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Digitalization of planning and navigating recreational outdoor activities

Supplementary Information

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Introduction

The advent of digital technologies has brought significant changes to the way people plan and navigate outdoor activities. With the increasing availability of digital tools such as mobile apps, GNSS devices (often referred to as GPS devices), and outdoor platforms (◘ Table 1), outdoor recreationists now have a multitude of options to choose from when preparing for their next adventure. The use of digital tools for outdoor activities has become increasingly popular and the predicted process of digitalization in outdoor activities is well underway (Arts, Fischer, Duckett, & van der Wal, 2021; Jepson & Ladle, 2015). Studies showed that recreationists trusted digital tools in specific cases more than analog information (Immoos & Hunziker, 2015; Moczek, Dworschak, & Klar, 2020). The use of outdoor apps, in particular, has grown significantly in the past decade, providing users with access to a wealth of information about routes, conditions, and safety precautions. At the same time, there is debate over whether digital technologies are improving the nature experience, recreation, and health aspects of being in nature (Arts et al., 2021; Carter, Green, & Speed, 2018; Senda-Cook, 2013; Shultis, 2015).

Visitor management is of particular importance when sport activities take place in sensitive habitats where they could threaten endangered flora and fauna (Astelbauer-Unger, Plattner, & Stock, 2020; Marion, Leung, Eagleston, & Burroughs, 2016; Peters, Ruess, & Heurich, 2023). In fact, recreationists are often not aware how their activity impacts their natural environment (Blanc, Guillemain, Mouronval, Desmonts, & Fritz, 2006; Sterl, Brandenburg, & Arnberger, 2008). On the other hand, managers of protected areas should be aware of the whereabouts of recreationists in order to adapt visitor management and implement effective strategies (Ghermandi, 2022; Schmücker & Reif, 2021). The efficacy of management measures depends, besides on how appealing they are, mainly on how many recreationists are reached and at which stage of their tour (Esfandiar, Pearce, Dowling, & Goh, 2022; Zejda & Josef, 2019). The best time to influence people is during the planning phase (Hunziker, Hubschmid, & Solèr, 2021; Immoos & Hunziker, 2014). Therefore, it is important to know how recreationists plan their activities (Josef & Kacetl, 2013).

It is only partially known how recreationists plan their activities (Scalabrini et al., 2023; Yamashita, 2022). A survey of the German Hiking Club found that 62% of hikers used digital information to plan their tours, with 56% relying solely on signposts for navigation and 25% relying solely on digital information (BTE Tourismus- und Regionalberatung & Deutscher Wanderverband, 2018). To prepare for their trip, 84% of German bike travelers used Internet sources; 29% of them used printed bike maps, while 26% used printed travel guides. During the trip, 68% of the travelers used signposts and the same number used apps for smartphones, while 60% used the Internet directly (ADFC, 2023). A total of 95% of long-distance hikers on the Pacific Crest Trail in the United States reported using a mobile phone for navigation (Fox, 2018). Furthermore, 97% of hikers on the Pacific Crest Trail reported carrying a smartphone, and on average, they used their phone for 3 h and 23 min a day, primarily for navigation purposes (Amerson, Rose, Lepp, & Dustin, 2019). A study conducted with climbers found that the tools used for tracking activities differed between various sports (Daiber, Wiehr, Kosmalla, & Krüger, 2016). In addition, age plays a decisive role in the way information is obtained (BTE Tourismus- und Regionalberatung & Deutscher Wanderverband, 2018; Kang, Jodice, & Norman, 2020).

Part of effective visitor management is utilizing the channels already used by recreationists. By examining the planning and navigating behavior of outdoor recreationists, we can better understand

Table 1 Tools for planning and navigating outdoor activities[a]

Name	Category	Publisher	Website	Additional information
Strava	Mobile app and website	Strava, Inc.	strava.com	Supports various nature activities; to record time, compare your performance with others and record and navigate tours
Outdooractive	Mobile app and website	Outdooractive GmbH	outdooractive.com	Supports various nature activities; to plan tours, receive tour recommendations, share tour information with others and record and navigate tours
Komoot	Mobile app and website	Komoot GmbH	komoot.de	Supports hiking, running and biking (no winter sports); to receive tour recommendations, share tour information/ highlights with others, plan and navigate tours
AllTrails	Mobile app and website	AllTrails, LLC	alltrails.com	Supports various nature activities; to plan tours, receive tour recommendations, share tour information with others and record and navigate tours
Bergfex	Mobile app, website and more	Bergfex GmbH	bergfex.de	Supports various nature activities; to receive tour recommendations, information for weather and snow heights, share tour information
BayernAtlas	Geodata platform	Bayerisches Landesamt für Digitalisierung, Breitband und Vermessung	geoportal.bayern.de/ bayernatlas	Map and aerial photographs from the Bavarian administration, several maps for landscape use or nature conservation are included
OpenStreetMap (OSM)	Community-based Geodata platform	OpenStreetMap Foundation	openstreetmap.de	Community-generated geodatabase that serves as the basis for most map applications such as outdoor platforms

[a]In this study, the term "tool" refers to any instrument used by a recreationist to plan or navigate during an activity. The term is used broadly and encompasses outdoor platforms, analog tour guide books, and individual local knowledge

how digitalization has changed effective visitor management strategies to mitigate negative impacts on natural ecosystems. We investigated the usage of digital and analog tools in the two phases of the customer journey—*planning* (mainly before the activity) and *navigating* (during the activity)—which also changes with the use of smartphones, and considered interrelations with factors such as age, location of the activity, and type of activity (Huertas & Orden-Mejía, 2022; Kang et al., 2020; Mieli, 2023; Shen, Sotiriadis, & Zhang, 2020). The tools used in our survey were also employed in other comparable surveys (BTE Tourismus- und Regionalberatung & Deutscher Wanderverband, 2018).

Methods

Planning and navigating behaviors of recreationists were assessed via survey conducted from 11 June 2022 to 15 September 2022. The survey (26 questions, Supplement 1) assesses information regarding the tools used for planning and for navigating a person's last outdoor activity as well as details on the activity and their personal background.

Study area and data collection

The study included a total of 410 respondents, of whom 154 participants completed the survey on-site, and 62% of respondents were reached through links or QR codes.

On-site, the survey was made available on tablets and smartphones as computer-assisted personal interviewing (CAPI) to be filled in by randomly chosen recreationists on nine highly frequented locations in the Naturpark[1] Fichtelgebirge and the Naturpark Fränkische Schweiz—Frankenjura, located in northeast Bavaria, Germany.

The survey was also distributed via QR codes by rangers of these protected areas and advertised on posters at central points of interest, primarily huts and shelters, in these parks. To reach further potential participants, the survey was shared by local and regional tourism information centers, the regional DAV (German Alpine Association) sections, the regional IG-Klettern (interest group for

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[1] Naturpark is a name for a protected area in Germany, in which the cultural landscape is conserved and at the same time touristically used.

climbers), local hiking clubs, ski schools, the mountain bike school and trail center Bullhead House, and the regional groups of the DIMB (interest group for mountain bikers). Additionally, the survey link was shared via social media channels such as Instagram, Facebook, and local WhatsApp groups.

This may have led to a higher proportion of participants who are more open to digital tools, potentially underrepresenting recreationists with a more skeptical stance toward digital media.

Data analysis

All analyses were performed using R Statistical Software (R Foundation for Statistical Computing, Vienna, Austria; v4.3.1; R Core Team 2023). To ensure informative results, sport activities with fewer than 10 participants were excluded from analysis. For each research question, all answers that were applicable to that specific question were utilized (see Supplement 2). We categorized the tools used into three categories: (1) analog, (2) digital, and (3) local knowledge. As the study primarily focused on digital and analog tools, local knowledge was only included if additional conclusions could

be drawn. Missing data were excluded separately for each analysis. The data were analyzed using R. Script and data are deposited on https://doi.org/10.5281/zenodo.10261382.

To test the relationship between the categories of planning tools, age, activity type, and the region in which the activity was performed, we used the generalized linear model of the R-package visreg (Breheny & Burchett, 2017). To gain a more precise understanding of behavior, the respondents were grouped by the most important factor, the type of activity (sport discipline), for further analysis.

Results

Recreationists planned (86%) and navigated (73%) during their last outdoor activity with at least one digital tool. The activities mostly occurred in the adjacent protected areas Naturpark Fichtelgebirge ($n = 146$), Naturpark Fränkische Schweiz—Frankenjura ($n = 125$), and Naturpark Frankenwald ($n = 19$), which nearly border each other.

The surveyed recreationists were between 16 and 81 years of age (mean ± SD = 40.5 ± 14.9 years; see Supplement 3). The respondents participated mainly in trail running, mountain biking, hiking, or sport climbing (see ◘ Figs. 1 and 2). Outdoor activities with fewer than 10 participants were excluded from the study (biking, road biking, e-biking, jogging, Nordic walking, via ferrata climbing, canoeing, or at a gym).

To examine the influence of activity type on tool choice, we categorized the respondents by their chosen outdoor activity and analyzed the proportion of digital or analog used tools. The activity ($p = 0.004$) and age ($p = 0.018$) of the recreationists had a significant influence on the choice of the tool category. While 90% of 30-year-olds used digital tools as their main planning tool, 73% of 60-year-olds did the same.

The activity had a greater effect on the selection of tools for planning outdoor activities than the age of the recreationist (see ◘ Fig. 1). According to the results, digital tools are the primary planning instrument for most outdoor recreationists. A majority of trail running (93%), moun-

tain biking (93%), and hiking (84%) enthusiasts preferred to use digital tools for planning their activity, while sport climbers were the exception and tended to predominantly rely on analog tools (57%, see ◘ Figs. 1 and 2). Furthermore, the vast majority of respondents used at least one digital tool for planning their outdoor activities, while only between 0% (trail running) and 11% (sport climbing) relied exclusively on analog tools (see ◘ Fig. 2).

The tools utilized for the planning and navigation phases of outdoor activities differ, with a greater variety of tools being employed for activity planning. A majority of outdoor recreationists (82%) utilized multiple tools for planning their activities, while nearly half (48%) relied on a single tool for navigation. On average, respondents used 3.4 ± 2.0 (mean ± SD) tools during the planning phase and 1.9 ± 1.1 (mean ± SD) tools for in-field navigation.

The outdoor platforms AllTrails and Bergfex and the websites of the protected areas were used exclusively for planning (◘ Table 1). BayernAtlas, the websites of tourist information centers, printed maps, Outdooractive, tour flyers, tour and climbing guides, Strava, climbing apps, and the website of the nature park were mainly used to plan (> 66% of total use) and only seldom to navigating during the activity. Google, Komoot, local knowledge, and signposts were frequently used for navigation, with OpenStreetMap being the only tool used more often for navigation than for planning. Furthermore, it is noteworthy that a higher percentage of individuals preferred using Komoot (53% for planning, 38% for navigating) and Google (40% for planning, 29% for navigating) than signposts (31% in planning, 28% in navigating), which is the traditional analog tour navigation tool (see ◘ Fig. 3).

Not only did the use of tool categories differ depending on the activity in which the recreationists were involved, but the specific tools chosen also varied. However, in every activity, local knowledge was used by approximately 20–25% of participants for both planning and navigating.

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Abstract

Effective visitor management requires reaching visitors with fitting information at the right time through the channels they already use. To identify effective communication channels, 410 recreationists were interviewed in north-east Bavaria to determine how they plan and navigate their outdoor activities. Interviews were conducted onsite (38%) as well as through digital media (62%). The study found that the majority of people use digital tools when planning (86%) and navigating (73%) outdoor activities. Additionally, most people (84%) use more than one tool for planning activities, while almost half (48%) use only one tool for navigation. The choice of tools was largely influenced by the planned activity. Trail running (93%), mountain biking (93%), and hiking (84%) were mostly planned using a digital main tool, while sport climbing was mainly planned using an analog main tool (57%), with 87% of sport climbers using printed guidebooks. Age had a smaller effect on tool choice, with 90% of 30-year-olds using a digital main tool for planning outdoor activities compared to 73% of 60-year-olds. The study demonstrates the importance and the diversity of digital tools used for outdoor activities that need to be considered for effective visitor management in tourism as well as nature conservation.

Keywords

Visitor management · Nature sports · App · Non-consumptive leisure activities · Adventure tourism

For trail running, popular planning tools included Komoot, Outdooractive, Google, and Strava. During the activity, signposts and Komoot were the most commonly utilized tools for navigation. Diverse trail running recreationists utilized different tools, resulting in a significant proportion of "other" tools (see Supplement 4). Mountain bikers mostly relied on Komoot for both planning and navigation, while hiking recreationists primarily used Komoot and Google for
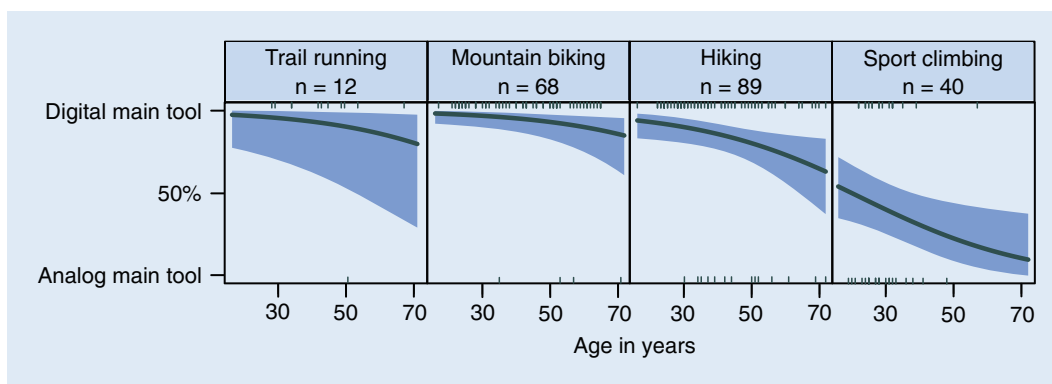
Fig. 1 ◄ The use of a digital main tool for activity planning declines with increasing age of the participant, as shown by these generalized linear models. Each *whisker* on the *upper edge* of the graph represents at least one digital planned tour, each one at the *bottom edge* an analog planned tour
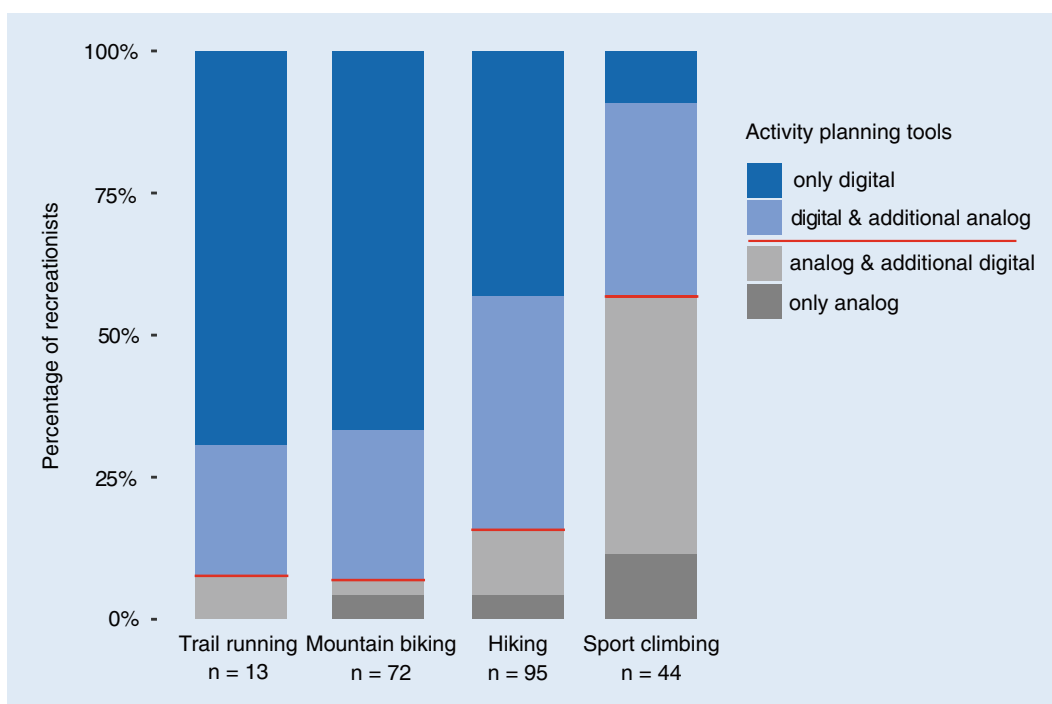

Fig. 2 ◄ Proportion of recreationists who mainly use digital tools (*upper part, above the red line*) or analog tools (*lower part*) for planning outdoor activities, according to recreational activity: trail running, mountain biking, hiking, and sport climbing. Recreationists were further grouped depending on whether they only utilized digital tools (*dark blue*), mainly digital tools complemented by analog tools (*light blue*), mainly analog tools complemented by digital tools (*light gray*), or only analog tools (*dark gray*)

planning and navigation, with the addition of signposts for orientation. On the other hand, sport climbing recreationists often relied on printed guidebooks and websites for planning and orientation. Additionally, Google was frequently used as a tool for orientation (see ◘ **Fig. 3**).

Tools utilized for navigation were also used for planning by the same individuals to a significant extent (see Supplement 5). Other tools were solely used for planning and not during the tour (see ◘ **Fig. 3**). Both for the planning and navigation phase, the most frequently accessed sources of information are often used in combination (see Supplement 6).

As the recreationists were asked about both the tools they used overall for planning and the tools they primarily rely on for planning, further insights into how these tools were utilized can be gained. Interestingly, only Komoot, OpenStreetMap, and AllTrails were more frequently used as a main tool than supplementary to other main tools. Climbing guidebooks and local knowledge were primarily (<75%) used as supplementary tools. All other tools were predominantly (>75%) used as supplementary tools (see ◘ **Fig. 4**).

Discussion

Technological advancements and evolving societal attitudes have transformed how outdoor enthusiasts plan and navigate their activities. According to this survey and other recent research, the vast majority of people rely on digital tools for planning and navigation while engaging in outdoor activities (Fox, 2018; Amerson et al., 2019). Digitalization in outdoor recreation (Arts et al., 2021) has progressed to the point where digital media is, in certain circumstances, more trusted than analog information (Immoos & Hunziker, 2015; Moczek et al., 2020).

The shift from analog to digital tools transformed the planning and navigating behavior of recreationists and has far-reaching implications for visitor management and conservation efforts but presents both challenges and opportunities (Bergman et al., 2022; Jepson & Ladle, 2015; Moczek et al., 2020; Zink, Porst, Leibl, & Heurich, 2022).
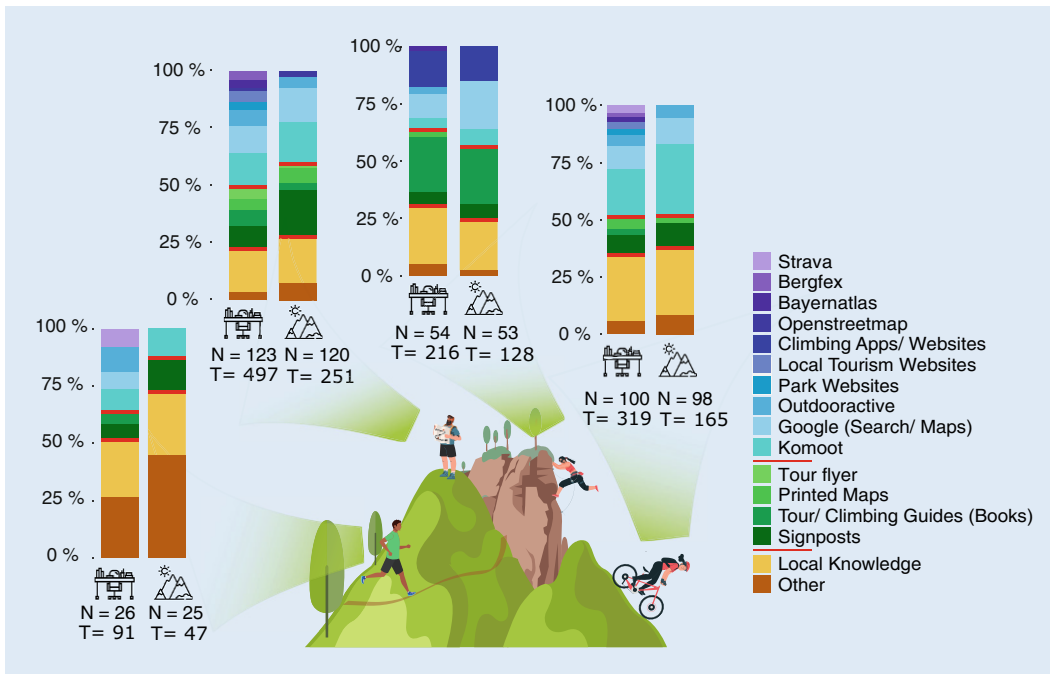
Fig. 3 ◄ The tools utilized for planning (*left bar*) and navigating outdoor activities (*right bar*) differ. *n* indicates the number of respondents, *T* the number of tools they used in total. Tools that were used by fewer than five people were categorized in "other digital tools" or "other analog tools." Each *bar* is divided into *three sections* by *two red lines*: the *top section* represents the percentage of digital tools, the *middle section* the percentage of analog tools, and the *bottom section* represents the usage of local knowledge
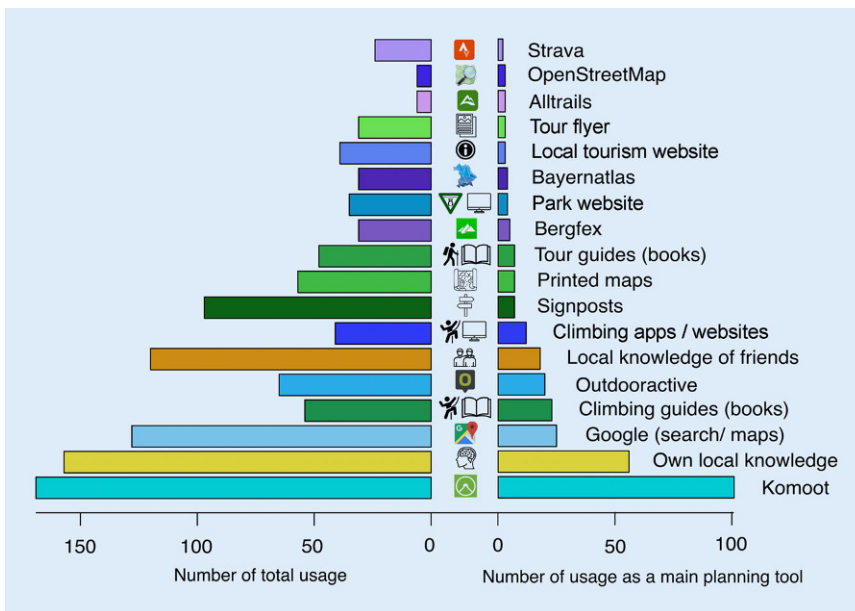

Fig. 4 ▲ Recreationists were surveyed about the tools they used for planning, and which among those tools was their primary planning tool. The *left side* of the chart shows the frequency of use for each tool during the planning phase, while the *right side* outlines how often each tool was used as the primary planning tool. The *green bars* represent analog tools, the *blue to purple bars* represent digital tools, and the *yellow to orange bars* indicate the category of local knowledge

a disregard for rules. Nevertheless, these platforms have significant potential for disseminating nature conservation concerns through their extensive user base and immediate communication and interaction capabilities. Despite the novel challenges resulting from changes in visitor behavior due to digitization, this potential has largely remained untapped. Currently, collaboration between outdoor platforms and protected areas in Germany is in the early stages of development.

By incorporating information about the boundaries, regulations, and codes of conduct of protected areas into outdoor platforms, this information can become more accessible to recreationists. The digital integration provides several advantages over analog tools. Outdoor platforms have the capability to provide users with information that is tailored to their specific needs, the current stage in the customer journey, and the scope of information. They also create the opportunity to provide the user with extensive information without overwhelming them with excessive data. Digital media also provides the possibility of incorporating video, sound, or gamification elements. This personalized information ensures that users receive relevant and timely guidance based on their

Some digital tools, such as Komoot and Outdooractive, are based on user-generated tour description content. These outdoor platforms seldom provide their users with nature conservation regulations. Unofficial trails, including those within protected areas, are often unwanted by the management

of these areas. Nevertheless, they are frequently part of route suggestions of outdoor platforms (Loosen, Capdevila, Pigeon, Wright, & Jacob, 2023). Simultaneously, these platforms offer users the convenience of easily sharing tour recommendations with a large number of other users, which can result in

individual preferences and current circumstances, a central factor for successful visitor management (Esfandiar et al., 2022; Immoos & Hunziker, 2014). This highlights the significance of activity-specific information sources. The results of this study align with prior research (BTE Tourismus- und Regionalberatung & Deutscher Wanderverband, 2018; Daiber et al., 2016).

Furthermore, nature conservation approaches can be communicated through outdoor platforms during the planning phase, widely acknowledged as the most crucial stage (Immoos & Hunziker, 2015). This means recreationists can be well informed about the specific requirements and responsibilities even before visiting protected areas, thereby promoting responsible and sustainable outdoor activities. However, this can pose a challenge for the management of protected areas, especially considering the various tools in use.

One of the key benefits offered by digital tools is the ability to gather data. Studies have shown that social media can be used for monitoring in protected areas (Ghermandi, 2022; Pellicer-Chenoll et al., 2022; Tenkanen et al., 2017). Outdoor platforms offer even more accurate data regarding the volume and location of visitor activities, some of them in real time (Horst, Taczanowska, Porst, & Arnberger, 2023; Norman & Pickering, 2017; Rice, Mueller, Graefe, & Taff, 2019). By harnessing this information and integrating it with the understanding of which tool corresponds to each activity, activity-specific forecasts are possible. On the other hand, it may be necessary to combine different tools to depict the complete visitor flow, encompassing all activities. The scope and timing of visitor presence offer supplementary insights into the efficiency of visitor management strategies.

As 84% of recreationists used multiple tools to plan their activities, visitors can be reached through different channels. Tool categories were commonly intermixed to the extent of their usage. Considering the extensive use of diverse digital tools, the study simultaneously reveals the complexities associated with the transition from analog to digital methods.

Altering the map material forming the basis of outdoor platforms may be more impactful than modifying user-generated content. Numerous outdoor platforms are based on the geospatial database OpenStreetMap (Hennig, 2017). OpenStreetMap is community-driven and not accessible for automated large-scale data import and content limited. However, alternative data sources, such as the data provided by Digitize the Planet e. V., an association that digitizes nature conservation relevant data and makes them available as open source, are also used by some platforms. Compounded by the discovery that numerous digital tools are employed for planning and navigation, the skillful handling of diverse tools becomes essential for efficient visitor management.

Limitations and future research directions

The use of different tools for various activities can be attributed to the fact that these tools are designed specifically for different activities. However, it is possible that nature visitors who frequently participate in one activity and were asked about a different activity may still have used the tools they use for their preferred activity, even if they are not suitable for the activity in question.

Regrettably, the survey did not gather data concerning whether recreationists used particular sources to acquire specific information, such as distinguishing between sources for road conditions and tour descriptions (refer to Supplement 1) or supplementing digital information with analog information due to a lack of trust solely in digital information. Since this information is vital for effective visitor management, further research is needed to gain a more comprehensive understanding of the specific information of sources and platforms that visitors rely on.

This survey follows related surveys in not differentiating between the channels through which the participants were reached. As 62% of the participants were reached through digital media, this methodology may have to some extent unintentionally excluded individuals who relied on analog means of communication, potentially leading to a biased sample. The survey set-up does not allow one to distinguish between different digital channels through which recreationists were reached. The response rate was also not recorded.

Given that many related surveys have been conducted using similar approaches (ADFC, 2023; BTE Tourismus- und Regionalberatung & Deutscher Wanderverband, 2018), further research should investigate the biases that may arise from this methodology and explore alternative approaches in order to ensure a more representative sample.

Conclusion

Digital tools play a substantial role throughout various stages of the customer journey of outdoor recreationists. During the planning phase, 86% of the recreationists used a digital tool, and 73% used one for navigation during the tour. Integrating digital information sources, especially outdoor platforms like Komoot and Outdooractive, for recreationists into visitor management strategies offers significant benefits for protected areas. However, the variety of tools used also presents notable challenges. When integrating these tools, it should be noted that some are specifically used by visitors for particular activities. Conversely, reaching visitors engaged in specific activities can be achieved by using the appropriate tool. Further research should concentrate on the type of information used from differing sources.

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Declarations

Conflict of interest. A. Schwietering, M. Steinbauer, M. Mangold, M. Sand and V. Audorff declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies mentioned were in accordance with the ethical standards indicated in each case.

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