Chatting with Forestry Guidelines: Using Chatbots to Improve Access to Complex Forest Knowledge

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Abstract Forestry guidelines play a crucial role in translating environmental policy into actionable practices, yet they are often complex, text-heavy, and difficult for non-experts to navigate. In this paper, we present a prototype called Forea Bot, a conversational AI system developed to address the challenge of accessing forest knowledge. The system uses a retrieval-augmented generation (RAG) architecture. Developed from a socioinformatics perspective, it combines large language models with curated forestry documents and is shaped by participatory design insights. We present findings from an evaluation conducted during a workshop with forestry stakeholders and discuss how such systems shape trust in chatbot responses and make visible tensions between conflicting sources of knowledge in forestry-related communication. While not a substitute for expert consultation, our findings suggest that chatbots like Forea Bot can complement traditional channels of knowledge exchange, particularly in domains characterized by complexity, value pluralism, and limited access to expertise.

CCS Concepts: • **Human-centered computing** → *Collaborative and social computing devices*; **Empirical studies in HCI**; **Interactive systems and tools**; • **General and reference** → General conference proceedings.

Additional Key Words and Phrases: Conversational AI; Chatbots; Forestry Management; Retrieval-Augmented Generation; RAG; Environmental Communication; Knowledge Accessibility; HCI; Forest Policy; Domain-Specific AI

1 Introduction and Background

In recent years, German forests have been significantly impacted by climate change, resulting in widespread deforestation events [11, 16, 31]. The evolving climate crisis continues to threaten forest ecosystems, and further crises appear likely given that approximately four out of five trees show signs of damage [5]. Forest owners are therefore seeking strategies to ensure the resilience of their forests [1, 14, 23].

This leads to increased complexity in forest management. Due to forest damage, managers must make long-term decisions today that will need to endure for decades and even centuries—such as selecting suitable tree species and

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designing appropriate tree mixes. They must do this despite considerable uncertainty about future climatic conditions [30]. In addition, our understanding of what this means for specific locations or ecosystems (such as forests) is still evolving. Under these conditions, it is difficult to predict which forest compositions will remain viable in the future. As a result, there is a growing need for well-informed forestry stakeholders. As Sousa-Silva et al. point out, a lack of knowledge and information slows down forest climate adaptation, even though stakeholders are highly aware of climate change and concerned about its impacts on forests [26]. In this regard, information technology has the potential to make new knowledge accessible (e.g. [15, 23, 25].

To support forest owners, local governments have introduced several measures, including the publication of forestry guidelines, the provision of planning software, and the subsidization of forest management consulting. In this paper, we examine the role of forestry guidelines and use two key policy documents provided by the regional forest authority: the Forest Condition Report NRW [21] and the Forest Management Concept NRW [32]. These guidelines describe the current state of forests in North Rhine-Westphalia (NRW) and provide recommendations for forest regeneration and species selection.

Although these documents are informative and generally well written, they face usability challenges. If too short, they may be unclear; if too detailed, they can overwhelm the reader. To address this problem, we explore the use of Retrieval-Augmented Generation (RAG), a technology built on large language models (LLMs). RAG enables users to interact with the content of forestry guidelines through a chatbot interface, allowing them to pose specific questions or request summaries on particular topics. This approach offers a more accessible and user-friendly means of engaging with complex policy materials.

Forest visitors and small forest owners, in particular, often do not have the same access to expert forestry consultants as medium and large-scale forest owners. Yet the visibly deteriorating state of many forests sparks curiosity and raises questions. Unfortunately, there are not enough experts available to answer all these questions, as they are already in high demand for rebuilding damaged forests. This results in a gap that chatbots can help to bridge.

In this paper, we present the prototype development of such a RAG system. We explain the motivation behind its creation, how it functions, and share preliminary insights from forestry stakeholders. We also outline the methodological approach in detail. Finally, we discuss the role of trust in chatbots and explore how diverse perspectives could be incorporated into such a technology.

2 Methodology

We used principles of participatory design and grounded design to develop the chatbot, drawing on qualitative interviews and expert workshops [27, 28]. The following sections detail the study design, data collection, and participants.

2.1 Study Design and Data Collection

This work is part of a three-year research project exploring how digital tools can support climate-adaptive forestry. Using ethnographic and participatory design methods, the project aims to uncover practical and socio-technical solutions that enhance forest management decision-making.

The study followed an iterative, four-phase process. First, an ethnomethodological approach combined semi-structured interviews with extensive field observations during in situ visits to forestry stakeholders [8, 24]. These interviews focused on daily forest work, recent forest damage, and strategies for climate change adaptation and mitigation. With the goal to learn how decisions are made and by whom. Conducted primarily in forest settings, interviews were

documented through detailed field notes taken by two researchers, supplemented occasionally with audio recordings. Notes were cross-compared and thematically analyzed [3, 4, 6].

Second, findings from the fieldwork were presented, contextualize and reflect in an expert workshop. Insights from this workshop and the interviews informed the third phase: the co-design of a chatbot prototype with the research team and selected stakeholders. Finally, the chatbot system was evaluated in a second expert workshop focused on usability, utility, and alignment with the socio-technical ecosystem of forestry decision-making. Structured note-taking guided by predefined categories (e.g., "Usability," "User Group," "Usage Intent," and "Sensemaking") supported a collaborative, workshop-based analysis to derive implications for further development.

2.2 Participants

The data used in this study derive from a combination of interviews and expert workshops. Most participants live and work in the region under investigation and possess extensive knowledge of forest ecosystems and management practices, gained through professional experience or academic training. In total, we conducted interviews with 28 individuals, including forest owners, foresters, hunters, biologists, government employees, consultants, and other secondary stakeholders. While the interviews provided valuable contextual insights, the primary data sources are two expert workshops. The first workshop included ten external participants: three from government forestry administration, four private forest owners, two foresters, and one forest consultant. The second workshop also involved ten participants: three from government administration, one forest owner, three foresters, one consultant, and two biologists. Six individuals (60%) participated in both workshops, contributing to a continuity of dialogue and reflection across sessions.

3 Findings & Development

3.1 Problem Description

In the study region, approximately 60% of forested land is privately owned, much of it by individuals who manage their forest as a side activity or in a volunteer capacity. A significant portion of this land is held in forest cooperatives, which trace their origins to the communal practices of small-town populations. These cooperatives are often multi-generational, with shares passed down within families, resulting in many owners per forest plot. While this creates a deep emotional connection to the land, it also leads to fragmented ownership and, frequently, only limited forestry knowledge among stakeholders.

At the same time, it became evident that traditional forest management concepts—rooted in a monocultural, production-focused past—have only limited relevance for the future. As there is a high degree of uncertainty what sort trees could strive in the future. Today's forestry is shaped by increasing ecological complexity, especially as efforts shift toward mixed-species reforestation to build climate resilience. These type of forests are recommended by foresters, biologists and government agencies. The reasons for the recommendations are not only ecology driven but also follow an economical logic. The concept of diversification aims to reduce the impact of the loss of one tree species. If one species does not survive, others can take over and maintain overall stability.

Although government agencies have published detailed guidelines for reforestation and sustainable forest management, these materials require time and motivation to read and interpret—resources many owners lack. In addition, while professional foresters offer tailored advice for specific woodland parcels, this service typically incurs costs if it is related to a specific forest. This can be a barrier, especially for small forest owners or people that are not decision takers in cooperatives or family owned forests. These findings highlight the need for low-threshold, accessible information

systems that can help forest owners navigate the complexity of modern forestry and take informed action without requiring expert-level knowledge or significant financial investment.

Additionally, our fieldwork revealed a growing public dissatisfaction with the state of local forests, particularly in the wake of recent large-scale disturbances such as the bark beetle infestations that accounted for a large scale lost of forest in the region. Many forest owners and community members expressed concern about visible degradation and uncertainty about how to support sustainable recovery.

In response to these challenges, we developed a chatbot system to provide accessible, context-aware forestry knowledge that supports informed decision-making without replacing human expertise.

3.2 System

The system described here was developed based on results from an initial workshop, where participants discussed eight key themes relevant to forest management—such as drones, ecosystem services, and forest knowledge. Participants collectively prioritized improving access to forest knowledge as a primary objective for new digital tools, particularly to address the challenges outlined in the previous section.

In response, we developed a prototype called *Forea Bot*, a conversational AI system designed to support stakeholders such as forest owners, practitioners, and the public in accessing reliable forestry knowledge. It is built using a Retrieval-Augmented Generation (RAG) architecture that combines semantic search with large language models to deliver context-aware answers.

The chatbot draws on official sources, including the *Forest Management Concept NRW* (192 pages) [32] and the *Forest Condition Report NRW 2023* (68 pages) [21]. The former is a modular framework aimed at fostering site-appropriate, resilient mixed forests. The latter is a scientific report assessing forest health in NRW, focusing on climate stress, pests, and regeneration challenges.

To enable retrieval, both documents were embedded using OpenAI's 'text-embedding-3-large' model and indexed in a FAISS vector database. GPT-4o was used for language generation, providing fluent, German-language responses by default.

The system is configured through a tailored prompt and filtering scheme. The prompt instructs the model to act as a knowledgeable forester, respond with source-based detail, and end each message with "Weidmannsheil!". A traditional greeting used among hunters (forest owners are often also hunters). Filters further constrain the output to ensure a professional tone, medium-length responses, no emojis, and no humor. Figure 1 shows an example interaction with the chatbot.

The chatbot aims to reduce the complexity of forestry information, especially for small forest owners without access to expert advice. While it increases accessibility, it is not a substitute for professional consultation. Limitations include incomplete domain coverage, opaque capabilities, and reduced accuracy on niche topics. Nonetheless, the system demonstrates the potential of domain-specific chatbots in environmental knowledge dissemination.

3.3 Preliminary Insights

With the developed system at hand we organized a workshop with forestry stakeholders to evaluate the chatbot and to define future developments. The discussions in the workshop showed that while the tool offers real potential, it must deal with uncertain knowledge, practical limitations, and different user needs. Below, we present the main findings in four categories: (1) What counts as good forest advice?, (2) Challenges in using the chatbot in the real world, and (3) Who the chatbot is really useful for (4) Design recommendations of the participants.

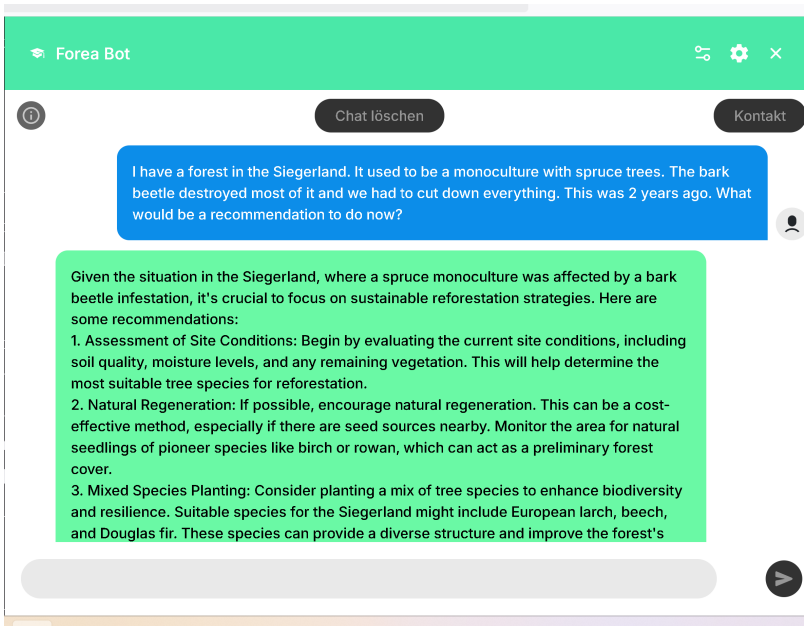


Fig. 1. Example question to the chatbot, for the purpose of this paper asked in English

3.3.1 What Counts as Good Forest Advice? Participants raised several questions about the reliability and clarity of the information provided by the chatbot, especially regarding tree species recommendations. While the chatbot uses official forestry data, some users felt this information doesn't always match local realities. For example, although species like sycamore maple are recommended in general guidelines, this specific tree does not grow well in the area in the long run, as the soil conditions are not optimal.

Some participants also pointed out that looking only at individual tree species is not enough. Forest ecosystems are complex. One example was the coastal fir, which is considered climate-adapted but causes problems because its needles repel water and slow down soil absorption.

"You have to look at the ecosystem, not only the specific tree specie"– (Workshop participant Group 1)

These discussions show that forestry knowledge is not always clear-cut or agreed upon. The chatbot should help users understand that different opinions exist, and not just present a single "correct" answer.

3.3.2 Challenges in Using the Chatbot in the Real World. It was unclear how users would discover or access the chatbot. A dedicated and clearly identifiable hosting platform is needed. However, the choice of host raises important questions about credibility and responsibility. For example, if a government agency were to host the chatbot, it could face reputational or legal risks if the chatbot provides incorrect or hallucinated advice. At the same time, it is essential that the chatbot be associated with a trusted and authoritative institution to ensure user confidence.

One potential solution could be to host the chatbot through a non-governmental organization (NGO). However, the NGO would need to be well-known and respected, so that users can easily find and trust the chatbot. Another option could be an umbrella organization for forest owners, such as the Waldbauernverband (Association of Forest Farmers)

or the umbrella organization for forest cooperatives. These actors combine a degree of trustworthiness and sectoral relevance while avoiding some of the legal burdens faced by state institutions.

Additionally, participants suggested creating location-based access to the chatbot—for example, by placing QR code signs in damaged forest areas that visitors could scan to learn more about the site and its context. However, this idea also raised concerns. Participants noted that installing such signs would increase the workload for forest owners, as it obliges them to keep the area around the sign safe to avoid liability for accidents. This means they must take measures such as cutting overhanging branches and ensuring that nearby trees are not at risk of falling. This highlights that even seemingly simple digital tools, like a chatbot or a QR code, are embedded in a broader socio-legal and spatial system involving land ownership, public safety obligations, and infrastructure. As a result, implementing new technologies in forest settings is often more complex than it initially appears.

3.3.3 Intended Users and Practical Use Cases. There was wide agreement that the chatbot could be helpful—but only for certain groups. People involved in forest cooperatives often already have strong connections to local foresters and do not need extra tools. These groups tend to be well-informed and share knowledge internally. However, individual forest owners, especially those without close ties to forestry services, could benefit more from quick and accessible advice. Some participants said that urban forest owners—who live far away from their land—might be especially likely to use such a tool.

At the same time, concerns were raised about digital exclusion. Older forest owners or people who are less comfortable with technology might find it difficult to use a chatbot. This creates a risk that the tool will only serve certain demographics unless accessibility is carefully considered.

One appreciated feature of the chatbot was that it names its sources at the end of each response. Participants saw this as a trust-building element that helps users judge the reliability of the information. “It’s positive that the sources are named.” – (Workshop participant Group 2)

4 Discussion

Chatbot systems deployed in contested domains like forest management must navigate complex dynamics of perspectives. This chapter addresses how trust is shaped by context and explores design strategies.

4.1 Trust in Chatbots Across Perspectives

Trust is a contextual factor that strongly depends on the involved target group [7]. Different social groups and professional communities do not necessarily trust each other due to differing interests and perspectives [13]. In the domain of forest management, environmental organizations often prioritize the ecological wellbeing of forest ecosystems, advocating for slow-growing, native tree species that support biodiversity and maintain ecological balance. In contrast, forest owners may favor fast-growing species as they prioritize the timber production, sometimes at the expense of broader ecological considerations. While both groups typically aim to promote healthy forests and often find common ground and collaborate, their differing priorities can occasionally lead to tensions. These diverging goals can lead to conflicts and distrust, as each group evaluates the forest through a distinct lens shaped by their respective values and objectives.

A similar complexity emerges when considering the hosting of a chatbot designed to assist with forestry-related inquiries. The entity responsible for hosting such a tool significantly influences the trust users place in it [10, 12]. Ideally, the host should be seen as a neutral and trustworthy authority. However, trust can be jeopardized when the

chatbot's knowledge is limited. For example if users ask questions outside the scope of the retrievable knowledge base (e.g., applying German forestry guidelines to forests in other countries). This issues might mean that local authorities hesitate to host the chatbot on their webpage due to concerns over potential misinformation and a lack of control over its outputs, even when prompts are carefully constrained.

An environmental NGO could serve as an intermediary host, particularly if its mission aligns with promoting awareness and critical engagement with such tools. By openly acknowledging the limitations of the chatbot and transparently communicating its scope and sources (such as official guidelines), the NGO could foster informed use. Nonetheless, even in this role, the NGO itself must be a widely trusted actor, as the perceived credibility of the chatbot will be influenced not only by its data sources but also by the perceived neutrality and authority of the host organization.

4.2 Representing Different Schools of Thought Through Multi-Agent Interaction

In regard to the forest, conflicting schools of thought coexist. Some view the forest as a resource for timber production, while others regard it as a home to biodiversity that provides habitat for a wide range of plant and animal species [9, 29]. A forester and a biologist may view and engage with the forest quite differently, shaped by their education and training, disciplinary paradigms, and roles. While such positional differences are often intuitive and apparent in human to human interaction, they might be less obvious within chatbot systems.

These positions represent value-laden perspectives that are not easily resolved within a single, "quasi-neutral" chatbot system. One way to address this tension is to combine knowledge from different schools of thought within a single chatbot system. This approach ensures that multiple viewpoints are represented in one place. For example, multiple agents could be developed, each based on a different database or value framework. These agents could be designed to represent different policies, ideologies, or leadership traditions. In such a system, the agents could engage in dialogue with each other, making their differences and underlying guidelines transparent to the user. The user would take on the role of an observer - listening to the discussion, asking clarifying questions, and exploring follow-up inquiries. This design could help users better understand the range of positions and reflect on their own position in a more informed way. We see potential in such a multi-agent interaction design not only for forestry-related applications, but also for other areas of HCI. Unlike traditional chatbot systems, which typically follow a one-to-one interaction model, multi-agent systems offer space for more complex, dialogic exploration. This could be relevant for applications involving political or philosophical discourse, cultural education, or social science teaching, where contrasting perspectives need to be made explicit and tangible for reflection and learning.

Another, more modular approach could be to develop two separate chatbot systems, each powered by its own Retrieval-Augmented Generation (RAG) database and guided by distinct prompts. For instance, a chatbot named FORESTBOT could represent forestry expertise, while BIOBOT could embody biological or ecological perspectives. In this setup, a user asks a question and receives two responses—one from each chatbot. Each agent would have the ability to read the other's answer and optionally respond, allowing for limited cross-agent engagement. This dual-agent setup might have several potential advantages. It could help reduce hallucinations, as conflicting information lead to an increase in hallucinations in chatbots [9, 19]. Moreover, it would clarify the epistemic roles of each agent, making it explicit to users which knowledge base or disciplinary framework is being drawn upon. However, this design also introduces technical challenges. For instance, it requires safeguards to prevent runaway dialogue loops, where agents endlessly respond to each other. Effective turn-taking protocols or interaction caps would be essential to avoid such outcomes.

4.3 Limitations

This study has four main limitations. First, the qualitative design makes the findings exploratory, and it is unclear whether a more representative sample would yield similar results. Second, social dynamics may have influenced participants to withhold critical feedback (see [2, 22]). Third, a halo effect may have biased evaluations due to the chatbot's nature-themed personality (see [18]). Fourth, longer-term studies are needed to understand how the chatbot is used over time in real-world contexts.

5 Conclusion

With the development of a RAG-based LLM chatbot, we aim to reduce informational complexity for forest stakeholders. This complexity arises not only from the accelerating impacts of climate change but also from a shifting paradigm in cultivated forestry, where ecosystem services such as carbon sequestration, water retention, and microclimate regulation are gaining importance [17, 20, 26] demanding a broader range of expertise and often bringing together conflicting perspectives and forms of knowledge . While government agencies respond to this by issuing forest management guidelines, these documents often fall short in terms of usability and accessibility. A retrieval-augmented chatbot can help bridge this gap by making such information more approachable and easier to navigate for a wider group of users.

At the same time, it is important to acknowledge the limitations of such systems. Chatbots are not a substitute for human expertise: they lack the intuitiveness of real-time conversation, may leave users uncertain about what kinds of questions they can ask, and are confined to the knowledge they have been provided (Yet, human-to-human conversations are not always ideal either). Nonetheless, when transparently designed and thoughtfully integrated, chatbots can serve as a valuable complement to traditional forms of knowledge exchange in forestry.

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