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Rural experiences and resilience: the role of local and indigenous knowledge in flood management

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ABSTRACT

Floods are among the most significant natural hazards and are expected to affect both urban and rural areas increasingly under climate change. Engineering-based solutions alone have proven insufficient for addressing flood risks associated with extreme weather events. This study investigates how indigenous knowledge can be integrated with scientific approaches to improve understanding of flood-generating factors and support more inclusive flood management. Focusing on the Düzce Melen Basin in northwestern Türkiye, the research incorporates the experiential knowledge of village heads from flood-prone rural communities. Data were collected through descriptive semi-structured interviews with 30 village heads and analyzed using thematic analysis. The findings identify eight main themes related to flood causes: climate and meteorology, hydrology and topography, socio-economic and behavioural factors, institutional practices and administrative structures, natural cycles and indigenous knowledge, forest and land use, settlement and construction, and infrastructure and river improvement. The study also examines local and academic experts' perceptions of the role of indigenous knowledge in flood management. Results indicate that local knowledge can complement scientific data, particularly in data-scarce rural areas, improving flood susceptibility assessment and supporting more context-specific risk reduction strategies. The study proposes a framework for integrating community-based knowledge into flood susceptibility analysis.

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KEYWORDS
Local/indigenous knowledge; flood; local community leaders; Melen Basin

1. Introduction

When considering the number of occurrences of different types of disasters worldwide, floods are by far the most prevalent type of disaster. In terms of mortality rate, they rank third after earthquakes and storms. In terms of the number of people affected, they rank first, and in terms of economic losses, they rank second after storms ((CRED) 2025). Indeed, it is predicted that with climate change, there will be an increase in the number of meteorological disasters, particularly floods (IPCC 2023). These data necessitate the adoption of measures that will increase people's resilience to floods, as well as structural measures for flood management.

People take their personal observations into account when adapting to their physical environment and forming perceptions about natural hazards (Kienberger 2012). There is strong consensus in the literature that flood experience is a decisive factor in increasing community participation in flood management (Puzyreva and de Vries 2021). When the necessary datasets for flood management are unavailable, information obtained from local communities and human observations of the environment can be a valuable resource for understanding how people perceive their surroundings and respond to flood events (Brandt *et al.* 2020). Flood risk analysis should not be limited to metric (statistical) data, but should also include people's social and cultural interpretations of flood hazards (Lechowska 2018). Therefore, consulting with the local community, gaining public acceptance for flood management and subsequent plans, and making people more aware of flood risk and related issues and regulations is of vital importance (Hadian *et al.* 2022, Tiepolo *et al.* 2023).

Marginalised individuals, including those who are illiterate and may have a limited understanding of scientific concepts, can discuss disaster risk reduction with scientists who have a weak understanding of the local context (Fischer 2000, Cadag and Gaillard 2012).

It is of great importance that indigenous peoples and their knowledge are recognised as valuable allies in the fight against climate change and sustainable development issues (Magni 2017, Hong and Chang 2020). Local knowledge can be an important resource for identifying hazards and strengthening resilience, even if communities have very little experience with a particular type of hazard (Matti and Ögmundardóttir 2021). Incorporating local knowledge into risk management offers an approach that supports communities in adapting to environmental changes and developing their local skills and knowledge during

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this process (Reichel and Frömming 2014). Local knowledge research aims to ensure that development resources reach disadvantaged groups more effectively. In this process, the integration of local knowledge with scientific knowledge and the strengthening of communication between scientists and local communities are crucial; linking local knowledge with scientific research can contribute to the development of new research and applications (Shaw 2012).

The integration of local knowledge into the mapping process has been shown to provide important factual data and insights about the social and physical environment, while also identifying communities' vulnerabilities to disasters and developing disaster management strategies. These contributions can be incorporated into other, typically science-based activities and methodologies associated with contemporary disaster risk management programmes and policies (Tran *et al.* 2009). Indeed, following the Hyogo Framework for Action, adopted by the United Nations Office for Disaster Risk Reduction, the Sendai Framework for Disaster Risk Reduction was adopted to provide guidance on disaster risk management. The Sendai Framework emphasises the empowerment of local authorities and communities through inclusive and non-discriminatory participation. Furthermore, by encouraging the use of traditional, indigenous and local knowledge and practices alongside scientific knowledge in disaster risk assessment and management, it aims to ensure that policies and strategies are better suited to the local context (UNISDR 2015).

Our approach to assessing and integrating both expert and non-expert spatial knowledge in flood risk assessment can encourage greater collaboration between residents, public officials and emergency response teams, and promote a broader two-way communication process between experts and non-experts in flood risk planning and communication (Cheung *et al.* 2016).

Although the importance of local knowledge in disaster risk management is recognised, its integration into official flood risk assessment processes remains limited. The predominance of quantitative and engineering-based approaches, coupled with the absence of a robust legal framework mandating public participation, results in local knowledge not being utilised sufficiently in decision-making processes. This situation undermines the effectiveness of risk management strategies, particularly at the local level.

This study contributes to the literature by demonstrating that local knowledge obtained from village headmen can be systematically integrated into flood susceptibility analysis. In doing so, it proposes a structured framework for combining community-based knowledge with factor-based flood modelling.

The research questions in this context focus on the following points: (i) Can village heads' scientific and local knowledge regarding flood disasters be utilised in pre-disaster preparations? (ii) In what respects do village heads' perceptions of flooding align with or diverge from scientific flood risk indicators (precipitation, topography, drainage, etc.)? (iii) What evidence is there regarding local knowledge within the catchment area?

To address the research questions, a qualitative approach was adopted and semi-structured interviews were conducted with village headmen in the study area. The data were analyzed using thematic analysis and the headmen's flood perceptions were compared with scientific flood risk indicators such as rainfall, topography, and drainage.

1.1. Local/ indigenous knowledge and community-based disaster risk reduction

Various terms are used in the literature to refer to LK; these include (but are not limited to) 'indigenous knowledge', 'indigenous technical knowledge' 'local knowledge', 'traditional ecological knowledge', 'rural community knowledge' and 'citizen science'(Berkes 1993, Dennis M Warren *et al.* 1995, Robertson and McGee 2003, Davis 2006, Silvertown 2009, Campos *et al.* 2012, Kelman *et al.* 2012, Nakashima *et al.* 2012, Naess 2013, Goldman and Lovell 2016, Kom *et al.* 2023).

Indigenous knowledge consists of methods and practices developed through the long-term, intergenerational experiences of a community in a particular place, grounded in a deep understanding of the local environment. Emerging within the community, this knowledge is transmitted through informal means, collectively owned, continuously adapted and refined over time, and plays a vital role in sustaining livelihoods and ensuring the well-being of the community (D Michael Warren 1991, Change 2001, Barker 2017, Berkes 2017, Mwalwimba *et al.* 2024, Longkumer and Kannan 2026).

According to Shaw *et al.* (2009), the integration of local and indigenous knowledge into disaster risk reduction policies is based on four main rationales. First, indigenous knowledge can be transferred across different communities and adapted to similar conditions. Second, incorporating this knowledge into the process enhances community participation in disaster risk reduction efforts and empowers local actors. Third, it provides deep and context-specific insights that make significant contributions to decision-making processes. Finally, the informal modes of transmission of indigenous knowledge have the potential to serve as an effective model for disaster risk reduction education (Shaw *et al.* 2009). Despite the increasing frequency of documenting local and indigenous knowledge and practices in the context of climate change and disasters, insufficient effort has still

been made to translate this knowledge into concrete actions that enhance community resilience and adaptive capacity (Hiwasaki *et al.* 2014).

Community-Based Disaster Risk Management (CBDRM), one of the approaches that has gained prominence in the disaster risk management literature in recent years, emphasises the active participation of local communities and the central role of local actors in the identification, assessment and reduction of disaster risks. This approach argues that disaster risk management should not be limited solely to technical and institutional processes, but must also be integrated with local knowledge, community experiences and local governance structures (Shaw 2012).

The CBDRM framework also emphasises key principles in disaster risk management, such as bottom-up governance (Pandey and Okazaki 2005), the use of local knowledge systems, and participatory decision-making processes. From this perspective, disaster risks can be understood not only through scientific models and technical analyses, but also through local communities' environmental observations, experiences and everyday practices. The joint assessment of local and scientific knowledge ensures that disaster risk reduction strategies are both more inclusive and better suited to the local context (Kelman *et al.* 2009, Gaillard and Mercer 2013, Lee *et al.* 2022).

Documenting indigenous knowledge is inherently challenging, as it is typically transmitted from one generation to another without a formal or traceable recording mechanism. Therefore, such studies can play a crucial role in systematically documenting this knowledge, facilitating knowledge exchange among different communities, and significantly enriching the existing body of literature in this field (Islam *et al.* 2018).

In this study, both local knowledge and indigenous knowledge are employed. Local knowledge is addressed as a broader concept that encompasses community-based understandings and practices, whereas indigenous knowledge is considered a more specific, place-based form of knowledge deeply rooted in particular cultural and geographical contexts. Therefore, local knowledge offers a broader perspective that includes local viewpoints.

1.2. The role of local community leaders (village headmans) in community-based disaster risk management

Top-down policies have largely failed to prevent disasters from occurring (Maskrey 1989). Disaster risk reduction is a multi-scale, multi-stakeholder process that requires the participation of various actors at local, national and international levels (Gaillard and Mercer 2013). When identifying hazards, discussing mitigation options, communicating risk, establishing priorities for recovery in the event of a disaster, and implementing strategies to increase resilience through planning laws, building regulations and land use decisions, there is a constant need for coalitions from local to regional scales to build resilience for collaborative problem-solving by involving the entire fabric of society (Cutter *et al.* 2013).

The integration of local knowledge into disaster management encourages the active participation of local communities in the process, while also enabling a more accurate and comprehensive assessment of disaster risks. Local knowledge, which is a particularly important resource for communities living in rural areas, is informed by these communities' past experiences, environmental observations and cultural heritage. Incorporating this knowledge into decision-making processes helps policymakers better understand disaster sensitivities and local dynamics. As a result, the disaster management plans developed become both more inclusive and better suited to local conditions (Tran *et al.* 2009, Cruz-Bello and Alfie-Cohen 2022). Engaging with the local community is of critical importance in ensuring that flood management and future planning are embraced by society and in raising individuals' awareness of flood risk issues and the legal framework (Hadian *et al.* 2022).

At the local level, village headmen play a critical role in ensuring the effectiveness of disaster management and developing participatory, functional policies. They represent the community socially, economically and politically, have the ability to communicate directly with local residents, possess knowledge about risks and security vulnerabilities in the region, and facilitate public access to resources (Turan and Oral 2023).

Community leaders, in particular, are regarded as critical actors who act as a bridge between local residents and official institutions. In this context, muhtars – the lowest administrative unit within Turkey's local government system – possess significant potential in disaster risk management processes, acting both as community representatives and as intermediaries facilitating communication with public institutions. The CBDRM approach emphasises that such local leaders can play a key role in understanding disaster risk, developing community-based measures, and implementing risk reduction activities at the local level.

2. Materials and methods

2.1. Study area

Düzce is located in the north-western region of Turkey. Situated in a closed plain surrounded by mountains, the settlement is of critical importance as it is the drinking water basin for Istanbul, Turkey's

metropolitan city. Thirty-eight per cent of Istanbul's drinking water supply comes from the Melen Basin in this province (Municipality 2023). For this reason, flood disasters in this basin are also of greater importance. The province has an area of 2,492 km^2, a population of 405,131, and consists of 8 districts (Figure 1).

The establishment of Düzce as a province resulted from the 7.4 Mw earthquake centred in Gölcük on 17 August 1999 and the 7.2 Mw earthquake centred in the Kaynaşlı district of Düzce. Its main rivers are Küçük Melen, Asar Suyu, Uğur Suyu, Aksu Deresi, and Büyük Melen. Due to its role in supplying drinking water to Istanbul, it is subject to special protection regulations and various restrictions on construction and land use. Its topography and the convergence of rivers in the plain have led to numerous flood disasters throughout history. Looking at the climate data measured between 1959 and 2024 for the province of Düzce, where a large part of the basin is located, the average number of rainy days is highest in December with 15.32, the number of rainy days is highest in August with 5.91, and the annual number of sunny days is 133.6. the highest average total rainfall is 100.7 mm in December, the lowest is 47.2 mm in July, and the annual rainfall is 838 mm. The highest rainfall measured between 1959 and 2024 was 118 mm on 14 July 1965 (Meteorology 2024), resulting in major flooding in the main rivers and streams of the Melen Basin, such as the Great Melen, Little Melen, Uğursuyu, Asarsuyu, Karasu, and Aksu. Nine of the 21 flood disasters that occurred in history took place in July (forestry 2019).

When examining the distribution of floods in the study area by month, it is seen that 23 of the 28 flood events studied occurred between April and August, accounting for 82% of the total disasters. Based on this, it can be said that flood hazards occur more frequently as a result of sudden rainfall during the summer months (Figure 2).

Data on damage assessment studies conducted for structures during floods that occurred in the study area in 2019, 2021, 2022, and 2023 are presented in Table 1. Damage conditions are classified as undamaged, slightly damaged, moderately damaged, severely damaged, and destroyed.

The research was carried out in 30 rural settlements with a combined population of 18,142 inhabitants. The population size of the surveyed villages varies between 102 and 2,721, with an average population of approximately 605. In accordance with ethical considerations, village names were not reported to protect participant confidentiality.

2.2. Data collection and analysis

The study is descriptive in nature and was conducted using semi-structured interviews, a qualitative research method, and describes data obtained through on-site observation. The study employed a phenomenological design, one of the qualitative research designs. Data were collected through semi-structured interviews conducted with village headmen who had directly experienced flood events. A total of 30 interviews were carried out using an interview form consisting of four open-ended questions adapted from a World Bank report (Bank 2021), five demographic questions, and three questions related to indigenous knowledge. The interviews were conducted via face-to-face and telephone communication, depending on participants' availability. The village headmen were informed about the purpose of the interview, the interview and analysis processes, and their verbal consent was obtained. Interview questions focused on participants' demographic characteristics, flood experiences, flood management practices, and perceived causes of flooding. Although a semi-structured format was followed, participants often elaborated on their personal flood experiences. In such cases, additional probing questions were asked to clarify or further explore emerging issues. Interviews lasted an average of 15 min, with the longest interview exceeding one hour. Audio recordings were obtained with participants' consent, and all recorded interviews were transcribed verbatim.

In qualitative research, sample size determination is context-dependent and shaped by the scientific paradigm guiding the study. In qualitative research, the concept of 'data saturation' (Tutar *et al.* 2024), defined as the absence of new information, is a useful concept when discussing sample size (Boddy 2016). Practical research indicates that samples of 12 individuals may represent situations where data saturation occurs in a relatively homogeneous population (Boddy 2016), with an average of 30 individuals being recommended (Baker and Edwards 2012). In this study, interviews were conducted with 30 village heads, but after 20 interviews, it was observed that no new codes or themes emerged. Although data saturation was reached with 20 individuals, the interviews continued up to 30 people. This sample corresponds to 7.63% of the total number of villages in the study area ($N = 393$). To ensure the anonymity of participants, the names of the village heads have been replaced with codes P1, P2 … P30.

All interview transcripts were reviewed repeatedly by the researchers and analyzed using an inductive thematic analysis approach based on the framework proposed by Braun and Clarke (2006). In the first stage, researchers familiarised themselves with the data. Subsequently, meaningful words, phrases, and statements were manually coded without the use of qualitative data analysis software. Coding was carried out independently by two researchers, and the

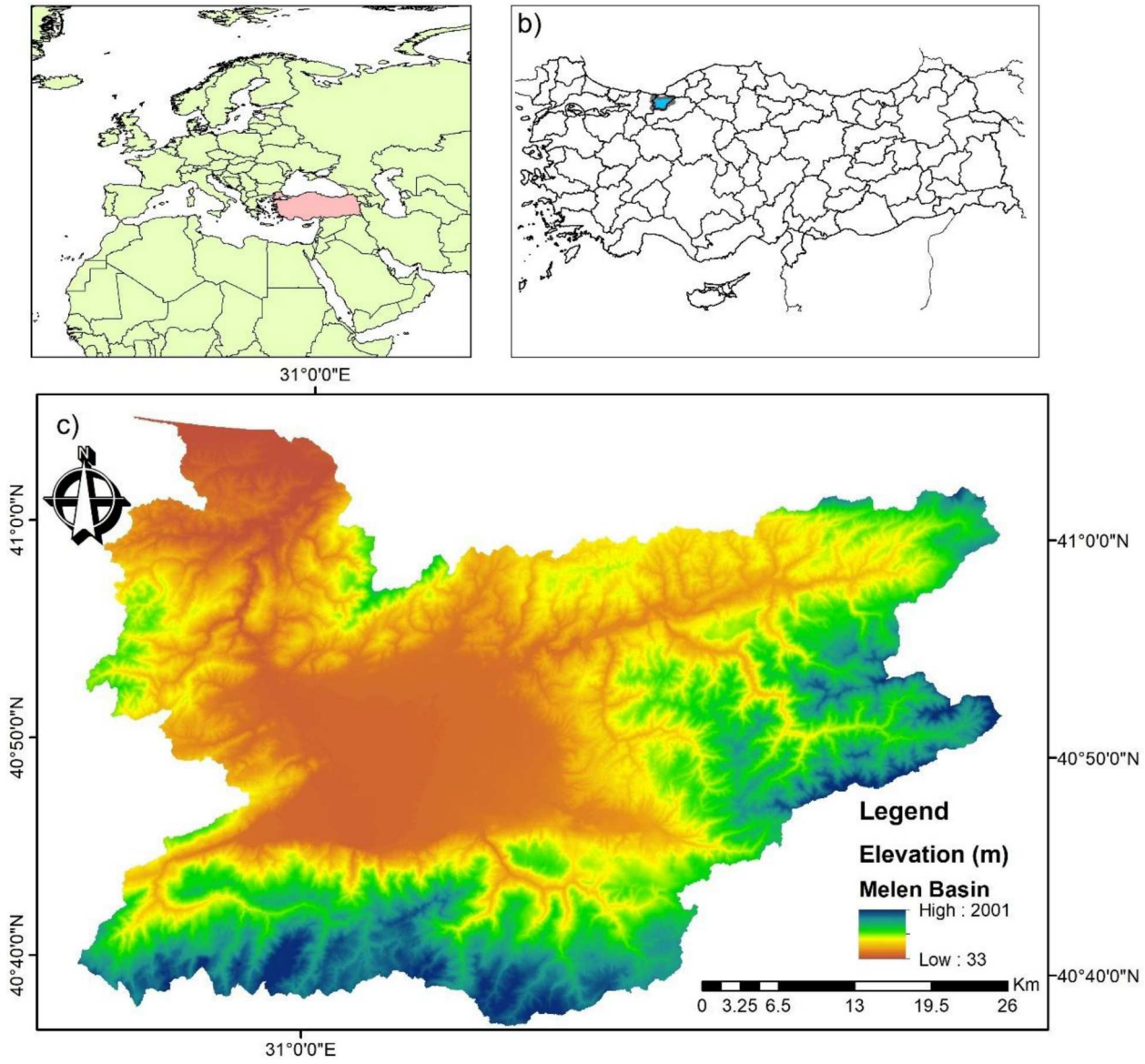

Figure 1. Study area, (a) Location of Turkey on the world map, (b) Location of the Melen Basin in Turkey, (c) Melen Basin.

resulting codes were compared and refined through discussion. During this process, redundant codes were removed and similar codes were merged.

The finalised codes were grouped according to their relationships with flood susceptibility factors and criteria. Through this inductive procedure, flood susceptibility factors and criteria were derived directly from the interview data. Selected direct quotations from participants were included in the findings section to support and illustrate the qualitative results. All Turkish expressions used during coding and analysis were carefully translated into English by the researchers to preserve semantic and contextual accuracy.

In addition to the interviews, a questionnaire was administered to 17 academic experts and 13 local experts to collect their views on indigenous knowledge, enabling a complementary assessment of expert perspectives (Table 2).

2.3. Participant characteristics and inclusion/exclusion criteria

Participants were selected through purposive sampling, with inclusion criteria defined as having experienced flooding, being an active village headman, and being able to participate in the research. Some participants had experienced flooding, while others had not. This also enabled the identification of factors and criteria determining where flooding had not occurred. Within this scope, the mayors of settlements affected by the flood disasters that occurred in the Melen Basin in 2019, 2021, 2022, and 2023 were invited to participate in the study. The vast majority of the village headmen, who were interviewed either by telephone or in person at their settlements, agreed to participate in the study. It was not possible to interview some village headmen who were unavailable at the time of the telephone interview. However,

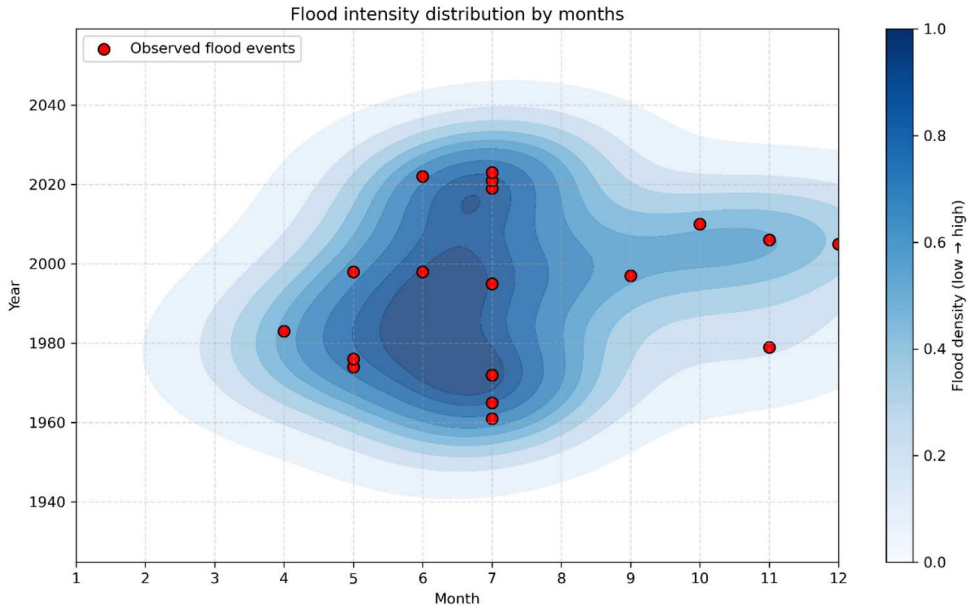

Figure 2. Flood intensity distribution by months.

interviews continued until the total number of interviews reached 30.

Inclusion criteria: Currently serving as a village head in the research area; having experienced or witnessed at least one flood event during their term of office; agreeing to share their local observations and experiences regarding flood disasters; and providing voluntary participation and informed consent.

Exclusion criteria: Village heads whose term of office is very short (e.g. newly elected) and who lack sufficient experience of flood events; participants who cannot provide knowledge and experience directly relevant to the research topic; and individuals who refuse to complete the interview or do not consent to the use of their data.

Academic experts were selected from among those with studies related to the topic of floods. In this context, preference was given to those with articles published in journals indexed in the Web of Science database, particularly in SCI, SSCI and AHCI. A total of 60 academics were identified, although only some of them agreed to participate in the study. Local experts were selected from among those who played an active role in the preparation and implementation of the Düzce Provincial Risk Reduction Plan. The selected local and academic experts were: civil engineers, geological engineers, urban planners, architects/landscape architects, cartographic engineers, meteorological engineers, physical geography and forest engineers.

Although there are female village heads in a few neighbourhoods within the urban areas of the Melen basin, there are no female village heads in the rural areas due to their traditional, social and cultural structure. Consequently, none of the village heads interviewed were women. Some information about the village mayors who participated in the study is provided in Table 3, and information about the experts is provided in Table 4.

2.4. Ethical considerations

All procedures involving human participants in this study were conducted in accordance with national

Table 1. Flood hazards and building damage status, showing the number of buildings in each damage category.

	Building damage status and numbers				
Flood year	Undamaged (a structure that has not suffered any damage due to a natural disaster)	Minor damage (fine plaster cracks), plaster spalling, fine cracks up to 1–4 mm wide on walls, cracks up to 10 mm wide and partial spalling on infill and curtain walls	Moderately damaged (significant cracks 5–10 mm wide in load-bearing walls, partial collapse and separation in partition, infill, and curtain walls)	Severe damage (cracks wider than 10 mm in load-bearing walls, separation and crushing at building corners, conical collapses, separation of the building from the vertical, partial or complete collapse of partition, infill, and curtain walls)	Collapsed (partial or complete collapse of the building's structural system, partial or complete collapse of the roof)
2019	112	438	3	213	
2021	46	82	0	3	1
2022	38	143	0	9	6
2023	103	102	0	6	7
Total	299	765	3	231	14

Table 2. Interview question guide for local and indigenous knowledge.

No	Questions
1	What are the main causes of the flooding incidents in your village?
2	What are your thoughts on the characteristics of areas that have experienced flooding and those that have not?
3	Are there any traditional signs or observations of nature in your region that can help predict floods in advance? If so, could you tell us about them?
4	During which periods or under what weather conditions do floods occur more frequently in your region? Could you explain?

ethical guidelines. Interviews were conducted with the informed consent of participants and were entirely voluntary. Participants were informed that they had the right to withdraw from the study at any stage of the research process. Interviews were conducted at times and locations preferred by the participants. Furthermore, at the beginning of the interviews, detailed information regarding the aims of the research, data confidentiality, and ethical guidelines was provided to the participants. In this context, ethical approval has been obtained from the Ethics Committee for Research in the Social and Human Sciences at Yıldız Technical University (Decision No. 2025.03 dated 3 March 2025).

Table 3. Basic information about participating village headman.

Category	Subgroup	No. of Participants
Gender	Female	–
	Male	30
Age	18–24	–
	25–34	2
	35–49	7
	50–70	20
	71 and above	1
Level of education	Primary school	9
	Secondary school	8
	High school	11
	University	2
	Master's degree	–
	Doctorate	–
	Other	–
The elevation of the settlement	0–100	4
	100–200	13
	200–300	6
	300–400	3
	400–500	1
	500 and above	3
Length of stay in the settlement	1–10	–
	11–20	–
	21–30	–
	31–40	2
	41 and above	28
The period during which he served as village headman	1–5	6
	6–10	8
	11–15	8
	16–20	4
	21 and above	4
Flood damage	I was directly affected	22
	I was indirectly affected	7
	Neither	1

2.5. Trustworthiness and rigour

In this study, the reliability and scientific rigour of the qualitative research were ensured in accordance with the criteria of credibility, consistency, verifiability and transferability proposed by Guba and Lincoln (Guba and Lincoln 1994).

All interviews were conducted personally by the corresponding author. The researcher's role within the Ministry of Environment, Urbanisation and Climate Change, and their involvement in fieldwork at an institutional level following flood disasters, contributed to a deeper and more contextual understanding of the research context and participants' narratives. Furthermore, the principles of qualitative research rigour were observed throughout the data collection and analysis processes to mitigate potential risks of bias. The interviews were conducted within a semi-structured framework, with fidelity to the data as the guiding principle, and the findings were supported by direct quotations.

Credibility was ensured by achieving data saturation in the interviews with village heads. It was observed that no new codes or themes emerged after the twentieth interview; to enhance the robustness of the findings, the interviews were completed with 30 heads.

Table 4. Basic information on participating academic and local experts.

		No. of Participants	
Category	Subgroup	Academic	Local expert
Gender	Female	6	3
	Male	11	7
Age	18–24	–	–
	25–34	–	–
	35–49	11	9
	50–70	6	1
	71 and above	–	–
Level of education	Primary school	–	–
	Secondary school	–	–
	High school	–	–
	University		10
	Master's degree		–
	Doctorate	17	–
	Other		–
Expertise	Civil engineer	4	3
	Geologist	2	1
	Urban planner	2	3
	Architect/landscape architect	2	–
	Cartographer	1	3
	Meteorologist	1	–
	Forester	3	–
	Physical geographer	2	–
Length of service in the profession	1–5	–	–
	6–10	2	1
	11–15	3	4
	16–20	2	2
	21 and above	8	3
Flood damage	I was directly affected	1	–
	I was indirectly affected	7	5
	Neither	9	5

Consistency and verifiability were strengthened through the systematic conduct of the data collection and analysis process, the application of inductive coding, and the grounding of interpretations in recurring patterns observed throughout the interviews. The analysis process was documented, and the findings were supported by direct participant quotations.

Generalizability is supported by a detailed description of the research context, participant characteristics and the data collection process. The village heads' positions within the local administration and their experiences based on local knowledge enable the findings to be evaluated in similar socio-environmental contexts.

3. Result

3.1. General perceptions of indigenous knowledge

The perceptions of three different stakeholder groups (village heads, academics, local experts) regarding the current status, necessity and effectiveness of 'local knowledge' in the context of flood planning and management are presented comparatively in Table 5.

In all three groups, a large majority (ranging from 70% to 92%) stated that the public's opinion was not taken into account in flood management. This indicates a serious deficiency in the integration of local knowledge into official processes. Again, in all three groups, there is near unanimity (92-97%) that local knowledge should be sought or could be effective. This shows that all parties recognise the importance of local participation and support it as a normative principle.

3.2. Local and indigenous knowledge-based themes and related factors

Eight themes were identified from the interviews conducted as part of the research, along with the factors used in the flood sensitivity mapping related to these themes. Sensitivity is an internal fragility parameter that determines the severity of the damaging effect of the hazard on the system. Below are assessments supported by interview records related to these themes (Table 6).

3.2.1. Climate and meteorology

In the interviews, the frequency and severity of flood events were largely attributed to climatic variables. Most participants emphasised that sudden and intense rainfall following prolonged droughts led to flooding. One village head described the situation as follows:

> P7; '… The soil doesn't absorb water during drought, but if it softens the soil little by little, that's fine, but if it rains hard, it doesn't absorb and there's a flood …'

Such narratives show that the community combines climate observations gained over generations with disaster experience. Furthermore, this situation is supported by the literatüre (Douinot *et al.* 2022). A large proportion of participants also have seasonal awareness:

> P10, P4; '… June–July are the most dangerous months …'

These statements show that the local population has developed an intuitive knowledge system based on climatic cycles and created local risk calendars.

Factor relationship: This theme is related to the criteria of rainfall amount, rainfall intensity and seasonality.

3.2.2. Hydrology and topography

Most of the village heads emphasised that the terrain and drainage network play a decisive role in the formation of floods. One participant described the location of the village as follows:

> P20; '… My village is triangular in shape, rain fills it up in 1–2 h … the riverbed is narrow, so it couldn't cope …'

> P14; '… If the terrain is steep, water flows slowly. Because the terrain is steep, it immediately flows into the riverbed, causing flooding …'

Similarly, observations regarding the riverbed morphology are noteworthy:

> P6; '… The water at the end of our Mudurnu side flows directly into that basin, thankfully this valley is short, about 15–20 km as the crow flies. If this distance were about 25 km, there would be more flooding here …'

These statements show that the natural waterways have narrowed for both topographical and engineering reasons. Some village heads also mentioned the effect of slope:

> P8; '… The water coming down from the mountain rushes into the village; there is nowhere for it to stop …'

Factor relationship: Slope corresponds with the criteria of drainage intensity, river morphology, and floodplain width.

3.2.3. Forest and land use

Almost all participants emphasised that the reduction in forest cover and changes in land use increase the risk of flooding. Awareness of the water retention capacity of forests is quite high:

> P10; '… because the forests have been cut down excessively, they don't retain water, my friend. They don't retain water. One beech tree retains 2.5 tonnes of water, but because there are no trees, the water cannot be retained …'

Table 5. The perceptions of village headmen and experts regarding indigenous knowledge.

	Village headmen		Experts			
			Academi		Local expert	
Questions	Yes (%)	No (%)	Yes (%)	No (%)	Yes(%)	No (%)
Is the public's opinion (indigenous knowledge) being taken into account in flood planning and management?	30 (9)	70 (21)	18 (3)	82 (14)	8 (1)	92 (9)
Should the public's opinion (indigenous knowledge) be taken into account in flood planning and management?	97 (29)	3 (1)	94 (16)	6 (1)	92 (9)	8 (1)
Do you think that information about floods obtained from the local community (indigenous knowledge) can be effective in flood planning and management?	97 (29)	3 (1)	94 (16)	6 (1)	92 (9)	8 (1)

P12; ' … When I look around outside my area, there are no forests anywhere. There used to be forests, so when there was a flood, when it rained, our elders said that in winter, a forest tree absorbs this much water. Now, thankfully, some of our citizens have not left any forests around us to absorb water. They planted hazelnut trees. There are no forests in this area outside my village … '

P6; ' … We no longer have the forests we had 50 years ago. There are also major problems with water. They say that a beech tree stores 50 tonnes of water per year and releases it into the soil. There are no beech trees left; every year, 40–50 thousand cubic metres of beech are cut down; they have destroyed the forest. The forest has become like a barren wasteland. The forest is gone, the big trees are gone. They are still cutting them down … '

P22; ' … They cut down the forests, destroyed the forests, turned everything into hazelnut orchards, but hazelnuts have shallow roots and don't retain water … '

Table 6. Main theme and factor relationship.

Main Theme	Factor relationship
1. Climate and Meteorology	1.1. Rainfall amount
	1.2. Rainfall intensity
	1.3. Seasonality
2. Hydrology and Topography	2.1. Slope
	2.2. Drainage intensity
	2.3. River morphology
	2.4. Floodplain width
3. Forest and Land Use	3.1. Land use
	3.2. Vegetation cover ratio
	3.3. Soil permeability
4. Settlement Area and Construction	4.1. Settlement density
	4.2. Type of development
	4.3. Proximity to the floodplain
5. Corporate Applications and Management Structure	5.1. Disaster management
	5.2. Institutional coordination
	5.3. Early warning
	5.4. Public participation
6. Infrastructure and River Rehabilitation	6.1. Infrastructure adequacy
	6.2. Culvert capacity
	6.3. Bridge clearance
	6.4. Stream improvement status
7. Socio-economics and Behaviour	7.1. Waste management
	7.2. Land use discipline
	7.3. Social awareness
	7.4. Behavioural risk
8. Natural Cycles and Indigenous Knowledge	8.1. Local knowledge systems
	8.2. Ecological intuition
	8.3. Traditional early warning indicators

Some participants also mentioned the link between the herbicide used to dry the grass under the trees in hazelnut orchards, to make harvesting easier, and flooding.

P3 and P21; ' … The herbicide used to dry the grass prevents the soil from retaining water … '

Some village heads also mentioned that the construction of new roads and hydroelectric power plants (HES) fragmented forest areas:

P12; ' … When they built the HES, they cut down the forest, roads were opened, and those roads changed the direction of the flood … '

Factor relationship: It is directly linked to the criteria of land use, vegetation cover ratio, and soil permeability

3.2.4. Settlement area and construction

The settlement pattern and location are considered one of the key factors determining the impact of floods. The majority of participants stated that villages were established in safer areas in the past:

P8; ' … Infrastructure for settlement areas also prevents flooding. There are no problems on the hills, but there is more flooding in the valleys. Concrete construction also causes a lot of flooding. When it rains on this ramp, the water rises 15 cm … '

P4; ' … Old settlements were always built on high ground … '

In contrast, most new settlement areas are located in regions close to riverbeds:

P29 and P5; ' … A house was built on the riverbed, and it was washed away in the flood … '

Some participants also emphasised that new dangers have emerged with the change in the direction of development:

P4; ' … When new houses are built at the foot of the mountain, there is a risk of landslides … '

Factor relationship: It is related to the criteria of settlement density, type of development, and proximity to the floodplain.

3.2.5. Corporate applications and management structure

Many participants emphasised the lack of coordination between institutions and inadequate communication with the public:

> P8; '… Also, when land registration was carried out, titles were issued for areas close to the river, and when the flood came, I couldn't intervene. A man built a house on the river; if necessary, the title should be revoked. It was a mistake made at the time; who will be expropriated? Land titles should not have been issued for areas close to riverbeds …'

> P22; '… if structural measures are fully implemented, there will be no flooding, but the work is being done on a day-to-day basis and is incomplete …'

> P4 and P5; '… Institutions are not informing the public …'

> P3; '… Roads were opened without awareness, and HES projects were implemented. Something that collects a lot of water on the road. The excavated material from the HES construction was dumped in the forest, and it all came down with the flood …'

> P24; '… road works in the forest …'

However, some village heads stated that they were aware of the existence of early warning systems:

> P4; '… AFAD and meteorology provide early information, but the public does not know what to do …'

This situation demonstrates that, despite the existence of information transfer in disaster management, there are weaknesses in its translation into action at the local level.

Factor relationship: Disaster management is related to the criteria of institutional coordination, early warning, and public participation

3.2.6. Infrastructure and river rehabilitation

At the local level, inadequate infrastructure is cited as the most common cause of flooding.

> P9; '… The bridge piers were blocked, the water dammed up …'

> P15; '… There were bridges over the stream that were not part of any project. When the trees accumulated on the bridges during heavy rainfall, flooding occurred …'

> P8; '… If the bridge hadn't been blocked, there wouldn't have been flooding here. If it is repaired, there won't be any problems. As far as I can tell, the floods are caused by excessive logging, which affects the floods. They cut down the forest to build roads. I had two culverts that have disappeared; logging has affected this …'

The above statements emphasise that the flow paths have narrowed due to engineering errors. Some participants stated that the cleaning and remediation work carried out by the State Hydraulic Works (DSİ) provided only a temporary solution:

> P15; '… The reason people lost their lives here was because there were sharp turns in the stream. The deaths occurred in this section …'

> P14; '… The trees formed a dam, the water accumulated and accumulated, and when it suddenly burst, there was flooding everywhere. If there were no trees, there would be no flooding here. There was flooding between 1951 and 1954, but the water didn't reach here because there were no bridges and no trees …'

> P9; '… The bridge piers blocked the water, creating a dam …'

> P10; '… There is no flooding here because the riverbeds are clean and wide. The winding sections are more dangerous. If speed-reducing weirs were built in a few places, it would prevent flooding …'

> P30; '… If the stream is rehabilitated, there won't be any flooding …'

> P29; '… We feel relieved when the State Hydraulic Works cleans it, but when there's too much rain, it overflows again …'

These accounts show that the flow paths narrowed due to engineering inadequacies, thereby increasing the impact of the flood.

Factor relationship: Infrastructure adequacy, culvert capacity, bridge clearance and stream improvement status criteria coincide.

3.2.7. Socio-economics and behaviour

The village headmen stated that citizens' behaviour also contributes to the formation of floods.

> P8; '… After the flood, I had the brushwood cleared from the fields. The man throws the weeds from his hazelnut orchard into the stream. There will be nothing to obstruct the water flow …'

> P20 and P5; '… Citizens are throwing brushwood into the streams …', P3; '… Hazelnut orchard waste is being thrown into the stream …' and P10; '… Aren't there any weed killers? These cause us the most harm. When these weeds dry out, they flow directly into the streams with the water. When it rains, the soil doesn't hold together because there are no weeds …'

> P3; '… It comes from the citizens. Citizens have hazelnut orchards in many places where there are streams. Seventy percent of hazelnut orchards use weed killer. When weed killer is applied, when it rains, it falls from the tree branches to the ground, directly contacts the soil and takes effect; there is nothing to slow down the water, it takes effect immediately. In many hazelnut orchards, where human labour was previously used, there used to be a footpath, but now there is a tractor path in every hazelnut orchard. When the water poured onto the hazelnuts flows directly onto the tractor path without

finding any weeds, the water starts to accelerate immediately … '

The above statements show that small human-induced actions pose a systematic risk. Some village heads have emphasised that continuing to live in risky areas is also a significant problem:

P20; '… They don't leave the areas they should leave, saying 'nothing will happen to us … '

These observations show that individual behaviour triggers systematic environmental risks.

P21; '… Our village is settled like this, we don't have many houses in the riverbed. So people have fled to the mountains, so to speak. They moved away from the river a bit because there were a lot of flies in the river at the time. But they actually did the right thing … '

P7; '… Long before that, our villagers had settled down by the lake, in the floodplain. They came there in the 64s, settled there, and then came to this side because of the floods there and the rising and falling of the lake, plus things like malaria … '

Factor relationship: It relates to waste management, land use discipline, social awareness, and behavioural risk criteria.

3.2.8. Natural cycles and indigenous knowledge

Participants explain natural events using their own cultural calendars and observations.

P12, P7 and P20; '… Solstices are usually troublesome … '

P20; '… Our elders used to say that long droughts are followed by long rains. Act early during the harvest months or the crop will be ruined. We have also seen crops rot in the fields due to rain … '

P14; '… After extreme heat, there is either rain, hail or an earthquake … '

The above statements show that the local people associate natural cycles with disaster risk.

Another participant shared traditional knowledge about animals and plants.

P28; '… when there are many frogs, we expect floods, or when there is excessive algae growth/greening in the water … '

This information represents a culture of early warning based on empirical observation, rather than scientific evidence. Another participant mentioned an observation they made regarding the movement of clouds.

P18; '… when the clouds moving over these villages on the Akçakoca road, which is also our calloused road, move, the elders say rain is coming. When they come from the Yeşiltepe Akçakoca sea to the west, it doesn't rain, but when black clouds come from the northeast, we expect heavy rainfall … '

It has been determined that various protective measures have been developed in settlements constantly exposed to flooding, and that the timing of the floods can also be predicted. A village headman's statements on this matter are as follows.

P25; '… Generally, houses are built slightly higher, at a sub-basement level. Also, because these areas are constantly flooded, the interiors of the houses are tiled. It is easier to clean up after the flood recedes … We know day by day how much rain will cause the flood, how long it will take to reach the settlement area, and how long it will take to recede … '

According to the above statements, it is evident that the village headmen have observations regarding flood disasters, and these observational data have been reported for years.

Factor relationship: Local knowledge systems are related to ecological intuition and traditional early warning indicators.

4. Discussions

This study makes three main contributions to the disaster risk management literature. First, it moves beyond the predominantly qualitative treatment of local and indigenous knowledge by proposing a systematic approach to translating experiential knowledge into measurable flood susceptibility factors. While previous studies have emphasised the importance of local knowledge, they have often failed to operationalise it within analytical modelling frameworks.

Second, the study introduces a novel empirical approach by directly linking thematic insights derived from village headmen with commonly used flood susceptibility indicators such as rainfall, topography, land use, and infrastructure conditions. In doing so, it demonstrates how non-expert knowledge can be structured and integrated into factor-based flood modelling processes.

Third, the research contributes to the growing body of literature on community-based disaster risk management by empirically highlighting the critical role of local governance actors – specifically village headmen – as intermediaries between communities and formal institutions. This study shows that these actors are not only passive informants but also active knowledge producers whose insights can enhance both the accuracy and the social legitimacy of flood risk assessments.

Overall, the study provides a replicable and scalable framework for integrating local knowledge into disaster risk analysis, particularly in data-scarce rural contexts, thereby contributing to more inclusive, participatory, and effective flood management strategies.

The research findings reveal a strong consensus among stakeholders regarding the necessity of

utilising local knowledge in flood management. However, it is evident that this normative acceptance is not reflected in current practices. This situation indicates a significant gap between theory and practice, and between demand and supply.

Village heads stand out as both the strongest advocates of local knowledge and the group that evaluates current participation most positively. This suggests that they could play a key role as a 'bridge' or 'representative' in the process.

Local experts are the group that views the current situation most critically. This suggests that they have a closer view of the problems encountered in the field and the bureaucratic obstacles.

As in this study, previous studies have also indicated that indigenous knowledge should be preserved as a reference and guide for future research (Along *et al.* 2024, Mwalwimba *et al.* 2024, Ngonyani *et al.* 2024).It is inter-esting to note that the finding in this study regarding the period when there are many frogs and the excessive algae growth and greening in the water was also found in a study on coastal communities in Nigeria, which indicated that products should be harvested early (Obi *et al.* 2021). Another study again demonstrates that frog species and behaviours are used in a similar manner to our findings in predicting the direction of cloud movement to forecast rain and flood disasters (Acharya & Prakash 2019). Evidence that deforestation and land-use changes identified by village headmen contribute to increased flood risk has also been highlighted in previous studies (Ntajal *et al.* 2022).

A large proportion of settlements are located near plains and river valleys, primarily due to access to water resources, fertile agricultural land, and transportation opportunities. However, the persistence of settlements in areas with insufficient structural flood protection, despite frequent flood events, contrasts with the risk-avoidance patterns commonly emphasised in the literature. This suggests that economic and socio-cultural factors may outweigh potential flood risks in shaping settlement decisions (Mård *et al.* 2018). Conversely, several studies indicate that constructions in flood-prone areas have adapted over time to flood conditions, with communities developing experience-based strategies for coping with inundation (Devitt *et al.* 2023). This highlights the role of adaptive capacity and local resilience mechanisms in explaining the persistence of settlements despite flood hazards.

The absence of participants related to the institutional structure, the ad hoc nature of the work, the failure to inform the public, and similar findings regarding the potential effectiveness of local knowledge obtained from village heads have also been highlighted in previous studies (Turan and Oral 2023).

In this study, the discharge of agricultural and domestic waste into streams and rivers, which is thought to be effective in flood disasters, stems from the lack of a waste management system. As in previous studies, it has been shown that they are aware of the effects and risks of inadequate waste management practices (Madonsela *et al.* 2024, Madonsela *et al.* 2024). The study findings suggest that the identified factors can be integrated into flood management through pre-disaster flood susceptibility analyses. However, further research is needed to compare the observed findings on early warning systems with existing scientific studies. This highlights the necessity for future work to systematically assess the interplay between local observations and scientific data, as well as the effectiveness of early warning mechanisms.

In the study and interviews conducted, the main themes influencing flood risk emerged in order of importance as climate and meteorology, forest and land use, and infrastructure and river rehabilitation. Within these themes, key factors highlighted include vegetation density, rainfall intensity, culvert capacity, waste management, bridge span, seasonality, and land use. These findings underscore the importance of considering both natural and structural factors in flood management and provide a basis for developing prioritisation strategies in risk mitigation planning.

Consequently, it clearly demonstrates that the principle of participation, which is frequently emphasised in flood management literature, has not yet been implemented in the Turkish context, but that it is strongly desired by all stakeholders.

The research demonstrates that local and indigenous knowledge is not merely a traditional narrative, but a functional tool that supports and contextualises scientific models (Mwalwimba *et al.* 2024).

This study presents key findings on the alignment between scientific data and local observations, the socio-cultural dimensions of resilience, and the perceptions and use of indigenous knowledge among stakeholders.

Overlap between scientific data and local observations: The eight themes identified through thematic analysis (climate, hydrology, land use, etc.) are directly linked to the scientific parameters influencing flood formation. For example, villagers' observations that the herbicides used in their hazelnut orchards reduce the soil's water-holding capacity, or their coding of the 'June–July' months as the most dangerous period in their risk calendars, demonstrate that the local population accurately analyses environmental changes through long-term observation.

The socio-cultural dimension of resilience: In rural areas, resilience encompasses a 'culture of living with disasters' that goes beyond physical measures. The practice of tiling ground floors for easy cleaning, or the consideration of ecological indicators such as 'fly

infestations' (which actually signify a floodplain) when selecting settlement sites in the past, demonstrates that the local population possesses an internalised perception of risk.

The perception gap among stakeholders: One of the most striking findings is that, despite high levels of confidence in the effectiveness of local knowledge (92–97 per cent), its integration into official management processes remains very low (8–30 per cent). This situation indicates that the greatest obstacle to rural resilience is a lack of institutional coordination and a centralised approach to governance.

Flood management should not be solely engineering-oriented; rather, it needs to be framed within a more inclusive and participatory approach. In this context, the following recommendations are proposed for community-based disaster risk management in flood governance:

Systematic integration: It is recommended that local knowledge be systematically incorporated into official plans, particularly in rural areas with limited data, in order to improve the accuracy of risk maps. This approach will enable a 'two-way communication' between scientific methods and the local context.

Activating the 'Bridge' Role of Village Headmen (Muhtars): The social and political representation power of muhtars within communities should be utilised as a critical channel for identifying risks on-site and disseminating early warning systems to the public. The failure of warnings from institutions such as AFAD to translate into action at the local level indicates weaknesses in this bridging mechanism; therefore, the active involvement of local leaders in governance processes should be ensured.

Preservation of social memory: Documenting local knowledge will not only help reduce current risks but also ensure the transmission of social memory to future generations, thereby supporting the long-term resilience of rural communities.

Management of human-ınduced risks: Stricter land-use regulations and public awareness initiatives should be implemented to address human-induced factors identified by local communities but beyond their control, such as waste disposal in riverbeds, improper road construction, and deforestation.

5. Limitations and future research

At the same time, this study still has some limitations. Firstly, as the sample is largely limited to village heads serving in villages that have experienced disasters, this restricts the generalisability of the findings to villages and village heads with different characteristics. Secondly, the data were collected through participant-reported and interview-based methods and may therefore contain subjective assessments and potential biases. Thirdly, this study was conducted in a limited geographical area in North-Western Turkey, characterised by relatively dense forest cover and steep topography. In this context, the perceptions, experiences and assessments of village heads serving in regions with different geographical and socio-cultural characteristics may vary depending on cultural, environmental and behavioural factors. This circumstance should also be considered as a factor limiting the generalisability of the findings. Fourthly, the researcher's position, assumptions and interaction with participants may also have influenced the data collection and interpretation process.

Future studies may focus on validating flood-related assessments through the comparative analysis of expert opinions and the perspectives of village headmen (muhtars) within a vulnerability analysis framework. Such an approach would enable a more comprehensive and reliable understanding of flood risk by systematically examining both technical knowledge and local experiential insights. Moreover, comparing these two knowledge domains can help identify areas of convergence and divergence, thereby contributing to the refinement and validation of existing models. Ultimately, this line of research has the potential to support the development of more effective, participatory, and context-sensitive disaster risk reduction strategies at the local level.

6. Conclusion

This study examined the observations, experiences and local knowledge of village headmen living in rural settlements regarding floods, revealing how this knowledge can be utilised in flood management. The findings show that village headmen associate the causes of floods not only with natural processes but also with human-induced chang-es – such as transformations in land use, narrowing of riverbeds, deforestation, and un-planned construction. This situation reveals that local communities can perceive envi-ronmental changes through long-term observation and experience, and that this percep-tion supports scientific models related to flood sensitivity.

One of the most striking aspects of the study is the high perception that indigenous knowledge can be used in flood management and can be effective when used. This finding demonstrates that local knowledge is not merely a traditional form of knowledge but can also serve as a functional tool in disaster management and environmental planning pro-cesses. This will also facilitate the use of local knowledge in flood management and other rural planning efforts.

The eight themes identified through thematic analysis (climate and meteorology, hy-drology and topography, socio-economic and behavioural factors,

institutional structure, natural cycles, forest and land use, settlement and urbanisation, infrastructure and river rehabilitation) are directly related to the parameters that influence flood formation. This finding demonstrates that indigenous knowledge can be systematically integrated into flood management plans by classifying it under specific themes.

The study compares the local knowledge of village heads with scientific flood risk indicators, highlighting both overlapping and divergent points, and emphasises the importance of using local knowledge and scientific data together in flood management.

In conclusion, taking indigenous knowledge into account in flood management, particu-larly in rural areas where data is lacking, can increase the accuracy of risk assessments and enable the development of more feasible strategies at the local level. Furthermore, re-cording this cultural knowledge and passing it on to future generations will contribute to both the preservation of social memory and the sustainability of local resilience. Integrat-ing local knowledge with scientific methods will support the development of disaster management policies that are sensitive to the local context and strengthen the reliability of flood sensitivity maps.

When the local community's intuitive and experiential knowledge is combined with scientific methods through a 'two-way communication' process, it is possible to develop flood management strategies that are more sustainable and better suited to local conditions.

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Author contributions

Mustafa Tanrıverdi: Literature Review, Conceptualization, Data curation, Methodology, Result analysis, Conclusion and Writing original manuscript. Tülay Erbesler Ayaşlıgil: Literature Review, Conceptualization, Data curation, Methodology, Result analysis, Conclusion and Writing original manuscript.

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