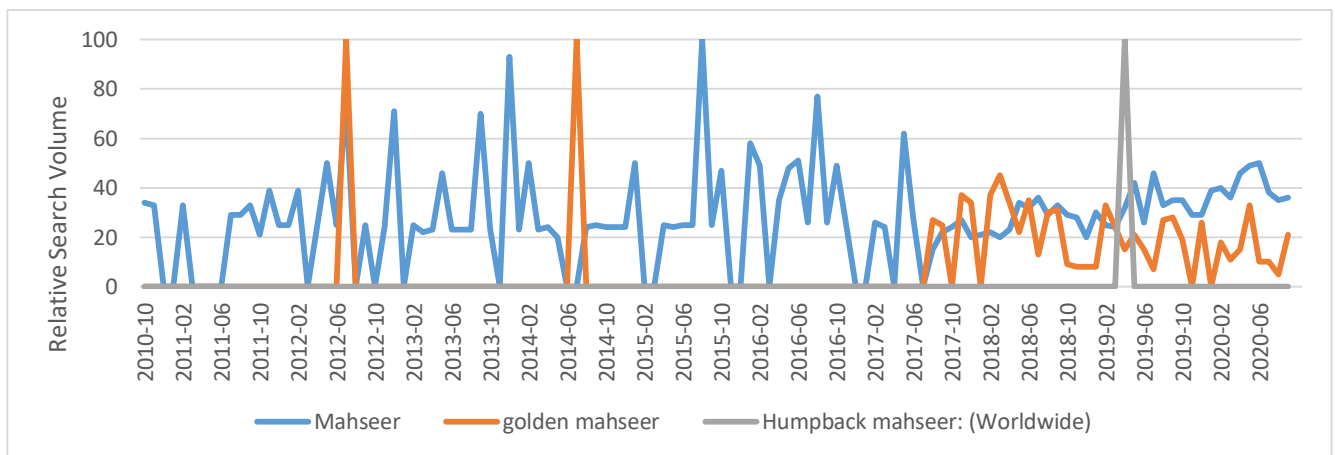
Figure 6. Relative Search Volume of different Mahseer species in YouTube searches from

2010-2020 (Worldwide)
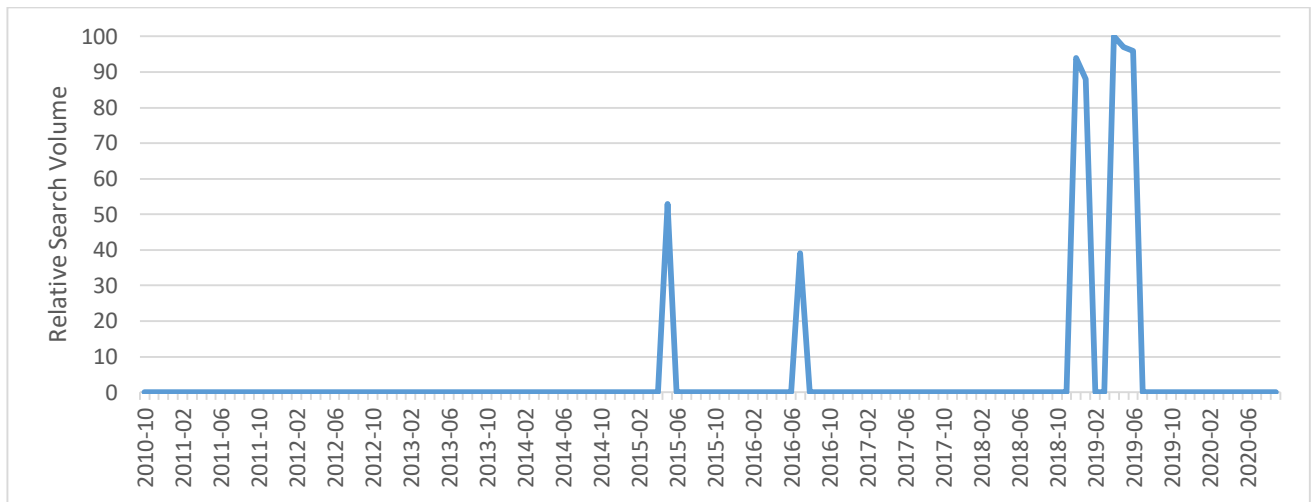
Figure 7. Relative Search Volume of Mahseer in News searches from 2010-2020 (Worldwide)

The Web search category revealed that people surfed the internet using the word Mahseer during the period considered for analysis when the geographical area was limited to India. Higher RSV was noticed for golden Mahseer continuously from October 2010 to April 2012, with moderate spikes appearing after July 2012. 'Humpback Mahseer' received attention only after April 2015, while 'blue finned Mahseer' received no attention (Fig.8). Image search, on the other hand, followed the trend of Web search (Fig.9). This result reveals that although the attention of the search on the internet was biased towards the golden Mahseer, slowly other species of humpback Mahseer is catching up, as shown by the peaks in the RSV which is a positive trend (Fig.10). Finally, between 2018 and 2020, a News search just revealed spikes for the words 'Mahseer' and 'golden Mahseer' (Fig.11).
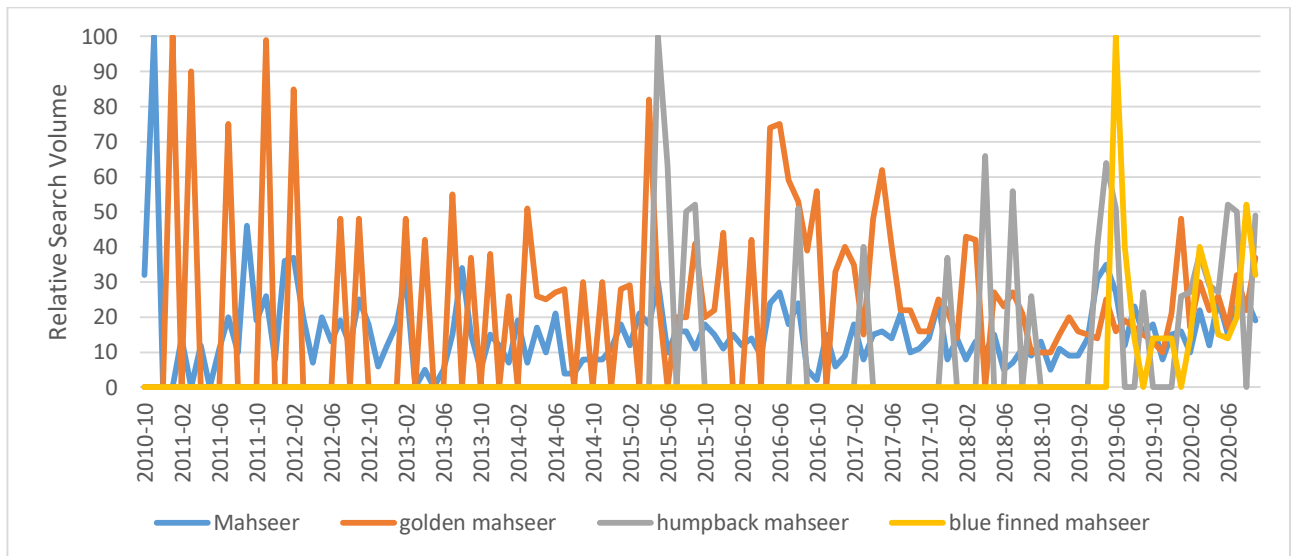
Figure 8. Relative Search Volume of different Mahseer species in Web searches from 2010-
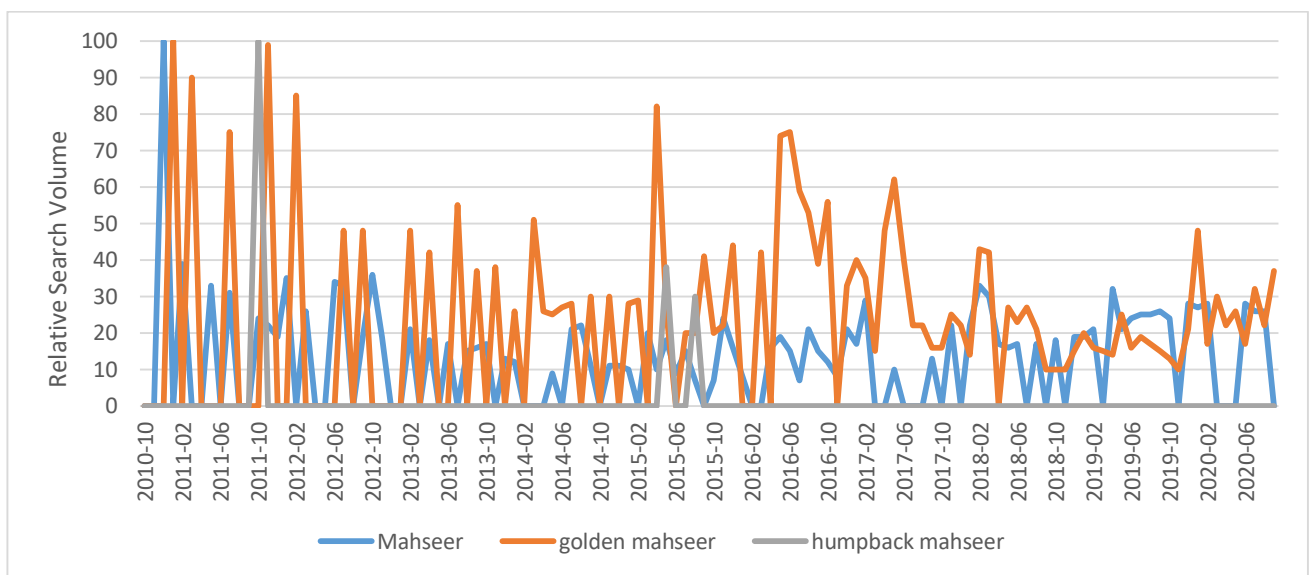
2020 (India)

Figure 9. Relative Search Volume of the different Mahseer species in Image searches from
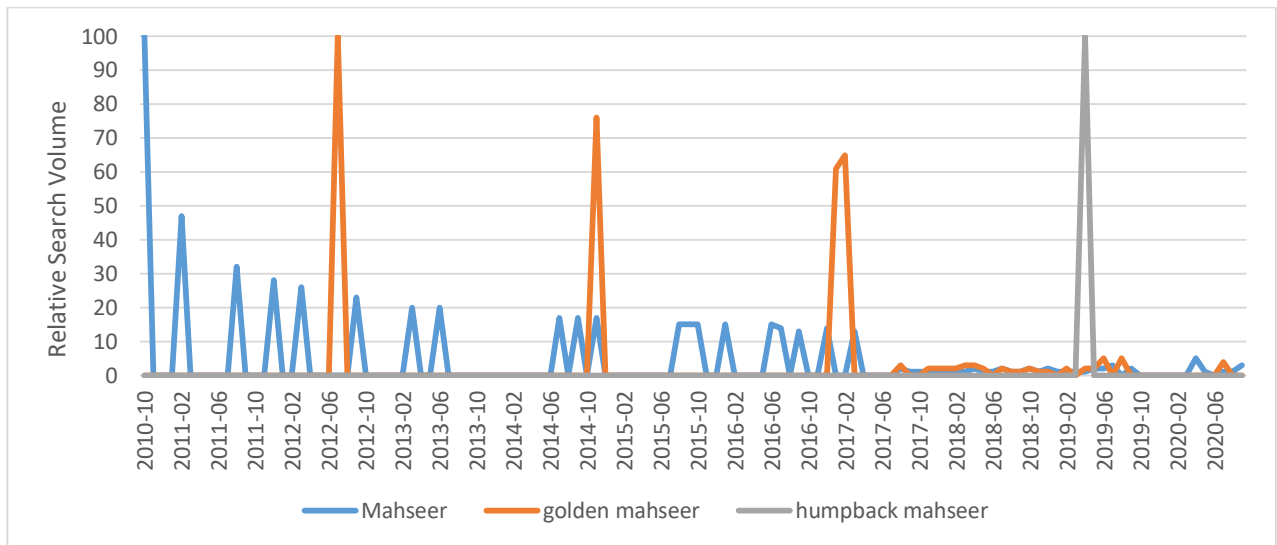
2010-2020 (India)

Figure 10. Relative Search Volume of different Mahseer species in YouTube searches from 2010-2020 (India)
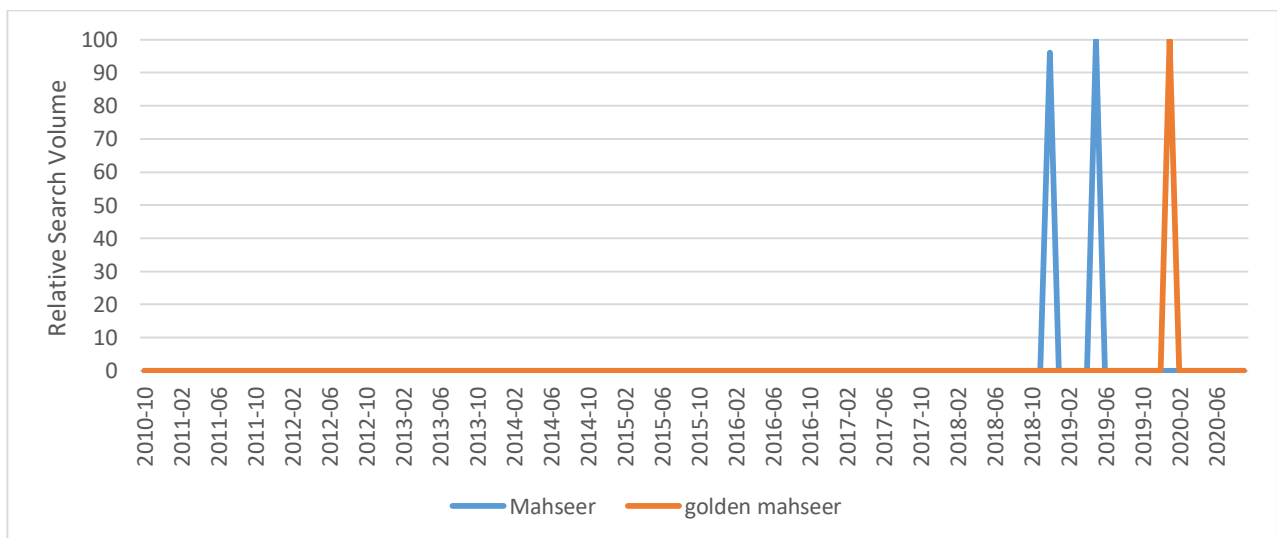
Figure 11. Relative Search Volume of different Mahseer species in News searches from 2010-2020 (India)

Search for Mahseer by nations (Worldwide)

In this study I mapped search for in Mahseer came from different nations and states of India using the same set of keywords used in the previous inquiries. The results showed that for all the categories and different species of Mahseer the relative search volume in 'Worldwide'

location is highest in Bhutan for 'Mahseer' in the Web category (Fig.12a), India and Norway for 'Golden Mahseer' (Fig 12b),' Blue finned Mahseer'(Fig.12c) and 'Humpback Mahseer' (Fig. 12d) for the Web search category. For the Image search category, Bhutan showed the highest relative search volume for "Mahseer' (Fig. 13a) while India showed the highest search volume for Blue finned Mahseer (Fig.13b) and Humpback Mahseer (Fig. 13c). In the News category, only the keyword 'Mahseer' showed the highest search volume in India (Fig.14a). Lastly, in the YouTube category, the highest search volumes were seen in Bhutan for 'Mahseer'(Fig.15a) and India and the United States of America for 'Golden Mahseer' and India for 'Humpback Mahseer' (Fig. 15b and 15c). While the other countries were not listed as they showed the RSV less than 9%.
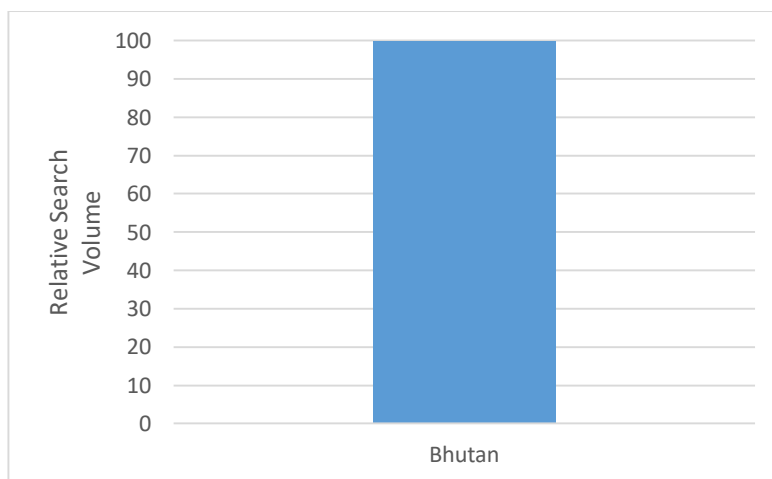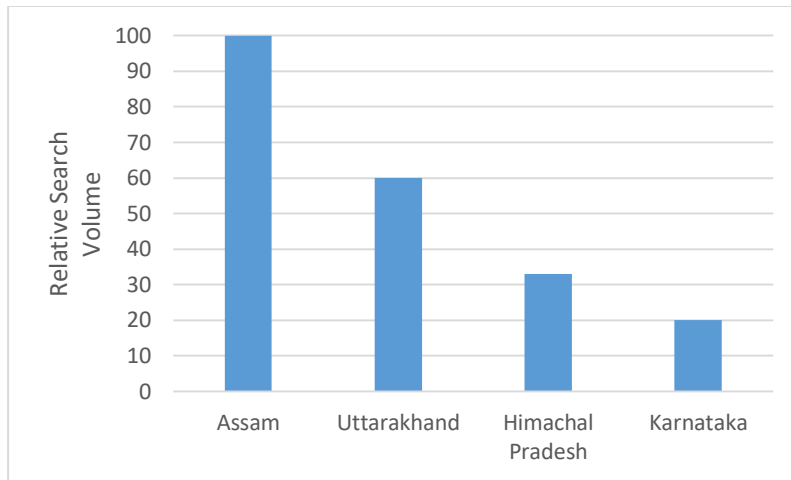

Figure 12a. Relative Search Volume of Mahseer in Web searches from 2010-2020 by geographical region (Worldwide)
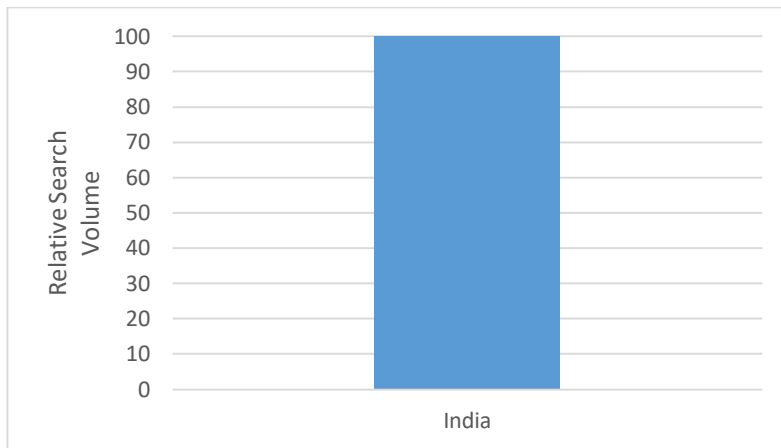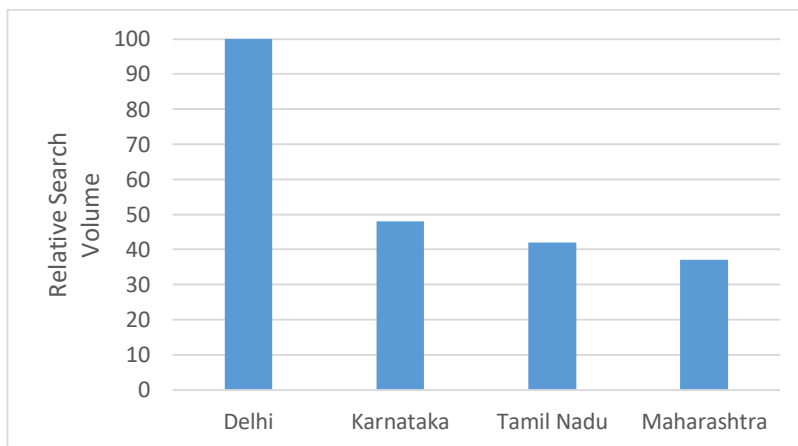
Figure 12b. Relative Search Volume of Golden Mahseer in Web searches from 2010-2020 by geographical region (Worldwide)
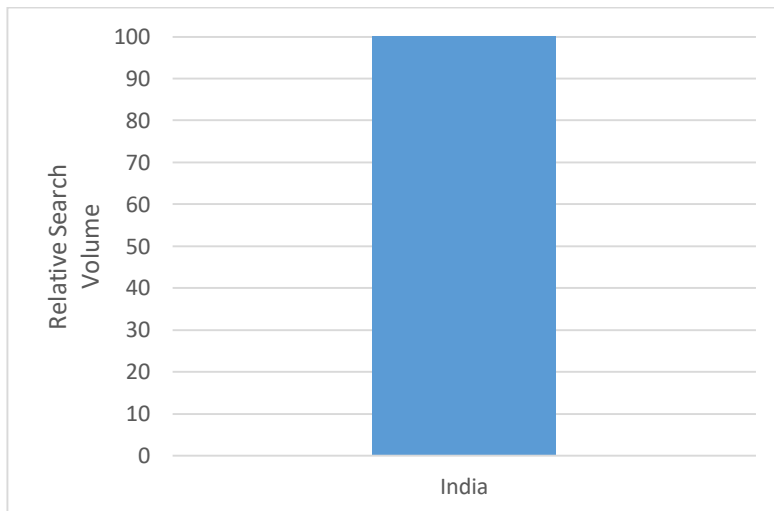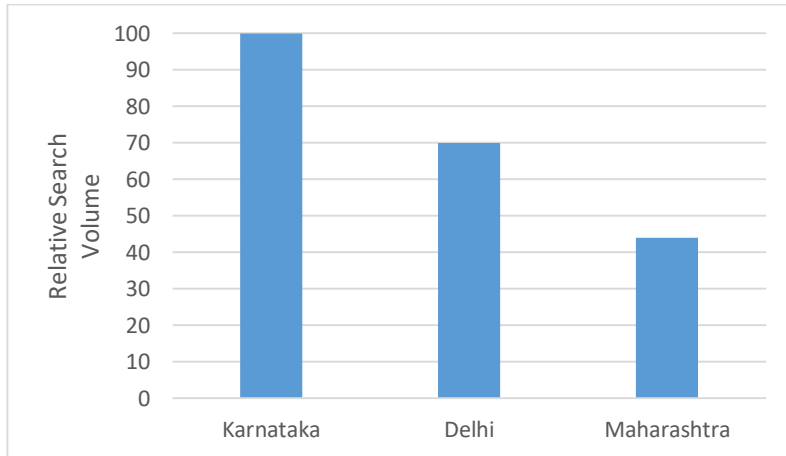

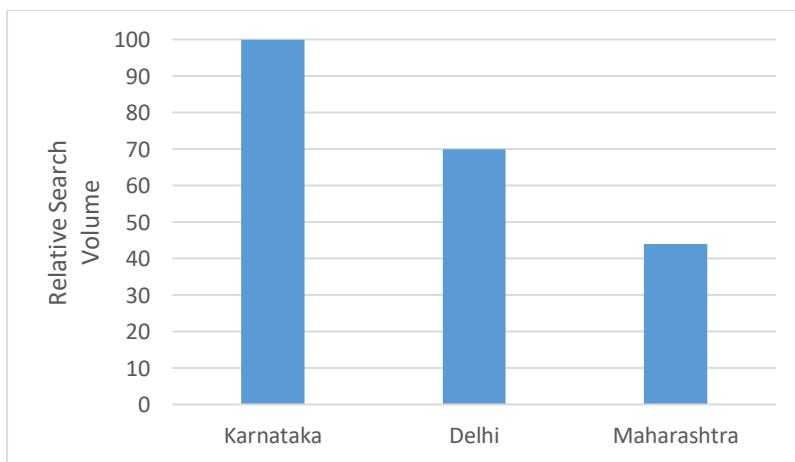*Figure 12c. Relative Search Volume of Blue finned Mahseer in Web searches from 2010-2020 by geographical region (Worldwide)*
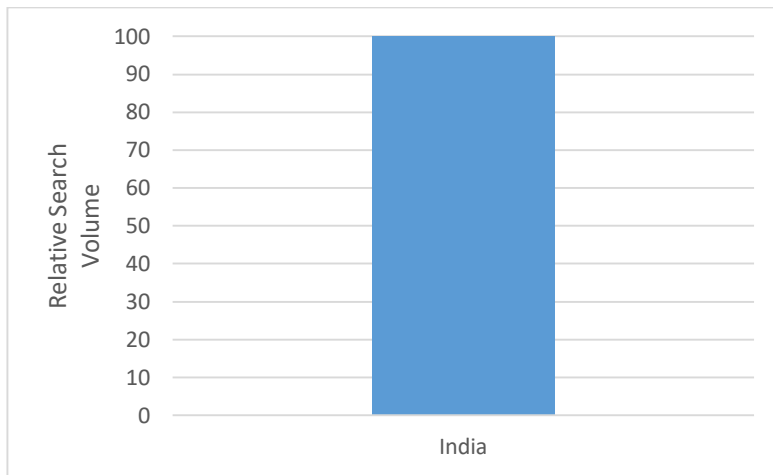
Figure 12d. Relative Search Volume of Humpback Mahseer in Web searches from 2010-2020 by geographical region (Worldwide)
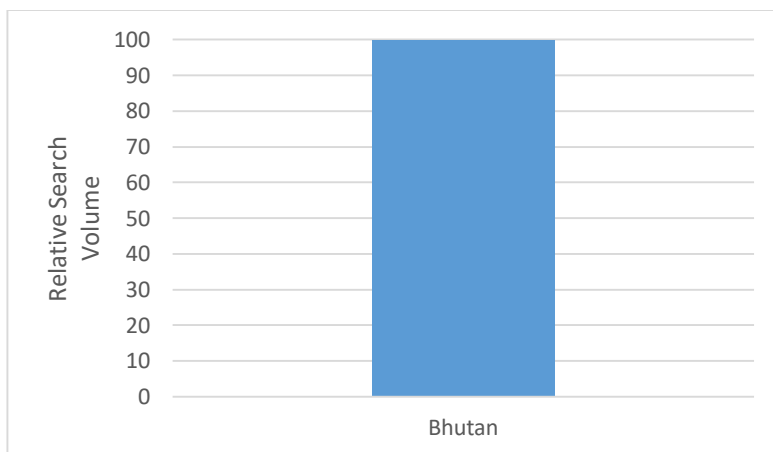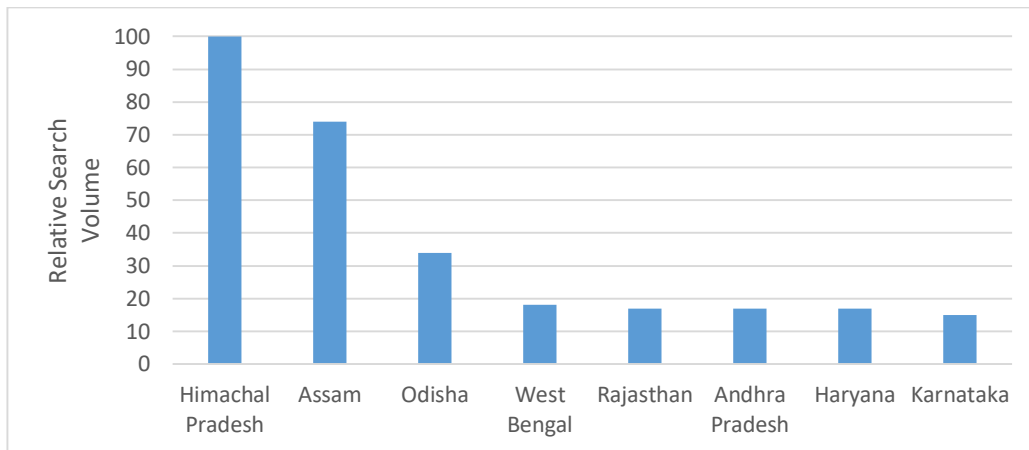

Figure 13a. Relative Search Volume of Mahseer in Image searches from 2010-2020 by geographical region (Worldwide)
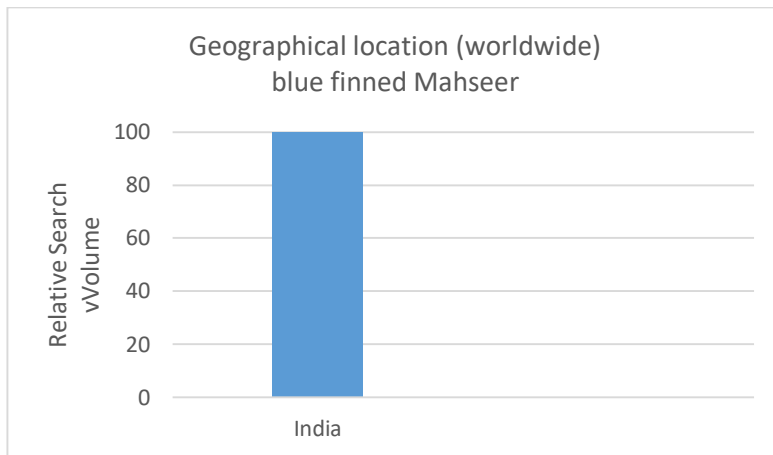
Figure 13b. Relative Search Volume of Blue finned Mahseer in Image searches from 2010-2020 by geographical region (Worldwide)
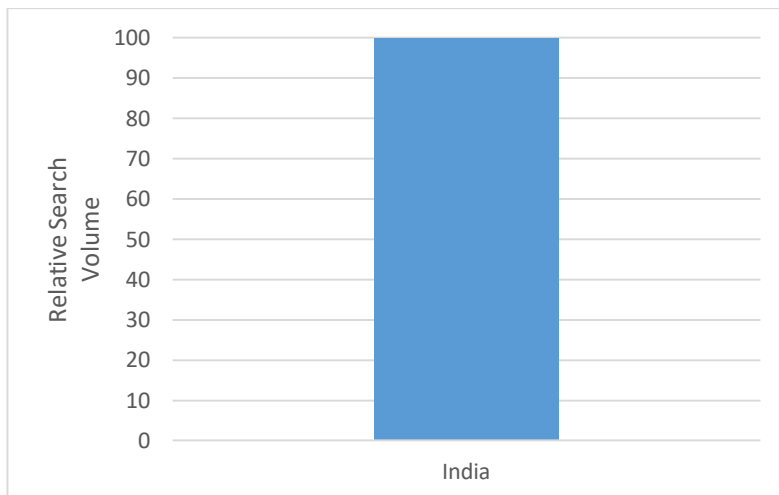
Figure 13c. Relative Search Volume of Humpback Mahseer in Image searches from 2010-2020 by geographical region (Worldwide)
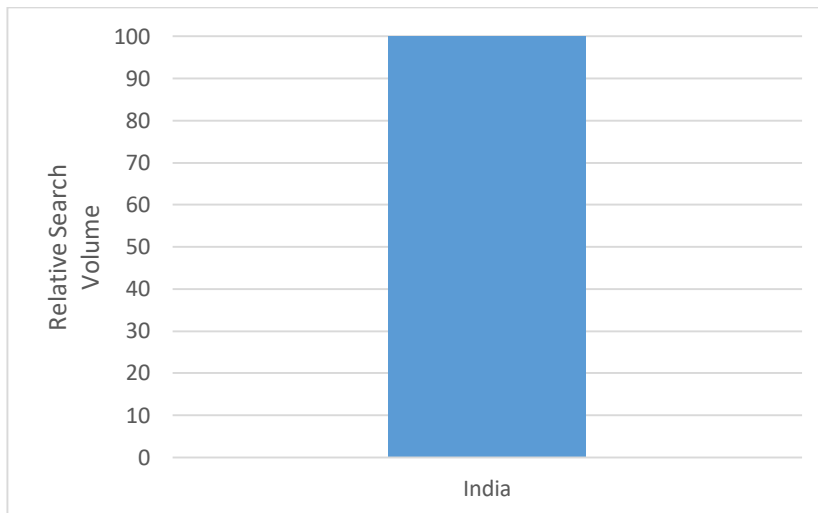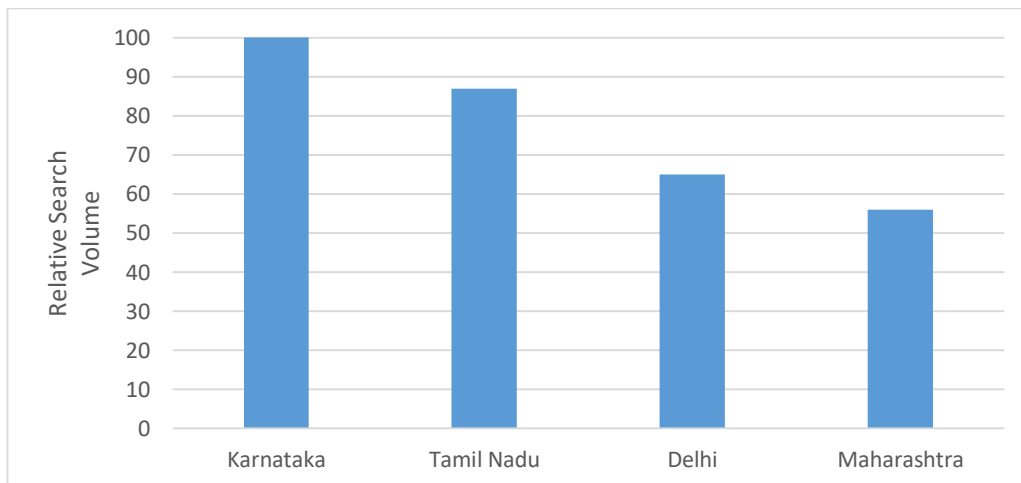
Figure 14a. Relative Search Volume of Mahseer in News searches from 2010-2020 by geographical region (Worldwide)
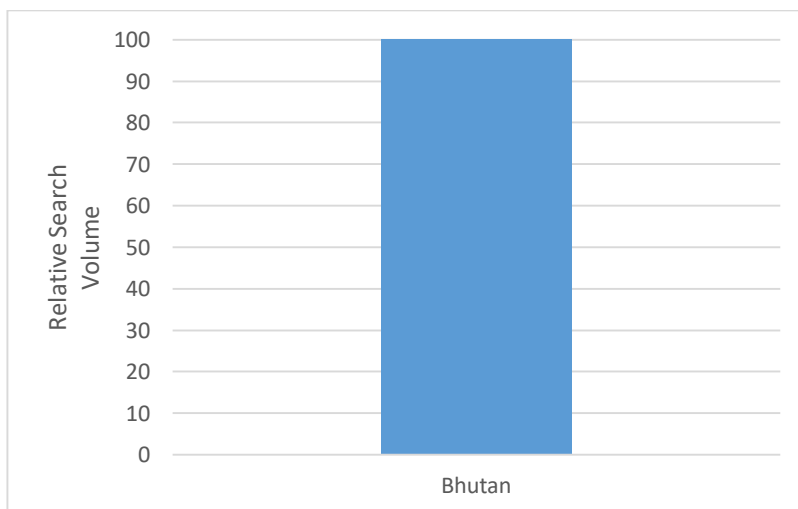
Figure 14a. Relative Search Volume of Mahseer in News searches from 2010-2020 by geographical region (Worldwide)
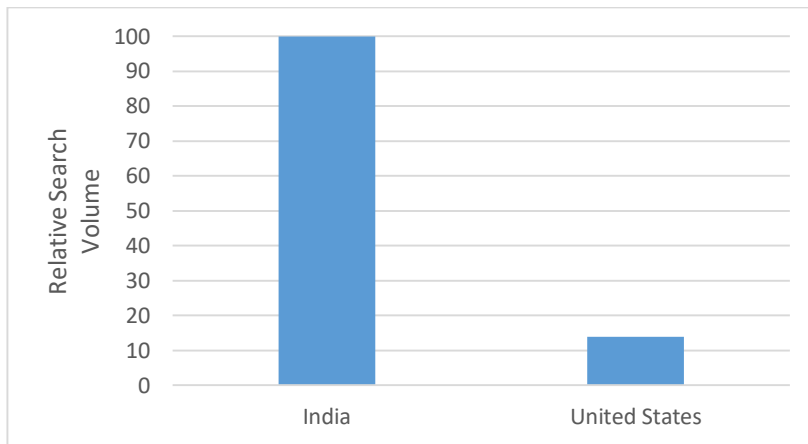
Figure 15b. Relative Search Volume of Golden Mahseer in YouTube searches from 2010-2020 by geographical region (Worldwide)
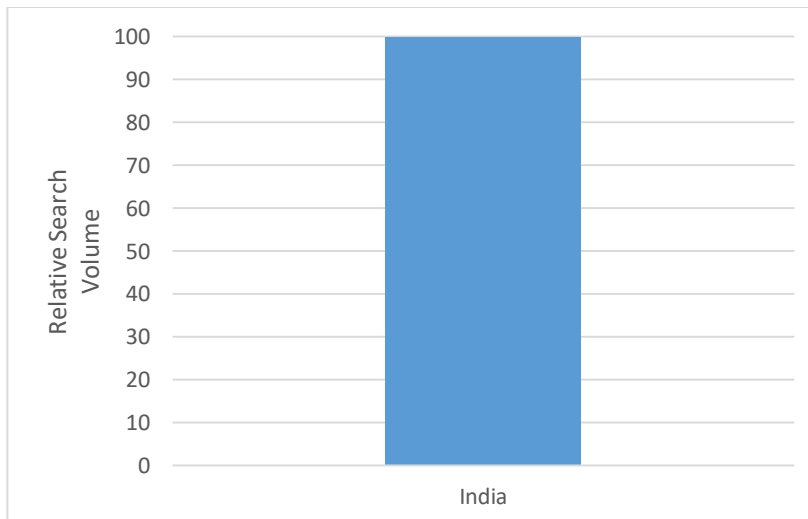
Figure 15c. Relative Search Volume of Humpback Mahseer in YouTube searches from 2010-2020 by geographical region (Worldwide)

Interest in Mahseer by sub region (India)

The highest RSV for the keyword 'Mahseer' (Fig. 16a) was observed coming from Assam, Uttarakhand, Himachal Pradesh, and Karnataka when the web search analysis was carried out Delhi scored the highest RSV for 'Golden Mahseer' (Fig. 16b), Bihar, Tamil Nadu, Uttar

Pradesh for 'Blue finned Mahseer' (Deccan Mahseer; Fig. 16c), and Karnataka, Delhi for the keyword 'Humpback Mahseer'.

Figure 16a. Relative Search Volume of Mahseer in Web searches from 2010-2020 by geographical region (India).

Figure 16b. Relative Search Volume of Golden Mahseer in Web searches from 2010-2020 by geographical region (India).
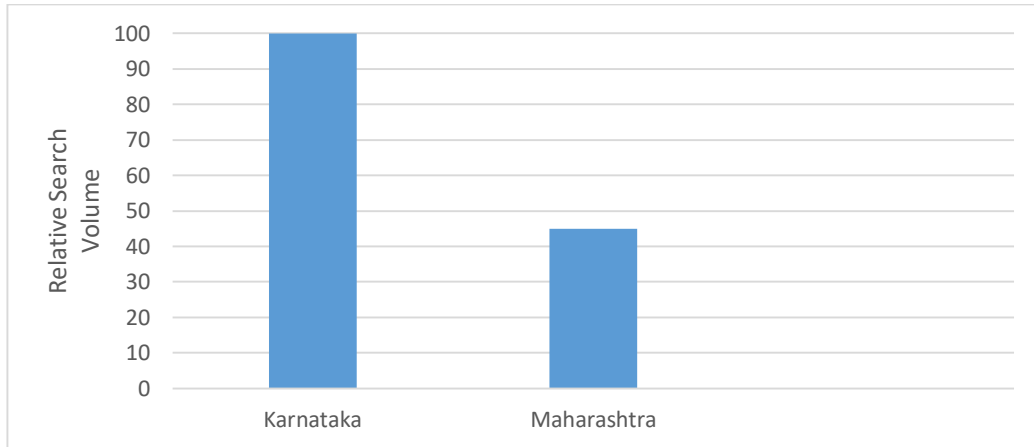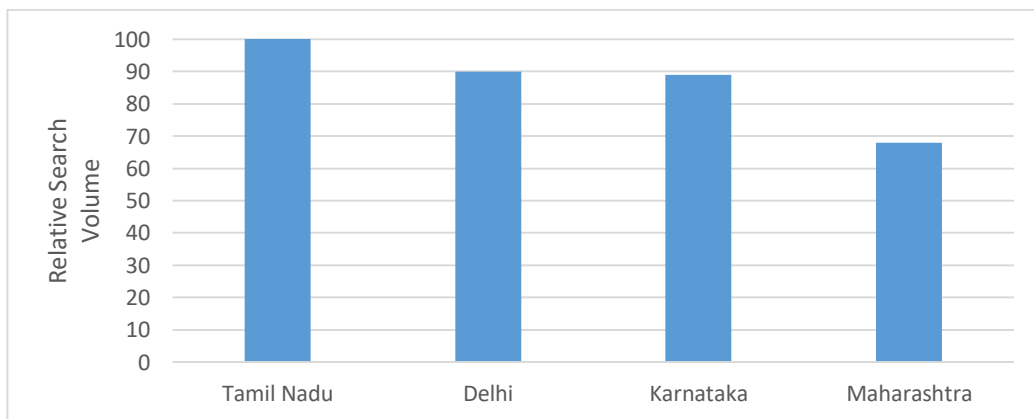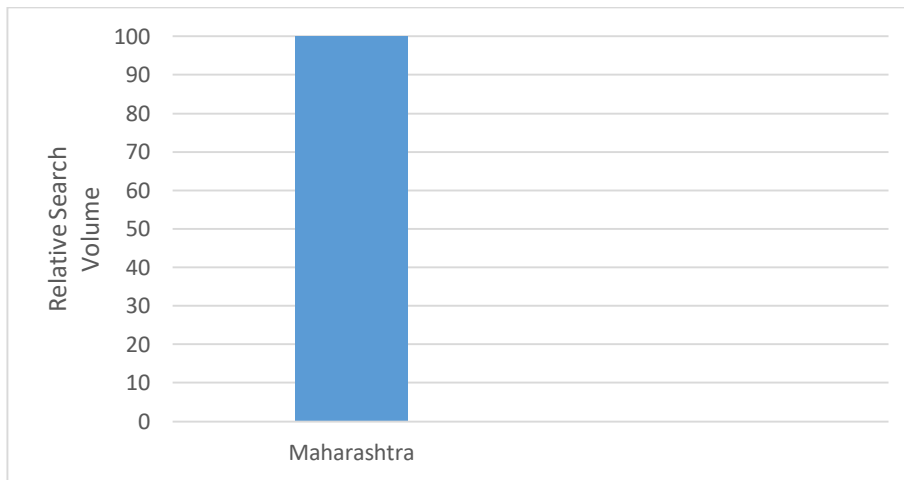
Figure 16c. Relative Search Volume of Blue finned Mahseer in Web searches from 2010-2020 by geographical region (India).

 Figure 16d. Relative Search Volume of Humpback Mahseer in Web searches from 2010-2020 by geographical region (India).

For the Image category, the images of 'Mahseer' were most searched in Himachal Pradesh, Assam (Fig. 17a), while those of 'Golden Mahseer' and 'Humpback Mahseer' were most searched in Karnataka, Tamil Nadu, Delhi, and Maharashtra (Fig.17b and Fig.17c)

Figure 17a. Relative Search Volume of Mahseer in Image searches from 2010-2020 by geographical region (India).

Figure 17b. Relative Search Volume of Golden Mahseer in Image searches from 2010-2020 by geographical region (India).

Figure 17c. Relative Search Volume of Humpback Mahseer in Image searches from 2010-2020 by geographical region (India).

Lastly, in the YouTube category, the highest relative search volume was seen in Tamil Nadu, Delhi, Karnataka and Maharashtra for 'Golden Mahseer' and only Maharashtra for 'Humpback Mahseer' while the other states RSV were less than 10%. conservation-related (Fig.18a and Fig.18b).

Figure 18a. Relative Search Volume of Golden Mahseer in YouTube searches from 2010-2020 by geographical region (India).

Figure 18b. Relative Search Volume of Humpback Mahseer in YouTube searches from 2010-2020 by geographical region (India).

Correlation analysis of Relative Search Volumes of Mahseer and selected conservation related topics

RSVs for the topics related to Mahseers such as 'angling', 'spawning', and 'overfishing' were collected along with the term Mahseer on the Google Trend keeping India as the geographical region under conservation. These data were extracted and subjected to correlation analysis. The result of this study revealed that RSVs of term Mahseer and relative search volumes of the terms angling (Pearson's R = 0.425; $p < 0.00001$), overfishing (Pearson's R is 0.5314; $p < 0.00001$), and spawning (Pearson's R = 0.4388; $p < 0.00001$) exhibited a very strong correlation (Fig. 19-21).
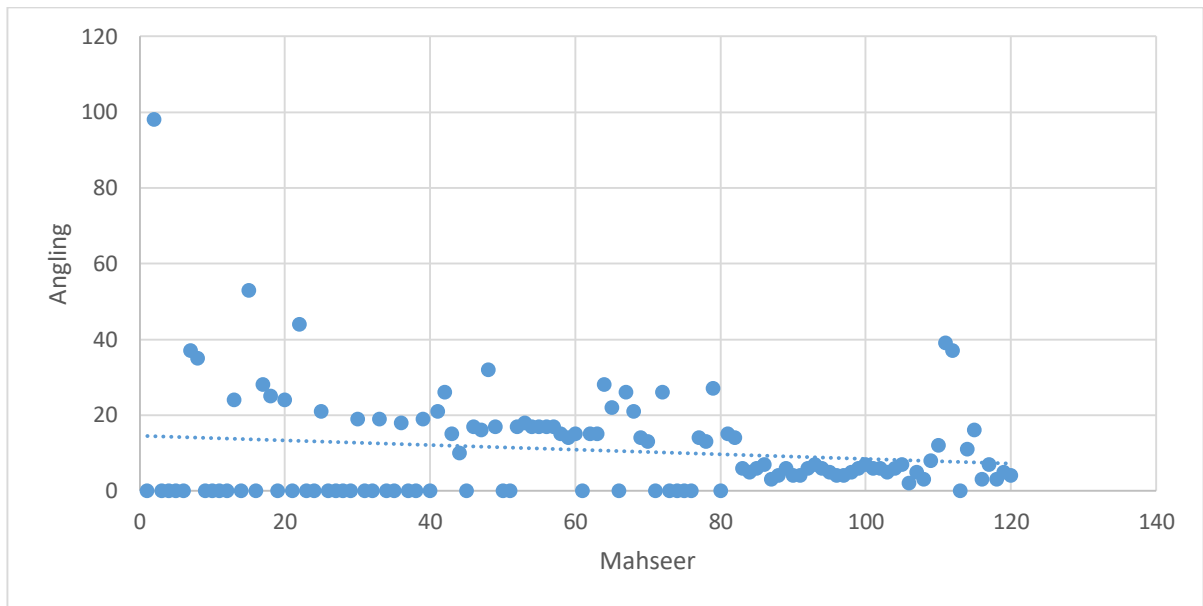
Figure 19. Correlation of the keywords 'Mahseer' and 'Angling' from 2010-2020 (India).
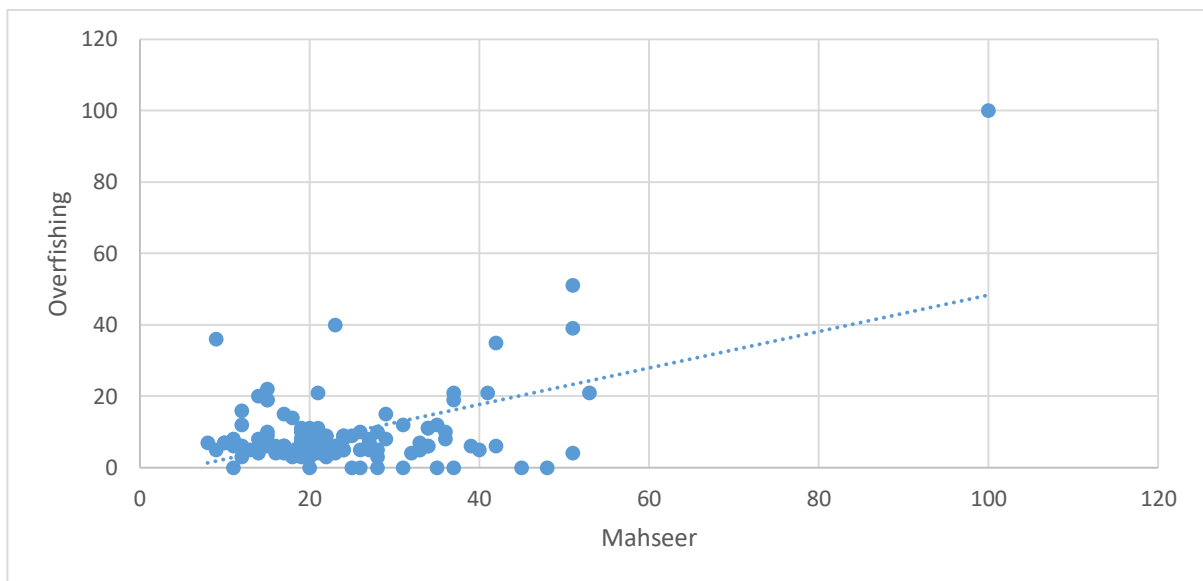
Figure 20. Correlation of the keyword 'Mahseer' and 'Overfishing' from 2010-2020 (India).
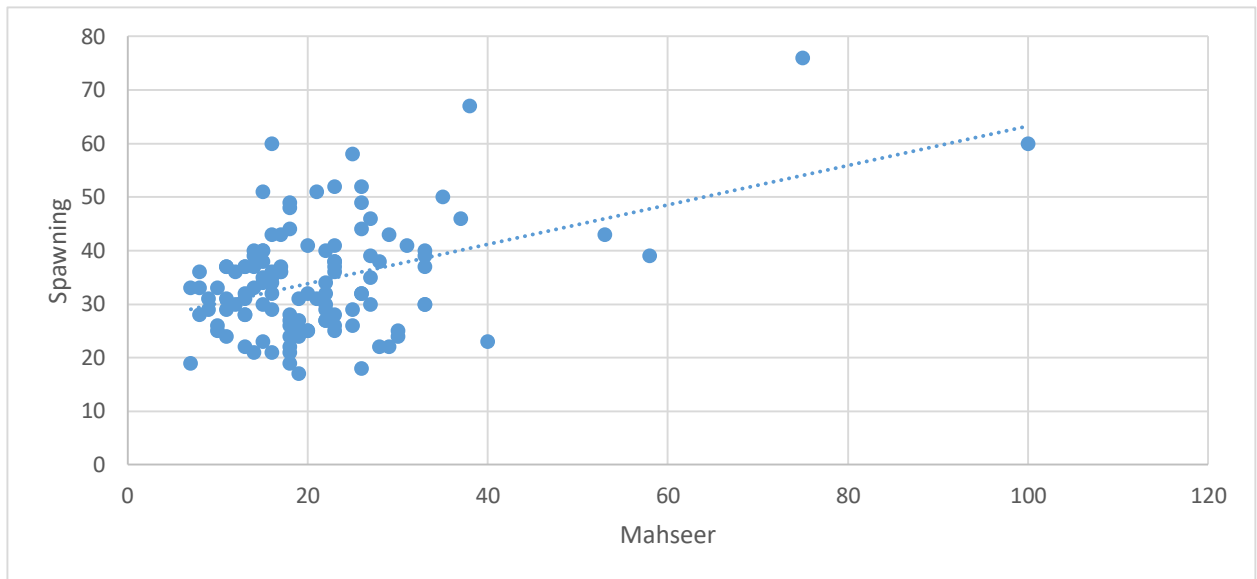
Figure 21. Correaltion of the keyword 'Mahseer' and 'Spawning' from 2010-2020 (India)

Media and Mahseer

The results of the Mediacloud analysis revealed that the online media published within India were less than 5 Stories per Day on Mahseer between the years 2016 and 2018 (Fig. 22a). For 'Deccan Mahseer' it was observed that from 2013 to 2018 only one Story per Day was published; however, this frequency increased to nearly two stories per day from 2018 to 2020 (Fig. 22c). For 'Humpback Mahseer', 'Orange finned Mahseer' (Humpback Mahseer), and 'Blue finned Mahseer' (Deccan Mahseer) only one Story per Day was covered in the period of five years from 2015 to 2020 (Fig. 22d and 22e, 22f). Similarly, fewer than one story per day was covered in this period on the subjects of 'Mahseer Conservation' and 'Mahseer Angling' by the media (Fig 22g and 22h). Lastly, starting from the year 2012 to 2020, no story regarding the extinction of the Mahseer was covered by the online media (Fig. 22i).
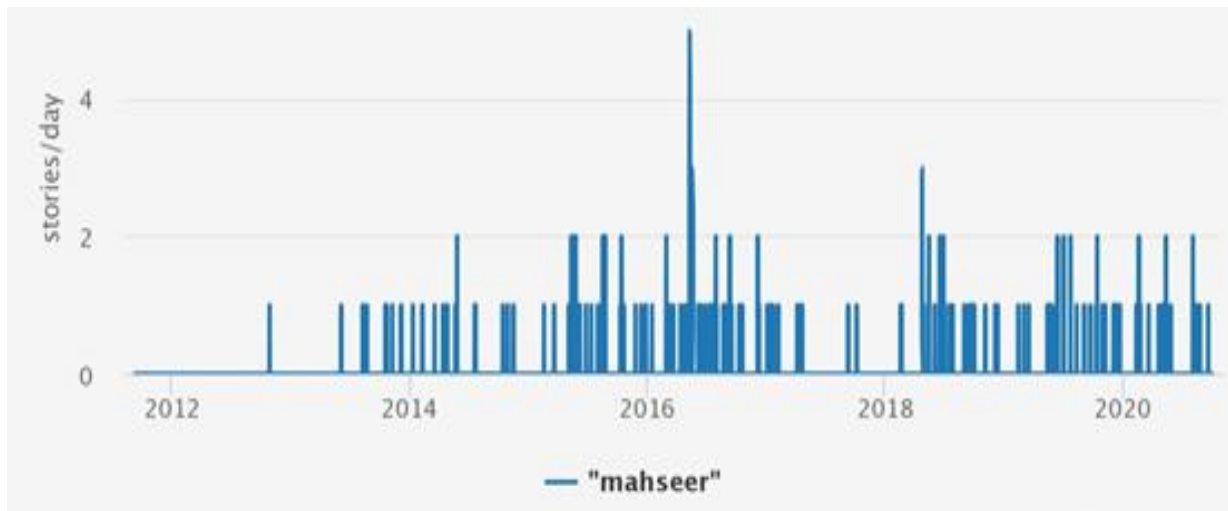
Figure 22a. Stories published with keyword Mahseer per day on different media during 2010-2020.
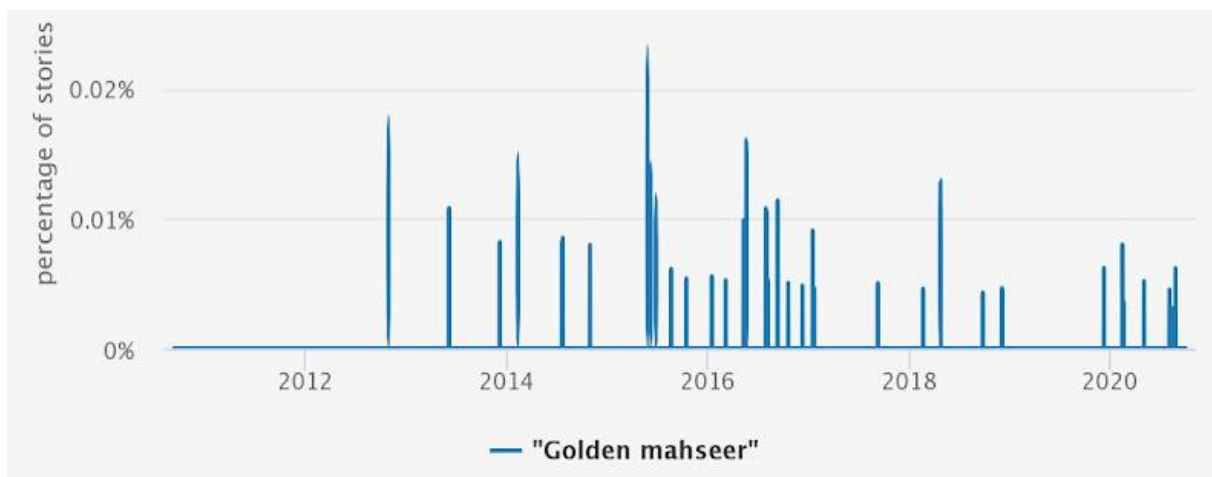

Figure 22b. Stories published with keyword Golden Mahseer per day on different media during 2010- 2020
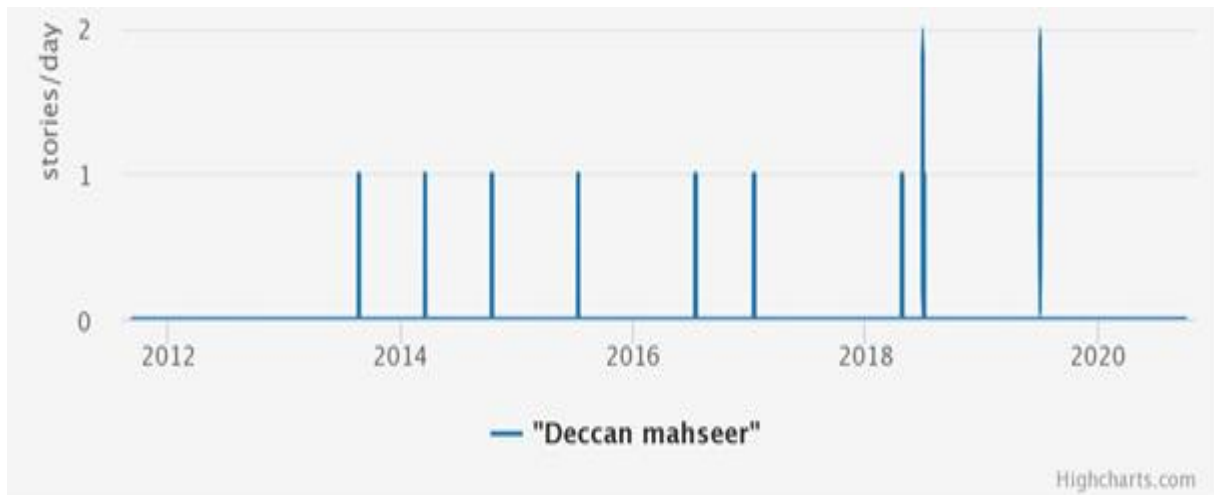
Figure 22c. Stories published with keyword Deccan Mahseer per day on different media during 2010-2020
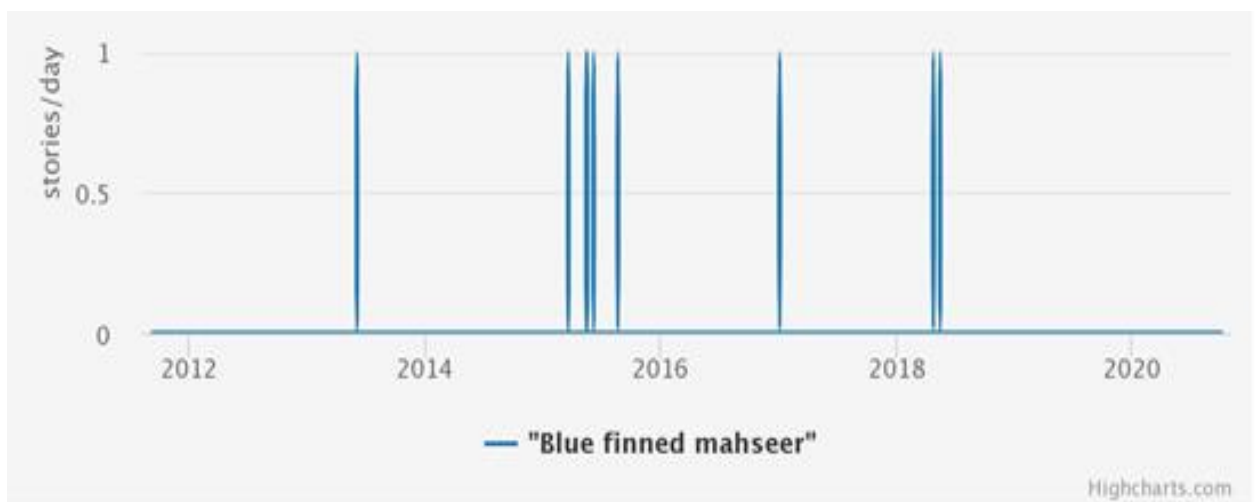

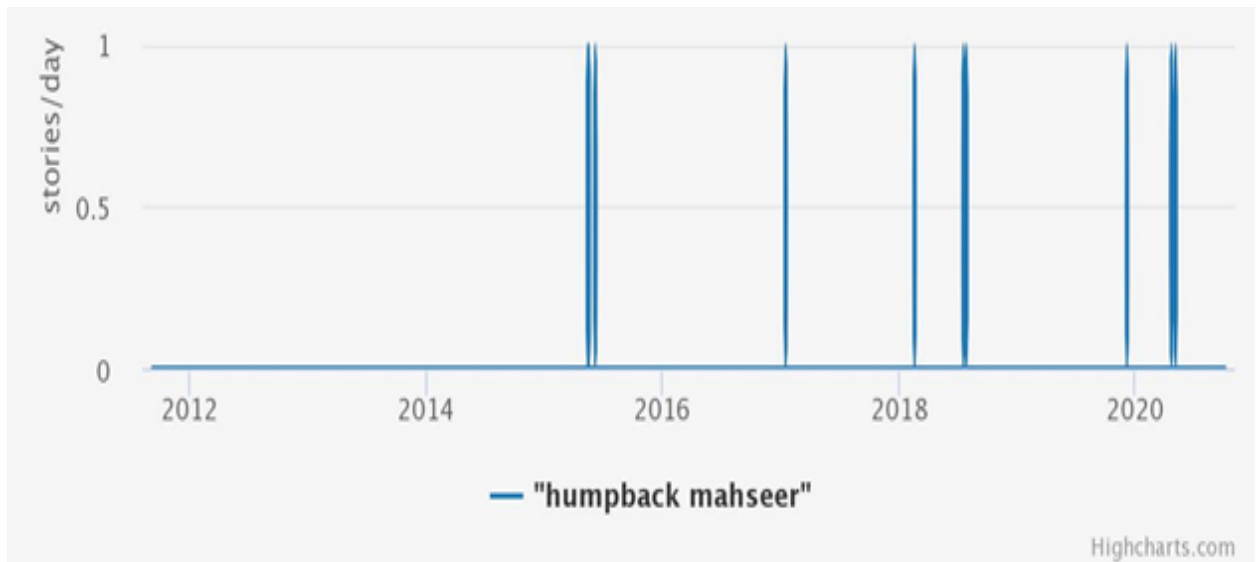*Figure 22d. Stories published with keyword Blue finned Mahseer per day on different media during 2010-2020*

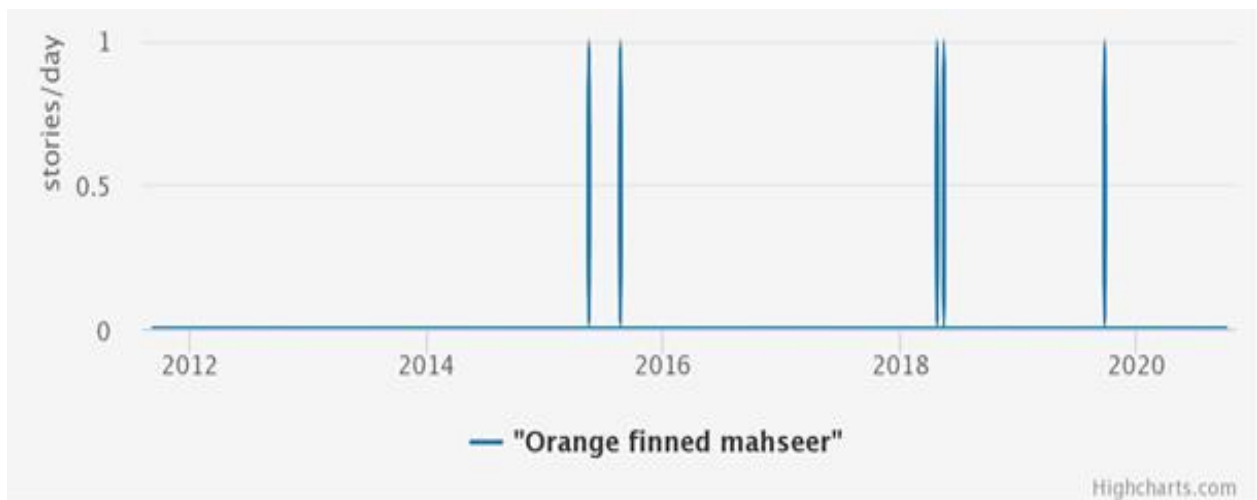*Figure 22e. Stories published with keyword Humpback Mahseer per day on different media during 2010-2020*

Figure 22f. Stories published with keyword Orange finned Mahseer per day on different media during 2010-2020
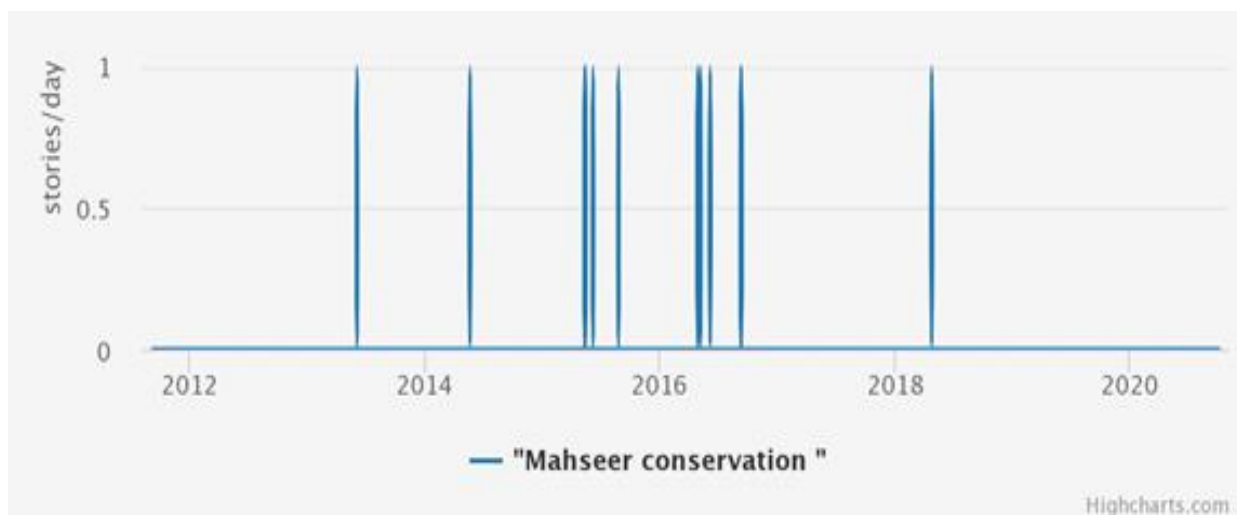
Figure 22g. Stories published with keyword Mahseer Conservation per day on different media during 2010-2020
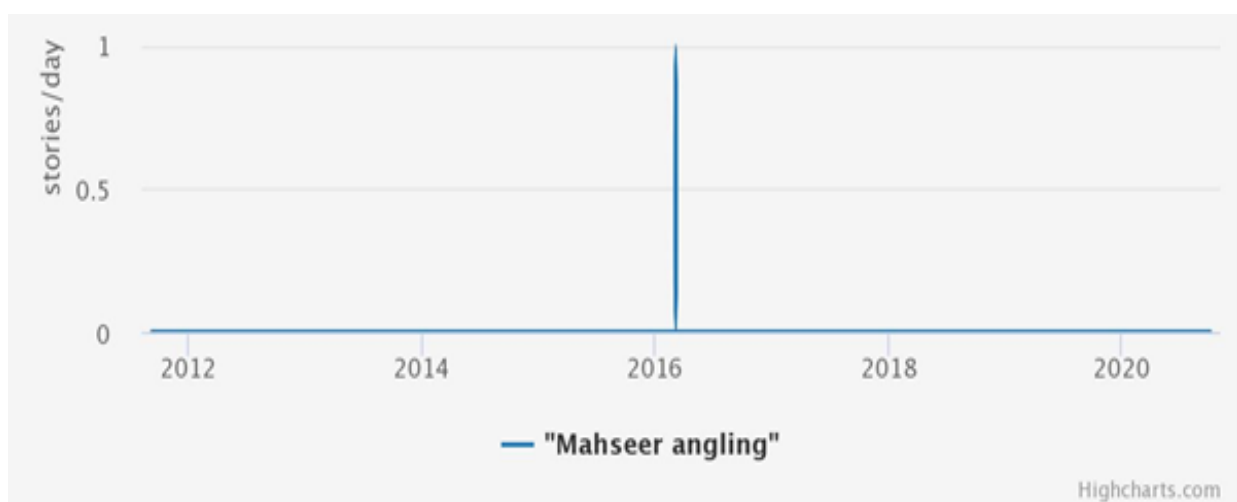

Figure 22h. Stories published with keyword Mahseer Angling per day on different media during 2010-2020

Figure 22i. Stories published with keyword Mahseer Extinction per day on different media during 2010-2020

A word cloud analysis was carried out for identifying the most frequently co-occurring words associated with our search query using Word Cloud Generator. The results for these showed that the top words associated with 'Mahseer' were 'Mahseer, conservation, breeding, India, endangered and cauvery' (Fig 23a). For 'Golden Mahseer' the associated words were 'Mahseer, conservation, breeding, India, endangered, and Cauvery' (Fig 23b). 'Mahseer, deccan, endangered, breeding and conservation were the top words associated with 'Deccan Mahseer' (Fig 23c). Lastly, for 'Humpback Mahseer' and 'Orange finned Mahseer' the top words were ''Mahseer, endangered, orange finned, Cauvery, angling, blue finned, conservation, India' (Fig. 23d and. 23e). While for 'Mahseer Angling', 'Mahseer Extinction' and 'Mahseer Conservation' no data was available.

Figure 23a. Word cloud of the co-occurring words associated with our search query 'Mahseer'. The period considered was from 2010-2020

Figure 23b. Word cloud of the co-occurring words associated with our search query 'golden Mahseer'. The period considered was from 2010-2020

Figure 23c. Word cloud of the co-occurring words associated with our search query 'deccan Mahseer'. The period considered was from 2010-2020

Figure 23d. Word cloud of the co-occurring words associated with our search query 'orange finned Mahseer'. The period considered was from 2010-2020

Figure 23e. Word cloud of the co-occurring words associated with our search query 'humpback Mahseer'. The period considered was from 2010-2020.

Has the focus of the scientific community changed over the years?

Keywords from scientific publications on Mahseer from Google Scholar and SCOPUS were also extracted. Our results illustrate the most commonly and frequently occurred keywords among all the publications by the researchers and enthusiasts. The word cloud from Google Scholar shows the most prevalent keywords for publications on Mahseer were 'Tor, Mahseer and Putitora' (Fig. 24a), for Golden Mahseer were 'Tor, Putitora, Golden, Recreational' (Fig.24b), for Humpback Mahseer they were 'Endemism, Fauna, Status, Fish' (Fig.24c), for Deccan Mahseer they were 'Mahseer, Enrichment, Khudree, Shoaling, Rearing, Growth (Fig.24d) and lastly for Blue finned Mahseer were 'Tor, Endangered' (Fig.24e). Similarly, for SCOPUS publications, the most frequent keywords for Mahseer were 'Tor, Mahseer' (Fig.25a), for Golden Mahseer was 'Tor, Golden, Putitora' (Fig 25b) and for Deccan Mahseer were 'Khudree, Enrichment, Tor' (Fig. 25c). Furthermore, the SCOPUS data for Humpback Mahseer and Blue finned Mahseer was not available.
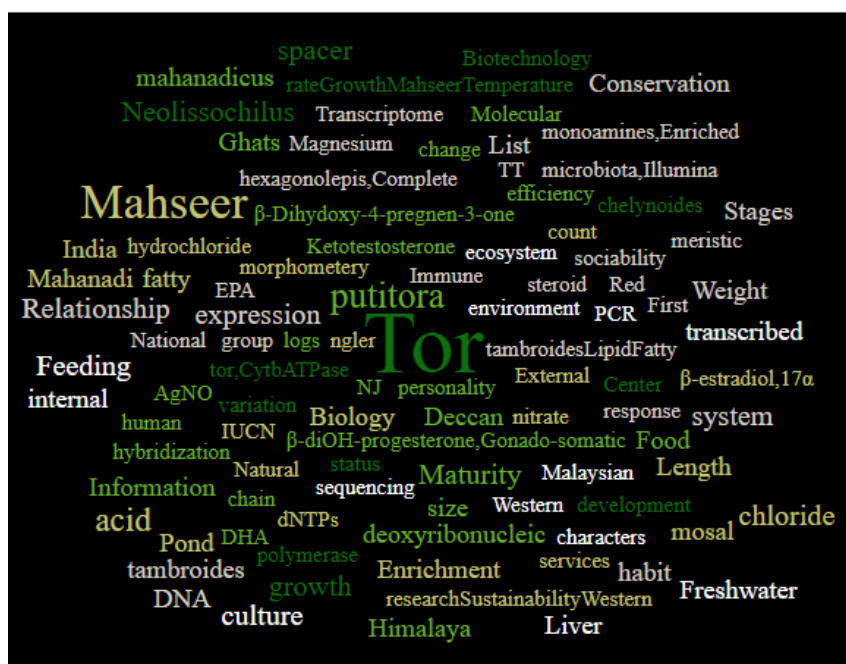
Figure 24(a) Word cloud of the keywords of the scientific papers published on 'Mahseer', extracted from Google Scholar. The time period considered was from 2010-2020
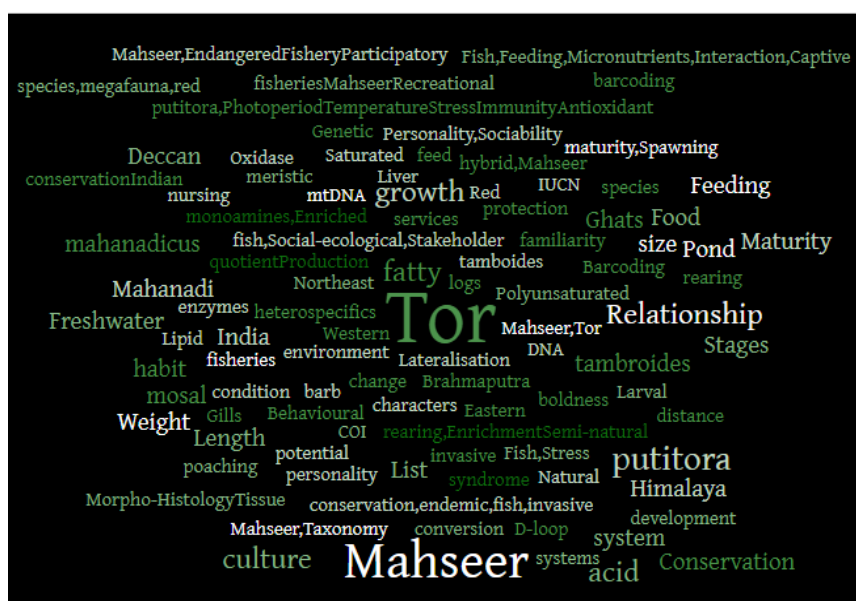
Figure 24b. Word cloud of the keywords of the scientific papers published on 'golden Mahseer' extracted from Google Scholar. The period considered was from 2010-2020
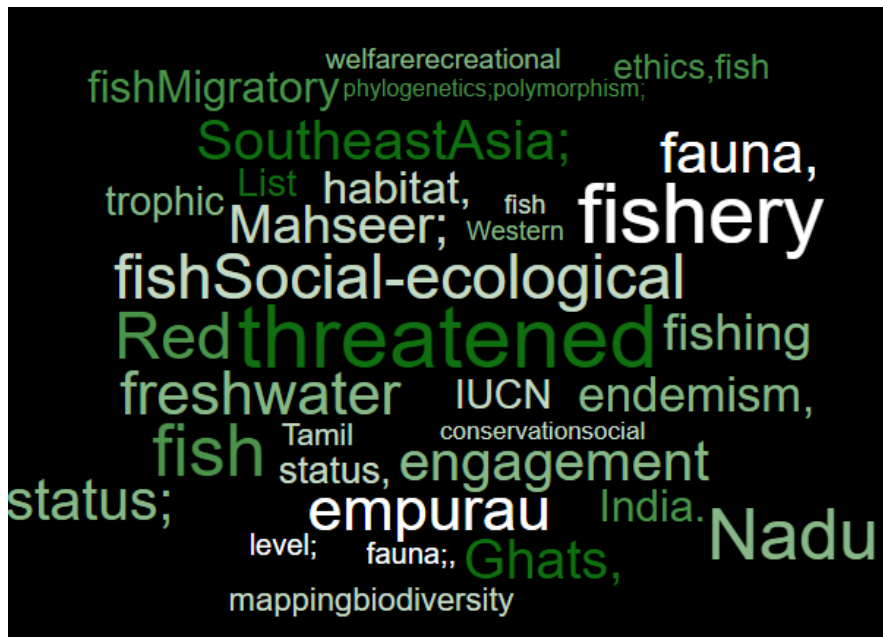
Figure 24c. Word cloud of the keywords of the scientific papers published on 'humpback Mahseer' extracted from Google Scholar. The period considered was from 2010-2020

Figure 24d. Word cloud of the keywords of the scientific papers published on 'deccan Mahseer' extracted from Google Scholar. The period considered was from 2010-2020
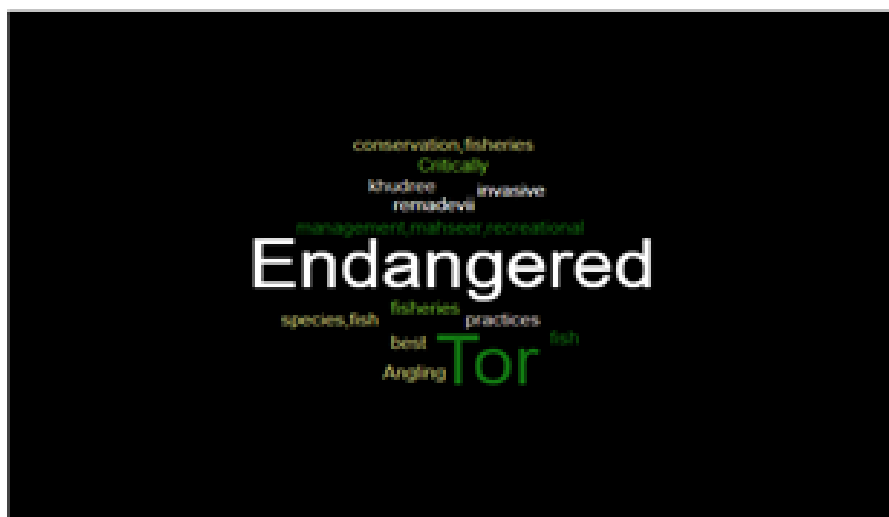
Figure 24e. Word cloud of the keywords of the scientific papers published on 'bluefinned Mahseer' extracted from Google Scholar. The period considered was from 2010-2020
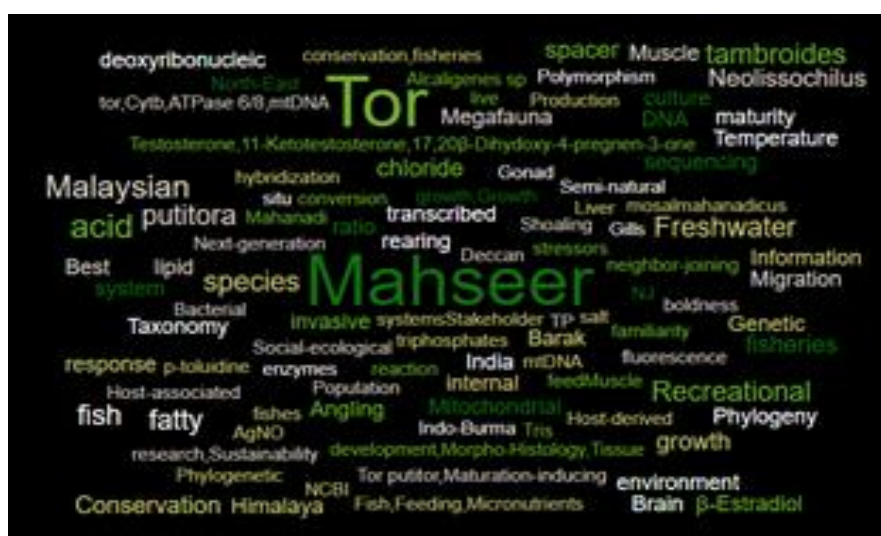
Figure 25a.Word cloud of the keywords of the scientific papers published on 'Mahseer' extracted from SCOPUS. The period considered was from 2010-2020

Figure 25b. Word cloud of the keywords of the scientific papers published on 'golden Mahseer' extracted from SCOPUS. The period considered was from 2010-2020

Figure 25c. Word cloud of the keywords of the scientific papers published on 'deccan Mahseer' extracted from SCOPUS. The period considered was from 2010-2020

To test the sentiment of the were on social media towards Mahseers, we considered four social media platforms viz. Facebook, Twitter, Instagram, and YouTube, and extracted the textual content of posts and comments. For Facebook the total number of posts collected for Golden Mahseer (N=147), Humpback Mahseer (N=38), Deccan Mahseer (N=36) (Fig 26a), for Twitter, Golden Mahseer (N=30), Humpback Mahseer (N=57), Deccan Mahseer (N=17) (Fig. 26b), Instagram Golden Mahseer (N=52), Humpback Mahseer (N=17) Deccan Mahseer (N=4) (Fig. 26c), YouTube, Golden Mahseer (N=35), Humpback Mahseer (N=18), Deccan Mahseer (N=29) (Fig.26c). The results illustrate that these lexicons showed mainly a neutral sentiment for the Mahseer species with significant instances of neither positive sentiments nor negative sentiments. However, 'Golden Mahseer' showed a high frequency of neutral posts and comments in Facebook, Instagram, and YouTube also, moderate positive sentiment (+1, +2) scores in YouTube, while Humpback Mahseer had the highest frequency of neutral text on Twitter.
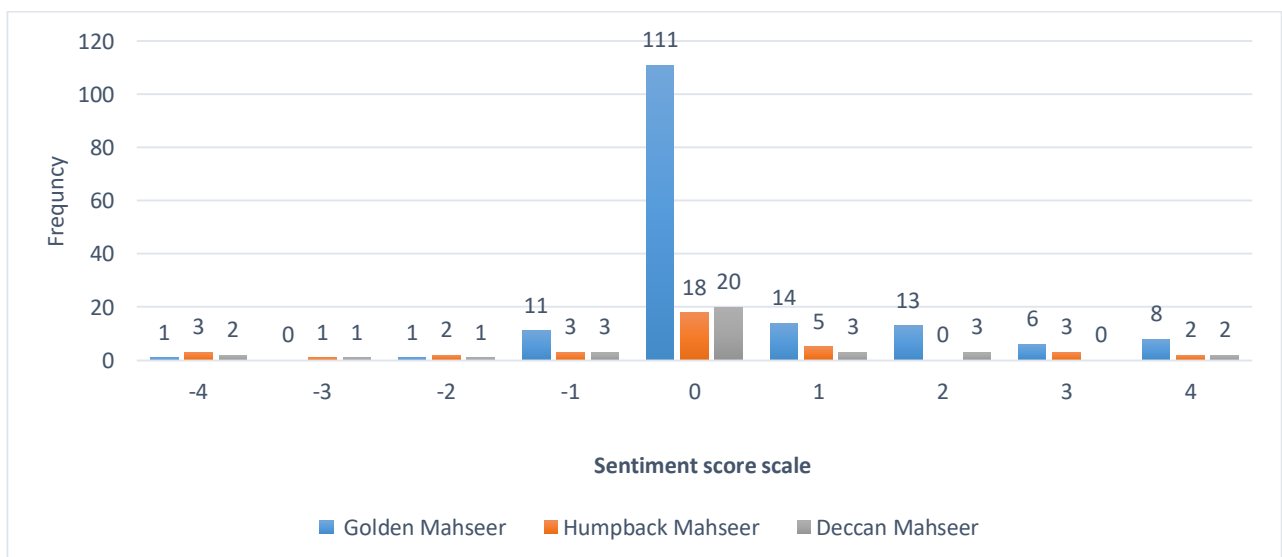
Figure 26 (a) Sentiment scores of the posts on various species of Mahseers collected from Facebook
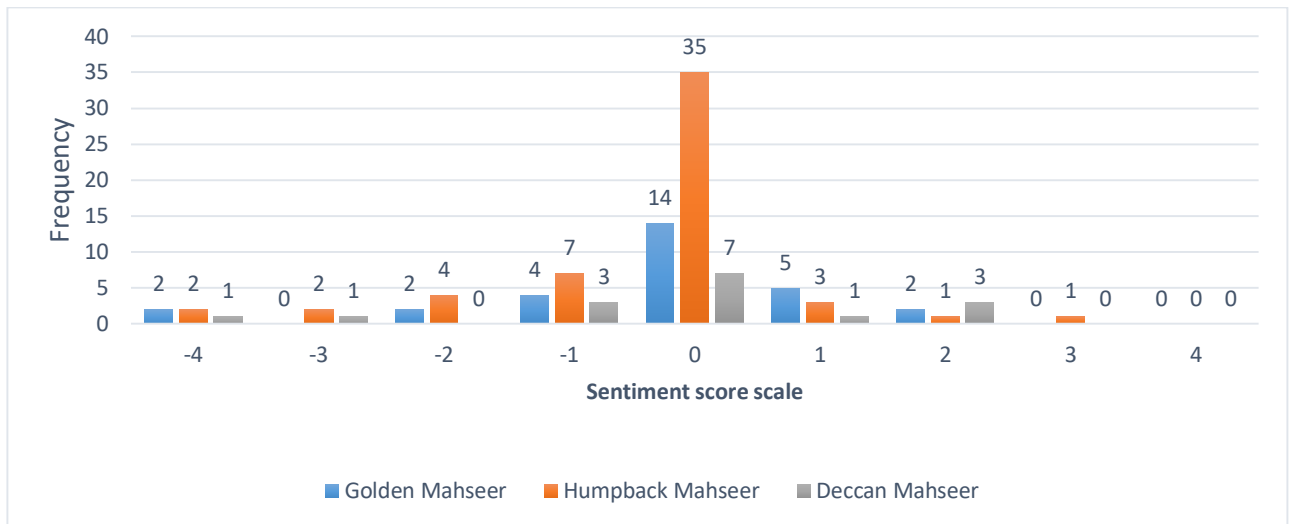
Figure26 (b) Sentiment scores of the posts on various species of Mahseers collected from Twitter
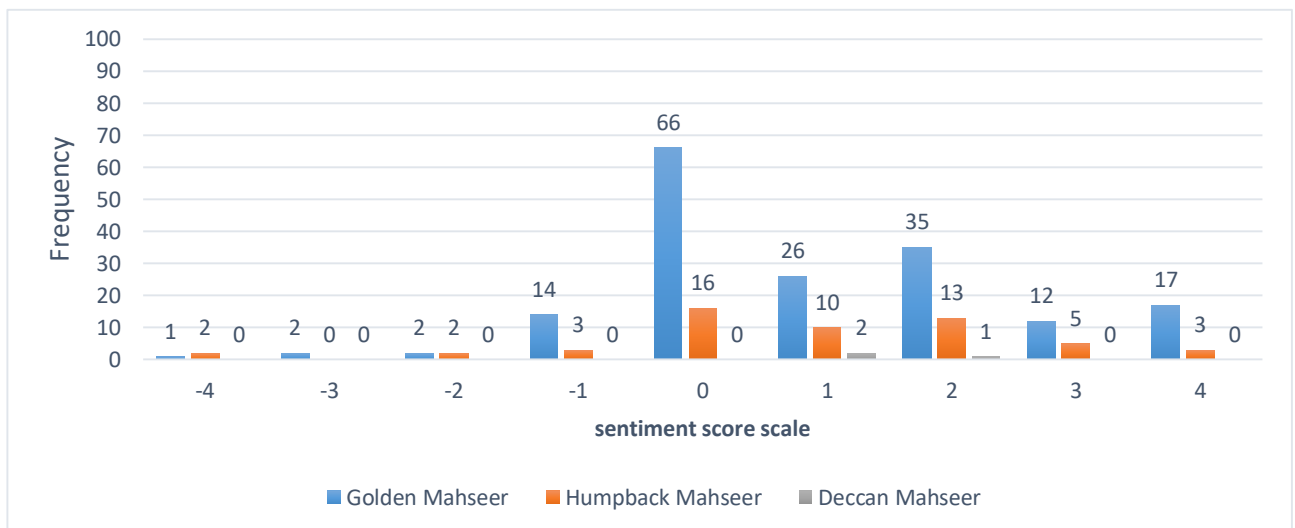
Figure26 (c Sentiment scores of the posts on various species of Mahseers collected from Instagram
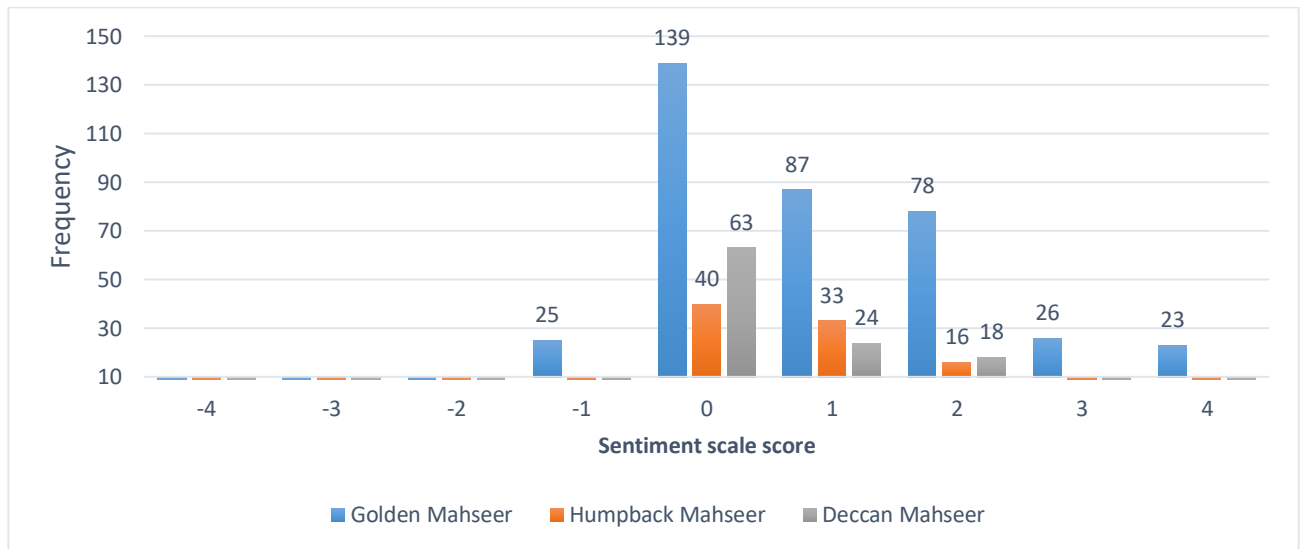
Figure26 (d) Sentiment scores of the posts on various species of Mahseers collected from YouTube

People searching for information on various animal and plant species on the internet and uploading their observations or reflection in the forms of text, image and video on various social media platforms got an enormous popularity in the last two decades. This information, if processed properly, could be useful in generating a bird's eye view of the activities, knowledge sentiments and emotion kept by people towards different species and availability of knowledge of the times and places and topics on which people are most involved can enhance the effectiveness of the awareness campaigns and conservation projects (Jaric et al. 2020). For instance, Andrea et al. (2016) demonstrated a seasonal pattern of interest in the red kite, a reintroduced species in the United Kingdom. They discovered a distinct and seasonal trend in which the highest popularity indexes for the term red kite were obtained in May and June (i.e. during the main breeding season), and this pattern was replicated year after year. Although Google Trends is a relatively recent data source in ecology and conservation, it is already used as a measure of problem salience or attention in political science studies (Boulton et al. 2011; Dube and Kaplan, 2012).

Analysis of the Google Trends data on different species of Mahseers surviving in the aquatic ecosystems of the Indian subcontinent revealed that the term Mahseer was being searched by the people from different parts of the world from the beginning of the study period that is 2010. Bhutan and India together displayed the highest relative search index worldwide for Mahseers although some other counties with very low RSV (less than 15%) such as USA and Norway were also observed in the result of the trend displayed by the Google Trend. The reason behind the increased RSV in these countries may be the presence of the Mahseers in larger water bodies and the contribution it is giving to angling and tourism. Additionally, the first telemetry project on Mahseer for conservation was started in Bhutan (National Geographic blog)

attracting more attention from the scientific community, media and anglers. Furthermore, Mahseer is considered to be sacred in Buddhism and Hinduism, and the general public is typically inclined towards saving and conserving animals associated with religious sentiments and also express their sentiment towards such animals when they come in the news (Pinder et al. 2019). Various species of Mahseers have been reported from different nations such as *Tor ater* from Laos, *Tor barakae* from India, *Tor dongnaiensis*(Vietnam), *Tor kulkarnii*(India), *Tor laterivittatus*(China, Laos), *Tor mosal*(India, Myanmar), *Tor polylepis*(China), *Tor sinensis*(China, Vietnam and Laos), *Tor tambra*(Indonesia, Malaysia), *Tor tor*(Bangladesh, Bhutan, India, Myanmar, Nepal, Pakistan), *Tor yingjiangensis*(China). However very little interest shown by the people from these nations, evident from the lesser RSV points to the need for initiating programmes to make people aware of Mahseers and conserving this species in these nations.

Segregation of the search data (worldwide) based on the species revealed that golden Mahseer was the species deciding the dynamics of this trend till recently, and people started searching for other species such as humpback Mahseer and blue finned Mahseer in the last couple of years. Within India, the highest public attention on the internet for this species was seen between July to September. The spawning of golden Mahseers happens during this period (Nautiyal, 1984; Pathani, 1983) and in India, the angling of this game fish is a celebrated event that happens between June – October (AdventureNation,2018). In the time period 2019-2020 a hike in the search volumes for Humpback Mahseer was observed in Web, Image, News, YouTube. This worldwide spike in attention towards humpback Mahseer may be the result of two events happened in this time period related to this species; 150 yearlong discussions and debates on the taxonomic position of this species came to an end and the scientific community accepted the name Tor *ramadevi* for this species in the year 2018 (Thiruvananthapuram first.in, 2018). Furthermore, this fish was listed as 'Critically Endangered' by IUCN in 2019. The

conference organized by WWF (World Wide Fund) focusing on the identification and conservation of the Mahseer species and improving its status in the month also may have contributed to increasing the interest of various stakeholders in this species.

Within India, Assam showed the highest search volume because Mahseer is a species getting special consideration in this region. Angling competition of this iconic game fish takes place annually at the Jia Bharoli river in Assam. The state also has the oldest angling group that is the Bharoli Angling and Conservation Association which has also come up with a hatchery in the Eco Camp Nameri, for breeding and conservation of the Mahseer (Northeast now blog). Although the golden Mahseer is a native of the rivers of the Himalayan region the higher levels of search for this species had come from the south Indian states such as Karnataka and Tamil Nadu. Humpback Mahseer which is endemic to the Western Ghats in the rivers of the states Karnataka, Maharashtra and Kerala got higher attention from these states. However, blue fin Mahseer had a good representation in the search trend analysis and searches came from various states of central and southern India. Tata Power in Maharashtra took the initiative to conserve this declining species as part of its freshwater fish protection initiative, the Humpback Mahseer Project. This project aims to protect Humpback Mahseer and its natural habitats the major rivers of south and central India. Kaveri Mission, another initiative implementing a variety of micro-projects to resolve a wide range of issues affecting the health of the Kaveri River catchment, including the steadily decreasing population status of the iconic Humpback Mahseer fish, which is endemic to Kaveri and finds nowhere else on the planet (Indiacsr, 2018). These initiatives actively disseminating information into the society may be generating the interest in the public about the Mahseers. Hence, other states focusing on the conservation of the Mahseers should make plans in this line to generate public interest in the species they focus.

Understanding the seasonal variation in the interest of the public can help in identifying time suitable for conducting information dissemination, awareness programmes etc. For instance, a study conducted on these seasonal fluctuations in the interest of the public in the red kite revealed a close positive association between their breeding time and the search activity on the internet for this species (Andrea, 2016). The present study revealed that in the case of Mahseer terms angling, spawning, and overfishing are tightly correlated with the public interest. This results points to the need for keeping the anglers and angling competitions and breeding period as the targets of online and offline intervention to attract the attention of the public to these species. Hence it is advised that more public awareness programmes should be conducted at the time of angling competition and breeding period of different species of Mahseers. Furthermore, the correlation between the overfishing and public interest reveals that people are concerned about the over exploitation of this species. Hence the analysis of the mind-set of various stakeholders involved in the conservation of Mahseer is essential to find sustainable plans to protect this species.

Media report issues of importance to the public and the content and framing of the news broadcasted could impact the perception and behaviour of many people consuming it (McCombs & Reynolds, 2002). There is also research available to prove that attention given by the media to a problem can have a vital impact on the mind-set of the society towards it and the topics less discussed by the media could continue 'out of the mind of the people' (Dwivedi et at. 2020). The result of the exploration of the media interest in the topics 'Angling', 'Extinction', and 'Conservation' of the Mahseer was not a one which could make a person interested in the protection of this species happy. The number of articles published during the study period was very low and among the various keywords studies term 'Mahseer' was the most frequently used one by the media online, indicating that attention is converged towards the group Mahseer. This result points to the need for publishing more articles related to the

issues faced by the Mahseers and giving special emphasis to the species of Mahseers endemic to the areas in which the media has maximum circulation.

Conclusion

Our study illustrates that Internet-based tools for monitoring user activity can provide a flexible and detailed approach to assessing public interest in a wide range of conservation topics and projects. The findings of our study indicate spatial and temporal variation in interest in various Mahseer species over the last ten years in India and around the world. The study of public interest, understanding, attitude, and emotions toward the species showed that the general public was more inclined towards Golden Mahseer and Humpback Mahseer since they were the most frequently searched for species over 10 years, However, as demonstrated by the number of articles published by the media industry, overall interest in Mahseer in online media has decreased. Our analysis of scientific literature revealed that research publications on Golden Mahseer, Humpback Mahseer, and Deccan Mahseer centered on conservation, as these species' populations are decreasing at a faster pace. We also discovered a clear association between social media data volume and online news volume in the case of the extinction of the Humpback Mahseer, while other incidents involving other species only appeared in social media or online news. Finally, public opinion on social media demonstrated that people have a neutral attitude toward Mahseer. This expertise might be fruitfully employed in large-scale efforts to conserve and protect a wide range of threatened and endangered species. For example, more could be done to encourage public understanding of the Mahseer and other important animals. Although Culturomics research is in its infancy, iEcology and conservation culturomics is likely to experience rapid development over the coming years and become one of the major research techniques in ecology. Increasingly, conservation researchers around the world are exploring its potential to provide insights into the complex interactions between human culture and the natural world. Culturomics has enormous potential not only to instigate discussion and experimentation but also to promote cooperation between conservationists, computer scientists, information engineers, and the digital humanities.

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